Quantitative Easing in a Heterogeneous Monetary Union*

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Abstract

I analyse the transmission of Quantitative Easing and assess its distributional effects in a heterogeneous monetary union. Focusing on the European Monetary Union (EMU), I capture two types of heterogeneity: *cross-country* – debt profiles (long-term debt liquidity, short-term to long-term debt, debt-to-GDP ratio) and *within-country heterogeneity* – unequal household financial participation. I develop a Two-Country, Two-Agent New Keynesian model with a liquidity constraint, calibrated to EMU core and peripheral countries during the Global Financial Crisis. My main finding is that heterogeneity within a monetary union critically shapes the impact of Quantitative Easing. Across countries, differences in debt profiles shape the aggregate response of output via the portfolio rebalancing channel. Bond liquidity governs the strength of the portfolio reallocation while the short-to-long-term debt ratio drives its direction. Within countries, disparities in households' access to financial markets condition both the aggregate output response and the distributional effects of QE.

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'Since 1999, the euro area has successfully weathered several shocks, including the bursting of the dotcom bubble, the ripple effect of 9/11, the surge in global commodity and energy prices, and the persistence of sizeable global imbalances [...] However, there is still substantial and persistent heterogeneity across euro area countries.'

Bini (2007) Speech, *European Central Bank*

1 Introduction

The creation of the European Monetary Union generated episodes of convergence across member states, yet substantial divergences have persisted between the core and the periphery (Auray and Eyquem (2021), De Grauwe (2020)). These divergences intensified during the Global Financial Crisis, reflecting both cross-country heterogeneity—notably differences in sovereign debt composition and liquidity—and within-country heterogeneity, such as unequal household access to financial markets. Understanding how Quantitative Easing interacts with these structural differences is therefore essential for evaluating its aggregate and distributional consequences in the euro area.

A central question arises: How does QE transmit across heterogeneous euro area economies, and does it generate distributional effects? Some evidence points to a prominent role for the portfolio rebalancing channel. When the central bank purchases long-term bonds, yields fall, prompting investors to seek higher returns by reallocating their portfolios toward riskier assets. This mechanism can stimulate aggregate activity but also increase within-country inequalities, as gains accrue mainly to market participants (Albertazzi et al. (2018), Hohberger et al. (2019)). Yet these analyses largely abstract from persistent cross-country differences, especially in the liquidity of sovereign bonds and debt structures, that may substantially modify QE's transmission.

The core innovation of this paper is to incorporate heterogeneity at both the household and country levels within a unified monetary union framework, thereby providing a tractable environment to reexamine the propagation of QE and its real and distributional consequences. I develop a Two-Country (core and periphery), Two-Agent New Keynesian (TANK^2) model, building on Bilbiie (2008), Galí and Monacelli (2005)). A resaleability constraint à la Kiyotaki and Moore (2012) is introduced for long-term sovereign bonds to capture differences in debt liquidity. When investors wish to sell long-term bonds, they cannot typically do so costlessly or instantaneously. Instead, the ability to unwind positions depends on liquidity, which determines how easily these assets can be sell. With this resell constraint, households are obliged to keep a fraction of long-term bonds in their portfolio that are not considered liquid. Introducing a resale constraint, therefore has important implications for the portfolio-rebalancing channel of Quantitative Easing (QE). Following a QE, the long-term yields decline and investors seek to reallocate their portfolios toward alternative assets; however, their capacity to do so depends on the liquidity of the sovereign bonds they hold. Higher liquidity facilitates portfolio adjustments, while lower liquidity dampens the extent of reallocation and may attenuate the transmission of QE to broader economy.

In this paper, I develop a Two-country monetary union model featuring a core and a periphery economy. Fiscal policy is conducted independently in each country through national governments, which issue two types of sovereign bonds: short-term and long-term debt. Long-term bonds are held both by households (in the core and the periphery) and by the central bank. The central bank implements a common monetary policy using two instruments: a Taylor rule that sets the short-term nominal interest rate, and Quantitative Easing (QE). Following Harrison (2017) and Cantore and Meichtry (2024), QE is modelled as purchases of long-term government bonds, with the stock of such purchases evolving according to an autoregressive process. The remaining share of long-term bonds issued by governments is held by a subset of households—the optimisers. In both economies, two types of households coexist: rule-of-thumb households and optimisers, who differ in their access to financial markets. Only optimisers can participate in asset markets. They may hold domestic short-term debt, domestic and foreign long-term bonds, accumulate physical capital, and undertake investment. Long-term bonds issued by both core and periphery governments are subject to a resaleability constraint, following Kiyotaki and Moore (2012). I assume that only a fraction of these long-term bonds is considered liquid and can be used as collateral. Optimisers can therefore obtain resources by leveraging this liquid share of their holdings, while retaining the remaining, illiquid fraction in their portfolios. The degree of liquidity of long-term bonds thus affects the extent to which optimisers can rebalance their portfolios in response to changes in yields. Households also earn dividends from ownership of intermediate-goods firms. These firms produce differentiated intermediate goods subject to Rotemberg (1982) price-adjustment costs, which prevent prices from being fully flexible. Final-goods producers operate in perfect competition and aggregate intermediate goods into a final consumption good.

I first investigate how QE transmits and assess its impacts on output and income inequalities, in a closed-economy (countries are isomorphic, no heterogeneity) TANK with resell constraint. The findings suggest that QE operates through *four main transmission channels*: the portfolio rebalancing channel, the labour market channel, the inflation and fiscal channels. Following the implementation of QE, optimising households adjust their portfolios by increasing holdings of short-term bonds, investment, and physical capital, thereby enhancing productive capacity – the *portfolio rebalancing* channel. The resulting rise in output raises labour demand, prompting rule-of-thumb households to expand their labour supply. This adjustment leads to higher wages and increased consumption among these households- the *labour market* channel. Additionally, higher wages and employment offset the fiscal burden linked to increased public debt, while inflation temporarily erodes the real value of nominal assets, particularly affecting optimising households – the *inflation and fiscal* channels. Together, these mechanisms generate a persistent increase in aggregate output. From a distributional perspective, the relative consumption gains are more pronounced for rule-of-thumb households than for optimising households, implying a short-term reduction in income inequality. However, this distributional effect gradually fades, resulting in a neutral impact in the medium run.

