What Does It Take?
Quantifying Cross-Country Transfers in the Eurozone*

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Abstract

We compute the cross-country transfers that result from unconventional monetary policy in the Eurozone. The ECB funds the expansion of its aggregate balance sheet mostly by issuing bank reserves and cash in core countries. The national central banks (NCBs) in periphery countries then borrow from the core NCBs at below-market rates to fund the asset purchases and bank lending. In addition, NCBs in the periphery lend more to their own banks at below-market rates. To compute the cross-country transfers, we compare the resulting cross-country distribution of NCB income to a counterfactual scenario without the ECB and without non-marketable intra-Eurozone debt. We document significant and persistent transfers from the core to the periphery.

Keywords: Unconventional Monetary Policy, Financial Repression, Monetary Union, Target2

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1 Introduction

The Eurozone is a monetary union, but not a fiscal union. Its member states retain fiscal sovereignty: each national central bank (NCB) is fiscally backed only by its own national government, and hence face a joint national budget constraint. NCBs receive no fiscal backing from other Eurozone governments. Consequently, transfers between NCBs have direct implications for taxpayers across the Eurozone.

Our paper quantifies the intra-Eurozone transfers between NCBs that result from substituting non-marketable debt for bonds when the European Central Bank (ECB) engages in unconventional policies. The Eurosystem's balance sheet had grown to 56% of GDP in the Eurozone by the end of 2021. Most of this growth has happened through an expansion of the NCB balance sheets, because NCBs carry out 90% of the asset purchases.[1] As the ECB funds its asset purchases mostly by issuing bank reserves in core countries, the NCBs of core countries have accumulated claims on the NCBs of periphery countries intermediated by the ECB.[2] These intra-Eurozone claims are referred to as Target2 assets and liabilities within the Eurosystem. For example, between 2014 and 2021, the Bundesbank has funded its balance sheet expansion mainly by issuing bank reserves, while the Banca d'Italia has done so by issuing Target2 IOUs.[3]

Before the introduction of unconventional policies, core countries were already lending to the periphery, but such transactions took place at prevailing market rates. Under the new regime, the ECB has effectively become the intermediary of this cross-country lending.[4]

Unconventional monetary policies operate through large-scale swaps of marketable securities, such as government bonds, for non-marketable securities, such as reserves or Target2 claims. By exchanging non-marketable for marketable securities—an arrangement often described in the literature as financial repression—such policies necessarily generate transfers. Some agents obtain funding below market rates, thereby receiving transfers, while others face above-market costs,

[1] See Appendix E for a brief discussion of the implementation of national debt asset purchases.

[2] The core NCBs accumulate claims on the ECB while periphery NCBs issue IOUs to the ECB through the Target2 system.

[3] Typically, changes in Target2 imbalances do not change the net claims of one country on another country (De Grauwe and Ji, 2012). For example, in the case of QE, the claim of a German financial intermediary on the Italian government, in the form of an Italian bond, is simply replaced by a claim of the German NCB on the Italian NCB. However, this swap of one type of debt for another is not irrelevant, because the latter is not a market transaction, and the rate of return on that claim is lower than the rate of return on equivalent marketable claims.

[4] Prior to the introduction of unconventional measures, cross-border flows from the core to the periphery were intermediated through interbank lending and through cross-country holdings of government bonds. The sovereign debt crisis, and the associated rise in default risk, led to a freezing of interbank markets and to the repatriation of government bond holdings.

thereby paying them. Once we consolidate the budget constraints of NCBs and their national governments (Sargent and Wallace, 1981), it becomes apparent that the public sector in the periphery borrows at the risk-free rate for the share of their outstanding bonds absorbed by the Eurosystem.

When the ECB expands its balance sheet, the Eurozone periphery borrows from the core through the Eurosystem at a low rate below the market rate. If these Target2 claims are risk-free, the ECB must be the senior creditor. In this case, periphery countries' government debt held by private investors would be rendered riskier, since private bondholders are effectively subordinated to the ECB. However, existing empirical evidence implies that QE in the Eurozone successfully lowers yield spreads and reduces credit risk.

As balance sheet expansions are concentrated in times of stress in bond markets, taxpayers in core countries like Germany are likely to be exposed to credit and currency risk—on the asset side of the Bundesbank—in high risk episodes, but they are not compensated for this risk. The ECB pools the income net of expenses earned by the NCBs on their balance sheets, and then redistributes the pooled income back to NCBs based on their capital key shares. Each NCB's holding of its domestic sovereign debt is exempt from the pooling arrangement. As a result, NCBs in the periphery can borrow at low interest rates from the core to earn the carry profit on its own high-risk sovereign bonds.

We argue that this core-periphery pattern is an equilibrium phenomenon whenever investors impute a non-zero probability to a break-up of the Eurozone. All else equal, Eurozone banks will strictly prefer to hold reserves in the core countries, because core currencies would be expected to appreciate against periphery currencies in case of a Eurozone exit or break-up. As a result, bank reserves in the core and the periphery should not trade at par. Given that they do in the Eurosystem, banks strictly prefer to hold core reserves in equilibrium. Similarly, households strictly prefer to hold cash in the core countries. To the best of our knowledge, ours is the first paper to argue that this core-periphery pattern is an equilibrium phenomenon. This evidence from reserve accumulation in the core suggests that reserves in the periphery are exposed to currency redenomination risk.

To quantify the implicit transfers due to income pooling, we compare the income from the pooling arrangement to a counterfactual scenario without Eurozone, without the ECB pooling arrangements and without non-marketable debt. In this counterfactual scenario, NCBs do not pool the income, and assets earn market rates of return. Importantly, we assume that the Eurozone governments only borrow from other Eurozone governments at the prevailing market rates. We

impute NCB incomes and expenses based on these assumptions. Importantly, we do not assume that Target2 claims are as risky as government bonds.

In the counterfactual scenario, these European countries are part of a fixed exchange rate regime. The Bundesbank would buy assets denominated in Italian Lira and Spanish Pesetas to defend the peg whenever there is flight to safety. Safe asset demand for German assets would put upward pressure on the Deutsche Mark. A real-world example that corresponds to the counterfactual is the case of Switzerland. To defend the peg with the Euro, the SNB was forced to massively buy Euro-denominated assets, mostly government bonds. The balance sheet of the SNB is 112% of Swiss GDP in 2022.

As the ECB balance sheet has grown, the intra-Eurozone transfers that are implied by the ECB's management of its balance sheet have become larger. Our paper quantifies the intra-Eurozone transfers. We believe we are the first to do so. Over this period between 2004 and 2023, Germany paid a cross-border transfer of 10.9% of GDP to other countries, while Italy and Spain received a cross-border subsidy of 5.7% and 7.5% of their GDP, respectively. However, Italian and Spanish taxpayers receive only a smaller cumulative net subsidy of 2.4% and 2.4% of their GDP in the same period, because part of the cross-border transfers accrue to Italian and Spanish banks, not taxpayers. When accounting for all NCBs and ECB, cross-country subsidies should sum to zero.

These cross-border transfers, arising from cross-border lending, measure total transfers to taxpayers *and* to banks, arising from cheap lending to banks within a country.[5] In our counterfactual scenarios without the Eurozone, we impute market rates not only to cross-country IOUs but also those within individual countries. Since the onset of the European sovereign debt crisis, the NCBs have provided cheap long-term funding to euro area banks. The so-called Long-Term Refinancing Operations (LTROs) are long-term loans extended to banks at highly favorable rates—often below the short-term lending rates, such as EONIA or the €STR. These cheap loans generate within-country transfers from the NCBs to the banking sector. This decomposition reveals substantial within-country subsidies to the banking sector for Italy and Spain, with cumulative subsidies of 3.3% and 5.1%, respectively. These figures are significantly higher than those observed for Germany (1.5%). The gap between peripheral and core countries emerges due to the large volume of bank lending (LTROs) extended by the Italian and Spanish central banks. Italy receives 5.7% of GDP in cross-country subsidies, but it spends 3.3% on its own banks. As a result, the net taxpayer subsidy received is 2.4%. In contrast, within-country transfers in Germany are borne entirely by

[5]Throughout the paper, we use the terms "LTROs" and "bank lending" interchangeably.

German taxpayers, who contributed a cumulative transfer of 12.4% of their GDP in total between 2004 and 2023.

Our counterfactual calculation is conservative in the following sense. The gap between the actual and the counterfactual income of the NCBs is our measure of the implicit transfers in the Eurozone. Our counterfactual exercise uses historical yields of marketable instruments, such as bank borrowing costs and sovereign bond yields. However, the reason these assets (e.g., LTROs) or government bond holdings are on the ECB balance sheet is precisely because the ECB aimed to reduce market bond yields and other interest rates.[6] This naturally implies that the observed rates are distorted relative to an equilibrium where such policies were absent. These effects could be large (see, e.g., Altavilla et al., 2021; Lane, 2023; De Santis and Holm-Hadulla, 2023; Haddad et al., 2025). Without these interventions, the yield spreads on the peripheral debt would be even higher than the ones we observed, and the measured transfers would be larger.

Furthermore, there is evidence that government bonds issued by the core are expensive, because they benefit from safe asset demand and earn convenience yields, whereas periphery government bonds are cheap, even after fully accounting for default risk (Jiang et al., 2021). When you take a periphery bond and add credit insurance, the synthetic core bond is still cheaper than a real core bond. As a result, QE implies that core taxpayers are asked to buy back expensive securities, whereas periphery taxpayers are asked to buy back cheap securities.

We conduct a robustness analysis with respect to the core-periphery spreads to show how much this consideration further magnifies the cross-country transfer estimate. We consider a no-QE counterfactual with a 100 basis point increase in yields for peripheral countries. Under this scenario, we find that Germany's cumulative subsidy rises to 13.2% of GDP, approximately 3 percentage points higher than in the baseline scenario. Meanwhile, the cross-country subsidies received by Italy and Spain increase to 8.1% and 10.5% of GDP, respectively. The difference between the baseline and this alternative scenario with higher spreads illustrates the sensitivity of these subsidies to changes in sovereign bond yields.

We also find it useful to draw a comparison with the U.S., which is a currency and fiscal union. In the U.S., market participants are indifferent between holding reserves at the Federal Reserve Bank of New York and the Federal Reserve Bank of San Francisco because there is no risk of these districts leaving the dollar zone. However, in the Eurozone, they are not. When the ECB

[6]The sovereign bond yields in the Eurozone include explicit and implicit price support provided by the ECB. For example, in 2022, the ECB rolled out the TPI (Transmission Protection Initiative) which allowed the ECB to intervene whenever the spreads between the periphery and the core were not fully justified by the macro fundamentals.

implements large-scale asset purchases, it replaces marketable debt with non-marketable debt that trades at par in all Eurozone countries. The ECB treats reserves held at the Bundesbank and the Banca d'Italia as equivalent. But financial market participants do not think of these as equivalent, presumably because they impute a non-zero probability to a break-up of the Eurozone or Eurozone exit. Banks obviously prefer to hold reserves in the core countries. We see large asymmetries between the core and the periphery balance sheets.

As a result, quantitative easing has different public finance implications in a monetary union that is not a fiscal union. In the U.S., a monetary union that is also a fiscal union, quantitative easing really amounts to a shortening of the consolidated government's maturity structure, transferring interest rate risk from the private sector back to taxpayers (Jiang et al., 2020). The Fed buys back long-term bonds from the private sector and issues short-term reserves. In the Eurozone core, the consolidated governments in core countries take on credit risk on the asset side of the NCBs, but they are not compensated for this risk. In the periphery, the consolidated governments borrow at below-market rates from the core. Large-scale asset purchases thus transfer credit risk from the private sector to taxpayers in the core countries. This can be interpreted as a form of financial repression. The ECB thus lowers the cost of funding for periphery countries by imposing hidden taxes on core countries.

We also discuss whether Target2 claims should be considered senior to sovereign debt. Historical precedents suggest that similar intra-system claims or IOUs have often been subject to haircuts in episodes involving the dissolution of monetary unions or sovereign default. We then formalize the implications of Target2 seniority for the effects of quantitative easing on sovereign spreads through a policy dilemma. If Target2 claims were indeed senior to government debt, QE would effectively subordinate private bondholders and should therefore lead to higher sovereign spreads. However, sovereign spreads declined following QE announcements. Because we observe a reduction in sovereign spreads associated with QE, this evidence suggests that investors either do not treat Target2 claims as senior to sovereign debt or expect fiscal transfers within the Eurosystem that mitigate the subordination risk.

The policy implications of our findings are straightforward. We highlight an important trade-off for Eurozone policymakers. A large ECB balance sheet may stabilize financial markets, but it inevitably generates cross-country fiscal transfers. Conversely, a lean balance sheet may limit such fiscal spillovers but heightens the risk of sovereign debt crises. In the end, the burden of adjustment falls on the fiscal discipline of Eurozone member states. Finally, while we quantify the

transfers, core countries also benefit in other ways from the euro, and it may have been costly not to undertake these policies. Our contribution is to highlight a set of costs that the literature has so far neglected. As these policies are implemented, and as the ECB decides how to manage its balance sheet going forward, these costs must be explicitly taken into account.

Literature. Monetary and fiscal policymakers are inexorably linked by a common budget constraint (Sargent and Wallace, 1981), implying that monetary and fiscal policies are always coordinated. Within the Eurosystem, the ECB is not fiscally backed by the national governments of the Eurozone. Instead, the Eurosystem is backed by the NCBs, which are backed by their respective national governments. Our work is closest to Bassetto and Caracciolo (2021), who analyze the potential outcomes in the event of a Eurozone default. Sinn and Wollmershaeuser (2011) also investigate the institutional design of the Target2 system. In contrast, our contribution is to quantify the intra-Eurozone transfers that arise even in the absence of default, highlighting a novel and largely overlooked dimension of the Eurozone's institutional design.

Governments often seek to borrow at below-market rates. Economists refer to this as financial repression (McKinnon, 1973; Shaw, 1973). One mechanism is the issuance of non-marketable debt that earns rates of return below the market rate of return (Reinhart et al., 2011). In a monetary union that is not a fiscal union, the market rate of return varies across countries, but the policy rate does not. As a result, the incidence of financial repression varies across countries.

There is large literature on the economics of financial repression in emerging market economies. The literature on financial repression in advanced economies is smaller. Reinhart and Rogoff (2009) document that financial repression was used in advanced economies after WWII to reduce the debt overhang. Hall and Sargent (2011) decompose the variation in the debt/output ratio. Acalin and Ball (2022) focus specifically on the U.S. experience after WW-II, and argue that financial repression was instrumental in decreasing the debt/output ratio. Payne and Szőke (2025) also explore the role of financial repression in lowering the government's funding costs of the U.S., while Chien et al. (2023) examine the role of financial repression in Japan's accumulation of public debt. Becker and Ivashina (2018); Acharya and Steffen (2015a); Andreeva and Vlassopoulos (2019) find evidence of financial repression in the Eurozone.

In the last decades, large-scale asset purchases have been studied as a tool of monetary policy to be used mainly when the policy rates hits the zero lower bound. However, large-scale asset purchases have often been used as an instrument of fiscal policy, especially during and in the

aftermath of wars, in the U.S., the U.K. and other European countries (Sargent et al., 2019; Hall and Sargent, 2022). Our work studies the impact of these purchases in the context of a monetary union that is not a fiscal union.

The rest of the paper is organized as follows. Section 2 documents the dramatic expansion of NCB balance sheets during asset purchase programs, revealing how periphery countries accumulate Target2 liabilities while core countries accumulate corresponding claims, which creates fundamental imbalances within the Eurosystem. In Section 3, we develop a theoretical framework that contrasts the effects of quantitative easing with and without income pooling, demonstrating how the Eurozone's income pooling arrangements systematically create implicit transfers between member countries. Section 4 quantifies implicit transfers by comparing actual outcomes to counterfactual scenarios without Eurosystem income pooling, decomposing total subsidies into within-country and cross-border components to reveal the full scope of fiscal redistribution. In Section 5, we analyze the scenarios in which Eurozone countries might default on their obligations and the implications for the transfer mechanisms we identify. Section 6 discusses the implications of the seniority of Target2 liabilities for the effects of quantitative easing on sovereign spreads. Section 7 concludes.

2 Core vs. Periphery Imbalances in the Eurozone

2.1 The Expansion of Central Bank Balance Sheets

We start by analyzing the balance sheets of Banca d'Italia and the Bundesbank. Table 1 offers snapshots at the end of 2014, 2021, and 2023. These dates mark respectively the year before the start of the Asset Purchase programme (APP) in 2015, the peak year of APP in 2021, and the most recent one in 2023. All numbers are expressed as percentages of the country's GDP in that year.

Over the past decade, we observe a significant expansion of central bank balance sheets. For example, the Bundesbank's balance sheet grew from 26.3% of GDP in 2014 to 83.2% in 2021. Similarly, the Banca d'Italia's balance sheet increased from 32.6% to 84.4% of GDP over the same period. These balance sheet expansions were largely driven by debt-security purchases and bank lending. The two combined rose from 3.9% to 40.4% of GDP in the Bundesbank's balance sheet and from 14.4% to 61.4% in the Banca d'Italia's balance sheet. Debt-security holdings are predominantly composed of national government bonds, which increased from 0% to 21.4% of GDP in the Bundesbank's balance sheet and from 0% to 29.2% in the Banca d'Italia's balance sheet.

2.2 Eurosystem Central Bank Balance Sheet Items

In addition to the increase in balance sheet size, the Eurosystem features several special or unique balance sheet items, which we discuss in detail below.

Target2. In the euro area, payments arising from the Eurosystem's monetary policy operations, as well as interbank and commercial transactions, are processed through Target2. The Target2 balance of each national central bank (NCB) reflects its net claim on, or liability to, the ECB. Across all euro-area countries, the net claims of the NCBs and the ECB should sum to zero.[7] For example, the Bundesbank's Target2 claim rose from 15.7% of German GDP in 2014 to 34.8% in 2021, while the Banca d'Italia's Target2 liabilities increased from 12.8% of GDP in 2014 to 32.3% in 2021 and 25.0% in 2023.

Figure 1 illustrates the evolution of Target2 balances in the euro area, highlighting the major creditor and debtor countries. The secular increase in Target2 imbalances since the global financial

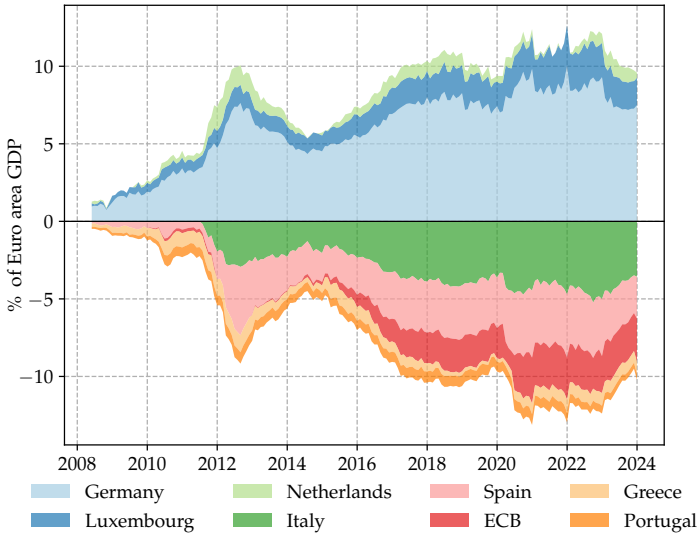
[7]Since small amounts of Target2 claims are held by participants outside the Eurosystem, the aggregate net Target2 balance is close to, but not exactly, zero.

Table 1: Balance Sheet of Banca d'Italia and Bundesbank

	Deutsche Bundesbank			Banca d'Italia		
% of GDP, Year End	2014	2021	2023	2014	2021	2023
Assets						
Bank Lending	2.2%	12.0%	1.8%	12.0%	24.9%	7.2%
National Debt Securities	0%	21.4%	18.4%	0%	29.2%	25.6%
Other Debt Securities	1.7%	7.0%	6.1%	2.2%	7.4%	5.9%
Gold, FX and Others	6.6%	8.3%	8.4%	17.1%	20.2%	19.3%
Eurosystem Target2	15.7%	34.8%	26.4%	0.0%	0.0%	0.0%
Eurosystem Banknotes	0.0%	0.0%	0.0%	1.4%	2.8%	2.2%
Liabilities						
Banknotes	8.2%	10.4%	9.1%	10.1%	13.2%	11.7%
Bank Reserves	3.1%	31.5%	26.9%	0.9%	22.2%	9.0%
Capital and Others	5.9%	27.3%	11.8%	8.7%	16.7%	14.4%
Eurosystem Banknotes	9.2%	14.1%	13.2%	0.0%	0.0%	0.0%
Eurosystem Target2	0.0%	0.0%	0.0%	12.8%	32.3%	25.0%
Sum	26.3%	83.2%	61.1%	32.6%	84.4%	60.1%

Note: The amount of national debt securities is imputed as eight-ninths of the combined public sector securities holdings under the PSPP and PEPP programs. This ratio is determined by the APP purchasing guidelines. The term "Other Debt Securities" refers to debt held for monetary policy purposes other than national debt securities.
Unit: % of GDP. Source: ECB, Eurostat, Bundesbank annual reports, Banca d'Italia and authors' calculation.

Figure 1: Target2 Imbalance among ECB and Selected NCBs



Unit: % of Euro are GDP. Source: ECB and Euro Stat.

crisis has been driven primarily by financial capital flows rather than by current-account imbalances (De Grauwe and Ji, 2012; Whelan, 2014; Perotti, 2020; Eisenschmidt et al., 2024). The first notable expansion, from 2009 to 2012, coincides with the European sovereign debt crisis. During this period, peripheral countries—heavily affected by the crisis—experienced significant capital flight to safer core countries. During the crisis, as discussed in more detail in Section 2.4, banks in core countries were reluctant to lend to peripheral banks due to concerns about default. In response, the ECB stepped in to provide liquidity to peripheral banks through bank lending (LTROs), by issuing bank reserves in the core.[8] The ECB's response was accompanied by a sharp rise in Target2 imbalances. Between 2009 and 2012, bank lending in Italy increased from 1.7% to 16.7% of GDP. This expansion in lending by the Banca d'Italia closely paralleled the growth of its Target2 liabilities, which rose from 0% of GDP in 2009 to 15.6% in 2012.