The main finding of this present paper is the role played by both heterogeneity. Within-country heterogeneity crucially shapes both the magnitude of the output response and the distributional consequences of Quantitative Easing. Peripheral countries, characterised by more unequal access to financial markets, benefit relatively more from QE than their core counterparts. This finding aligns with the predictions of the Two-Agent New Keynesian (TANK) framework (see Galí et al. (2007a); Bilbiie (2008)). In such settings, a larger share of hand-to-mouth households acts as an amplifier: income gains are consumed one-for-one, reinforcing the expansion in aggregate demand and output. Cross-country heterogeneity, i.e., public debt composition and liquidity, influences the strength but not the direction of QE transmission across countries. While both core and peripheral economies experience economic expansion following a QE shock, the effect is significantly more pronounced in core countries. This divergence is driven by the portfolio rebalancing channel. In core countries, the short-term to long-term debt is lower with a more long-term debt liquidity. When long-term bond yields decrease, the optimisers want to reallocate their portfolio selling their long-term debt. In core, the optimisers can sell more quickly and easily these bonds compared to the periphery. In addition, they reallocate their portfolio toward capital and invest more than short-term bonds since the core government relies more on long-term bonds (low supply of short-term). This reallocation toward capital and investment in core increases output more in the core than in the periphery. Conversely, in economies characterised by higher debt levels, greater reliance on short-term instruments, and less liquid bond markets, tighter refinancing conditions constrain portfolio reallocation and dampen economic expansion. These results demonstrate that debt structure and bond market liquidity primarily determine the magnitude of QE's real effects, while the direction and distributional consequences remain broadly consistent across member states.

Taken together, these results underscore strong policy implications. A Central Bank in a heterogeneous monetary union should consider structural divergences into the design of monetary policy. In practice, this may call for tailoring asset purchase programmes to reflect cross-country differences in debt liquidity and maturity profiles, or for complementing QE with fiscal instruments that help redistribute the stimulus more evenly across member states.

In the second part of the paper, I pursue an empirical validation of the mechanisms. I apply Local Projections method (Jordà (2005)) to a panel of 13 economies over 2014–2020. Externally identified QE shocks derived from the EA-MPD database (Altavilla et al. (2019), De Luigi et al. (2023)) are combined with household survey data, Income Gini index, and sovereign debt and liquidity measures. The analysis proceeds in three stages: (*i*) a benchmark estimation without heterogeneity controls, (*ii*) an extension incorporating cross-country heterogeneity through debt profiles (debt-to-GDP ratios, maturity structures, and bond-market liquidity), and (*iii*) an inclusion of within-country heterogeneity using the share of rule-of-thumb (hand-to-mouth) households. The results point out the role of monetary union heterogeneity as in the theoretical section. Indeed, greater expansion is experienced for countries with: higher debt liquidity with lower reliance on short-to-long-term debt or with higher unequal access to financial market (i.e. larger share of rule-of-thumb households). On distributional implications of QE, I do find similar conclusions than in the theoretical model. Within-country heterogeneity acts as an amplifier. Countries with more unequal access to financial market between households, experience more significant reduction of income inequalities.

Related Literature. This present paper is connected to the growing literature on the two-region New Keynesian model. Chen et al. (2023) examines the consequences of different fiscal consolidation schemes in the euro area. Bayer et al. (2023) analyses the effectiveness of different fiscal responses to energy supply shocks, specifically comparing energy subsidies and transfers based on historical energy consumption. Kabaca et al. (2023) explore in a two-region DSGE the optimal allocation of bond purchases, and how QE should be designed in the presence of asymmetries within the euro area? The asymmetries between core and periphery are in terms of substituability between assets of different maturity and origins, asset home bias and level of government. Evans and Onorante (2020) gauge the effectiveness of government bonds and corporate security purchases in a Two-country New Keynesian model of monetary union with a banking sector. Bletzinger and von Thadden (2021) develop a tractable model of a fiscally sound monetary union to explore the design issues of quantitative easing (QE) and its effectiveness in the context of asymmetric economic conditions and different fiscal policies between member countries. Auray et al. (2018) in a Two-country DSGE model explore the link between the interbank market and sensitivity risk in the EA during the GFC. They introduce heterogeneity between core and periphery by share of domestic public debt in the portfolio, debt-to-GDP. They show that unconventional monetary policy displays stronger effects in the periphery. In contrast to previous studies, that focus either on financial frictions, banking sectors, or fiscal rules, my model emphasises the role of cross and within-country heterogeneity (the share of rule-of-thumb households, public debt structure and bond liquidity) that act as amplifier of QE. This allows me to examine how within-union divergences affect not only aggregate transmission but also the distributional effects of Quantitative Easing across member states.

This paper contributes to the literature on the distributional impacts of Quantitative Easing

(QE) within the euro area. Early contributions such as Montecino and Epstein (2015) argue that income inequality tends to rise following QE, primarily via the asset price channel: higher equity returns disproportionately benefit wealthier households who hold a larger share of financial assets. Domanski et al. (2016) confirms this mechanism using household survey data from France, Germany, Italy, Spain, the UK, and the US. They find that wealth inequality has widened since the Global Financial Crisis, largely due to equity price increases, which were amplified by QE. Bond price increases and lower interest rates had more modest effects, while the surge in risky asset prices strongly favoured top-wealth households (top 5%). A similar conclusion is reached by Guerello (2018), who shows using panel VARs with consumer survey data that unconventional monetary policy tends to increase income inequality in the short term, especially in countries where financial wealth is highly concentrated. Interestingly, she finds the opposite for conventional policy, which reduces inequality over the medium term. In contrast, some empirical work points to mitigating effects. For instance, Lenza and Slacalek (2018), using a multi-country VAR with external instruments, show that QE tends to compress income inequality in the short run, primarily via labour market improvements that benefit low-income households. However, they find negligible effects on wealth inequality. The paper most closely related to mine is Hohberger et al. (2020), who develop a two-region DSGE model (euro area and rest of the world) with hand-to-mouth agents. They emphasise income composition and portfolio rebalancing channels, and find that QE initially increases inequality (through asset price gains), but reduces it in the medium run as labour income rises. However, their framework does not explicitly account for within-union asymmetries, such as structural imbalances between member states. Finally, Casiraghi et al. (2018), focusing on Italy, finds no statistically significant impact of QE on income or wealth inequality, suggesting that the distributional effects may be highly country-specific and shaped by local structural features. I clarify the distributional effects of QE by two types of heterogeneity: cross and within-country heterogeneity between core and peripheral euro area countries within a Two-country TANK model. I show that structural features such as the share of rule-of-thumb households, debt composition, and bond liquidity amplify the redistributive impact of QE without changing its direction. My findings suggest that the effectiveness and distributional implications of QE depend not only on household heterogeneity, but also on cross-country heterogeneity as the differences in debt profiles within the monetary union.