We also see a persistent rise in Target2 imbalances beginning in 2014, which is related to the Eurosystem's large-scale asset purchase programs as well as the expansion of bank lending. Under these programs, NCBs purchase substantial amounts of debt securities, often from private financial institutions located in core countries. For example, when the Banca d'Italia purchases €100 of Italian government bonds from Commerzbank in Frankfurt, Commerzbank receives €100 in re-

[8]Formally, reserves are created in the borrowing banks' accounts when they access LTROs. In practice, however, these reserves tend to migrate rapidly to core countries, so we describe them in the paper as being issued in the core.

serves held at the Bundesbank. The Bundesbank then records a Target2 claim on the Eurosystem, while the Banca d'Italia books the bonds on its asset side and a corresponding Target2 liability on its liability side. These purchases contributed to an expansion of bank reserves and to an increase in the Target2 claims of core NCBs, in this case the Bundesbank.

In this way, asset purchases in the periphery are largely settled through the creation of Target2 liabilities by their NCBs, such as the Banca d'Italia. As a result, Target2 imbalances tend to increase during the asset purchase programs. As noted by De Grauwe and Ji (2012), such transactions effectively swap one German claim on Italy—namely Commerzbank's holdings of Italian government bonds—for another, the Bundesbank's Target2 claim on the Banca d'Italia, without raising Germany's total net claims. At the same time, marketable government bonds are replaced by non-marketable central bank claims, with important consequences for cash flows and valuations.

Figure 1 also shows the net position of the ECB, which is not zero. The ECB conducts its purchases under the Asset Purchase Programme (APP) by issuing reserves through the NCBs. This process leads to an increase in the Target2 balances of the NCBs, while the ECB records a corresponding Target2 liability on its own balance sheet.[9]

Banknotes. Banknotes listed on the balance sheet of each NCB reflects its capital key share of total banknotes issued by Eurosystem instead of the actual amount of banknotes held in each country. Depending on the local households' preference for holding cash, the actual amount of currency held may be higher or lower than the amount implied by the capital key. The difference, which could be an asset or a liability position, is recorded as Eurosystem Banknotes. By construction, the total sum of net claims on Eurosystem Banknotes has to be zero for the Eurosystem. The actual amount of cash holding for each country's NCB is then the sum of the two balance sheet items (Banknotes and Eurosystem Banknotes).

For example, the Bundesbank carries a significant amount of Intra-Eurosystem banknote liabilities—around 14.1% of GDP in 2021—reflecting the higher preference for cash in Germany. In contrast, the amount of banknotes in circulation in Italy is lower than its capital key share, resulting in a claim under Intra-Eurosystem banknotes on the asset side of Banca d'Italia's balance sheet. This claim amounted to 2.8% of GDP in 2021. Banknotes and Eurosystem banknotes are identical assets. The distinction between the two items on the balance sheet serves to redistribute seignior-

[9]The expansion of the ECB's balance sheet is shown in Appendix C

age income across the Eurosystem. Currently, Eurosystem banknote positions are remunerated at the main refinancing operations (MRO) rate. The positive remuneration of these positions not only redistributes seigniorage income among NCBs, but also channels a portion of that income from the NCBs to the ECB. In our view, this redistributed seigniorage income can also be regarded as a form of cross-country transfer.

Debt Securities. In NCB balance sheets, the asset holdings due to APP (asset purchase programme) and PEPP (pandemic emergency purchase programme) as well as earlier purchase programs such as SMP (securities markets programme) and CBPP (covered bond purchase programme) are divided into two sub-categories: (i) National Debt Securities and (ii) Other Debt Securities. The National Debt Securities capture domestic government bonds acquired by its own NCB under APP and PEPP. Other Debt Securities is the residual, which is the sum of all other security holdings due to the SMP, CBPP, as well as non-government securities such as supranational bonds and corporate bonds purchased under APP and PEPP. The separation of these two sub-items is motivated by their different income-pooling rules, which we clarify in Appendix B.

Both Italian and German central banks hold a large amount of national debt in terms of their GDP share. From 2014 to 2021, the Bundesbank's national government debt asset increased from 0% to 21.4% of GDP, and the Banca d'Italia's debt asset increased from 0% to 29.2% of GDP. Other than the national government bonds, the amount of bank lending also increased. It went up by about 12.9% of GDP in Italy and rose 9.8% in Germany between 2014 and 2021. Overall, the balance size of expansion due to the APP, PEPP, and bank lending are about 30% to 40% of GDP for both countries during the active-APPs periods.

In 2021, the German NCB also carried more than 20% of GDP in other liabilities, which include two major items: liabilities to German general government, 6.8% of GDP, and liabilities to non-euro area central banks, 10.6% of GDP.

Asymmetry. The evolution of NCBs' balance sheets is asymmetric. In the case of the Bundesbank, the overall rise in its liabilities, including banknotes, bank reserves and other liabilities, actually exceeds the amount of asset purchases and bank lending combined. The excess liabilities are absorbed by the German Target2 claims on the periphery. In contrast, the increase of the currency and bank reserves in Banca d'Italia is insufficient to fund its bank lending and asset purchases. The shortage is made up by the increase of its Target2 liabilities owed to core coun-

Table 2: Balance Sheet of Synthetic Core vs. Periphery NCB

	Core			Periphery		
% of GDP, Year End	2016	2021	2023	2016	2021	2023
Assets						
Bank Lending	2.1%	13.1%	1.5%	11.6%	21.8%	4.1%
National Debt Securities	8.9%	21.9%	18.8%	13.0%	31.5%	26.7%
Other Debt Securities	2.9%	5.5%	4.8%	8.8%	11.0%	9.2%
Gold, FX and Others	6.6%	7.9%	8.2%	11.2%	12.3%	11.0%
Eurosystem Target2	20.9%	26.7%	21.7%	0.0%	2.2%	2.0%
Eurosystem Banknotes	1.2%	1.6%	1.3%	4.9%	7.1%	6.8%
Liabilities						
Banknotes	8.3%	10.0%	8.8%	11.1%	12.8%	10.9%
Bank Reserves	15.2%	32.5%	26.5%	4.4%	25.1%	13.2%
Capital and Others	11.2%	23.2%	11.2%	9.2%	14.7%	12.6%
Eurosystem Banknotes	7.9%	10.6%	9.8%	0.9%	0.5%	0.5%
Eurosystem Target2	0.0%	0.5%	0.0%	23.9%	32.7%	23.5%
Sum	42.7%	76.8%	56.3%	49.5%	85.9%	60.8%

Note: The synthetic core NCB includes Germany, the Netherlands, and Finland. The synthetic periphery NCB consists of Ireland, Greece, Spain, Italy, and Portugal. The nominal GDP shares of the synthetic core and periphery countries, relative to the total Eurozone, are approximately 38% and 32%, respectively. The amount of national debt securities is imputed as 80% of the total debt securities holdings for monetary policy purpose.
Source: ECB (Disaggregated balance sheet of Eurosystem), Euro Stat and authors' calculation

tries. A significant fraction of the Banca d'Italia balance sheet expansion is financed by issuing non-marketable debt through its Target2 account. The periphery thus borrows from the core at below-market rates as the ECB expands its balance sheet.

Table 2 aggregates across core and periphery NCBs' balance sheets. We use Eurosystem data whose sample starts from 2016. By comparing the composition of assets and liabilities, we can see that the NCBs in the core countries tend to be net holders of Target2 assets, whereas the NCBs in the periphery countries tend to be net sellers of these claims. To the extent that (1) these claims do not earn market rates of return, and (2) monetary income from these claims are first collected by the ECB and redistributed to NCBs in ways that are different from the actual ownership, which we show in detail in Section 3, the Eurosystem generates a significant amount of implicit cross-country subsidies and transfers between core and periphery countries. As a result of these transfers, monetary policies in the Eurozone have important fiscal implications.

2.3 Consolidated balance sheets

Having introduced the key items on NCB balance sheets, we next consolidate the balance sheets of NCB and national governments. This consolidation perspective has been well understood at least since Sargent and Wallace (1981). Table 3 reports the 2023 consolidated balance sheets of Germany and Italy and their corresponding decomposition. As shown in this table, the public sector buys back its debt through the central bank by issuing banknotes and bank reserves. Clearly, the issuance by the German NCB exceeds the amount of its own debt purchases. The excess liabilities are matched by its Target2 claims. In contrast, the purchase of government debt by the Italian NCB is insufficient to finance its acquisitions and is mostly financed by its Target2 liabilities. By the end of 2023, the Italian public sector had effectively swapped debt amounting to about 25% of GDP into Target2 liabilities.

Table 3: Consolidated Balance Sheet Germany vs. Italy

	Germany			**Italy**		
2023 Year End, % of GDP	Consolidated	NCB	Gov't	Consolidated	NCB	Gov't
Assets						
Gold SDR and FX	7.1%	7.1%	0.0%	10.8%	10.8%	0.0%
Deposits	8.9%	0.0%	8.9%	0.0%	0.0%	0.0%
Bank Lending	1.8%	1.8%	0.0%	7.2%	7.2%	0.0%
Loans	4.5%	0.0%	4.5%	4.6%	0.0%	4.6%
Other Debt Securities	9.2%	6.1%	3.1%	10.1%	9.0%	1.1%
Equities	17.6%	0.0%	17.6%	9.6%	0.0%	9.6%
Eurosystem Target2	26.4%	26.4%	0.0%	0.0%	0.0%	0.0%
Eurosystem Banknotes	0.0%	0.0%	0.0%	2.2%	2.2%	0.0%
Other Assets	4.4%	1.3%	3.0%	11.8%	3.2%	8.6%
Sum (Assets)	**79.7%**	**42.6%**	**37.1%**	**56.2%**	**34.5%**	**21.7%**
Liabilities						
Banknotes	9.1%	9.1%	0.0%	11.7%	11.7%	0.0%
Deposits	0.0%	0.0%	0.0%	5.2%	0.0%	5.2%
Bank Reserves	26.9%	26.9%	0.0%	9.0%	9.0%	0.0%
National Debt Securities	28.9%	-18.4%	47.3%	86.4%	-25.6%	111.9%
Loans	13.1%	0.0%	13.1%	14.2%	0.0%	14.2%
Eurosystem Target2	0.0%	0.0%	0.0%	25.0%	0.0%	25.0%
Eurosystem Banknotes	13.2%	13.2%	0.0%	0.0%	0.0%	0.0%
Other Liabilities	15.5%	11.8%	3.7%	29.8%	14.4%	15.4%
Sum (Liabilities)	**106.8%**	**42.6%**	**64.2%**	**181.3%**	**34.5%**	**146.8%**
Net Liabilities	**27.1%**	**0.0%**	**27.1%**	**125.0%**	**0.0%**	**125.0%**

Unit: % of GDP. Source: ECB, Euro Stat, Deutsche Bundesbank, Banca D'Italia and authors' calculation.

Table 4 provides a snapshot of the evolution of consolidated balance sheets in Germany and Italy. The net liabilities represent the burden on taxpayers in each country. Clearly, Target2 imbalances comove closely with asset purchase programs. Quantitative easing can be interpreted as debt monetization, while quantitative tightening can be viewed as the reissuance of debt back to the market. Unsurprisingly, as large-scale asset purchases were implemented after 2014, Target2 imbalances grew. The year 2021 marked the peak of the asset purchase programs. At that time, Germany's public sector held Target2 assets equivalent to 34.8% of GDP, in contrast to 32.3% of GDP in Target2 liabilities owed by the Italian public sector. The German public sector mainly funded the expansion of its balance sheet by issuing reserves (31.5% of GDP in 2021). The German public sector then deploys this funding to lend 34.8% of GDP to the rest of the Eurosystem. The Italian public sector funded itself mainly by borrowing from the Eurosystem (32.3% in 2021) and by issuing reserves (22.2%). As the ECB began implementing QT policies, Target2 imbalances started to shrink.

2.4 Core vs. Periphery Imbalances Intermediated by the ECB

Why have we seen this asymmetry in the evolution of NCB balance sheets in the core vs the periphery? Consider a version of the Eurozone with only two countries: Germany (the lender in the core) and Italy (the borrower in the periphery). Germany G generates excess savings, reflected in a surplus of deposits, while Italy I faces funding needs.[10]

Pre-Crisis German banks may prefer to channel funds through Italian banks rather than directly purchasing government bonds or lending to the non-financial sector.[11] In this setting, the German banking sector lends to the Italian banking sector via the interbank market. Table 5 illustrates the balance sheet mechanics. For simplicity, we focus on national debt (ND) in the borrower country's balance sheet, though the logic easily extends to bank loans or corporate bonds. Suppose UniCredit in Italy seeks to fund the purchase of €10 of national debt (ND_I), while German banks hold €10 of excess liquidity in deposits (DD). Commerzbank in Germany then lends €10 to UniCredit through the interbank market (IBL), and UniCredit uses these funds to acquire €10 of Italian government bonds (ND_I).

[10] These needs may take the form of government debt issuance, corporate bond financing, or bank lending to the non-financial sector.

[11] First, Italian banks can use the funds to purchase government bonds or extend credit to domestic firms. Second, it may be advantageous for sovereign bonds to be held on the balance sheets of domestic banks, either because they have better information about local credit risk or because the sovereign is less likely to default on debt held domestically.

Table 4: Evolution of Consolidated Balance Sheet

	Germany			Italy		
Year End, % of GDP	**2014**	**2021**	**2023**	**2014**	**2021**	**2023**
Assets						
Gold SDR and FX	5.4%	7.2%	7.1%	7.3%	11.1%	10.8%
Deposits	9.7%	12.5%	8.9%	0.0%	0.0%	0.0%
Bank Lending	2.2%	11.7%	1.8%	12.0%	24.9%	7.2%
Loans	5.6%	5.2%	4.5%	5.8%	5.4%	4.6%
Other Debt Securities	6.6%	11.0%	9.2%	8.7%	12.2%	10.1%
Equities	16.8%	20.8%	17.6%	8.8%	10.3%	9.6%
Eurosystem Target2	15.7%	34.8%	26.4%	0.0%	0.0%	0.0%
Eurosystem Banknotes	0.0%	0.0%	0.0%	1.4%	2.8%	2.8%
Other Assets	3.6%	3.4%	4.4%	12.2%	12.8%	11.1%
Sum (Assets)	**65.7%**	**106.6%**	**79.7%**	**56.1%**	**79.5%**	**56.2%**
Liabilities						
Banknotes	8.2%	10.3%	9.1%	10.1%	13.2%	11.7%
Deposits	0.0%	0.0%	0.0%	9.7%	7.0%	5.2%
Bank Reserves	3.1%	31.5%	26.9%	0.9%	22.2%	9.0%
National Debt Securities	60.2%	38.6%	28.9%	125.1%	106.6%	86.4%
Loans	21.8%	15.5%	13.1%	11.3%	12.7%	14.2%
Eurosystem Target2	0.0%	0.0%	0.0%	12.8%	32.3%	25.0%
Eurosystem Banknotes	9.2%	14.1%	13.2%	0.0%	0.0%	0.0%
Other Liabilities	8.5%	31.0%	15.5%	16.1%	27.6%	29.8%
Sum (Liabilities)	**111.0%**	**141.0%**	**106.8%**	**186.1%**	**221.6%**	**181.3%**
Net liabilities	**45.3%**	**34.4%**	**27.1%**	**130.0%**	**142.1%**	**125.0%**

Unit: % of GDP. Source: ECB, Euro Stat, Deutsche Bundesbank, Banca D'Italia and authors' calculation.

Before the GFC and the European sovereign debt crisis, the interbank market was sufficiently active to support such transactions. Commerzbank in Germany would lend to UniCredit at the prevailing market rate, and UniCredit would use the funds to purchase government bonds or extend credit to domestic firms. In this environment, the interbank market cleared without central bank intervention. This corresponds to scenario (*a*) in Table 5.

Bank Lending (LTROs). This recycling of surpluses in the interbank market was common prior to the European debt crisis or at least before the GFC. After the crisis, the ECB emerged as the main intermediary of imbalances within the Eurozone between the core and the periphery countries. Banks in the lender/core countries have been reluctant to lend to banks in the periphery due to fear of default. Banks in the periphery held large amounts of risky national debt. As a result, banks in the core were unwilling to lend to banks in the periphery at the interbank lending rate.

As the interbank market ceased to function, the ECB stepped in as an intermediary between the core and the periphery, primarily through unconventional monetary policy measures. In the initial phase, this intermediation took place via LTROs,[12] since full-scale QE lacked sufficient political support. Through LTROs, the ECB supplied liquidity to peripheral banks, effectively channeling reserves originating in core countries. Carpinelli and Crosignani (2021) document that "banks used most liquidity to buy domestic government bonds and substitute missing wholesale funding." In this sense, the ECB borrowed from the lender countries in the form of reserves and reallocated them to support banks in the borrower countries.

The associated balance sheet changes under LTROs are depicted in scenario (*b*) of Table 5. The ECB provided €10 in liquidity to UniCredit via an LTRO (BL), which UniCredit then used to purchase €10 of Italian national debt (ND_I) from Commerzbank. To settle the transaction, the ECB created reserves at the Bundesbank, thereby increasing German Target2 claims.[13]

[12] An additional program implemented during this period was the SMP.

[13] The transaction chain is as follows: (i) UniCredit borrows €10 through an LTRO; (ii) the Bank of Italy credits UniCredit's reserve account; (iii) UniCredit transfers these reserves to purchase €10 of government bonds from Commerzbank; (iv) Commerzbank's reserve account at the Bundesbank is credited with €10.

Table 5: Balance Sheet Changes

	Scenario (a): Pre-Crisis					
	Banking Sector		National Central Bank		NCB + Gov't	
Country	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
G	$IBL = +10$	$DD = +10$				
I	$ND_I = +10$	$IBL = +10$				
	Scenario (b): LTROs					
	Banking Sector		National Central Bank		NCB + Gov't	
Country	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
G	$BR_G = +10$	$DD = +10$	$T2 = +10$	$BR_G = +10$		
I	$ND_I = +10$	$BL_I = +10$	$BL_I = +10$	$T2 = +10$	$BL_I = +10$	$T2 = +10$
	Scenario (c): Quantitative Easing					
	Banking Sector		National Central Bank		NCB + Gov't	
Country	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
G	$BR_G = +10$	$DD = +10$	$T2 = +10$	$BR_G = +10$		
I			$ND_I = +10$	$T2 = +10$		$T2 = +10$ $ND_I = -10$

Note: BR denotes bank reserves, ND denotes national debt, IBL denotes interbank lending, BL denotes central bank lending, DD denotes demand deposit, and $T2$ denotes Target2 balances.

In general, the interest rate on central bank lending was at or below the reserve rate. This ultra-low funding cost amounted to an implicit subsidy for banks. Italian banks could therefore earn a carry trade—the spread between the yield on government bonds and the LTRO lending rate. Acharya and Steffen (2015b) discuss this strategy in detail. In practice, Italian banks were not only compensated for bearing duration and credit risk, but also benefited from below-market borrowing costs. From the perspective of the consolidated public sector, Italy effectively issued non-marketable debt through its Target2 account in order to support its banking system via LTROs.

Quantitative Easing (QE). In January 2015, the ECB launched its first Public Sector Purchase Programme (PSPP), which was later expanded in 2020 to include the Pandemic Emergency Purchase Programme (PEPP). These QE programs involved the purchase of government bonds and other securities from banks in the core, aiming to provide liquidity to banks in the periphery. Under QE, periphery NCBs purchased government bonds from banks in the core by borrowing through the Target2 system. The balance sheet changes under QE are depicted in scenario (*c*) of Table 5. The Banca d'Italia purchased €10 of Italian national debt (ND_I) from Commerzbank in Germany. The issued bank reserves flow to the core country, thereby increasing Target2 balances. In this case, the Italian NCB holds Italian government bonds and earns the spread between the bond yield and the low Target2 borrowing rate. However, the lender country's NCB bears interest rate and credit risk without compensation. From the perspective of the consolidated balance sheet, Italy effectively substituted non-marketable debt (Target2) for marketable bonds through QE.[14]

Within- and Cross-Country Transfers. Before the crisis, it was possible to intermediate these imbalances through the interbank market (Scenario (*a*) of Table 5). The driving force is the excess savings in the lender/core country and the funding needs of the borrower/periphery country.

After the crisis, the ECB stepped in to intermediate these imbalances, first by lending to banks in the lender country (Scenario (*b*)) and then by purchasing government bonds from banks in the lender country (Scenario (*c*)). In both cases, periphery countries borrow from core countries at below-market rates, generating cross-country transfers. ECB interventions effectively intermediate the imbalances between lender/core and borrower/periphery countries in the Eurozone at non-market rates.

[14] A substantial share of QE bond sales originated from non-euro-area investors. Since only euro-area banks with reserve accounts at the Eurosystem could transact directly with NCBs, these investors typically sold bonds via such banks (e.g., Commerzbank). The transaction left investors with wholesale euro-denominated deposits, while the intermediating bank's reserve account at its NCB was credited.

The ECB's intermediation has important implications for the distribution of income across countries. In the first case, the core subsidizes the NCB (and ultimately taxpayers) in the periphery through a cross-country transfer, while taxpayers in the periphery subsidize their banks via within-country transfers. In the second case, the core directly subsidizes the periphery NCB (and ultimately taxpayers) through a cross-country transfer.

3 Fiscal Implications of Eurozone Monetary Arithmetic

To highlight our points, this section considers a simplified environment in which the impact of ECB policies can be clearly analyzed. Countries are indexed by c, and we focus on two: Italy (I), representing a peripheral country, and Germany (G), representing a core country.[15] Asset types are indexed by i, and there are five: bank reserves (BR), cross-country claims or Target2 balances ($T2$), central bank lending (BL), national government debt (ND), and government debt held by the NCB (QE). We denote by $A_c^i \geq 0$ and $B_c^i \geq 0$ the asset and liability positions of asset i in country c, respectively. Since any positive asset can be viewed as a negative liability, the identity $A_c^i \equiv -B_c^i$ always holds. Finally, the gross return on asset i in country c is denoted by R_c^i.

In each country c, the NCB remits an amount $T_{c,t+1}$ to the government at period $t+1$, where the precise definition of $T_{c,t+1}$ will be specified later. The government's flow budget constraint at period $t+1$ is given by:

$$B_{c,t}^{ND} R_{c,t+1}^{ND} = \underbrace{S_{c,t+1}}_{\text{Fiscal Primary Surplus}} + \underbrace{T_{c,t+1}}_{\text{Central Bank Remittance}} + B_{c,t+1}^{ND}, \tag{1}$$

where $S_{c,t+1}$ is the fiscal surplus required to refinance the debt, conditional on the paths of $B_{c,t}^{ND}$, $R_{c,t+1}^{ND}$, and $T_{c,t+1}$.

The amount of each NCB's remittance depends on the monetary policy implemented by the Eurosystem. Motivated by the data, we consider two types of non-conventional monetary policy in this simplified environment: QE and bank lending.

[15] Our analysis focuses primarily on transfers among NCBs and abstracts from implicit transfers that occur through the ECB's balance sheet.

3.1 Autarky

It is useful to start with a counterfactual autarky case that assumes no cross-country lending or borrowing. In other words, each country's monetary policy is fully funded by issuing its own reserves:

$$A_{c,t}^{QE} + A_{c,t}^{BL} = B_{c,t}^{BR}.$$

The NCB's remittance is given by:

$$T_{c,t+1}^{Autarky} = \underbrace{A_{c,t}^{QE} R_{c,t+1}^{ND}}_{\text{QE Interest Income}} + \underbrace{A_{c,t}^{BL} R_{c,t+1}^{BL}}_{\text{Bank Lending Income}} - \underbrace{B_{c,t}^{BR} R_{t+1}^{BR}}_{\text{Cost of Reserves}},$$

which states that the interest income of the NCB on its asset side, net of the cost of issuing reserves, constitutes the return harvested by the NCB. By substituting $A_{c,t}^{QE} + A_{c,t}^{BL} = B_{c,t}^{BR}$ into the equation above, we obtain:

$$T_{c,t+1}^{Autarky} = \underbrace{A_{c,t}^{QE}\left(R_{c,t+1}^{ND} - R_{t+1}^{BR}\right)}_{\text{QE Seigniorage}} + \underbrace{A_{c,t}^{BL}\left(R_{c,t+1}^{BL} - R_{t+1}^{BR}\right)}_{\text{Bank Lending Seigniorage}}. \tag{2}$$

If the NCB can issue reserves at a rate R_{t+1}^{BR} that is lower than the government debt cost $R_{c,t+1}^{ND}$, this generates QE seigniorage revenue that is remitted to the government. Similarly, bank lending can also produce seigniorage revenue if the lending rate exceeds the cost of reserve funding.

Moreover, assume that the market bank lending rate equals the national debt rate, $R_{c,t}^{BL} = R_{c,t}^{ND}$. While we will relax this assumption later, it is broadly consistent with empirical evidence showing that bank corporate bonds are priced at a spread slightly above the national debt rate. Under this additional assumption, the remittance reduces to:

$$T_{c,t+1}^{Autarky} = \left(A_{c,t}^{QE} + A_{c,t}^{BL}\right)\left(R_{c,t+1}^{ND} - R_{t+1}^{BR}\right) = \underbrace{B_{c,t}^{BR}\left(R_{c,t+1}^{ND} - R_{t+1}^{BR}\right)}_{\text{Total Seigniorage}}. \tag{3}$$

In general, the total fiscal benefit is proportional to the quantity of reserves issued, $B_{c,t}^{BR}$, which reflects the NCB's capacity to conduct balance sheet expansion policy. This logic applies broadly, including to jurisdictions such as the United States and the United Kingdom, where NCBs can—at least temporarily—reduce the government's funding cost by capturing the spread between long-term sovereign yields and the interest paid on reserves.

3.2 Cross-Country Claims

As motivated by the balance sheet data of NCBs, consider a more realistic case in which country I does not fully fund its QE and bank lending program. Specifically, it issues only a limited amount of reserves, and the resulting funding gap is closed by issuing cross-country claims:

$$A^{QE}_{I,t} + A^{BL}_{I,t} = B^{BR}_{I,t} + B^{T2}_{I,t}, \tag{4}$$

where $B^{T2}_{I,t}$ denotes the cross-country liability issued by country I and held by country G. Conversely, suppose country G issues reserves in excess of its own QE allocation, thereby financing purchases both in its own country and in the periphery:

$$A^{QE}_{G,t} + A^{T2}_{G,t} = B^{BR}_{G,t},$$

where we omit bank lending of country G for simplicity, though the logic can be extended to include it.

Note that the net liability of cross-country claims is zero, $B^{T2}_{I,t} = A^{T2}_{G,t}$. Hence, the non-conventional monetary policies—QE and bank lending—across the Eurozone are funded by the issuance of total bank reserves (summing the two equations above):

$$A^{QE}_{I,t} + A^{BL}_{I,t} + A^{QE}_{G,t} = B^{BR}_{I,t} + B^{BR}_{G,t}.$$

Finally, assume that each NCB purchases an amount of its national debt according to its capital key share, α_c. That is, $A^{QE}_{c,t} = \alpha_c A^{QE}_t$, where A^{QE}_t represents the total amount of QE implemented across countries, $A^{QE}_t \equiv \sum_k A^{QE}_{k,t}$.

We then consider a counterfactual scenario in which country G issues reserves domestically and lends the surplus directly to country I by purchasing its sovereign debt. Section 4.1 discusses the assumptions of this counterfactual scenario in detail. Thus, the cost of funding equals the return on its sovereign bonds: $R^{T2}_{t+1} = R^{ND}_{I,t+1}$. Maintaining the assumption $R^{BL}_{c,t} = R^{ND}_{c,t}$, the NCB remittance of country I satisfies:

$$T_{I,t+1} = \underbrace{\alpha_I A^{QE}_t R^{ND}_{I,t+1}}_{\text{QE Interest Income}} + \underbrace{A^{BL}_{I,t} R^{ND}_{I,t+1}}_{\text{Bank Lending Income}} - \underbrace{B^{BR}_{I,t} R^{BR}_{t+1}}_{\text{Cost of Reserves}} - \underbrace{B^{T2}_{I,t} R^{ND}_{I,t+1}}_{\text{Cost of Cross-Country Borrowing}}.$$

Using the identity $A_{I,t}^{QE} + A_{I,t}^{BL} = B_{I,t}^{BR} + B_{I,t}^{T2}$, we can simplify the expression for central bank remittances as:

$$T_{I,t+1} = \underbrace{B_{I,t}^{BR}\left(R_{I,t+1}^{ND} - R_{t+1}^{BR}\right)}_{\text{Total Seigniorage}}, \tag{5}$$

which is lower than the seigniorage revenue in equation (3), since $B_{I,t}^{BR} < A_{I,t}^{QE} + A_{I,t}^{BL}$. This occurs because only part of Italy's QE and bank lending programs is funded by its own reserves, so it does not capture the full seigniorage revenue. This revenue accrues to country G, which issues the excess reserves.

For country G, the NCB remittance is determined by:

$$\underbrace{\alpha_G A_t^{QE} R_{G,t+1}^{ND}}_{\text{QE Interest Income}} + \underbrace{A_{G,t}^{T2} R_{I,t+1}^{ND}}_{\text{Cross-Country Lending Income}} = \underbrace{B_{G,t}^{BR} R_{t+1}^{BR}}_{\text{Cost of Reserves}} + T_{G,t+1},$$

which can be rewritten as

$$T_{G,t+1} = \underbrace{A_{G,t}^{QE}\left(R_{G,t+1}^{ND} - R_{t+1}^{BR}\right)}_{\text{Home QE Seigniorage}} + \underbrace{A_{G,t}^{T2}\left(R_{I,t+1}^{ND} - R_{t+1}^{BR}\right)}_{\text{Foreign QE and Bank Lending Seigniorage}}. \tag{6}$$

Here, $A_{G,t}^{T2}$ is the cross-border asset position arising from lending reserves to country I to fund its QE and bank lending program. This term reflects the gains from the spread between the national debt rate and the interest paid on reserves. The total seigniorage collected by country G is proportional to the amount of reserves it is able to issue and deploy across both QE and cross-country operations. Note that $A_{G,t}^{QE} + A_{G,t}^{T2} = B_{G,t}^{BR}$, implying that part of the reserves issued by country G fund its own QE program, while the remainder finances QE operations in the periphery. Accordingly, the central bank of G collects seigniorage from excess returns earned on QE at home by buying domestic bonds and abroad by buying foreign bonds.

Thanks to debt monetization, taxpayers in both countries benefit from a reduction in the required fiscal surplus, proportional to the amount of reserves issued, $B_{c,t}^{BR}$. From an economic perspective, this reflects each country's capacity to supply safe and liquid reserve liabilities to the financial system.

3.3 Eurozone Income Pooling

We next evaluate the impact of the ECB's institutional arrangements, which have two key features: (i) **income pooling**: NCB income is pooled across countries (i.e., between Italian and German NCBs), and (ii) **interest rate remuneration**: the interest rates received on central bank assets and liabilities could be different from what a competitive market would dictate. For clarity, the main text considers only this simplified environment, with full generality deferred to the Appendix B.

Income Pooling. Under the current institutional arrangement of the Eurosystem, some components of central bank income and losses are pooled across countries, while others remain at the national level. We distinguish two cases.

First, some balance sheet items are *fully pooled* across countries in proportion to their capital key α_c, including the cost of bank reserves and the income from bank lending (LTROs) and cross-country lending (intermediated via the Target2s system). Specifically:

1. *Bank Reserves.* The cost attributed to country c from reserve liabilities becomes

$$R^{BR}_{t+1} \cdot \alpha_c (B^{BR}_{I,t} + B^{BR}_{G,t})$$

   instead of $R^{BR}_{t+1} B^{BR}_{c,t}$.

2. *Bank Lending (LTROs).* The income attributed to country c from LTRO operations becomes

$$\alpha_c (A^{BL}_{I,t} R^{BL}_{I,t+1} + A^{BL}_{G,t} R^{BL}_{G,t+1})$$

   instead of $A^{BL}_{c,t} R^{BL}_{c,t+1}$. In practice, LTROs are priced below the MRO rate and vary across banks and lending rounds. Empirically, we found that the overall rate is close to the bank reserve rate: $R^{BL}_{c,t+1} \approx R^{BR}_{t+1}$.

3. *Cross-Country Lending (Target2).* Target2 balances are remunerated at the MRO rate. However, as Italy's liability is Germany's claim ($B^{T2}_{I,t} = A^{T2}_{G,t}$), the aggregate Target2 balance across national central banks is zero, though in practice this may deviate slightly due to the ECB's own Target2 position. Thus, the income attributed to country c from cross-country claims becomes 0 from $A^{T2}_{c,t} R^{ND}_{c,t+1}$.

Second, the income arising from QE operations is only *partially pooled*. Each NCB retains the

spread between its national debt rate and the MRO rate, while the remaining income is pooled across countries. Thus, income attributed to country c is:

$$\underbrace{A_{c,t}^{QE}\left(R_{c,t+1}^{ND}-R_{t+1}^{MRO}\right)}_{\text{Retained Spread Income}}+\underbrace{\alpha_c\sum_k A_{k,t}^{QE}R_{t+1}^{MRO}}_{\text{Pooled Income}}.$$

Under the simplifying assumption that each country's QE holdings are proportional to its capital key—i.e., $A_{c,t}^{QE}=\alpha_c A_t^{QE}$, which held approximately in the data—we have that each NCB fully retains the returns harvested on its domestic government bonds:

$$\alpha_c A_t^{QE}\left(R_{c,t+1}^{ND}-R_{t+1}^{MRO}\right)+\alpha_c A_t^{QE}R_{t+1}^{MRO}=\alpha_c A_t^{QE}R_{c,t+1}^{ND}.$$

Thus, despite the partial pooling mechanism, the final income from QE ends up not being pooled: each country retains the full income on its holdings.

Pooling and Transfers. As shown in Equation (4), we assume that country I borrows from country G via cross-country claims to fund part of its QE purchases and bank lending programme. It holds that:

$$\underbrace{\alpha_I A_t^{QE}+A_{I,t}^{BL}-B_{I,t}^{BR}}_{\text{Required External Funding}}=\underbrace{B_{I,t}^{T2}}_{\text{Cross-Country Borrowing}}. \tag{7}$$

Then, the following corollary describes the remittance of country I under income pooling.

Corollary 1. *Under the assumption that $R_{I,t+1}^{BL}=R_{t+1}^{BR}$, the country I's remittances after income pooling is given by:*

$$\underbrace{T_{I,t+1}^{Pooling}}_{\textit{Remittance under Pooling}}=B_{I,t}^{BR}\left(R_{I,t+1}^{ND}-R_{t+1}^{BR}\right)-A_{I,t}^{BL}\left(R_{I,t+1}^{ND}-R_{t+1}^{BR}\right)+B_{I,t}^{T2}\left(R_{I,t+1}^{ND}-R_{t+1}^{BR}\right). \tag{8}$$

Appendix A.1 presents the proof. Corollary 1 highlights the redistribution effect under income pooling, and states that the remittance can be decomposed into three terms: the first term represents the seigniorage Italy retained from issuing reserves; the second term captures the implicit subsidy to domestic banks, which constitutes a cost to taxpayers; the third term reflects the benefit received from underpriced cross-country borrowing. The difference between Equation (5) no pooling and Equation (8) with pooling sheds light on the amount of transfers received by the

taxpayers in country I.

In addition, after plugging equation (7) into equation (8), the pooling transfer can be rewritten as

$$\underbrace{T_{I,t+1}^{\text{Pooling}}}_{\text{Remittance under Pooling}} = A_{I,t}^{QE}\left(R_{I,t+1}^{ND} - R_{t+1}^{BR}\right) = \alpha_I A_t^{QE}\left(R_{I,t+1}^{ND} - R_{t+1}^{BR}\right),$$

which indicates that income pooling redistributes seigniorage revenue in a proportional way according to the capital key; hence, the after-pooling seigniorage remittance of each country does not depend on its actual issuance of bank reserves.

By the same logic (see Appendix A.1 for details), Germany's seigniorage income is also independent of its issuance of bank reserves and is given by:

$$T_{G,t+1}^{\text{Pooling}} = A_{G,t}^{QE}\left(R_{G,t+1}^{ND} - R_{t+1}^{BR}\right) = \alpha_G A_t^{QE}\left(R_{G,t+1}^{ND} - R_{t+1}^{BR}\right). \tag{9}$$

Since $A_{G,t}^{QE} < B_{G,t}^{BR}$, country G retains only part of the seigniorage produced using its own reserves. The difference between Equation (6) and Equation (9) shows the seigniorage of country G is reduced by $A_{G,t}^{T2}\left(R_{I,t+1}^{ND} - R_{t+1}^{BR}\right)$, which is exactly the cross-country transfer from G to I.

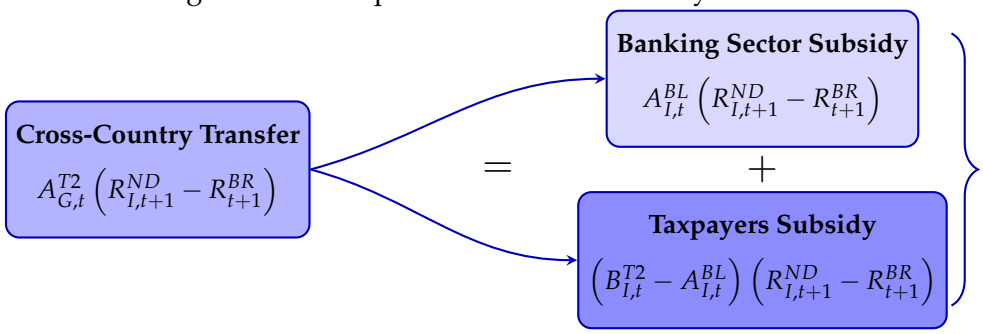
It is interesting to note, by comparing Equation (5) and Equation (8) that the taxpayers of country I do not gain the full amount of cross-country transfer. This is because Italy allocates a share of the transfer to subsidize its own banking system, which constitutes a cost to its taxpayers. We can further decompose the cross-country transfer paid by Germany into a subsidy to Italian taxpayers and its banks:

$$\underbrace{A_{G,t}^{T2}\left(R_{I,t+1}^{ND} - R_{t+1}^{BR}\right)}_{\text{Cross-Country Transfer}} = \underbrace{A_{I,t}^{BL}\left(R_{I,t+1}^{ND} - R_{t+1}^{BR}\right)}_{\substack{\text{Banking Sector}\\ \text{Subsidy}}} + \underbrace{\left(B_{I,t}^{T2} - A_{I,t}^{BL}\right)\left(R_{I,t+1}^{ND} - R_{t+1}^{BR}\right)}_{\substack{\text{Taxpayers}\\ \text{Subsidy}}}. \tag{10}$$

Figure 2 provides a visual representation of this decomposition, illustrating how the cross-country transfer from Germany is divided into subsidies that benefit both the Italian banking sector and Italian taxpayers.

This discussion clarifies how the Target2 system creates implicit transfers, first between core and periphery countries, and then between the central bank and the banking sector within each country. Similarly, when the German NCB is engaged with LTROs with respect to its domestic banking sector, a banking sector subsidy also arises in Germany.

Figure 2: Decomposition of Cross-Country Transfer



3.4 Debt Valuation and Implicit Cross-Country Transfers

We explore the implications of the ECB's QE operation for the valuation of government debt. Let $M^c_{t,t+s}$ denote the nominal stochastic discount factor of country c between periods t and $t+s$. Assume that government debt is correctly priced such that $\mathbb{E}_t M^c_{t,t+1} R^{ND}_{c,t+1} = 1$, i.e., we abstract from convenience yields, and we assume that the transversality condition holds. Then, by iterating the flow budget constraint, equation (1), forward, the net present value (NPV) budget constraint of the treasury in country c can be derived (see Appendix A.2) as:

$$B^{ND}_{c,t} = \mathbb{E}_t \sum_{s=1}^{\infty} M^c_{t,t+s} \left(S_{c,t+s} + T_{c,t+s}\right),$$

implying that the national debt position must be backed by the net present value of all future primary surpluses and remittances from the NCB.

Seigniorage and Mispricing. We now consider the effect of QE operations on debt valuation under income pooling. As shown in Subsection 3.3, the remittance from the NCB to its treasury in country c is given by

$$T^{\text{Pooling}}_{c,t+1} = A^{QE}_{c,t}\left(R^{ND}_{c,t+1} - R^{BR}_{t+1}\right).$$

Note that $T^{\text{Pooling}}_{c,t+1}$ with income pooling is exactly the same as the autarky QE case. In this simplified scenario, we obtain the following corollary:

Corollary 2. *Assume the national debt is priced accurately that* $\mathbb{E}_t M^c_{t,t+1} R^{ND}_{c,t+1} = 1$. *Under income pooling, the debt valuation of country c is backed by future surpluses and remittances:*

$$
\begin{aligned}
B_{c,t}^{ND} &= \mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s}^{c} S_{c,t+s} + \alpha_c \, \mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s}^{c} \left(R_{c,t+s}^{ND} - R_{t+s}^{BR} \right) A_{t+s-1}^{QE} \\
&= \mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s}^{c} S_{c,t+s} + \alpha_c \, \mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s}^{c} \left(1 - R_{t+s}^{BR} \right) A_{t+s-1}^{QE}. \qquad (11)
\end{aligned}
$$

Appendix A.3 presents the proof. Even if the national debt is priced accurately, the pooled Eurozone income from bond purchases funded by bank reserves could still generate seigniorage revenue and subsidies as long as there is a mispricing in bank reserves, i.e., $\mathbb{E}_t M_{t,t+1}^{c} R_{t+s}^{BR} < 1$. In other words, if bank reserves are priced fairly—such that $\mathbb{E}_t M_{t,t+1}^{c} R_{t+1}^{BR} = 1$ then there is no seigniorage revenue and, consequently, no cross-country transfers.

Currency Risk. Nevertheless, in a currency union where countries retain the option to exit and devalue their currency, bank reserves cannot be priced uniformly across all member states. A single interest rate on reserves cannot, in general, satisfy the condition, $\mathbb{E}_t M_{t,t+1}^{c} R_{t+1}^{BR} = 1$, for all SDFs, which are denominated in different base currencies whenever currency risk is present.

More concretely, suppose the Italian government bonds are priced accurately. And suppose the interest rate on reserves is priced correctly for the German SDF, $\mathbb{E}_t M_{t,t+1}^{G} R_{t+1}^{BR} = 1$. If Italy exits the Eurozone with positive probability and devalues its currency in bad states of the world, then it easy to derive an expression for the redenomination wedge:

$$
\mathbb{E}_t M_{t,t+1}^{I} (1 - R_{t+1}^{BR}) = 1 - \frac{\mathbb{E}_t M_{t,t+1}^{I}}{\mathbb{E}_t M_{t,t+1}^{G}} \geq 0.
$$

Specifically, Define the shadow nominal rate i_t^c as $-\ln \mathbb{E}_t M_{t,t+1}^{c}$. Let $p_t^I \geq 0$ denote the log currency risk premium on a long position in country I:

$$
p_t^I = -\mathbb{E}_t \Delta s_{t+1}^I + i_t^I - i_t^G,
$$

where s_{t+1}^I denotes for the nominal exchange rate of country I. The interest rate spread, which captures the redenomination wedge, is then determined by the expected depreciation and the log currency risk premium:

$$
i_t^I - i_t^G = \mathbb{E}_t \Delta s_{t+1}^I + p_t^I > 0.
$$

In other words, the shadow nominal risk-free rate in country I (unobserved) can coincide with the

reference rate only if there is no risk of exit, and hence no currency risk.