This paper also builds on the long-standing literature on Optimal Currency Areas (OCA), which examines under what conditions a group of countries can share a common currency without sacrificing macroeconomic stability. The first generation of OCA theories, pioneered by Mundell (1961), McKinnon (1963), Ingram (1973), and later revisited by Krugman (2001), focuses on the trade-off between exchange rate flexibility and economic integration. These early models emphasise factors such as labour mobility, openness, and synchronisation of business cycles as preconditions for the success of a currency union. A more recent, microfounded wave of OCA literature develops formal New Keynesian models to assess the design of optimal monetary and fiscal policy in a currency union. For example, Benigno (2004) and Galí and Monacelli (2008) show how the presence of nominal rigidities and asymmetric shocks calls for coordinated fiscal rules and a monetary policy that targets union-wide aggregates. Farhi and Werning (2017) extend this framework to consider the role of cross-country transfers and fiscal risk-sharing in absorbing asymmetric shocks. More recently, papers like Bayer et al. (2023) and Chen et al. (2023) incorporate heterogeneous agents and incomplete markets into multi-country models, further exploring how fiscal and monetary tools interact across structurally diverse members of a union.

In line with this literature, I study the role of Quantitative Easing in a heterogeneous monetary union. While most prior OCA models focus on conventional policy rules or fiscal mechanisms, my paper adds to the debate by showing how heterogeneity within and between countries as unequal access to the financial market, public debt composition, and asset market liquidity; affect the transmission and equity implications of QE across countries. This approach highlights a complementary dimension of the OCA framework: that even centralised monetary interventions can have different consequences across countries when heterogeneities persist in the currency area.

Roadmap of this paper. The remainder of the paper is organised as follows. The section 2.1 documents the evolution of cross and within-country heterogeneity in the Euro Area during the Global Financial crisis. It also provides evidence on unconventional monetary policies implemented by the European Central Bank at that time. Section 3 introduces a model of heterogeneous monetary union with liquidity constraint à la Kiyo. Section 4 outlines the calibration strategy of the model. Section 5 presents the main results of the Quantitative exercise. Section 6 investigates QE transmission in the EA using Local Projections. Section 7 provides policy implications based on sections 5 and 6. Section 8 concludes.

2 The Euro Area during the GFC

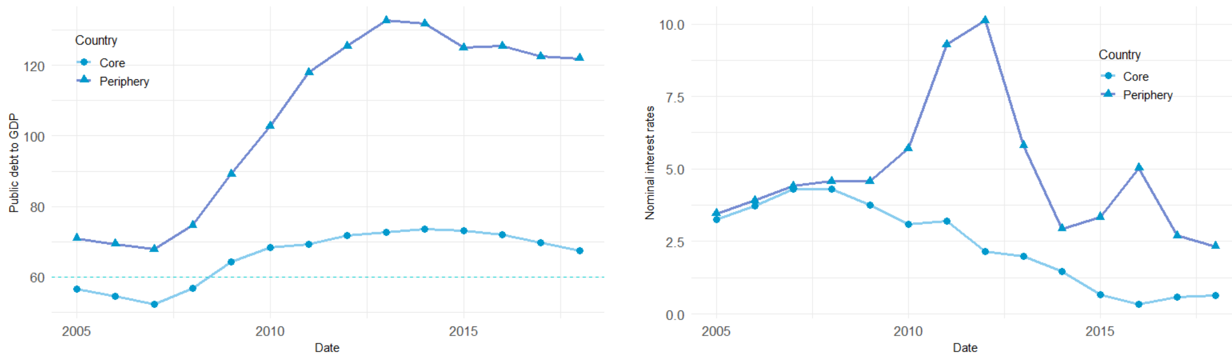
This section 2 provides an overview of the Euro Area during the Global Financial crisis. In section 2.1, I provide evidence on heterogeneity in the European Monetary Union; regarding cross-country heterogeneity, i.e. different debt profiles in the monetary union, and within-country, i.e. households 'access to the financial market. Then in section 2.2, I describe the monetary policies implemented by the European Central Bank at that time.

2.1 Divergences in the EA

The Global Financial Crisis (GFC) exposed and exacerbated heterogeneity within the Eurozone, highlighting the divergences between core countries such as Germany and France and peripheral countries such as Spain, Greece and Italy. These imbalances, rooted in pre-crisis trends, led to sharply contrasting economic trajectories during and after the crisis. The periphery was characterised by weak public finances, higher debt burden (level of public debt and interest rates) and deficits in the current account. Although the crisis hit the core countries, the economic situation was more favourable with lower debt burdens and current account.

(i) Public Debt: level & composition – In Figure **??**, I plot the public debt and 10-y government bond yields in core and periphery.

While both, core and periphery economies experienced similar trends in public debt accumulation, the magnitude of these dynamics differed. In core, debt levels remained relatively stable, hovering close to the threshold established by the Stability and Growth Pact (60% of GDP). In contrast, the periphery saw a sharp escalation in public debt, which surged at 120% of GDP. Moreover, the cost of debt servicing in the periphery was substantially higher than in the core, mainly due to a higher perceived risk.



(a) Public debt (core vs periphery)

(b) 10-year government bond yields

Figure 1: Public debt and 10-year government bond yields in core and periphery. Data: European Central Bank.