Even when the debt is priced correctly, the currency risk associated with an exit from the Eurozone will give rise to a currency redenomination wedge, simply because all countries are imputed the same reference rate on bank reserves:

$$\mathbb{E}_t M^I_{t,t+1}(1 - R^{BR}_{t+1}) = 1 - \exp(i^G_t - i^I_t) \equiv \kappa^{€}_{I,t} \geq 0.$$

An increase in the risk of an Italian exit from the Eurozone results in an increase in the currency risk premium p^I and/or increase in the expected rate of depreciation of the Italian currency against the German currency. As a result, seigniorage revenue that accrues to Italy increases in high marginal utility states of the world. This also explains why reserves accumulate in Germany, not in Italy: $\mathbb{E}_t M^I_{t,t+1} R^{BR}_{t+1} \ll 1$. Financial institutions holding reserves in Italy are exposed to redenomination risk without compensation.

Default. Another source of mispricing arises from the potential default of the Italian government. Suppose there is a non-zero probability of default π_{t+1}, which is already reflected in the pricing of $R^{ND}_{I,t+1}$. Hence, the condition, $\mathbb{E}_t M^I_{t,t+1} R^{ND}_{I,t+1} = 1$, still holds. Suppose that the same probability of default applies to all IOUs of the Italian government, including its Target2 liabilities. In this case, the return on IOUs is R^{BR}_{t+1} if the claim is repaid in full, while in the event of default the return is reduced by a haircut, $R^{HC}_{t+1} < R^{BR}_{t+1}$. Hence, the effective return is the stochastic payoff

$$\tilde{R}^{BR}_{t+1} = \begin{cases} R^{BR}_{t+1}, & \text{with probability } 1 - \pi_{t+1}, \\ R^{HC}_{t+1}, & \text{with probability } \pi_{t+1}. \end{cases}$$

which implies that the expected return is

$$\mathbb{E}_t[\tilde{R}^{BR}_{t+1}] = (1 - \pi_{t+1}) R^{BR}_{t+1} + \pi_{t+1} R^{HC}_{t+1}.$$

The wedge between the correctly priced national debt and the effective return is then given by

$$\begin{aligned} \mathbb{E}_t \left[M^I_{t,t+1} \big(R^{ND}_{I,t+1} - \tilde{R}^{BR}_{t+1} \big) \right] &= \mathbb{E}_t \left[M^I_{t,t+1} \big(1 - R^{BR}_{t+1} \big) \right] + \mathbb{E}_t \left[M^I_{t,t+1} \pi_{t+1} \big(R^{BR}_{t+1} - R^{HC}_{t+1} \big) \right] \\ &\equiv \kappa^{€}_{I,t} + \kappa^{\text{HC}}_{I,t}. \end{aligned}$$

The wedge is therefore composed by a component due to redenomination risk and a component

due to default risk.

Debt Valuation. Hence, even if the Italian government bonds are priced correctly, the shadow nominal risk-free rate in country I (unobserved) will typically be higher than the rate on reserves. In other words, since currency and default risks are not reflected in the borrowing rates, the Italian government can fund itself at an artificially low cost, which constitutes a form of seigniorage. This seigniorage revenue effectively reduces the burden on Italian taxpayers:

$$B_{I,t}^{ND} = \mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s}^{I} S_{I,t+s} + \alpha_I \mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s}^{I} \kappa_{I,t+s} A_{t+s-1}^{QE},$$

where $\kappa_{I,t} \equiv \kappa_{I,t}^{\text{€}} + \kappa_{I,t}^{\text{HC}}$.

Transfers to Taxpayers. The following corollary spells out the implicit transfers to Italian taxpayers that arise from income pooling and asset mispricing.

Corollary 3. *For Italy, the stand-in periphery country, its debts are backed not only by primary surpluses but also by seigniorage revenue generated through the ECB's QE operations, which are funded by the issuance of reserves both domestically and abroad. Namely,*

$$B_{I,t}^{ND} = \mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s}^{I} S_{I,t+s} + \mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s}^{I} (R_{I,t+s}^{ND} - R_{t+s}^{BR})(B_{I,t+s-1}^{BR} + B_{I,t+s-1}^{T2}). \tag{12}$$

In contrast, the non-pooling NPV budget constraint is given by:

$$B_{I,t}^{ND} = \mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s}^{I} S_{I,t+s}^{NP} + \mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s}^{I} (R_{I,t+s}^{ND} - R_{t+s}^{BR}) B_{I,t+s-1}^{BR}, \tag{13}$$

which states that its debts are backed only by seigniorage revenue from reserves issued domestically.

Appendix A.4 presents the proof. Hence, if we assume that the SDFs do not change between the pooling scenario and the non-pooling counterfactual scenario, the NPV of cross-country subsidy to the taxpayers is given by the difference between equations (12) and (13):

$$\mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s}^{I} S_{I,t+s}^{NP} - \mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s}^{I} S_{I,t+s} = \mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s}^{I} (R_{I,t+s}^{ND} - R_{t+s}^{BR}) B_{I,t}^{T2}.$$

In the next section, we turn to our quantitative exercise that maps this computation to real data.

4 Quantifying the Within and Cross-Border Transfers in the Eurozone

This section measures the implicit transfers by comparing the cash flow differences between the actual balance sheets and the counterfactual ones in the absence of income pooling and interest rate remuneration.[16]

4.1 Counterfactual Scenario

Our goal is to compare actual income and expenses against a counterfactual scenario in which (1) there is no Eurosystem income pooling arrangement and (2) all assets and liabilities earn a market rate. Our counterfactual scenario is one where NCBs can accumulate claims on other NCBs by acquiring national government debts of these other countries. We use the national government bond yields as the market interest rate in the counterfactual. Appendix Section B.2 describes how we compute the duration-weighted yield for each country. For the long-term portion of bank lending (LTROs, T-TLROs), we apply the prevailing yields on bank holdings of corporate bonds. For Eurosystem banknotes, we assign a market rate of zero.

Importantly, we do not claim that the risk characteristics of Target2 claims are exactly the same as those of the national government bonds. They are not. The states of the world in which the NCBs may default on the Target2 claims overlap only partly with the states of the world in which the national government defaults on its bonds. If the government default on the bonds, but remains in the Eurozone, then Target2 claims would be unaffected. However, periphery bonds are currently either held by NCB or by the national financial institutions. As a result, the NCB and private banks would have to be recapitalized by the national government. Hence, default on the bonds seems quite costly. If the government leaves the Eurozone and depreciates the currency, then it seems likely that the Target2 claims would at the very least be redenominated in the new currency. Many countries, including the U.S., have resorted to this strategy in the past. Instead, we simply assume that the NCBs accumulate foreign government bonds in the counterfactual scenario.

Target2 does not provide the public sector in periphery countries with a technology to borrow risk-free from the core. Instead, Target2 is a technology for transferring risk to taxpayers in the other Eurozone countries without compensation. If the return on Italian NCB's Target2 liabilities exactly matches the yield on Italian sovereign bonds, then financing debt through the Target2

[16] Instead of using a cash-flow analysis, Appendix D adopts an alternative approach by adjusting the balance sheet values to account for income pooling.

mechanism does not alleviate Italy's debt burden. That is how we construct the benchmark case in the counterfactual.[17]

4.2 Transfers

Our objective is to compare each central bank's after-pooling income within the Eurosystem to a counterfactual scenario in which the NCB either pays or receives the market rate and is not subject to income pooling by the ECB. We define the Transfer received by the NCB in country c for asset i as the difference between the counterfactual market income and the actual after-pooling income received within the Eurosystem. Appendix Section B provides a detailed description of the subsidy calculation.

We report the actual (post-pooling) and counterfactual (market rates and no-pooling) income in Figure 3. Our sample covers the time series of Germany, Italy, France, and Spain. In all of these countries, we find non-trivial gaps between the actual and counterfactual incomes.

Figure 3a reports the net income of the German NCB. The counterfactual income is persistently higher than the actual (post-pooling) income by a large margin. The gap averaged to 0.62% of German GDP per annum from 2004 to 2023. This gap also widened during the 2012 European sovereign debt crisis and the 2022 interest rate hike when the spreads between periphery and core bond yields increased. Figure 3b reports the net income of the Italian NCB. We see the opposite pattern since early 2010: the counterfactual income is persistently lower than the actual (post-pooling) income. The negative gap was on average 0.12% of Italian GDP per annum from 2004 to 2023.

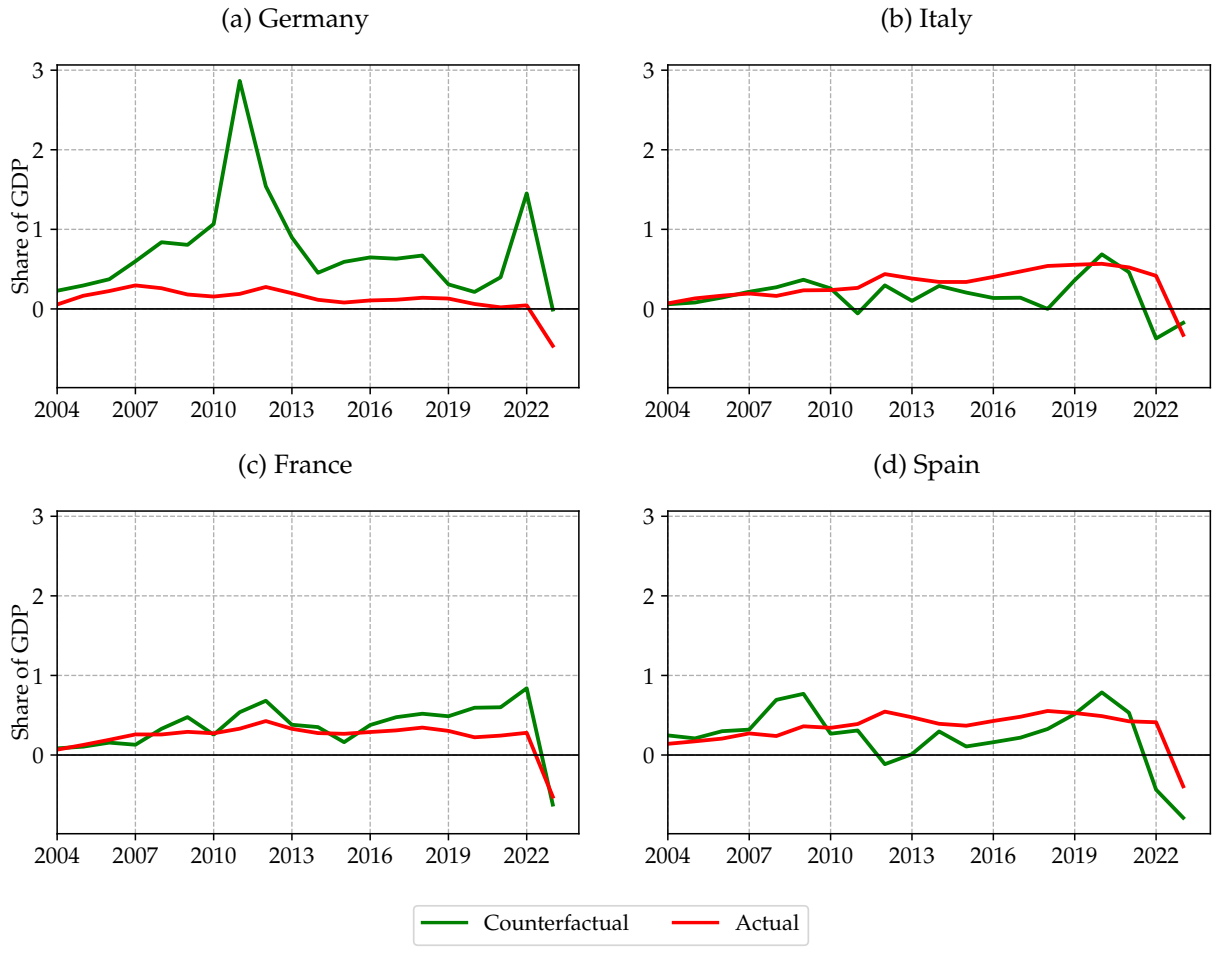
Figure 3c and Figure 3d show the net income of the French and Spanish NCB, respectively. The French central bank has a similar pattern to the German NCB, while the Spanish central bank has a similar pattern to the Italian NCB. On average, the counterfactual income is higher than the actual income by 0.13% of GDP for France, indicating that France is implicitly subsidizing the Eurosystem. In contrast, the counterfactual income is lower than the actual income by 0.12% of

[17] Consider an extreme case: the Italian NCB buys back all of Italy's sovereign debt, leaving the Bank of Italy with a corresponding Target2 liability to the Eurosystem. In this scenario, the Italian government would have no incentive to default on its own debt, since all of it would be held within the public sector. On the consolidated balance sheet, the debt effectively cancels out. All sovereign debt would have been replaced by Target2 liabilities. This is essentially debt monetization. In the absence of a monetary union, the cost of monetized debt is ultimately borne by domestic households through inflation or financial repression. Within a monetary union, however, the cost can be shifted from domestic to foreign households if the returns on Target2 liabilities are lower than the yields on sovereign debt. In other words, our benchmark case measures the cost of debt monetization borne by foreigners, which corresponds exactly to cross-country transfers.

GDP for Spain, indicating that Spain is implicitly receiving a subsidy from the Eurosystem.

Figure 4 plots the cumulative actual and counterfactual income of the NCBs. The figure clearly shows that while the subsidy may appear small on an annual basis, its persistence over time results in a quantitatively significant subsidy. Table 6 presents the average and cumulative actual and counterfactual income, along with the total subsidy. The table further decomposes the subsidy into within-country and cross-country components, which we explain in greater detail below. Quantitatively, we find that Germany and France pay a cumulative cross-country subsidy of 12.4% and 2.7% of their GDP, respectively, from 2004 to 2023, whereas Italy and Spain receive cumulative cross-country subsidies of 2.4% and 2.4% of their GDP over the same period. These figures are non-trivial when compared to the interest expenses incurred by their respective governments.

Figure 3: Net Income of Central Banks



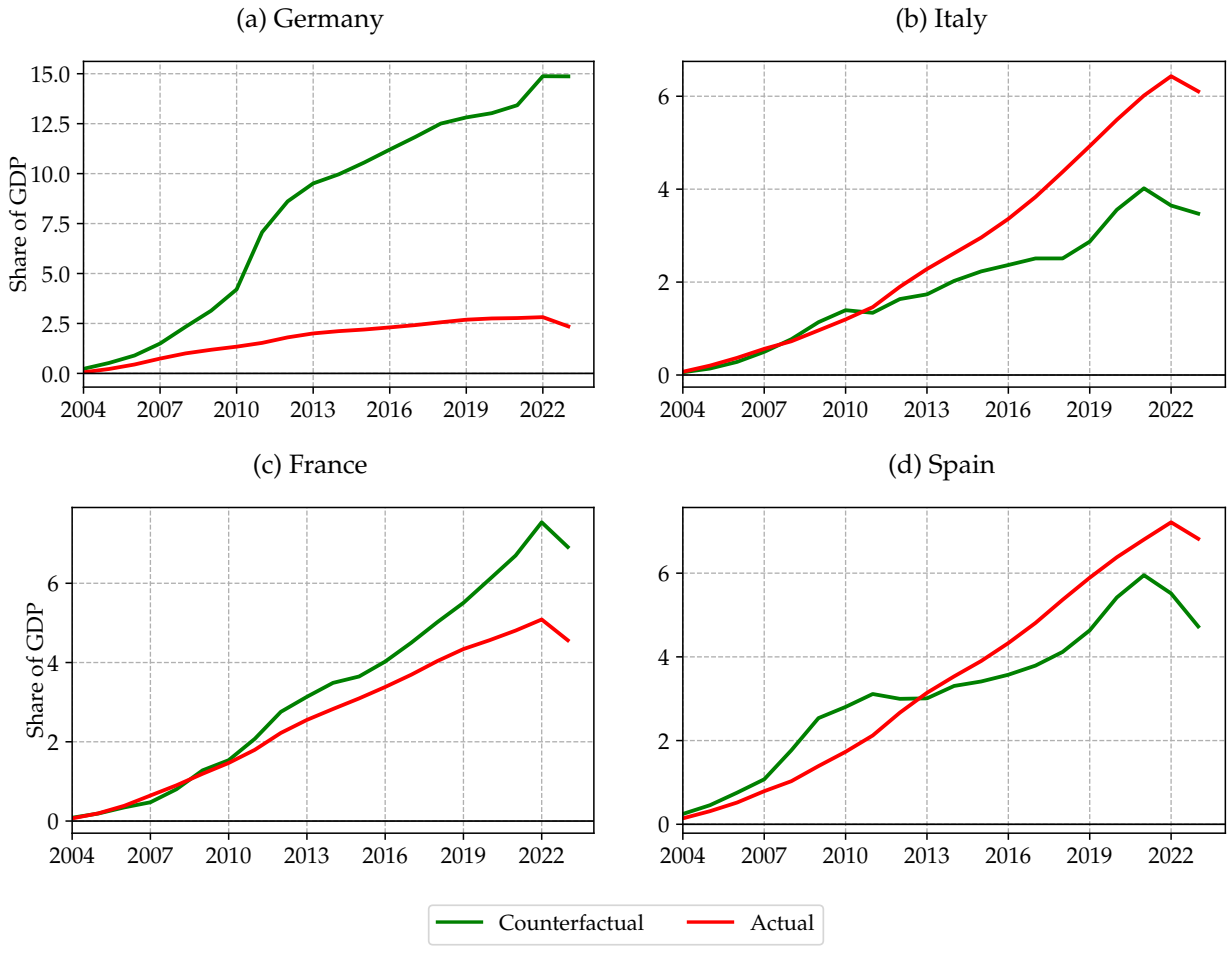
Unit: % of GDP. Source: Bloomberg, ECB, Annual reports of central banks and Authors' calculation

4.3 Within-Country vs. Cross-Country Subsidy in Baseline

To interpret these subsidies, we find it useful to look into a central bank balance sheet in detail. Take, for example, the Banca d'Italia. Table 7 presents the item-by-item breakdown in 2014, 2021 and 2023. The middle panel shows the current-case net-income as percentage of GDP from the annual reports. Under the current scenario, the income of each balance sheet item is listed before pooling as the book income. Most of the NCBs, including the Banca d'Italia, do not report the net result of pooling of monetary income for each item. Instead, their annual reports only show the aggregate net result across all balance sheet items, which is listed as "Pooling Monetary Income."

In 2022, the Banca d'Italia ran an after-pooling income surplus at 0.42% of GDP, whereas the counterfactual income before pooling was -0.37% of GDP, resulting in a net subsidy of 0.79% of

Figure 4: Cumulative Net Income of Central Banks



Unit: % of GDP. Source: Bloomberg, ECB, Annual reports of central banks and Authors' calculation

Table 6: Actual vs. Counterfactual Income of NCBs in Baseline Scenario

Panel A: Average					
	Actual	Counterfactual			
	Total	Total	Transfer	Within	Cross
Germany	0.12	0.74	0.62	0.08	0.54
Italy	0.31	0.19	-0.12	0.17	-0.29
France	0.23	0.36	0.13	0.10	0.03
Spain	0.34	0.22	-0.12	0.25	-0.38
Panel B: Cumulative					
	Actual	Counterfactual			
	Total	Total	Transfer	Within	Cross
Germany	2.35	14.78	12.43	1.53	10.90
Italy	6.10	3.71	-2.39	3.32	-5.71
France	4.56	7.22	2.66	2.02	0.64
Spain	6.82	4.39	-2.43	5.10	-7.53

Note: Panel A shows the average of actual income, counterfactual income, the subsidy, the within-country subsidy and cross-country subsidy. Panel B shows the cumulative actual income, cumulative counterfactual income, cumulative subsidy, cumulative within country subsidy and cross-country subsidy. Numbers expressed as % of GDP. Source: ECB, Euro Stat, Annual reports of central banks and Authors' calculation.

GDP. The main item that explains this subsidy is Target2: the Banca d'Italia had a large liability under this category. If it were to pay a market interest rate on this liability, which we assumed to be the government bond yields, then, it should have paid 1.47% of GDP on this liability. In reality, its book income was 0.20% of GDP before pooling when we evaluate the income using the book interest rate, which results in an implicit subsidy.

Having said that, another item stands out with the opposite sign: the Banca d'Italia has a claim against domestic banks. If it were to receive a market interest rate on this claim, it should have received an interest income of 0.52% of GDP. However, it received -0.10% of GDP before pooling, which results in a subsidy from Banca d'Italia to Italian domestic banks.