Beyond the observed disparities in sovereign debt levels and long-term yields between countries in the core and periphery of the euro area, notable differences emerge in the structure of public debt portfolios. A key distinction lies in the maturity composition of government debt. As reported by kabaca, the ratio of short-term to long-term debt is greater in peripheral countries, reaching approximately 45%, compared to 30% in core economies, reflecting a heavier reliance on short-term financing in the periphery. Turning to the holders of long-term public debt (defined as instruments with maturities exceeding one year), portfolio composition also diverges markedly. Peripheral economies exhibit a pronounced home bias, with approximately 97% of long-term sovereign bonds held as domestic debt. In contrast, investors in core countries display greater portfolio diversification: only 55% of their long-term sovereign bond holdings consist of debt issued by core countries.

(ii) Share of households – Another divergence between core and periphery countries lies in the population. The share of households having access to assets differs in the monetary union. Often referred to as non-hand-to-mouth (Ricardian or optimisers), the share of these households differs across these regions. Based on the Household Finance and Consumption (HFCS) data, we observe a higher share of hand-to-mouth households in the periphery. In core, the share of households holding assets is 0.75, against 0.6 for the periphery.

2.2 (Un)conventional Monetary Policies

The Global Financial Crisis and subsequent Eurozone Crisis prompted unprecedented policy responses from the European Central Bank (ECB). Initially, the ECB modified its collateral framework to maintain financial system liquidity. Following sovereign downgrades (especially for periphery countries as Greece, Ireland, Italy, Portugal and Spain) in 2008, the ECB expanded eligible collateral to include BBB-rated government securities, primarily benefiting peripheral economies. During the acute phase of the Eurozone Crisis (2010-2012), the ECB further liberalised its collateral policies, accepting Greek government bonds despite their deteriorating credit quality and eventually suspending minimum rating requirements for Greek sovereign debt in 2012. The post-crisis period (2013-2015) saw a gradual tightening of eligibility criteria, though peripheral sovereign debt continued to face elevated haircuts.

The Quantitative Easing– As conventional monetary policy reached its effective lower bound in 2015, the ECB transitioned to quantitative easing through its expanded Asset Purchase Program (APP). The APP encompassed multiple facilities, including the Asset-Backed Securities Purchase Program (ABSPP) and the third Covered Bond Purchase Program (CBPP3). The centrepiece was the Public Sector Purchase Program (PSPP), which committed to €60 billion in monthly purchases, totalling €1.14 trillion. While sharing operational similarities with previous interventions like the CBPP and Securities Markets Program (SMP), the PSPP's distribution mechanism marked a significant departure. The PSPP's structure comprised two components: supranational debt purchases (12 per cent) and sovereign debt acquisitions (88 per cent). The latter, representing approximately €44 billion monthly, followed capital key allocation rules based on member states' GDP and population weights.

In terms of the amount in billions, the two countries that have benefited the most from the PSPP, i.e., QE, have been Germany and France. Together, they represent half of the PSPP. Now, if we look at it relative to GDP and public debt, the conclusions differ. On the one hand, the average for core and periphery countries—19.5% for the core and 14.775% for the periphery – for public debt — suggesting that the PSPP has mainly benefited the core countries. On the other hand, looking at it relative to GDP, the opposite conclusion is found: 14.45% for core countries and 16%

	Amount in billion (euros)	*Relative to public debt (in %)*	*Relative to GDP (in %)*
Germany	459.3	21.9	14.1
France	375.7	16.9	16.4
Italy	326.7	14.3	19.0
Spain	230.3	20.3	19.8
Netherlands	102.8	24.9	14.1
Belgium	65.5	14.1	15.0
Austria	52.0	17.7	14.1
Portugal	31.1	12.5	16.1
Finland	29.2	21.7	13.0
Ireland	25.3	12.0	9.2

Table 1: PSPP for the ten largest euro area countries

(a) Source: Lehment (2019), ECB; Statistical Data Warehouse

for periphery countries.

3 A Two-country TANK of a Monetary Union

I consider a Two-country Two-Agent New Keynesian (TANK[2]) model, where households consist of optimisers and rule-of-thumb. The optimisers have access to multiple assets with varying degrees of liquidity, short-term and long-term government bonds, and capital. The rule-of-thumb households do not have access to any market, and they consume their revenue. The economy includes intermediate and final goods producers. Fiscal policy is conducted by the governments of each country, which collect taxes. The Central Bank employs unconventional monetary tools, specifically the Quantitative Easing (QE).

I borrow the open economy framework from Galí and Monacelli (2005), adding the two-agent structure as Bilbiie (2008), Debortoli and Galí (2024). In the benchmark case, I assume that the countries are isomorphic, a TANK *closed-economy* framework. In the second scenario, I introduce heterogeneity regarding the shares of rule-of-thumb (optimisers) households. Core and periphery do not have the same share of rule-of-thumb (optimisers); larger in the periphery than in the core. In the third scenario, I abstract from this channel and instead introduce an alternative form of heterogeneity. I first assume that the debt-to-GDP ratios are not equal across countries, with also a different debt decomposition. The composition of public debt—specifically the share of short-term versus long-term bonds —varies across countries. I also introduce a difference in the resale constraint. At each step, I will focus on a particular imbalance to capture its possible effects on the transmission of the QE, as best as possible.

In what follows, I assume that the core is Home (H) and the periphery is Foreign (F), where the starred variables refer to Foreign. The countries are symmetric in everything in the benchmark.

3.1 Households

There is a continuum of households with a share η, the rule-of-thumb (r), that consume their wage. The remaining $(1-\eta)$ are the optimisers (o), that invest, hold capital, public debt and the intermediate good firms.

The period utility function of household type $j = \{o, r\}$ is:

$$\mathrm{U}(c_t^j, l_t^j) = \left[\frac{(c_t^j)^{1-\sigma}}{1-\sigma} - \zeta^j \frac{(l_t^j)^{1+\varphi}}{1+\varphi} \right], \tag{1}$$

where c_t is consumption, l_t the hours worked, σ is the inverse of the intertemporal elasticity of substitution, φ corresponds to the inverse of the Frisch elasticity of labour supply and ζ the valuation of leisure compared to consumption.

Consumption. Households consume core goods, c_{Ht} and periphery goods, c_{Ft}. The composite consumption is an aggregate with a CES function as:

$$c_t = \left[(1-\gamma)^{1/\omega} c_{Ht}^{\frac{\omega-1}{\omega}} + \gamma^{1/\omega} c_{Ft}^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}}. \tag{2}$$

In equation (2), $\gamma \in [0, 1]$ is the share of imported goods from the periphery (core) that can be a proxy of home bias in consumption. If $\gamma = 1$, there is no home bias. ω is the substituability between core and periphery goods. The aggregate price is obtained as:

$$p_t = \left[(1-\gamma)(P_{Ht})^{1-\omega} + \gamma (P_{Ft})^{1-\omega} \right]^{\frac{1}{1-\omega}} \tag{3}$$

where P_{Ht} and P_{Ft} are the core and periphery prices.

$$P_{Ht}c_{Ht} + P_{Ft}c_{Ft} = Z_t$$

where Z_t is a given level of expenditure. The utility maximisation provides the following demand functions:

$$c_{Ht} = (1-\gamma)\left(\frac{P_{Ht}}{p_t}\right)^{-\omega} c_t \tag{4}$$

$$c_{Ft} = \gamma\left(\frac{P_{Ft}}{p_t}\right)^{-\omega} c_t. \tag{5}$$

I denote s_t, the real exchange rate that is the price of foreign currency in terms of the domestic currency, defined as the relative foreign price index, expressed in a common currency:

$$s_t = e_t\frac{p_t}{p_t^*}, \tag{6}$$

where e_t is the nominal exchange rate. Given that p_t, the price level is not stationary.

$$\frac{s_t}{s_{t-1}} = \Delta e_t\frac{\pi_t^*}{\pi_t}. \tag{7}$$

In equation (7), $\Delta e_t \equiv \dfrac{e_t}{e_{t-1}}$ corresponds to the gross rate of nominal depreciation of the domestic currency. All goods are traded, and the law of one price holds,

$$p_H = s_t p_{Ht}^* \tag{8}$$

$$p_{Ft} = s_t p_{Ft}^* \tag{9}$$

The terms of trade represent the relative price of the foreign good in terms of a common currency:

$$tot_t = e_t\frac{p_t^*}{p_t} = \frac{p_{Ft}}{p_{Ht}}. \tag{10}$$

3.1.1 Long-term bonds and Liquidity

Only the optimisers may hold long-term public bonds issued by the government. They have access to bonds from the two countries: the core and the periphery. As in Woodford (2001), a nominal bond B_t^n issued at date t will pay χ^{k-1} at the date $t+k$, with $\chi \in [0,1]$ a coupon decay factor that drives the bonds' duration, equals to $(1-\chi)^{-1}$. The nominal return of bonds is:

$$R_t^l = \frac{1+\chi Q_t}{Q_{t-1}}, \tag{11}$$

where Q_t is the price of bonds. We can then express the real bond return as:

$$r_t^l = \frac{R_t}{\pi_t}. \tag{12}$$

Households have access to bonds issued by both countries. Core households may hold core and periphery bonds.

Liquidity constraint. A key feature of this paper is the incorporation of liquidity constraint, building on the framework introduced by Kiyotaki and Moore (2012). These frictions manifest as a *resaleability constraint*, which applies exclusively to optimising households. Unlike the setup in Kiyotaki and Moore (2012), where the constraint is imposed on equity, this present paper assumes that the constraint applies to bonds. Specifically, only a fraction $\phi_t \in [0,1]$ of bonds is considered liquid and can be used as collateral. The optimisers can thus acquire resources by leveraging a fraction ϕ_t of their long-term bonds, while retaining the remaining $(1-\phi_t)$ in their portfolios. The liquidity constraint is formalised as:

$$b_{Ht}^l + b_{Ft}^l \geq (1-\phi_{Ht})\left(\frac{b_{Ht-1}^l}{\pi_{Ht}}\right) + (1-\phi_{Ft})\left(\frac{b_{Ft-1}^l}{\pi_{Ft}}\right). \tag{13}$$

In (13) b_{Ht}^l and b_{Ft}^l are the long-term bonds issued by the core and the periphery, respectively. The resaleability constraint is written in real terms; therefore past nominal bond holdings are deflated by inflation to reflect their real collateral value. Core and peripheral bonds do not have the same liquidity constraint. I assume that peripheral bonds are less liquid than core ones, i.e., households are more constrained, they have to keep a larger share of peripheral bonds in their portfolio compared to core ones. Incorporating liquidity constraint on bonds in a Two-Country TANK is one of the novelties brought by this present paper, which can imply differences in *portfolio reallocation* across countries.

Liquidity constraint and QE transmission. Long-term bonds holding by households have an effect on the QE effects. Together with other assets, they influence how QE transmits. This mechanism is known as the *Portfolio rebalancing channel*. Following QE (the purchase of long-term bonds by the Central Bank), the yields of these bonds decline. Searching-for-yield, households (investors) having these bonds in their portfolio reallocate their portfolio toward riskier assets that have higher yields. This reallocation in turn boosts investment and consumption, boosting aggregate demand (see Albertazzi et al. (2018), Hohberger et al. (2019))

Now does liquidity constraint affect the portfolio rebalancing channel? When we embed liquidity constraint, the portfolio rebalancing channel is affected. Indeed, the QE (purchases of long-term bonds by the Central Bank) pushes the yields of these bonds down. Optimisers reallocate their portfolio toward other assets. The role of liquidity of these long-term bonds appears there. When long-term bonds are liquid (i.e. a high value of ϕ), the bonds can be easily sold, implying a simpler portfolio reallocation. In the opposite case, when bonds are less liquid (that is, a low value of ϕ), the optimisers are constrained and need to keep more long-term bonds in their portfolio, making portfolio reallocation more complex. Embedding liquidity constraint may thus affect the portfolio reallocation channel.