This discussion suggests that we need to distinguish the subsidy estimate between its *within-country* and *cross-country* components. Target2, Intra-Eurosystem Banknotes, and debt securities involve transactions between countries, while bank lending is a within-country transaction with domestic banks. As the central bank provides loans to domestic banks at favorable interest rates

Table 7: Net Interest Income of Banca d'Italia

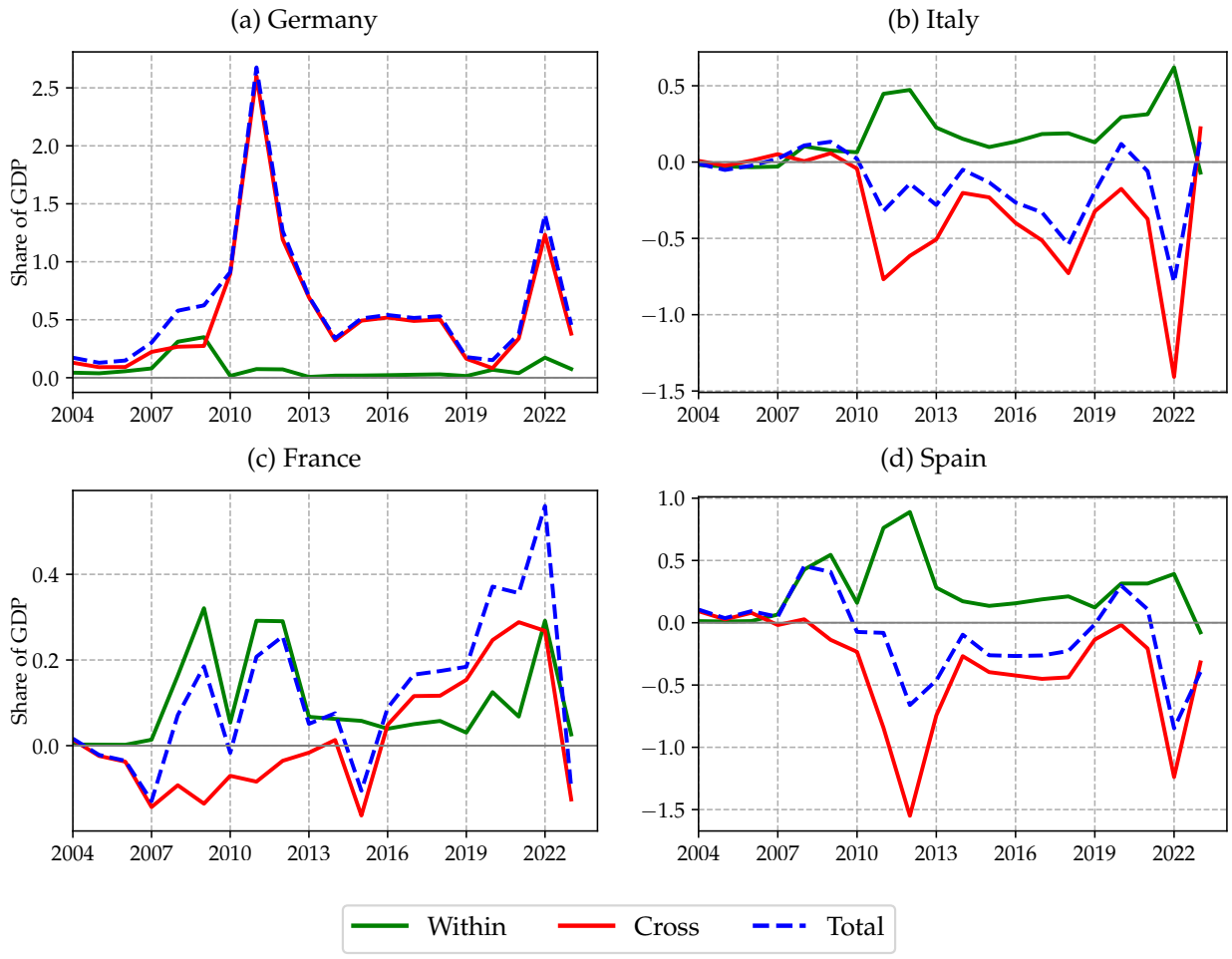
	Current			Counterfactual		
% of GDP, Year End	2014	2022	2023	2014	2022	2023
Income						
Bank Lending	**0.02**%	**−0.10**%	**0.38**%	**0.18**%	**0.52**%	**0.32**%
National Debt Securities	0.02%	0.37%	0.48%	0.02%	0.37%	0.48%
Eurosystem Banknotes	**0**%	**0.02**%	**0.10**%	**0**%	**0**%	**0**%
All Other Income	0.31%	0.37%	0.36%	0.31%	0.37%	0.36%
Sum	0.35%	0.66%	1.32%	0.50%	1.27%	1.16%
Expenditure						
Bank Reserves	0%	0.02%	0.38%	0%	0.02%	0.38%
Eurosystem Target2	**0.02**%	**0.20**%	**1.09**%	**0.23**%	**1.47**%	**0.82**%
All Other Expenditure	0.01%	0.15%	0.12%	0.01%	0.15%	0.12%
Sum	0.03%	0.37%	1.59%	0.24%	1.64%	1.32%
Pooling Monetary Income	**0.01**%	**0.12**%	**−0.05**%			
Net Income	**0.34**%	**0.42**%	**−0.33**%	**0.27**%	**−0.37**%	**−0.16**%

Unit: % of GDP. Source: ECB, Euro Stat, Banca d'Italia and authors' calculation

that are significantly below market levels, the mark-to-market adjustment also reflects a within-country subsidy. That said, the bank lending is also subject to income pooling between countries. Therefore, we should decompose the subsidy for the bank lending item into the within-country subsidy, which is proportional to the difference between the counterfactual market rate and the book rate, and the cross-country subsidy, reflecting the gap between the income generated through bank lending by an individual country and the final pooled income, which corresponds to a share α_c of the total income generated by all NCBs through bank lending. Bank lending is the only balance sheet item that includes both within-country and cross-country components. Therefore, we compute the total cross-subsidy income by summing the subsidies generated from various balance sheet items, along with the cross-country component of bank lending.

We decompose both within-country and cross-country transfers for all NCBs in our sample. Figure 5 presents this decomposition over time for Italy, Germany, Spain, and France. Take Italy, shown in panel (b), as an illustrative example. The Banca d'Italia exhibits a large and positive within-country transfer to its domestic banking sector. As a result, its total subsidy—represented by the dashed blue line—understates the cross-country subsidy it receives from the Eurosystem, which is depicted by the solid red line. In our calculation, the cross-country subsidy is approximately twice the size of the total subsidy.

Figure 5: Within and Cross-country Transfers



Unit: % of GDP. Source: Bloomberg, ECB, Annual reports of central banks and Authors' calculation

This discrepancy arises because the Banca d'Italia has significantly expanded its bank lending through LTROs and TLTROs since the onset of the sovereign debt crisis. These Eurosystem operations provide funding to credit institutions under favorable conditions. During this period, the counterfactual interest rate—estimated using corporate bond yields of similar maturity—was particularly high. This led to a substantial spread between the market rate and the actual lending rate, resulting in a sizable within-country subsidy.

In comparison, panel (a) shows that the German central bank has a relatively small transfer to its domestic central bank, and it pays out a large cross-country transfer to other NCBs. From this decomposition, we can see that the cross-country transfer from the core to the peripheral countries in the Eurozone is also more substantial.

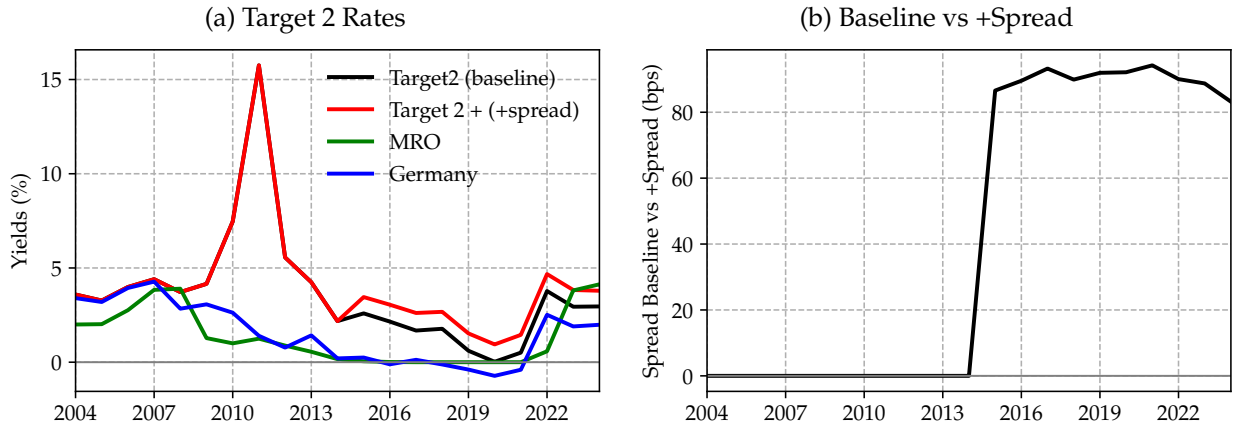
4.4 Counterfactual without QE

So far, our discussion centers on how the below-market rates on assets such as Target2 on NCBs' balance sheets imply cross-country transfers in the Eurozone. In our baseline calculation, we use actual historical market sovereign debt yields as the counterfactual interest rates. However, the main reason why the ECB engaged in policies such as quantitative easing is precisely to reduce bond yields and the spread of government bonds. For this reason, the historical bond yields we used are lower than in a counterfactual scenario without QE. Based on the findings of Altavilla et al. (2021); Lane (2023); De Santis and Holm-Hadulla (2023), we estimate the combined effect of the ECB purchase programs between 2015 and 2023 on the spreads to be between 90 and 120 bps for Italy, Spain, Portugal and Greece. We conduct a counterfactual analysis by increasing the spreads of the peripheral countries by 100 basis points.

We calculate an adjusted Target2 rate by increasing the spreads for peripheral countries (Greece, Italy, Portugal, Spain, and Ireland) by 100 basis points, which we refer to as the counterfactual Target2+Spread. Importantly, we use each country's bond yield to represent Target2 liabilities and the weighted average of Euro area country yields (where the weights reflect the share of net debtors in Target2) to represent Target2 assets. Figure 6 displays various rates: the MRO rate, the baseline Target2 rate (representing Target2 assets), the representative yield for Germany, and the Target2+Spread rate. Figure 6b illustrates the spread between the baseline Target2 rate and the Target2+Spread rate.

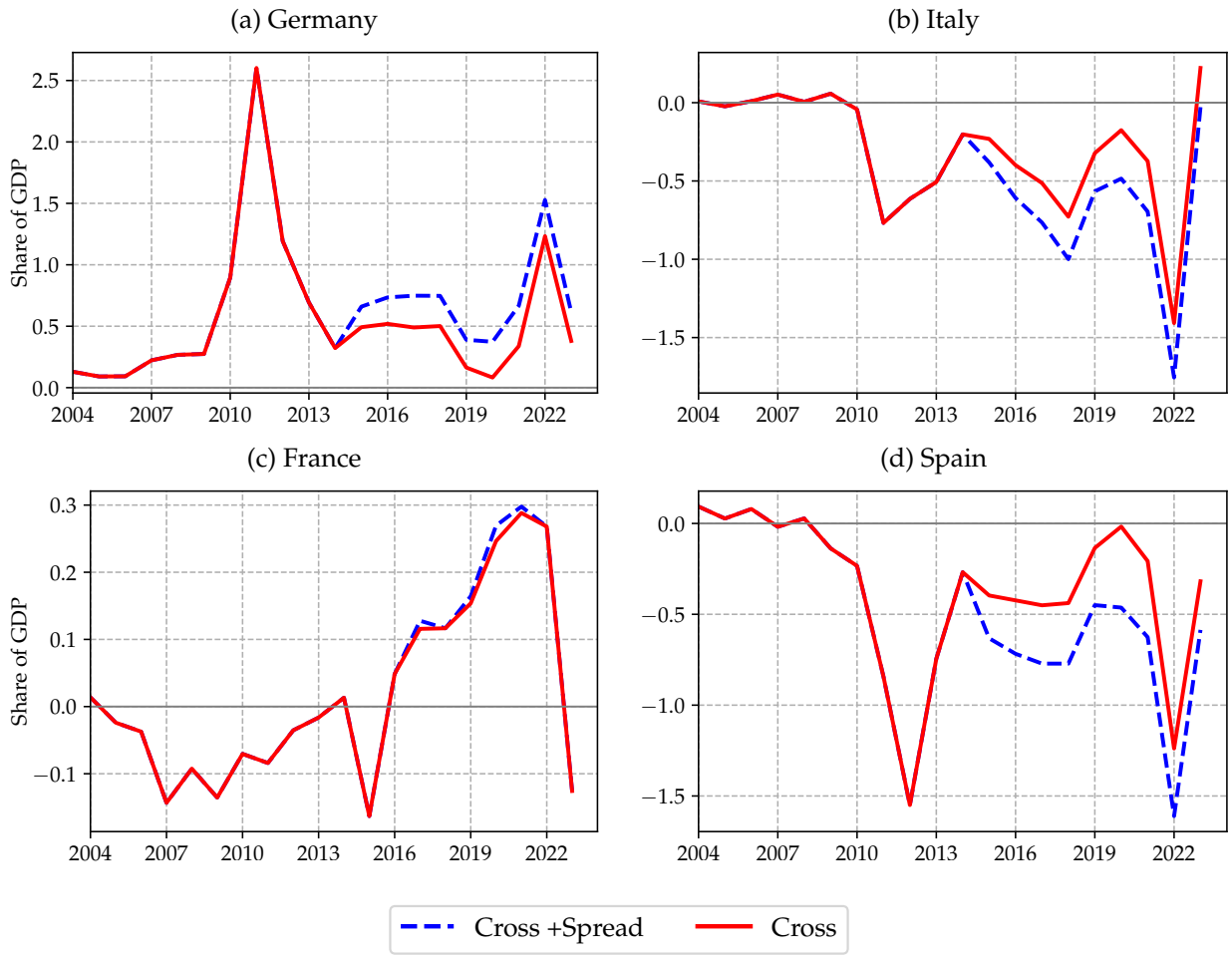
Then, we compute the cross-country transfers with the new Target2 rates. The results are

Figure 6: Target2 Rates



Unit: % of GDP. Source: Bloomberg, ECB, Annual reports of central banks and Authors' calculation

Figure 7: Cross-country Transfers, with Target2+Spread



Unit: % of GDP. Source: Bloomberg, ECB, Annual reports of central banks and Authors' calculation

Table 8: Cross-Country Transfers in Baseline vs High Spread Counterfactual.

	Panel A: Average		*Panel B: Cumulative*	
	Baseline	High Spread	Baseline	High Spread
Germany	0.54	0.66	10.90	13.16
Italy	-0.29	-0.40	-5.71	-8.07
France	0.03	0.03	0.64	0.70
Spain	-0.38	-0.53	-7.53	-10.53

Note: Panel A shows the average of the cross-country subsidy in the baseline counterfactual and high spread counterfactual. Panel B shows the cumulative numbers. Numbers expressed as % of GDP. Source: ECB, Euro Stat, Annual reports of central banks and Authors' calculation.

displayed in Figure 7. The cross-country subsidies increase significantly as a result of the higher spreads. The average cross-country subsidy paid by Germany increases from 0.54% to 0.66%, while the average subsidy received by Italy increases from 0.29% to 0.40%. As for France, the average subsidy remains broadly stable at 0.03%, while Spain's average subsidy received increases from 0.38% to 0.53%.

Once we account for the increased bond yields, we find that Germany's cumulative subsidy rises to 13.2% of GDP, which is approximately 3 percentage points higher than in the baseline scenario. Meanwhile, the cross-country subsidies received by Italy and Spain increase to 8.1% and 10.5% of GDP, respectively. The results are summarized in Table 8.

This counterfactual highlights the sensitivity of the subsidies to the bond yields. The magnitude of the cross-country subsidy suggests that, if peripheral countries' sovereign issuers were unable to issue non-marketable debt at favorable rates, the funding cost of their government liabilities would be much higher.

Note that for France, the additional spread has a limited effect. This is because, in the first part of the sample, France was a net borrower in Target2. Since we do not alter its borrowing rates, this does not impact the cross-country subsidy. In the second half of the sample, France becomes a lender through Target2; however, the size of its position remains small relative to its GDP, resulting in a minimal effect.

5 What Happens In Case of Default or Exit?

The central premise of the paper is that there is a non-zero probability of default or exit for Euro area countries. This is confirmed by the fact that investors ask for extra compensation to hold peripheral bonds. They also demand compensation for redenomination risk (Kremens, 2024; De Santis, 2015). This can be inferred from comparing different CDS contracts. In this section we discuss under what conditions cross-country claims arising through Target2 balances would be affected in case of default or exit.

Target2 claims are not direct claims from one country on another, but claims on the Eurosystem. These claims are not collateralized by any marketable assets, and there is no treaty mechanism to force a country to repay these debt. Target2 was originally created as the backbone of the Eurosystem to guarantee safe, fast, and reliable settlement of cross-border payments within the euro area. Under normal circumstances, cross-country payments broadly net out to zero over time, making

it efficient to centralize their settlement. Importantly, Target2 was not designed as a monetary policy instrument. The fact that it has acquired a new role—visible in the accumulation of large and persistent balances across national central banks—can be seen as an unintended consequence of the Eurosystem's unconventional policies.

Target2 claims can be risk-free. They can be considered risk-free if all of the following three conditions hold with probability one:

1. Target2 claims are senior to government bonds;

2. In the event of default, the debtor country has sufficient resources to repay Target2 claims in full;

3. In the event of exit, cross-country claims are redenominated in the currency of the lender rather than that of the borrower.

If these claims are risk-free, that would imply that all other creditors of, say, the Italian government have been subordinated to the ECB (condition 1). As a result, holding total credit risk fixed, unconventional monetary policy would have increased the riskiness of Italian bonds, by rendering their claims junior to those of the ECB, but that is counter-factual. The legal framework does not explicitly establish Target2 claims as senior to government bonds. Target2 balances are enforceable payment obligations within the Eurosystem, but there is no formal creditor hierarchy that would place them ahead of sovereign debt. Instead, Target2 is typically viewed as a liability of the Eurosystem as a whole, which means that the risk ultimately depends on the integrity of the monetary union. During the Euro area sovereign debt crisis, market participants often treated Target2 claims as de facto senior—for instance, in the context of Greece's restructuring, Target2 balances were perceived as untouchable—but this seniority remains a matter of convention rather than legal statute.

If any of these conditions fail to hold, Target2 claims may be at risk. The ECB and the other NCBs are exposed to credit risk. In case of a default, the ECB would use its own capital to cover losses. If its thin layer of capital is wiped out, the ECB can ask the members to recapitalize according to the capital key. If the ECB is unable to recapitalize, the NCBs would have to absorb the losses.

Moreover, even if seniority were to hold in principle, repayment depends on the debtor country's capacity to honor its obligations. In a scenario of sovereign default, resources may be insuf-

ficient to repay Target2 balances in full, particularly if domestic assets are already impaired or if the sovereign debt restructuring is deep.

Finally, a member country could default on its bonds without leaving the Eurozone. In that case, its NCB would remain in the Eurosystem and its Target2 claims would not be impacted. However, if a country leaves the Eurozone and devalues its currency, it may choose to default on or redenominate its Target2 liabilities, even without defaulting on its bonds. There is precedent for redenomination of debt and default on intergovernmental claims, even in the U.K. and the U.S. In 1933, the FDR administration famously abrogated the gold clause in all debt contracts, including government debt (Meyer, 2019). One year later, the U.K. officially defaulted on its WW-I loans from the U.S. government (Edwards, 2018). If claims were redenominated into the currency of the exiting country, their real value could be severely reduced. Greece chose to remain in the Eurozone. If it had left the Eurozone instead, its Target2 claims may have been impaired. Conversely, if they were maintained in the currency of the creditor NCB, their value would be preserved. Since the legal framework is silent on this issue, the risk of redenomination remains a source of uncertainty for Target2 claims.

Taken together, these considerations imply that Target2 balances cannot be regarded as risk-free. Their effective safety depends on legal interpretation, the fiscal capacity of debtor countries, and the institutional commitment to preserve the euro area in its current form.

Historical experience suggests that cross-border settlement claims are rarely preserved in their original form when monetary unions dissolve. In most cases, such claims have been either converted into government debt of the successor state or written off entirely.

A prominent example is the breakup of the Austro-Hungarian Empire after World War I. The liabilities of the Austro-Hungarian Bank were divided among the successor states, but there was no cooperative framework to safeguard cross-border claims. Balances were effectively transformed into long-term sovereign obligations, many of which rapidly lost value amid hyperinflation and fiscal distress (Garber and Spencer, 1994).

A second important case is the collapse of the Soviet ruble area in the early 1990s. Following the dissolution of the USSR, newly independent republics initially continued to use the ruble, creating unsettled cross-country balances. When Russia introduced its own ruble in 1993, these claims were either devalued, converted into bilateral government debts, or simply ignored, leaving creditors with substantial losses (Odling-Smee et al., 1996).

There is, however, one notable exception. The dissolution of Czechoslovakia in 1993 was ne-

gotiated in advance, with an explicit agreement on how to split the central bank's assets and liabilities. Because the rules of redenomination were clear and cooperative, cross-border claims were largely preserved, and the breakup generated only limited financial disruption (International Monetary Fund, 1990). This contrast highlights a key lesson: the fate of settlement balances depends less on their formal legal character than on whether the terms of exit are agreed ex ante.

6 QE and the Policy Dilemma

In the last section, we formalize the implications of Target2 seniority for sovereign credit spreads. The key insight is that if Target2 liabilities are senior to sovereign bonds, quantitative easing (QE) subordinates private bondholders and therefore raises the credit spreads they require. This follows from standard corporate finance theory and the structural credit model of Merton (1974). Throughout this section, we consolidate the government and the national central bank following Sargent and Wallace (1981).

Before QE, sovereign bonds are held by private investors and all creditors share losses *pari passu* in default states. After QE, however, the liability structure of the consolidated public sector changes. When the Eurosystem purchases sovereign bonds and liquidity flows across borders, the national central bank accumulates Target2 liabilities vis-à-vis the rest of the Eurosystem. Under consolidation of the government and the domestic central bank, the sovereign bonds held by the central bank cancel internally. QE therefore replaces privately held sovereign bonds with central-bank liabilities vis-à-vis the rest of the Eurosystem.

If Target2 claims are senior to sovereign bonds, the resulting liability structure resembles a tranched debt structure: Target2 liabilities form a senior tranche while privately held sovereign bonds become junior claims. Since junior claims absorb losses first in default states, they require higher credit spreads.

6.1 Setup

Let F denote the total face value of sovereign obligations due at date T. Following QE, a portion B^{T2} of these obligations takes the form of Target2 liabilities held by the Eurosystem, while the remaining $B^{ND} = F - B^{T2}$ corresponds to sovereign bonds held by private investors.

We assume that Target2 liabilities are senior to sovereign bonds. In default states, Target2 claims are repaid first and private bondholders receive the residual repayment.

Default occurs when the sovereign's repayment capacity at date T, denoted V_T, falls short of total obligations F.

Financial Resources We define the variable V_T, which admits two complementary interpretations. In the structural credit tradition of Merton (1974), V_T represents the market value of sovereign assets at maturity and default occurs mechanically when $V_T < F$. In the sovereign default tradition following Eaton and Gersovitz (1981), default is a strategic decision: the government compares the continuation value of repayment with that of default, taking into account exclusion from capital markets and other penalties. In the recursive frameworks of Aguiar and Gopinath (2006) and Arellano (2008), repayment occurs when the value of servicing debt exceeds the value of default.

In our setting V_T can therefore be interpreted as the maximum amount the sovereign is willing and able to repay. The only property required for our results is that the event $\{V_T < F\}$ has positive probability.

Pricing We price claims using a strictly positive stochastic discount factor (SDF) $M_T > 0$, so that the price of any payoff X_T is $\mathbb{E}[M_T X_T]$. No restrictions are imposed on M_T beyond positivity; risk-neutrality obtains as the special case $M_T = 1/R^f$, where R^f is the gross risk-free rate. The central object in the analysis is the *sovereign put*

$$P(K) = \mathbb{E}\left[M_T (K - V_T)^+\right], \tag{14}$$

which represents the present value of expected losses on a claim of size K, inclusive of any risk premium that investors require for bearing sovereign default risk. Since $M_T > 0$ and $(K - V_T)^+$ is convex in K, the function $P(K)$ is convex with $P(0) = 0$.

6.2 Bond Pricing

Pre-QE: Pari Passu Debt. Before QE ($B^{T2} = 0$), all obligations consist of sovereign bonds with total face value F. In default states ($V_T < F$), creditors share losses pro rata.

The price of a bond is therefore

$$q_{\text{pre}} = \mathbb{E}[M_T] - \frac{P(F)}{F}. \tag{15}$$

Each bondholder effectively sells $1/F$ of a put option with strike F.

Post-QE: Senior and Junior Claims. After QE, the liability structure consists of a senior Target2 claim B^{T2} and junior sovereign bonds with face value $F - B^{T2}$ held by private investors.

In default states the senior tranche is repaid first. Private bondholders receive the residual repayment

$$\max\{V_T - B^{T2}, 0\}.$$

The expected loss borne by private bondholders is therefore

$$P(F) - P(B^{T2}),$$

which represents the difference between total losses on the debt stack and the portion absorbed by the senior tranche.

Dividing by the face value of privately held sovereign bonds $F - B^{T2}$ gives the per-unit expected loss, so the bond price becomes

$$q_{\text{post}} = \mathbb{E}[M_T] - \frac{P(F) - P(B^{T2})}{F - B^{T2}}. \tag{16}$$

Private bondholders therefore effectively sell a *put spread*. The senior tranche absorbs the first losses, while sovereign bonds bear the residual risk.

Given these results, we can establish the claim that subordination raises the spreads on private debt:

Proposition 1 (Subordination)**.** *Fix the stochastic discount factor M_T. If default has positive probability and Target2 liabilities are senior to sovereign bonds, the introduction of Target2 claims strictly increases the credit spread on sovereign bonds held by private investors.*

The assumption that M_T is held fixed isolates the pure subordination effect: we ask how a change in the liability structure affects spreads for given investor preferences and macroeconomic conditions. The intuition then follows from the convexity of $P(\cdot)$. Comparing equations (15) and (16), the proposition is equivalent to the inequality

$$\frac{P(F) - P(B^{T2})}{F - B^{T2}} > \frac{P(F)}{F}, \tag{17}$$

which states that the slope of the chord of $P(\cdot)$ from B^{T2} to F exceeds the slope of the chord from 0 to F. This is precisely what convexity of $P(\cdot)$ implies for any $B^{T2} > 0$, with strict inequality whenever default has positive probability. The average cost of insuring a dollar of junior debt is therefore higher than the average cost of insuring pari passu debt of the same total face value: the junior tranche absorbs the first losses, making it riskier than the pari passu debt. The formal proof is provided in Appendix F.

6.3 The Policy Dilemma

Proposition 1 implies that if Target2 liabilities are senior, QE should increase sovereign credit spreads, holding M_T and the distribution of V_T fixed. Empirically, however, sovereign spreads declined following the announcement of the ECB's asset purchase programs. Taking T2 seniority as given—as suggested by the de facto treatment of T2 claims during the European sovereign debt crisis discussed in Section 5—this leads to a policy dilemma.

Proposition 2 (Policy Dilemma)**.** *Suppose Target2 liabilities are senior to sovereign bonds. The following two statements cannot hold simultaneously for a fixed distribution of V_T and fixed M_T:*

(A) *Quantitative easing reduces sovereign credit spreads.*

(B) *There are no implicit cross-country fiscal transfers within the Eurosystem.*

The proof is immediate. Under T2 seniority, Proposition 1 implies that subordination raises spreads for any fixed M_T and V_T. For spreads to fall—statement (A)—something must shift to compress $P(\cdot)$ enough to overcome the convexity effect. With M_T fixed, the only object that can do this is the distribution of V_T: spreads can decline if and only if QE raises the sovereign's repayment capacity, shifting V_T upward sufficiently that

$$\frac{\tilde{P}(F) - \tilde{P}(B^{T2})}{F - B^{T2}} < \frac{P(F)}{F}, \tag{18}$$

where $\tilde{P}(K) = \mathbb{E}[M_T(K - \tilde{V}_T)^+]$ denotes the post-QE sovereign put with the shifted repayment capacity $\tilde{V}_T \geq V_T$. But a shift in $\tilde{V}_T$ relative to V_T means that the periphery sovereign can repay more in bad states than it could without QE. In the Eurosystem, this improvement in repayment capacity comes from borrowing from core countries at below-market rates through the Target2 system—an implicit fiscal transfer. Hence statement (B) must fail.

Fiscal Transfers as the Resolution. The mechanism is transparent in the model. The sovereign put $P(K) = \mathbb{E}[M_T(K - V_T)^+]$ is decreasing in V_T: a higher repayment capacity reduces expected losses on all claims. When the periphery borrows from the core at below-market rates, as documented in Section 4, it effectively receives a transfer that augments its fiscal resources. Following the notation of Section 3, the remittance to the periphery NCB under income pooling, $T_{I,t+1}^{\text{Pooling}}$, exceeds the autarky counterfactual, directly relaxing the government budget constraint and raising V_T. Moreover, the transfer is largest precisely in bad states of the world—when T2 imbalances are largest and sovereign stress is highest—so it raises V_T most when $(K - V_T)^+$ would otherwise be largest. This state-contingent support compresses not only expected losses but also the risk premium embedded in $P(K)$, since the covariance of losses with M_T falls as V_T rises in distress states.

The transfers quantified in Section 4 are therefore the empirical counterpart of the $\tilde{V}_T - V_T$ shift required to reconcile T2 seniority with the observed decline in sovereign spreads following QE.

6.4 Discussion of Assumptions

A key assumption of our framework is that the stochastic discount factor of lenders is unaffected by QE. That is, we hold fixed the pricing kernel M_T and isolate the effect of subordination on sovereign spreads. This is a deliberate modeling choice, and it is worth discussing what it excludes and what it highlights.

Endogenous risk premia: a reinforcing effect. Holding M_T fixed can be a conservative assumption. Subordination concentrates junior bondholders' losses in precisely the states where the sovereign is most distressed — states where M_T is high. The risk premium embedded in $P(K) = \mathbb{E}[M_T(K - V_T)^+]$ would therefore rise not only because expected losses increase, but also because those losses covary more strongly with the SDF. Fixing M_T thus provides a lower bound on the spread increase implied by subordination.

Other channels of QE transmission: what we abstract from. A large literature identifies channels through which QE compresses spreads by altering the pricing kernel of lenders. In preferred habitat models (Vayanos and Vila, 2021), QE reduces the net supply of bonds that risk-averse arbitrageurs must absorb, compressing risk premia. In intermediary asset pricing frameworks (He and Krishnamurthy, 2013), QE relaxes balance sheet constraints, lowering the price of risk. Had-

dad et al. (2025) argue that central bank asset purchases are best understood as state-contingent promises to intervene in stress states. Corell et al. (2025) provide direct evidence for this view, showing that corporate QE transmits to bond prices primarily by reducing liquidity risk. In the notation of our model, all of these channels imply that QE changes M_T, and through M_T, the present value of losses $P(K) = \mathbb{E}[M_T(K - V_T)^+]$ for any given liability structure.

Our framework holds M_T fixed to isolate a channel that is absent from this literature: the mechanical effect of subordination on how losses are allocated across creditors, which operates independently of any change in the price of risk.

7 Conclusion

Our findings highlight the significant intra-Eurozone transfers that arise from the European Central Bank's management of its balance sheet. By replacing marketable debt with non-marketable debt through large-scale asset purchases and bank lending, the ECB redistributes financial risks across member states without compensation for these risks. These redistributions are particularly evident in the core-periphery divide, where core countries like Germany effectively subsidize periphery countries like Italy and Spain through the Eurosystem. This redistribution is driven by the structure of the Eurozone, which, unlike the U.S., is a monetary union of fiscally sovereign countries which can default and exit the Eurozone. As a result, market participants strictly prefer bank reserves held in the core, implying that the ECB tends to fund its balance sheet expansions in the core, not the periphery. As a result, the periphery is borrowing from the core at below-market rates.

Comparisons with the U.S. monetary and fiscal system further illustrate the distinct nature of the Eurozone's structure. Unlike the U.S. Federal Reserve system, where reserves are treated equally across all districts, the Eurozone's financial system reflects investors' concerns about potential fragmentation. This contributes to the core-periphery divide in reserve holdings, reinforcing financial disparities within the union. Ultimately, our results suggest that the ECB's monetary policies, while aimed at stabilizing financial markets, also serve as a mechanism of implicit fiscal redistribution across Eurozone member states.

Our quantification of these transfers underscores the scale of the implicit subsidies involved. The cumulative cross-country subsidies paid by Germany amount to 10.9% of GDP, while Italy and Spain benefit from negative subsidies of 5.7% and 7.5% of GDP over the period from 2004

to 2023. These estimates are conservative. These transfers are further amplified when considering alternative scenarios with higher sovereign bond spreads, illustrating the sensitivity of our estimates to variations in market conditions. Notably, we find that when sovereign bond yields increase by 100 basis points, Germany's cumulative cross-country subsidy rises to 13.2% of GDP, while the cross-country subsidies received by Italy and Spain grow to 8.1% and 10.5% of GDP, respectively.

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Appendix

A NCB Remittance and Government Budget Constraints

A.1 Proof of Corollary 1

Before income pooling, the remittance of country I and G are given, respectively, by

$$\begin{aligned} T_{I,t+1}^{\text{No Pooling}} &= \underbrace{A_{I,t}^{QE} R_{I,t+1}^{ND}}_{\text{QE Income}} + \underbrace{A_{I,t}^{BL} R_{t+1}^{BL}}_{\text{Bank Lending Income}} - \underbrace{B_{I,t}^{BR} R_{t+1}^{BR}}_{\text{Cost of Reserve}} - \underbrace{B_{I,t}^{T2} R_{t+1}^{T2}}_{\text{Cross-country Borrowing Cost}} \\ T_{G,t+1}^{\text{No Pooling}} &= \underbrace{A_{G,t}^{QE} R_{G,t+1}^{ND}}_{\text{QE Income}} + \underbrace{A_{G,t}^{T2} R_{t+1}^{T2}}_{\text{Cross-country Lending Income}} - \underbrace{B_{G,t}^{BR} R_{t+1}^{BR}}_{\text{Cost of Reserve}} . \end{aligned}$$

Under pooling, the QE income is not shared, while the bank lending income and reserve costs are fully shared, and the Target2 account yields zero. Consequently, the after-pooling remittances for country I and G, respectively, becomes:

$$\begin{aligned} T_{I,t+1}^{\text{Pooling}} &= \underbrace{A_{I,t}^{QE} R_{I,t+1}^{ND}}_{\text{QE Income}} + \underbrace{\alpha_I (A_{I,t}^{BL} R_{I,t+1}^{BL})}_{\text{Bank Lending Income}} - \underbrace{\alpha_I (B_{I,t}^{BR} + B_{G,t}^{BR}) R_{t+1}^{BR}}_{\text{Cost of Reserve}} \\ T_{G,t+1}^{\text{Pooling}} &= \underbrace{A_{G,t}^{QE} R_{G,t+1}^{ND}}_{\text{QE Income}} + \underbrace{\alpha_G (A_{I,t}^{BL} R_{I,t+1}^{BL})}_{\text{Bank Lending Income}} - \underbrace{\alpha_G (B_{I,t}^{BR} + B_{G,t}^{BR}) R_{t+1}^{BR}}_{\text{Cost of Reserve}} \end{aligned}$$

By utilizing, (1) assumption that $R_{I,t+1}^{BL} = R_{t+1}^{BR}$, (2)$A_t^{QE} + A_{I,t}^{BL} = B_{G,t}^{BR} + B_{I,t}^{BR}$, and (3) the QE allocation rule, $\alpha_c A_t^{QE} = A_{c,t}^{QE}$, the pooling remittance of country I can be rewritten step-by-step as

$$\begin{aligned} T_{I,t+1}^{\text{Pooling}} &= A_{I,t}^{QE} R_{I,t+1}^{ND} + \alpha_I A_{I,t}^{BL} R_{I,t+1}^{BL} - \alpha_I (B_{I,t}^{BR} + B_{G,t}^{BR}) R_{t+1}^{BR} \\ &= A_{I,t}^{QE} R_{I,t+1}^{ND} + \alpha_I \left[A_{I,t}^{BL} - (B_{I,t}^{BR} + B_{G,t}^{BR}) \right] R_{t+1}^{BR} \\ &= A_{I,t}^{QE} R_{I,t+1}^{ND} - \alpha_I A_t^{QE} R_{t+1}^{BR} \\ &= A_{I,t}^{QE} (R_{I,t+1}^{ND} - R_{t+1}^{BR}) \end{aligned}$$

Finally, replacing $A_{I,t}^{QE}$ in the above equation by $B_{I,t}^{BR} + B_{I,t}^{T2} - A_{I,t}^{BL}$ gives equation (8). By applying the same steps, the pooling remittance of country G can be rewritten as

$$T_{G,t+1}^{\text{Pooling}} = A_{G,t}^{QE} (R_{G,t+1}^{ND} - R_{t+1}^{BR})$$

A.2 Budget Constraint of the National Government

The period-t flow budget constraint of the government is given by

$$B_{c,t}^{ND} R_{c,t+1}^{ND} = S_{c,t+1} + T_{c,t+1} + B_{c,t+1}^{ND},$$

where $S_{c,t}$ denotes the primary fiscal surplus and $T_{c,t}$ denotes the remittance received from the NCB. Multiplying the equation above by the nominal pricing kernel $M_{t,t+1}^{c}$, we obtain

$$B_{c,t}^{ND} M_{t,t+1}^{c} R_{c,t+1}^{ND} = M_{t,t+1}^{c}(S_{c,t+1} + T_{c,t+1}) + M_{t,t+1}^{c} B_{c,t+1}^{ND}.$$

Taking expectations and assuming that government debt is correctly priced, such that $\mathbb{E}_t[M_{t,t+1}^{c} R_{c,t+1}^{ND}] = 1$, the above equation can be rewritten as

$$B_{c,t}^{ND} = \mathbb{E}_t\left[M_{t,t+1}^{c}(S_{c,t+1} + T_{c,t+1})\right] + \mathbb{E}_t\left[M_{t,t+1}^{c} B_{c,t+1}^{ND}\right].$$

Iterating this expression forward, the net present value (NPV) budget constraint of the treasury in country c is given by

$$B_{c,t}^{ND} = \mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s}^{c} \left(S_{c,t+s} + T_{c,t+s}\right),$$

implying that the national debt position must be backed by the net present value of all future primary surpluses and transfers from the NCB.

A.3 Proof of Corollary 2

Under income pooling, the remittance to each country c is given by

$$T_{c,t+1} = A_{c,t}^{QE}\left(R_{c,t+1}^{ND} - R_{t+1}^{BR}\right).$$

The NPV of the government budget constraint under income pooling is then

$$B_{c,t}^{ND} = \mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s}^{c} S_{c,t+s} + \mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s}^{c}\left(R_{c,t+s}^{ND} - R_{t+s}^{BR}\right) A_{c,t+s-1}^{QE}.$$

Under the assumption that QE follows the capital key, $A_{c,t}^{QE} = \alpha_c A_t^{QE}$, the equation above becomes identical to equation (11).

A.4 Proof of Corollary 3

Without income pooling, the seigniorage income is proportional to the amount of reserves the country is able to issue:

$$T_{c,t+1} = B^{BR}_{c,t}\left(R^{ND}_{c,t+1} - R^{BR}_{t+1}\right).$$

The NPV of the government budget constraint without income pooling is then

$$B^{ND}_{c,t} = \mathbb{E}_t \sum_{s=1}^{\infty} M^c_{t,t+s} S_{c,t+s} + \mathbb{E}_t \sum_{s=1}^{\infty} M^c_{t,t+s}\left(R^{ND}_{c,t+s} - R^{BR}_{t+s}\right) B^{BR}_{c,t+s-1},$$

which is the equation (13).

B Income Pooling and Implicit Cross-Country Transfers

In the Eurosystem, a portion of the income earned by NCBs is pooled and then redistributed based on their capital keys. Specific rules govern how income is pooled for each asset and liability item. In this section, we first present a general accounting formula that applies to all income-pooling items. Following that, we examine the pooling rules for specific balance sheet items.[18]

B.1 Income before and after Pooling

For each asset, we use $r^i_{c,book}$ to denote the book rate of asset i for the central bank of country c. The book rate represents the actual interest rate the NCBs charge for the asset. This interest rate may differ from $r^i_{c,Remun}$, the remuneration rate that the ECB uses for income pooling.

Let A^i_c denote the value of asset i held by the central bank of country c. We define the book income π^{NoPool}_{book} using the book interest rate as

$$\pi^{i,NoPool}_{c,Book} = r^i_{c,Book} A^i_c,$$

which measures the income that the national central bank directly receives from the asset. The book income is what is reported by the NCBs in their annual accounts. The ECB then collects $r^i_{c,Remun} A^i_c$ based on the imputed remuneration rate and redistributes $\alpha_c \sum_k r^i_{k,Remun} A^i_k$ as rebate back to the national central bank, where α_c represent the capital key share of the NCB in country

[18] See Table 2 in Belhocine et al. (2023) for a detailed discussion on income pooling by the ECB.

c. The after-pooling income $\pi_c^{i,Pool}$ is therefore

$$\underbrace{\pi_c^{i,Pool}}_{\substack{\text{After-Pooling}\\ \text{Income}}} = \underbrace{r^i_{c,Book} A^i_c}_{\substack{\text{Book}\\ \text{Income}}} - \underbrace{\left(r^i_{c,Remun} A^i_c - \alpha_c \sum_k r^i_{k,Remun} A^i_k \right)}_{\text{Pooling}}, \tag{19}$$

which is the NCB's actual net inflows of monetary income for asset i.

Table 9 shows the income after pooling for each balance sheet item according to Equation (19). For most items, the book rate is equal to the remuneration rate, i.e., $r^i_{c,Book} = r^i_{c,Remun}$, so that the income after pooling simplifies to

$$\pi_c^{i,Pool} = \alpha_c \sum_k r^i_{k,Remun} A^i_k,$$

where α_c represents the share of total income received by all NCBs allocated to country c. For example, in the case of income from Target2, the final income accruing to each central bank is $\alpha_c r_{MRO} \sum_k A_k^{T2}$. As discussed in Section 2, the sum of all NCB net positions equals the ECB's final net position, $\sum_k A_k^{T2} = -A_{ECB}^{T2}$, where A_{ECB}^{T2} represents the ECB's position. Since the ECB has a negative net balance, i.e., $A_{ECB}^{T2} < 0$, all NCBs receive positive income from Target2, distributed according to their capital key share. For example, in 2024, the ECB's net balance was -€382 billion, implying a total income accruing to NCBs of approximately €13 billion.

The only exception is the holdings of national debt securities. For these assets, the book rate is the actual interest rate received on debt holdings, while the remuneration rate is the MRO rate. This implies that each central bank receives an amount proportional to the overall Eurosystem holdings $\alpha_c r_{MRO} \sum_k A_k^{ND}$. Furthermore, NCBs also keep the spread between the sovereign bond

Table 9: NCB Income after Pooling

Balance Sheet Items	Book Rate	Remuneration rate	Income after pooling
Lending to Banks	Actual Rate	Actual Rate	$\alpha_c \sum_k r_k^{BL} A_k^{BL}$
National Debt Securities	Actual Rate	MRO Rate	$r_c^{ND} A_c^{ND} - r_{MRO} \left[A_c^{ND} - \alpha_c \sum_k A_k^{ND} \right]$
Other Debt Securities	Actual Rate	Actual Rate	$\alpha_c \sum_k r_k^{OD} A_k^{OD}$
Bank Reserves	Actual Rate	Actual Rate	$\alpha_c \sum_k r_k^{BR} A_k^{BR}$
Eurosystem Target2	MRO Rate	MRO Rate	$-\alpha_c r_{MRO} A_{ECB}^{T2}$
Eurosystem Banknotes	MRO Rate	MRO Rate	$-\alpha_c r_{MRO} A_{ECB}^{IB}$

yields of their country and the MRO:

$$\pi_c^{ND,Pool} = \underbrace{\left(r_c^{ND} - r_{MRO}\right)}_{\text{Bond Spread}} A_c^{ND} + \alpha_c r_{MRO} \underbrace{\sum_k A_k^{ND}}_{\text{Eurosystem Holdings}} .$$

In the data, it is approximately true that the domestic national debt holding equals the Eurosystem holding times the capital key share, i.e., $A_c^{ND} \approx \alpha_c \sum_k A_k^{ND}$, which simplifies this expression to $\pi_c^{ND,Pool} \approx r_c^{ND} A_c^{ND}$. In this case, the central bank keeps the entire income from its national debt holdings.