3.1.2 The optimisers

There is a fraction $(1-\eta)$ of optimisers. Based on Eurosystem Household Finance and Consumption (HFCS) data from the European Central Bank, I assume that the shares of optimisers and rule-of-thumb are not the same within the zone. The share of rule-of-thumb households, i.e., households that do not hold liquidity, is larger in periphery countries than in core countries. In France and Germany, the share of rule-of-thumb is around 25%, compared to 40% for Italy and Spain, for example. The optimisers instead can save and borrow in long-term bonds, capital, invest and receive dividends from their shareholdings in monopolistically competitive firms. Apart from these asset returns, savers earn labour income and pay taxes. They each maximise their lifetime utility from consumption and leisure, subject to their budget constraint in real terms, borrowing and resaleability constraint, taking prices and wages as given:

$$\max \ \mathbb{E}_t \sum_{t=0}^{\infty} \beta^o \left[\frac{(c_t^o)^{1-\sigma}}{1-\sigma} - \zeta^o \frac{(l_t^o)^{1+\varphi}}{1+\varphi} \right], \tag{14}$$

$$s.t \quad c_t^o + i_t^o + b_{Ht}^l + s_t b_{Ft}^l + b_{Ht}^s = r_{t-1}^l b_{Ht-1}^l + s_t r_{t-1}^{*l} b_{Ft-1}^l + r_t^s b_{Ht-1}^s + \theta w_t l_t^o + r_t^k k_{t-1}^o + \Gamma_t - t_t \tag{15}$$

$$s.t \qquad b_{Ht}^l + b_{Ft}^l \geq (1-\phi_{Ht}) \left(\frac{b_{Ht-1}^l}{\pi_{Ht}} \right) + (1-\phi_{Ft}) \left(\frac{b_{Ft-1}^l}{\pi_{Ft}} \right) \tag{16}$$

$$s.t \quad k_t^o = (1-\delta) k_{t-1}^o + \left[1 - \frac{\kappa_I}{2} \left(\frac{i_t^o}{i_{t-1}^o} - 1 \right)^2 \right] i_t^o \tag{17}$$

In (15), b_{ct}^s are the short-term issued the core. Γ_t are the dividends from the monopolistic intermediate good firm that are distributed only within the optimisers. For now, I do not distinguish tax rates t_t, such that both types, optimisers and rule-of-thumb households have the same tax pressure. I follow Debortoli and Galí (2024), introducing a scale-wage parameter, θ that drives the degree of wage adjustment. This parameter shows how easily or quickly wages can be adjusted in response to shocks[1].

Let λ_t and μ_t represent the Lagrange multiplier associated with the budget constraint and liquidity constraint, respectively. I derive the first-order conditions as:

$$c_t : (c_t^o)^{-\sigma} = \lambda_t \tag{18}$$

$$l_t^o : \zeta (l_t^o)^{\varphi} = \theta w_t (c_t^o)^{\sigma} \tag{19}$$

$$i_t^o : 1 = \mathbb{E}_t \beta_t \left[\frac{\lambda_{t+1}}{\lambda_t} \left(\frac{q_{t+1}(1-\delta) + r_{t+1}^k}{q_t} \right) \right] \tag{20}$$

$$b_{Ht}^s : \lambda_t = \beta \mathbb{E}_t \left[\lambda_{t+1} \frac{r_t^s}{\pi_{Ht+1}} \right] \tag{21}$$

$$b_{Ht}^l : 1 = \mathbb{E}_t \beta_t \frac{1}{\pi_{Ht+1}} \left[\frac{\lambda_{t+1} r_t^l + (1-\phi_{Ht+1}) \mu_{t+1}}{\lambda_t + \mu_t} \right] \tag{22}$$

[1] lower value implies higher wage rigidity

$$b^l_{Ft}: 1 = \mathbb{E}_t \beta_t \frac{s_{t+1}}{s_t} \frac{1}{\pi_{Ft+1}} \left[\frac{r^{l*}_t \lambda_{t+1} + (1 - \phi_{Ft+1}) \mu_{t+1}}{\lambda_t + \mu_t} \right] \tag{23}$$

Equation (18) characterizes the intratemporal consumption choice. Equations (19) and (20) represent the optimal labour supply and capital accumulation decisions, respectively, while 21 is the Euler equation for short-term domestic bond holdings, linking the intertemporal marginal rate of substitution to real returns. Equations (22) and (23) stem from the presence of a resaleability constraint on long-term public bonds, capturing differences in bond liquidity across countries. Specifically, equation 22 represents the Euler condition for domestic long-term bonds, while equation (23) governs the foreign long-term bonds. These conditions highlight that optimising households face portfolio adjustment limits that depend not only on expected returns, but also on the liquidity of the bonds they hold, governed by ϕ_F and ϕ_H.

3.1.3 The Rule-of-Thumb Households

A fraction η of households are rule-of-thumb consumers. Unlike optimising households, rule-of-thumb households cannot hold public debt or capital, nor do they have the opportunity to invest. Instead, they consume their entire wage income. Each rule-of-thumb household solves the following optimisation problem:

$$\max \ \mathbb{E}_t \sum_{t=0}^{\infty} \beta^r \left[\frac{(c^r_t)^{1-\sigma}}{1-\sigma} - \zeta^r \frac{(l^r_t)^{1+\varphi}}{1+\varphi} \right] s.t \quad c^r_t = \theta w_t l^r_t - t_t, \tag{24}$$

where c^r_t denotes consumption, w_t is the wage rate, l^r_t is labour supply, and t_t represents lump-sum taxes.

The optimality conditions for rule-of-thumb households are given by:

$$(c^r_t)^{\frac{1}{\sigma}} = \lambda_t, \tag{25}$$

$$w_t = \frac{1}{\theta} (c^r_t)^{\frac{1}{\sigma}} \zeta^r (l^r_t)^{\varphi}. \tag{26}$$

These conditions characterise the trade-offs between consumption, labour supply, and wages for rule-of-thumb households.

3.2 Production sector

The production sector is composed by a representative final good firm that produces a final good using inputs produced by a continuum of intermediate good firms indexed by i over the range $[0, 1]$. Intermediate good firms operate under monopolistic competition, setting their prices subject to Rotemberg (1982) quadratic adjustment costs. In this section, I describe the production sector for Home. The problem is the same for foreign, i.e. the periphery.

Final good producers. The final good producer operates in a competitive market and aggregates intermediate inputs according to CES technology:

$$Y_{Ht} = \left(\int_0^1 (Y_{Ht}(i))^{\frac{\varepsilon-1}{\varepsilon}} \, di \right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{27}$$

where ε represents the elasticity of substitution between intermediate goods. The profit maximisation problem of the final good firm is:

$$\max_{Y_{Ht}(i)} P_t \left(\int_0^1 (Y_{Ht}(i))^{\frac{\varepsilon-1}{\varepsilon}} \, di \right)^{\frac{\varepsilon}{\varepsilon-1}} - \int_0^1 p_t(i)(Y_{Ht}(i)) \, di, \tag{28}$$

that yields to the relative demand for $Y_{Ht}(i)$,

$$Y_{Ht}(i) = \left(\frac{p_{Ht}(i)}{P_t} \right)^{-\varepsilon} Y_{Ht}. \tag{29}$$

I derive from (29) the expression for the aggregate price level in the Core:

$$P_t = \left(\int_0^1 (p_t(i))^{\varepsilon-1} \, di \right)^{-\frac{\varepsilon}{\varepsilon-1}}. \tag{30}$$

Intermediate good firms. A continuum of intermediate good producers that produce intermediate goods, $Y_t(i)$ using physical capital, k_t that is not mobile across countries, and domestic labour l_t with the following technology:

$$Y_{Ht}(i) = a_t k_t(i)^{\alpha} l_t(i)^{1-\alpha} \tag{31}$$

where a_t measures the total factor productivity that follows an auto-regressive process:

$$log(a_t) = (1 - \rho_a) log(\bar{a}) + \rho_a log(a_{t-1}) + v_a.$$

Labour is not mobile across the Core and the Periphery. Intermediate producers face a common wage that they internalise to minimise the cost in each period. Intermediate good firms set their prices subject to Rotemberg (1982) quadratic adjustment costs defined as:

$$\kappa_p = \frac{\psi}{2} \left(\frac{P_{Ht}(i)}{P_{Ht-1}(i)} - 1 \right)^2 Y_{Ht}, \tag{32}$$

$\psi \geq 0$ measures the cost of price adjustment (in units of final goods). The profit maximisation problem of the firm is the following :

$$\max \mathbb{E}_0 \left[\sum_{j=0}^{\infty} (\beta)^t \frac{\lambda_t}{\lambda_0} \left[\frac{P_{Ht(i)}}{P_{Ht}} Y_{Ht}(i) - \theta w_t l_t - r_t^k k_{t-1} - \frac{\psi}{2} \left[\frac{p_{Ht}(i)}{P_{Ht-1}(i)} - 1 \right]^2 Y_{Ht} \right] \right] \tag{33}$$

subject to:

$$Y_{Ht}(i) = a_t k_{t-1}(i)^{\alpha} l_t(i)^{1-\alpha}$$

$$Y_{Ht}(i) = Y_{Ht} \left[\frac{P_{Ht}(i)}{P_{Ht}} \right]^{-\varepsilon}$$

The marginal cost, denoted as mc (which is the same across all intermediate goods firms) is equal to:

$$mc_t = \frac{1}{a_t} \left(\frac{r_t^k}{\alpha} \right)^{\alpha} \left(\theta \frac{w_t}{1-\alpha} \right)^{1-\alpha} \tag{34}$$

The equilibrium real profit of each intermediate firm is rebated as dividends to the optimisers, where the dividends are:

$$\Gamma_t = p_{Ht} Y_{Ht} - \theta w_t l_t - r_t^k k_{t-1} - \phi (\pi_{Ht} - \bar{\pi})^2 Y_{Ht} p_{Ht} \tag{35}$$

I derive the standard Phillips curve as the solution to the pricing problem:

$$\pi_{Ht}(\pi_{Ht} - \bar{\pi}) = \beta \mathbb{E}_t \left[\pi_{Ht+1}(\pi_{Ht+1} - \bar{\pi}) \frac{Y_{Ht+1}}{Y_{Ht} p_{Ht}} \right] + \frac{\varepsilon}{\kappa_p} \left(\frac{mc_t}{p_{Ht}} - \frac{\varepsilon - 1}{\varepsilon} \right) \tag{36}$$

Each country – core and periphery – has their own New-Keynesian Phillips curve.

3.3 Policy Framework

In each country, the government implements an independent fiscal policy. The monetary policy instead, is implemented at the monetary union, by the Central Bank.

3.3.1 Fiscal Policy

The government finances public spending and services existing debt through tax collection and bond issuance. The government budget constraint is:

$$b^l_{Ht} + b^s_{Ht} = r^l_{t-1} b^l_{Ht-1} + r_{t-1} b^s_{Ht-1} + g_t - t_t + \Pi_t, \tag{37}$$

where b^l_{Ht} denotes the real long-term bonds and b^s_{Ht} the short-term. g_t is real government spending (AR(1) process), t_t represents lump-sum taxes.[2], Π_t is the transfers from the Central Bank. The long-term bonds can be purchased by core and periphery households, and the central bank. The fiscal authority follows a tax rule that links taxes to total debt and public spending to their steady-state level.

$$\frac{t_t}{t} = \left(\frac{b^l_{Ht}}{b^l_H} + \frac{b^s_{Ht}}{b^s_H} \right)^{\rho_{\tau,bH}} \left(\frac{g_t}{g} \right)^{\rho_{\tau,g}}, \tag{38}$$

where $\rho_{\tau,bH}$ represent tax elasticity with respect to debt, the public spending, g_t follows an auto-regressive process:

$$log(g_t) = (1-\rho_g) log(\bar{g}) + \rho_g log(g_{t-1}) + v_g.$$

Integrating central bank purchases into the consolidated budget constraint of the government allows for capturing the monetary-fiscal interactions that are characteristic of the Quantitative Easing. Any loss or gains made by the central bank is rebated (financed) to (by) public spending (households).

[2]Total tax revenue is $t_t = \eta t^r_t + (1-\eta) t^o_t$.

3.3.2 Monetary Policy

In the monetary union – comprising core and periphery countries– the monetary authority implements a policy for the zone. All the policies rely on averages. In the euro area, the ECB uses euro-area-wide averages for inflation and output.