The total after-pooling income $\pi_c^{Pool} = \sum_i \pi_c^{i,Pool}$ is the sum across all assets and liabilities. Similarly, the total book income is $\pi_{c,Book}^{NoPool} = \sum_i \pi_{c,Book}^{i,NoPool}$. The difference between these two concepts of income, $\pi_{c,Book}^{NoPool} - \pi_c^{Pool}$ is reported in the annual accounts of each central bank as net result of pooling of monetary income.

Likewise, it is useful to define the effective balance sheet item $A_c^{i,Pool}$ to reflect the effective stock of its holdings after pooling adjustment:

$$A_c^{i,Pool} = A_c^i - A_c^i + \alpha_c \sum_k A_k^i = \alpha_c \sum_k A_k^i.$$

B.2 Counterfactual Market Income

Baseline Counterfactual Scenario. To compute the transfers, we consider a baseline counterfactual scenario in which there is no Eurozone and there is no income pooling arrangement. In this counterfactual, all assets and liabilities earn a market rate. NCBs can accumulate claims on other NCBs by acquiring foreign currency reserves. We assume that NCBs accumulate foreign currency reserves by buying the national government debt of these other countries.

Accordingly, for Target2 balances, we use the national government bond yields as the market interest rate in the counterfactual. We compute the duration-weighted yield for each country. For the long-term portion of bank lending (LTROs, T-TLROs), we apply the prevailing yields on bank holdings of corporate bonds. For Eurosystem banknotes, we assign a market rate of zero.

Importantly, we do not claim that the risk characteristics of Target2 claims are the same as those of the national government bonds, or that they have the same maturity structure. Instead, we simply assume that the NCBs accumulate foreign government bonds in the counterfactual scenario. The states of the world in which the NCBs may default on the Target2 claims overlap only

partly with the states of the world in which the national government defaults on its bonds. If the government default on the bonds, but remains in the Eurozone, then Target2 claims would be unaffected. However, periphery bonds are currently either held by NCB or by the national financial institutions. As a result, the NCB would have to be recapitalized by the national government. If the government leaves the Eurozone and depreciates the currency, then it seems likely that the Target2 claims would at the very least be redenominated in the new currency. Many countries, including the U.S., have resorted to this strategy in the past.

Subsidy. Our objective is to compare each central bank's after-pooling income π_c^{Pool} that it receives in the Eurosystem to a counterfactual scenario in which the NCB is paid or paying the market rate and faces no income pooling by the ECB. The market rate, which we denote as $r^i_{c,Mkt}$, could be different from both the book rate $r^i_{c,Book}$ and the remuneration rate $r^i_{c,Remun}$. Using this market rate, we define the counterfactual market income as

$$\pi^{i,NoPool}_{c,Mkt} = r^i_{c,Mkt} A^i_c.$$

We define the subsidy that the central bank in country c receives for asset i as the difference between the counterfactual market income and the actual after-pooling income:

$$\pi^{i,NoPool}_{c,Mkt} - \pi^{i,Pool}_c = r^i_{c,Mkt} A^i_c - \left(r^i_{c,Book} A^i_c - r^i_{c,Remun} A^i_c + \alpha_c \sum_k r^i_{k,Remun} A^i_k \right),$$

which is positive if the central bank pays out a subsidy and negative if it receives a subsidy. The subsidy can be decomposed into two components:

$$\pi^{i,NoPool}_{c,Mkt} - \pi^{i,Pool}_c = \underbrace{(r^i_{c,Mkt} - r^i_{c,Book}) A^i_c}_{\text{Mark to Market}} + \underbrace{r^i_{c,Remun} A^i_c - \alpha_c \sum_k r^i_{k,Remun} A^i_k}_{\text{Pooling}},$$

which are the effect due to the difference between the market rate and the book rate, and the pooling effect due to the ECB's redistribution of income.

We sum across all assets and liabilities of each central bank to obtain the overall subsidy for central bank of country c:

$$\pi^{NoPool}_{c,Mkt} - \pi^{Pool}_c = \sum_i \left(\pi^{i,NoPool}_{c,Mkt} - \pi^{i,Pool}_c \right),$$

which reflects the income the central bank would have earned had it applied the market interest rate and not pooled income with other central banks.

Within-Country vs. Cross-Country Subsidy. This discussion suggests that we need to distinguish the subsidy estimate between its *within-country* and *cross-country* components. Target2, Intra-Eurosystem Banknotes, and debt securities involve transactions between countries, while bank lending is a within-country transaction with domestic banks. As the central bank provides loans to domestic banks at favorable interest rates that are significantly below market levels, the mark-to-market adjustment also reflects a within-country subsidy. That said, the bank lending is also subject to income pooling between countries. Therefore, we should decompose the subsidy for the bank lending item into two components:

$$\pi_{c,Mkt}^{BL,NoPool} - \pi_{c}^{BL,Pool} = \underbrace{(r_{c,Mkt}^{BL} - r_{c,Book}^{BL})A_{c}^{BL}}_{\substack{\text{Mark to Market} \\ \text{Within-Country Subsidy}}} + \underbrace{r_{c,Remun}^{BL}A_{c}^{BL} - \alpha_{c}\sum_{k} r_{k,Remun}^{BL}A_{k}^{BL}}_{\substack{\text{Pooling} \\ \text{Cross-Country Subsidy}}}.$$

The first term on the right-hand side represents the within-country subsidy, which is proportional to the difference between the counterfactual market rate and the book rate. The second term captures the cross-country subsidy, reflecting the disparity between the income generated through bank lending by an individual country and the final pooled income, which corresponds to a share α_c of the total income generated by all NCBs through bank lending. Bank lending is the only balance sheet item that includes both within-country and cross-country components. Therefore, we compute the total cross-subsidy income by summing the subsidies generated from various balance sheet items, along with the cross-country component of bank lending.

B.3 Line by Line Analysis of Pooling

B.3.1 Target2

Income Pooling. For Target 2 the book yield and the remuneration rate (MRO rate) is identical for all country c, namely $r_{Book} = r_{Remun} = r_{MRO}$. Then, according to equation (19), the pooling

income of Eurosystem Banknotes can be rewritten as

$$\pi_c^{T2,Pool} = r_{c,Book}^{T2} A_c^{T2} - \left(r_{c,Remun}^{T2} A_c^{T2} - \alpha_c \sum_k r_{k,Remun}^{T2} A_k^{T2} \right) \tag{20}$$

$$= \alpha_c r_{MRO} \sum_k A_k^{T2} = -\alpha_c r_{MRO} A_{ECB}^{T2}, \tag{21}$$

where the last equality utilizes the property that the sum of net claims including ECB is zero, $\sum_k A_k^{T2} + A_{ECB}^{T2} = 0$. Since the net claims can offset each other among NCBs, the NCBs' pooling incomes only depend on the income paid or received by ECB. This implies the after-pooling income of each NCB is independent of its asset or liability position and only depends on the amount owned by the ECB. Consider the extreme case where ECB holds zero amount, then the after-pooling income must be zero by construction regardless of the remuneration rate. For Target2, the sum of net claims and liabilities of NCBs is minimal, $\sum_k A_k^{T2}$, indicating that the overall post-pooling income is negligible. Consequently, even if a central bank holds a net position in Target2, the effective yields paid or received on this item are close to zero.

Counterfactual Target2 claims are currently remunerated at the prevailing ECB MRO rate. We mark-to-market Target2 claims by assuming that these claims are remunerated in the same way as cross-country government claims, i.e., at the current yields on government bonds. For countries with positive Target2 claims (lenders), their returns are imputed as a weighted average of sovereign bond yields from Target2 debtor countries, with weights based on each country's share of Target2 liabilities. Conversely, a Target2 debtor country pays a rate equivalent to its own government bond yield.

For instance, consider a simplified Eurozone with only three countries: Germany, Italy, and Spain. Both Italy and Spain have Target2 liabilities owed to Germany, with each holding an equal share of 50% of the total liabilities. In this case, the Target2 remuneration rate for Germany is assumed to be the equally weighted average of the Italian and Spanish bond yields. Italy and Spain, in turn, pay for their Target2 liabilities at the rate of their respective sovereign bond yields. Since Target2 claims do not have a defined maturity, we assume the remuneration corresponds to the weighted average yield of all outstanding government bonds.

B.3.2 Eurosystem Banknotes (*IB*)

For Eurosystem Banknotes (IB) the book yield and the remuneration rate (MRO rate) is identical for all country c, namely $r_{Book} = r_{Remun} = r_{MRO}$. Then, according to equation (19), the pooling income of Eurosystem Banknotes can be rewritten in the same way as in for Target2 in Equation (21):

$$\begin{aligned}\pi_c^{IB,Pool} &= r_{c,Book}^{IB} A_c^{IB} - \left(r_{c,Remun}^{IB} A_c^{IB} - \alpha_c \sum_k r_{k,Remun}^{IB} A_k^{IB} \right) \\ &= \alpha_c r_{MRO} \sum_k A_k^{IB} = -\alpha_c r_{MRO} A_{ECB}^{IB},\end{aligned}$$

where the last equality utilizes the property that the sum of net claims including ECB is zero, $\sum_k A_k^{IB} + A_{ECB}^{IB} = 0$.

Counterfactual The remuneration rate on the Intra-Eurosystem banknotes and banknotes are both zero. A country is able to issue more domestic currency indicating its greater seigniorage revenue. This revenue is not shared among NCBs in our baseline scenario. Note that the ECB's 8% share of seigniorage revenue remains unchanged.

B.3.3 Bank Lending

Income Pooling. Bank lending (BL) consists of short-term bank lending (SBL) and long-term bank lending (LBL). Short-term bank lending primarily includes Main Refinancing Operations (MROs), while long-term lending comprises LTROs and T-LTROs. The remuneration rates for both short-term and long-term bank lending correspond to their respective book yields. The corresponding equation (19) is then simplified as

$$\begin{aligned}\pi_{c,i}^{Pool} &= r_{c,Book}^{i} A_c^{i} - r_{c,Remun}^{i} A_c^{i} + \alpha_c \sum_k r_{k,Remun}^{i} A_k^{i} \\ &= \alpha_c \sum_k r_{k,Book}^{i} A_k^{i}, \text{ for } i = SBL \text{ and } LBL\,,\end{aligned}$$

which indicates that the income of these items are fully and truly shared among NCBs.

Counterfactual For short-term bank lending, we assume that the MRO rate represents the actual market rate, implying $r_{c,Mkt}^{SBL} = r_{c,Book}^{SBL} = r_{c,Remun}^{SBL} = r_{MRO}$. For long-term bank lending, we use

the yield on euro-denominated corporate bonds issued by banks. This serves as an alternative financing option for banks, comparable to long-term borrowing, and can be benchmarked against corporate bond yields.

B.3.4 National Debt Securities

Income Pooling. We then turn into the national debt securities (ND) held by NCBs. First, the remuneration rate is identical for all NCBs and is set to the MRO rate. Its pooling income is then

$$\begin{aligned}\pi_c^{ND,Pool} &= r_{c,Book}^{ND} A_c^{ND} - r_{c,Remun}^{ND} A_c^{ND} + \alpha_c \sum_k r_{k,ND}^{Remun} A_k^{ND} \\ &= r_c^{ND} A_c^{ND} - r_{MRO} \underbrace{\left[A_c^{ND} - \alpha_c \sum_k A_k^{ND} \right]}_{\text{excess holdings}}\end{aligned}$$

where the excess holdings are defined as the national debts netting out of its capital key share of NCBs' aggregate. Given the purchase of national debts of each NCB roughly mirrors its capital key, we should expect that the exceeding holdings is relatively small. Hence, the net nation-debt-income transferred from NCB to ECB is small if the excess holdings are approximately zero. This shows that most of the national debt income stays with each NCB and the effect of income pooling is limited on the holdings of sovereign debts. As $r_{c,Book}^{ND}$ is already a market yield, we have: $r_{c,Book}^{ND} = r_{c,Mkt}^{ND}$.

B.3.5 Other Assets and Liabilities

We now examine the income pooling properties of bank reserves (BR), and other debt securities (OT). For these assets, we assume that the market rate is equal to the book rate, meaning that in our analysis, we focus solely on the effects of income pooling, excluding any mark-to-market effects. The remuneration rates for bank reserves (BR) and other debt securities (OT) are their corresponding book yields. The corresponding equation (19) is then simplified as

$$\begin{aligned}\pi_c^{i,Pool} &= r_{c,Book}^{i} A_c^{i} - r_{c,Remun}^{i} A_c^{i} + \alpha_c \sum_k r_{k,Remun}^{i} A_k^{i} \\ &= \alpha_c \sum_k r_{k,Book}^{i} A_k^{i}, \text{ for } i = BR, \text{and } OT\ ,\end{aligned}$$

which indicates that the income of these items are fully and truly shared among NCBs

B.4 Validation of our Income Pooling Formula

Many NCBs, such as the Bundesbank and Banca d'Italia, do not provide an item-by-item decomposition of net income transfers resulting from pooling. In general, their income statements only list itemized income *prior to* pooling. The net result of income pooling is reported only at an aggregate level, summing across all balance sheet items. Consequently, we cannot verify our formula for these countries due to the lack of detailed publicly available data.

One exception is the Banco de España, which does report a breakdown of pooled monetary income by balance sheet item. Table 10 presents a snapshot of this decomposition for 2022. The first panel shows income before pooling for each item—data that is generally available for most NCBs. The middle panel displays the net income effect of pooling, which is typically not disclosed by other NCBs. The sum of the first and second panels gives the income after pooling. This allows for a direct, item-by-item comparison between Table 10 and our income pooling formula, equation (19).

The comparison shows that Table 10 is consistent with the predictions of our formula. The after-pooling income from Target2 and Eurosystem banknotes is relatively small compared to the corresponding pre-pooling income. In addition, they have opposite signs. As indicated by our income pooling formula, the after-pooling income from Target2 and Eurosystem banknotes is independent of an individual NCB's asset or liability position and depends only on the amounts owned by the ECB. Since the ECB holds Target2 liabilities and Eurosystem banknote assets, the NCBs pay the ECB for its banknote holdings and receive income from the ECB for its Target2 liabilities.

The Banco de España does not disaggregate income from national debt securities and other debt securities, which are subject to different pooling rules. Instead, it reports only the combined income from pooled and non-pooled debt securities. As shown in Table 10, most debt security income is non-pooled. This aligns with the fact that most NCB-held debt securities are domestic sovereign bonds, the income from which is rarely pooled. In contrast, income from other debt securities—such as supranational bonds and non-public debt—is fully pooled, as predicted by our formula. However, these securities represent a relatively small share of total holdings.

Income from bank lending and bank reserves is fully pooled. The sign of the net pooling result reflects each NCB's position relative to its capital key share of the aggregate NCB income. The negative net pooling result for bank reserves (€197 million) implies that the Banco de España is-

Table 10: Banco de España Income Pooling Decomposition

2022 Year End	Before Pooling	Net Result of Pooling	After Pooling
Pooling Items			
Bank Lending	−1453.51	197.18	−1256.34
Pooled Debt Securities	926.13	−219.71	706.42
Bank Reserves	−530.01	−248.28	−778.29
Eurosystem Banknotes	1007.95	−1095.67	−87.73
Eurosystem Target2	−2771.29	3019.95	248.67
Non-Pooling Item			
FX	1052.83		1052.83
Non-Pooled Debt Securities	5613.53		5613.53

Unit: Million Euro. Source: Banco de Espana 2022 annual report.

sued fewer reserves than its capital key share, and therefore must contribute to covering the cost of reserves issued by other NCBs. The negative income generated by bank lending reflects a subsidy to the Spanish banking sector from the Banco de España, classified as a within-country transfer. However, due to income pooling, part of this subsidy is redistributed across the Eurosystem. In Spain's case, the positive net pooling result indicates that the subsidy to its banking sector was, in part, financed by other NCBs.

C ECB's Balance Sheet

Table 11 reports the balance sheets of the ECB. First, the amount of Intra-Eurosystem banknotes listed on the asset side is exactly equal to the banknotes listed on the liability side. The value of these two items is set at 8% of the total banknotes issued by the Eurosystem. Since the Intra-Eurosystem banknotes are remunerated at the MRO rate—which is typically above the zero rate earned on cash—this balance sheet arrangement ensures that the ECB receives 8% of the seigniorage revenue within the Eurosystem. Consequently, the figures reported in Table table: BS ECB are normalized by 8% of Eurozone GDP. In addition, over the past decade, the ECB's balance sheet has expanded significantly, growing from 22% of Eurozone GDP in 2014 to 68% in 2021. This expansion is largely driven by asset purchase programs executed directly by the ECB. Most of the increase in debt security holdings has been financed by a rise in Target2 liabilities.

Table 11: Balance Sheet of ECB

Year End	2014	2021	2023
Assets			
National Debt Securities	37.0%	44.8%	2.2%
Gold, FX and Others	7.6%	8.1%	7.6%
Eurosystem Banknotes	10.9%	12.4%	10.0%
Liabilities			
Banknotes	10.9%	12.4%	10.0%
Eurosystem Target2	35.2%	33.7%	2.9%
Eurosystem FX	3.5%	4.1%	5.0%
Capital and Others	9.1%	18.3%	4.9%
Sum	58.7%	68.5%	22.1%

Unit: % of eight percent eurozone GDP. Source: Euro Stat, ECB, and authors' calculation

D Effective Balance Sheet

This subsection employs an alternative approach to evaluate the fiscal implications of monetary policy. Instead of cash-flow analysis in Section 4, we adjust the value of the balance sheet in order to reflect the effects of income-pooling arrangement among NCBs. Obviously, for those balance items that are excluded from income pooling, their values remain unchanged. As shown in Appendix B.3, balance sheet items have different income-pooling rules and properties. Hence, their associated adjustments have to vary accordingly. We discuss them item-by-item below.

1. For Eurosystem Target2 and Banknotes, their effective incomes are independent of their own holdings and only depended on the holdings of ECB. As a result, we assign the value of these two items as the capital key share of ECB's holdings.

2. For banking lending, bank reserves and debts other than national debts held by NCBs, these incomes are pooled completely. Under the simplified assumption that the actual yield of these items are identical across NCBs. Their values can be adjusted from A_j^i to $\alpha_j \sum_k A_k^i$.

3. The adjustment of national debts (held by NCBs) is more involved. We keep the original value of national debt since its incomes are not pooled with zero excess holdings. Then, we add an adjustment item to reflect its excess holdings as $\alpha_j \sum_k A_k^{ND} - A_j^{ND}$ and is reported under the item named "National Debt Securities Pooling Adj".

Table 12: Summary of Adjusted Balance Sheet Value

Balance Sheet Items	Adjusted Value
Lending to Banks	$\alpha_c \sum_k A_k^{BL}$
National Debt Securities	A_c^{ND}
National Debt Securities Pooling Adj	$\alpha_c \sum_k A_k^{ND} - A_c^{ND}$
Other Debt Securities	$\alpha_c \sum_k A_k^{OD}$
Bank Reserves	$\alpha_c \sum_k A_k^{BR}$
Eurosystem Target2	$\alpha_c A_{ECB}^{T2}$
Eurosystem Banknotes	$\alpha_c A_{ECB}^{IB}$

The adjusted value for each balance sheet item is reported in Table 12. We then adjust the value of income-pooling items on NCB's balance sheet accordingly. The adjusted balance sheets for the Banca D'Italia and the Deutsche Bundesbank are reported in the last two columns of Table 14 and 13, respectively.

Clearly, the adjusted balance sheet is no longer balanced due to the income-pooling arrangement. In particular, the net asset position (assets minus liabilities) becomes positive for the Banca d'Italia, while it turns negative for the Deutsche Bundesbank. From the perspective of the consolidated balance sheet, these changes in liabilities translate one-to-one into the net liabilities of the public sector, which are backed by the future stream of tax revenues. In Germany's case, the burden on German taxpayers rises as the ECB scales up its QE policy and falls as the policy is unwound (QT). For Italian taxpayers, the opposite is true. This remains the case even if the ECB and NCBs purchase government bonds strictly in proportion to their capital key.

For the Deutsche Bundesbank, there are three major adjustments: the reduction of Target2 assets on the asset side, and the markdown of both bank reserves and Eurosystem banknotes on the liability side. The reduction in its liabilities is insufficient to offset the loss of Target2 assets. As a result, the Bundesbank suffers balance sheet losses. In contrast, the large cancellation of Target2 liabilities held by the Banca d'Italia generates net benefits, since the rise in other liabilities (primarily bank reserves) is smaller than the reduction in Target2 liabilities. Hence, under the current income-pooling arrangement, the Banca d'Italia benefits. Essentially, this agreement redistributes seigniorage revenues (broadly defined) across all NCBs: it disadvantages countries with a greater ability to generate seigniorage revenues, such as Germany, and benefits those with less capacity, such as Italy. The ability to generate seigniorage revenues is closely tied to a country's fiscal posi-

Table 13: Adjusted Balance Sheet of Deutsche Bundesbank

	No Pooling			Pooling		
% of GDP, Year End	2014	2021	2023	2014	2021	2023
Assets						
Bank Lending	2.2%	11.7%	1.8%	5.5%	16.0%	2.6%
National Debt Securities	0.0%	21.4%	18.4%	0.0%	21.4%	18.4%
National Debt Pooling Adj	0.0%	0.0%	0.0%	0.0%	1.8%	2.1%
Other Debt Securities	1.7%	7.0%	6.1%	1.8%	7.9%	6.6%
Gold, FX and Others	6.6%	8.3%	8.4%	6.6%	8.3%	8.4%
Eurosystem Target2	**15.7%**	**34.8%**	**26.4%**	**0.2%**	**2.4%**	**2.6%**
Asset Sum	26.3%	83.3%	61.1%	14.1%	57.9%	40.7%
Liabilities						
Banknotes	8.2%	10.4%	9.1%	8.2%	10.4%	9.1%
Bank Reserves	3.1%	31.5%	26.9%	3.2%	31.2%	22.2%
Capital and Others	5.9%	27.3%	11.8%	5.9%	27.3%	11.8%
Eurosystem Banknotes	**9.2%**	**14.1%**	**13.2%**	**0.7%**	**0.9%**	**0.8%**
Liability Sum	26.3%	83.3%	61.0%	18.0%	69.8%	44.0%
Net Liabilities	0.0%	0.0%	0.0%	3.9%	11.9%	3.3%

Unit: % of GDP. Source: ECB, Deutsche Bundesbank annual reports, Euro Stat and authors' calculation.

Table 14: Adjusted Balance Sheet of Banca D'Italia

	No Pooling			Pooling		
% of GDP, Year End	2014	2021	2023	2014	2021	2023
Assets						
Bank Lending	12.0%	24.9%	7.2%	6.8%	20.5%	3.3%
National Debt Securities	0.0%	29.2%	25.6%	0.0%	29.2%	25.6%
National Debt Securities Adj	0.0%	0.0%	0.0%	0.0%	0.5%	0.5%
Other Debt Securities	2.2%	7.4%	5.9%	2.2%	10.1%	8.4%
Gold, FX and Others	17.1%	20.2%	19.3%	17.1%	20.2%	19.3%
Eurosystem Target2	0.0%	0.0%	0.0%	0.3%	3.1%	3.3%
Eurosystem Banknotes	1.4%	2.8%	2.2%	0.0%	0.0%	0.0%
Asset Sum	32.6%	84.4%	60.1%	26.3%	83.6%	60.3%
Liabilities						
Banknotes	10.1%	13.2%	11.7%	10.1%	13.2%	11.7%
Bank Reserves	0.9%	22.2%	9.0%	4.0%	40.0%	28.3%
Capital and Others	8.7%	16.7%	14.4%	8.7%	16.7%	14.4%
Eurosystem Target2	12.8%	32.3%	25.0%	0.0%	0.0%	0.0%
Eurosystem Banknotes	0.0%	0.0%	0.0%	0.9%	1.2%	1.0%
Liability Sum	32.6%	84.4%	60.1%	23.7%	71.0%	55.3%
Net Assets	0.0%	0.0%	0.0%	2.6%	12.6%	5.0%

Unit: % of GDP. Source: ECB, Euro Stat, Banca D'Italia and authors' calculation

tion and discipline. In short, with the launch of APPs, the balance sheet gap widened and peaked in 2021. This is consistent with our argument that APPs induce significant cross-country transfers.

Graphically, for balance sheet items subject to income pooling, we assume that their after-pooling sizes are determined by the aggregate balance sheet of all NCBs multiplied with the capital key. Figure 8 reports this calculation for the countries in our sample. There are two main takeaways.

First, if we compare the assets and liabilities of each national central bank before and after pooling, we can see that the pooling adjustment always reduces the size of the balance sheet. This is a result of netting due to pooling: for example, Banca d'Italia has a net asset in Eurosystem Banknotes and a net liability in Eurosystem Target2, whereas Bundesbank has the opposite positions. After netting, these assets and liabilities offset each other and result in a smaller gross position in the balance sheet.

Second, while the actual assets and liabilities of each national central bank are balanced before pooling, the pooling adjustment can result in a positive or negative balance. For example, the Bundesbank's net balance is negative, while reflects the fact that it contributes more assets to the ECB for pooling than the pooled assets it receives according to its capital key share. In contrast, the Banca d'Italia has a positive net balance, which reflects the fact that it gives more liabilities to the ECB for pooling than the pooled liabilities it receives according to its capital key share. In this sense, the pooling adjustments on balance sheet sizes lead to similar conclusions: the core countries such as Germany and France are net contributors to the Eurosystem subsidy, whereas the periphery countries such as Italy and Spain are net recipients of the Eurosystem subsidy.

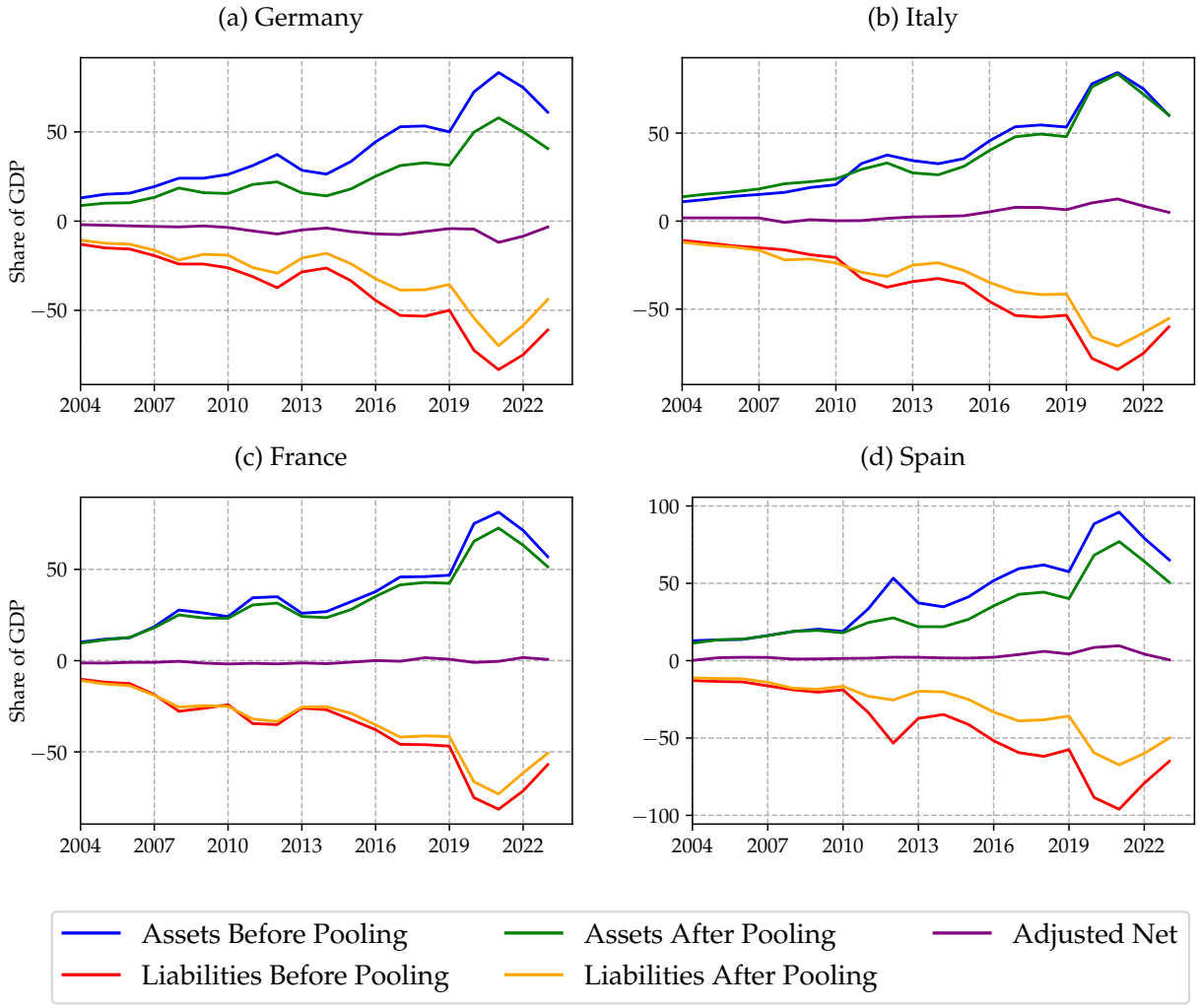
E Actual Allocation of Public Debt Purchases

E.1 Background Information regarding Public Debt Purchases

PSPP. The European Central Bank (ECB) introduced the asset purchase programme (APP) in mid-2014 as part of a broader set of unconventional monetary policy tools, which also included targeted longer-term refinancing operations. These measures were designed to enhance the transmission of monetary policy and to provide the necessary level of policy accommodation to maintain price stability. On March 9, 2015, the ECB began purchasing public sector securities through the public sector purchase programme (PSPP).

Purchases under the PSPP were generally guided by the ECB's capital key, which allocates

Figure 8: Adjusted Balance Sheet



Unit: % of GDP. Source: Bloomberg, ECB, Annual reports of central banks and Authors' calculation

shares to each national central bank (NCB) based on its economic size and population. However, the programme allowed for monthly flexibility, meaning that strict adherence to the capital key was not required each month. This flexibility facilitated the smooth execution of the programme.

Additionally, the timing of reinvestments of principal redemptions, and the option to stagger these reinvestments over time, could influence a jurisdiction's share of the monthly purchase volume. Consequently, this might also affect the purchase volumes of other jurisdictions.

Principal redemptions were reinvested within the same jurisdiction where the repayments occurred, while adjustments to the portfolio allocation across jurisdictions aimed to better align the PSPP portfolio with each NCB's capital key subscription. These adjustments were made within

the constraints of issuer and issue limits, the principle of market neutrality, and other programme guidelines.

PEPP. On March 18, 2020, the Governing Council of the European Central Bank (ECB) introduced the pandemic emergency purchase programme (PEPP) in response to the significant threats the COVID-19 pandemic posed to the euro area's economic outlook and the effectiveness of monetary policy transmission (as outlined in the Governing Council's decisions on that date). The Eurosystem began executing purchases under the PEPP on March 26, 2020.

The PEPP is a temporary asset purchase initiative that includes both private and public sector securities. Initially set at €750 billion, the programme's funding was first increased by €600 billion on June 4, 2020, and later by an additional €500 billion on December 10, 2020, resulting in a total of €1,850 billion. All asset types eligible under the pre-existing asset purchase programme (APP) were also incorporated into the PEPP, with the eligibility criteria for Greek Government securities being specifically waived.

For the acquisition of public sector securities within the PEPP, the allocation across jurisdictions is generally guided by the Eurosystem capital key. However, the programme is implemented with considerable flexibility, allowing adjustments based on prevailing market conditions to prevent an unwarranted tightening of financing conditions that could undermine efforts to counter the pandemic's downward pressure on inflation. This flexibility, applied over time and across different asset classes and jurisdictions, is set to maintaining the effective transmission of monetary policy according the ECB.

ECB. The purchase share of public debt executed by the ECB, which is around 10% of total public debt purchases, does not need to mirror the capital keys of member countries. As a result, even if the country shares of public debt purchases executed by NCBs follow exactly their capital key share. The overall purchase share of the Eurosystem could still deviate the capital key share as a result of the ECB's discretionary purchase power.

TPI. Finally, in 2022, the ECB rolled out its Transmission Protection Instrument (TPI) program, allowing the Eurosystem to buy government bonds of specific member countries that experience unwarranted increases in borrowing costs. The TPI program effectively allows the purchases of public debt departing from the capital key guideline.

E.2 Actual Purchase Allocation

As discussed above, while the guiding principle for the allocation of purchases across countries is the capital key, the actual net purchases of the ECB may result to be different. We collect data from the ECB and compute the actual allocation of purchases across countries. We gather data from the European Central Bank (ECB) website[19] and analyze it to calculate the distribution of purchase shares allocated to various countries. The capital key share data are obtained in two different ways. First, we use the annual-report data of NCBs and ECB and calculate the ratio of banknotes to total banknotes for each NCB. Second, we use the press release from the ECB to reconstruct the capital key ratio.[20].

Figure 9 plots the shares of PSPP and PEPP purchases of various countries. The shares are calculated as the cumulative net purchases in a country divided by the total cumulative net purchases (net of purchases of supranational bonds). We also plot the capital key share of each country.

In Germany, the PSPP share shows significant fluctuations over the observed period. Starting around 26.5% in 2016, the share experiences a general upward trend, peaking above 27.25% around 2021. However, this peak is followed by a sharp decline in 2022, where the share drops back to approximately 26.25% by 2024. The PEPP share, introduced in 2020, initially fluctuates but then stabilizes around 26.5% by 2022. There is a period of volatility in both shares between 2021 and 2022, reflecting shifts in the allocation strategy.

For Italy, the PSPP share starts near 18% in 2016 and initially trends upwards, reaching just under 19% by 2020. However, from 2021 onward, the share declines steadily, falling below 18% by 2024. The PEPP share, introduced around 2020, rapidly increases to over 21%, showing a significant deviation from the PSPP share. However, by 2022, the PEPP share begins to decline, stabilizing near 19% by 2024.

In France, the PSPP share begins close to 20% in 2016 and gradually increases, reaching around 22% by 2020. The share remains relatively stable around this level until 2024, with only minor fluctuations. The PEPP share, which starts around 2020, sees a rapid increase, aligning closely with the PSPP share by 2021 and then stabilizing around 20% by 2024. The stability in both shares indicates a consistent allocation strategy throughout the period.

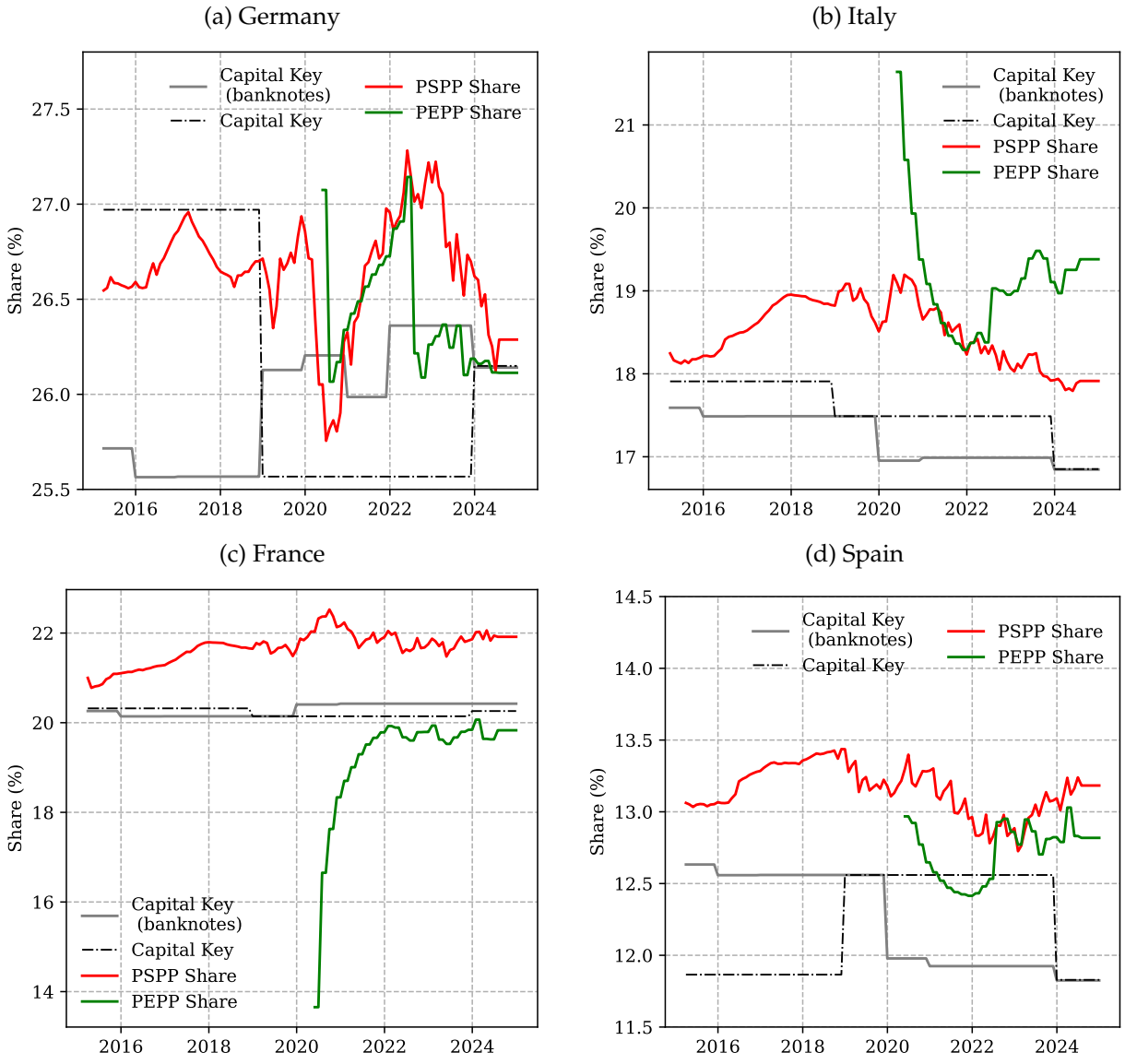
In Spain, the PSPP share begins around 12.0% in 2016 and rises steadily, peaking around 13.4%

[19] We download data for the PSPP programme at this web address and download data for the PEPP at this link.

[20] There are three waves of capital key changes. The change from 2013 to 2014, from 2018 to 2019, and from 2023 to 2024, which are available, respectively, in the following web address: link 1, link 2, and, link 3

by 2020. However, from 2021 onwards, the share declines, dropping below 13.0% by 2024. The PEPP share, introduced in 2020, shows a steep initial decline, reaching near 12.4% before recovering and stabilizing around 12.8% by 2024. The fluctuations in the PEPP share, particularly in 2021, indicate significant adjustments in the purchase program during that period.

Figure 9: Purchases versus Capital Key

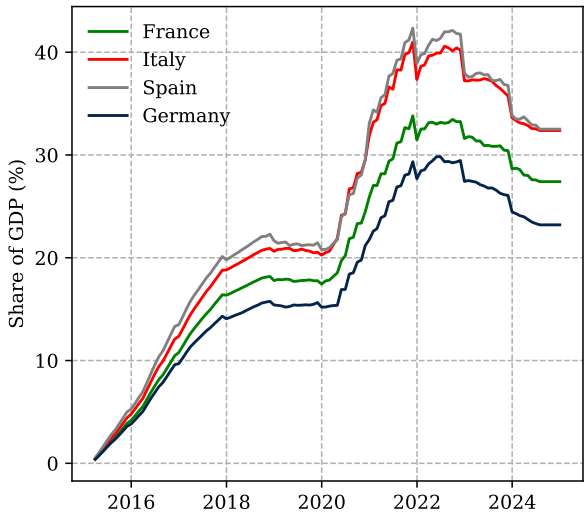


Source: Bloomberg, ECB, Annual reports of central banks and Authors' calculation

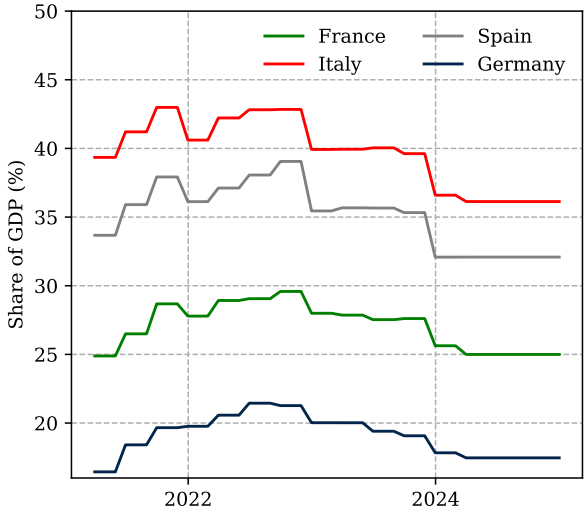
Purchases as Share of GDP. We compute the total net purchases in each country as share of the national GDP. The results are reported in Figure 10a. We also use data from Securities Holdings Statistics by Sector (SHSS) and download the total stock of holdings of government bonds by the ECB and compute the value as share of GDP for each country. This is a notion of stock. The data are only available starting in 2021 and are presented in Figure 10b.

Figure 10: Purchases as Share of GDP

(a) Cumulative Net Purchases



(b) Stock of Holdings



Unit: % of GDP. Source: Bloomberg, SHSS, ECB, Annual reports of central banks and Authors' calculation

F Proofs of Section ??

Proof of Proposition 1. Fix $M_T > 0$ and suppose $B^{T2} \in (0, F)$. We must show that $q_{\text{post}} < q_{\text{pre}}$. From equations (15) and (16) this is equivalent to

$$\frac{P(F) - P(B^{T2})}{F - B^{T2}} > \frac{P(F)}{F}.$$

Since $M_T > 0$ and $(K - V_T)^+$ is convex in K, the sovereign put $P(K) = \mathbb{E}[M_T(K - V_T)^+]$ is convex in K with $P(0) = 0$. Convexity of P with $P(0) = 0$ implies that the slope of the chord from the origin to any point $K > 0$ is non-decreasing in K. For $0 < B^{T2} < F$, this gives

$$\frac{P(F) - P(0)}{F - 0} \leq \frac{P(F) - P(B^{T2})}{F - B^{T2}},$$

which, using $P(0) = 0$, is exactly the required inequality (17).

Strictness holds whenever default has positive probability. In that case, on the event $\{V_T < F\}$, which has positive probability by assumption, $(K - V_T)^+$ is strictly increasing in K, so $P(K)$ is strictly convex and all inequalities above are strict. □

Proof of Proposition 2. Suppose Target2 liabilities are senior and fix $M_T > 0$. By Proposition 1, for any fixed distribution of V_T, subordination strictly raises the credit spread on sovereign bonds. For statement (A) to hold—QE reduces spreads—the distribution of V_T must shift upward sufficiently to satisfy inequality (18), reversing the subordination effect. Formally, we need $\tilde{V}_T \geq V_T$ almost surely with strict inequality on a set of positive probability, so that $\tilde{P}(K) < P(K)$ for all $K > 0$. But $\tilde{V}_T > V_T$ means the sovereign can repay strictly more than it could without QE in some states of the world. In the Eurosystem, this additional repayment capacity arises from the periphery borrowing from the core at below-market rates through the Target2 system— an implicit fiscal transfer. Hence statement (B) must fail. □