Taylor rule. The monetary authority sets the short-term nominal interest rate that is the same in both countries, according to the following Taylor rule as Bayer et al. (2025):

$$\frac{R_t}{\bar{R}} = \left(\frac{R_{t-1}}{\bar{R}}\right)^{\rho_r} \left[\left(\frac{n\pi_{Ht} + (1-n)\pi_{Ft}}{\bar{\pi}}\right)^{\phi\pi} \left(n\frac{Y_{Ht}}{Y_{Ht-1}} + (1-n)\frac{Y_{Ft}}{Y_{Ft-1}}\right)^{\phi y}\right]^{1-\rho_r} \tag{39}$$

In (39), $\bar{R}$ corresponds to steady-state short-term nominal interest rates. n and $1-n$ are the sizes of core and peripheral countries. The coefficients ϕ_π, ϕ_y capture the sensitivity of the Central Bank to the stabilisation of output growth and price inflation. ρ_r governs the interest rate smoothing.

Quantitative Easing. In addition, the Central Bank purchases bonds. I model the QE based on Harrison (2017) and Cantore and Meichtry (2024). The net asset purchases of the Central Bank are:

$$\Omega_t = b^l_{HCB_t} - r^l_t b^l_{HCB_{t-1}} \tag{40}$$

with

$$b^l_{HCB_t} = d_t b^l_{Ht} \tag{41}$$

b^l_{Ht} is the total of long-term public debt and d_t represents the share of bonds purchased by the Central Bank that follows an AR(1) process:

$$log(d_t) = (1-\rho_d)log(\bar{d}) + \rho_d log(d_{t-1}) + v^d_t.$$

where $v_d \sim \mathcal{N}(0, \sigma^2_d)$ is a QE shock.

The profit of the Central Bank is:

$$\Pi^{cb}_t + \Omega_{Ht} + \Omega_{Ft} = b^l_{Ht-1} + b^l_{Ft-1}, \tag{42}$$

where Π_t^{cb} the gains/losses made by the Central Bank, rebated to core and periphery. To match with the European Central Bank mandate, I suppose that the gains are equally redistributed to core and periphery.

3.4 Market Clearing and General Equilibrium

To close the model, I impose equilibrium conditions for goods, labour, capital, and the financial market.

Goods Market Clearing

In each region $i \in \{H, F\}$, total output equals domestic absorption plus net exports. The goods market clearing conditions are:

$$nY_{Ht} = n\left[c_{Ht} + i_{Ht} + g_t + \frac{\phi_p}{2}(\pi_{Ht} - \bar{\pi})^2 Y_{Ht}\right] + (1-n)c^*_{Ht}, \tag{43}$$

$$(1-n)Y^*_{Ft} = (1-n)\left[c^*_{Ft} + i^*_{Ft} + g^*_t + \frac{\phi_p}{2}(\pi^*_{Ft} - \bar{\pi})^2 Y^*_{Ft}\right] + nc_{Ft}. \tag{44}$$

Household Aggregation

Aggregate consumption, labour supply, capital, and investment in each region are weighted averages over rule-of-thumb (r) and optimising (o) households:

$$c_{jt} = \eta c^r_{jt} + (1-\eta)c^o_{jt}, \tag{45}$$

$$l_{jt} = \eta l^r_{jt} + (1-\eta)l^o_{jt}, \tag{46}$$

$$k_{jt} = (1-\eta)k^o_{jt}, \tag{47}$$

$$i_{jt} = (1-\eta)i^o_{jt}, \tag{48}$$

for $j \in \{H, F\}$. The total consumption in the home region is given by:

$$c_{Ht} = n(\eta c^r_{Ht} + (1-\eta)c^o_{Ht}) + (1-n)c^*_{Ht}. \tag{49}$$

Bond Market Clearing

Government bond markets are clear when total liabilities are absorbed by domestic and foreign private agents and the central bank:

$$0 = nb^{l}_{Ht} + (1-n)b^{l*}_{Ht} + b^{l}_{HCB_t} \tag{50}$$

$$0 = (1-n)b^{l}_{Ft} + nb^{l*}_{Ft} + b^{l}_{FCB_t}. \tag{51}$$

4 Calibration

I calibrate parameters of the model using empirical evidence from the Euro Area core and periphery countries, and previous studies. In the model, a period is a quarter. In this two-country TANK of a monetary union, I assume that countries are symmetric except for some parameters. Table 4 reports the calibration. Values in parentheses correspond to values used in scenarios with cross or within heterogeneity.

Parameters for both countries. Here, I present the common parameters of both countries. The discount factor, β, is set to 0.99. The intertemporal elasticity of substitution, σ, is equal to 1. Following the literature, I set the inverse Frisch elasticity of labour supply, φ, to 5.
The Production block – I target an elasticity of substitution between intermediate goods ε of 6, which implies a steady-state markup of 20%. The labour share α is $1/3$ and the capital share, $2/3$.
The monetary block – On Taylor rule, I target standard value for both sensitivity to inflation and output, namely $\phi_\pi = 1.25$ and $\phi_y = 0$. The interest rate inertia parameter is set to 0.75. I assume that the core and the periphery have the same size, i.e., $n = 1/2$.
The fiscal block – I follow Galí et al. (2007a), where both tax elasticities to debt and spending are respectively 0.33 and 0.1 and government spending to GDP is 0.2.

Country parameters. Now, I present parameters that differ across countries. This subset of parameters is estimated on EA data from 2014Q1 to 2020Q1. According to the scenarios, I target different values for debt-to-GDP ratio, short-term to long-term debt ratio and resale constraint. In the benchmark case, both countries have the same debt-to-GDP ratio, 0.8. In the third scenario, I make the distinction between countries, with a ratio of 0.8 for core and 1.2 for periphery. In the benchmark, I also assume that the short-term to long-term debt ratio is equal for both countries, while in the third scenario, 0.25 for core and 0.4 for periphery. Finally, I suppose that the resale constraint has the tight for both long-term bonds in the periphery, with a $\phi_H = \phi_F = 0.8$. Then, I relax this assumption in scenario 3, such that $\phi_H = 0.8$ and $\phi_F = 0.6$. I assume that in the case of homogenous monetary union, the share of rule-of-thumb is set to 0.3 in both countries as in Bilbiie (2008). Then, in the within-country heterogeneity scenario, the share is equal to 0.25 in core and 0.4 in the periphery based on HFCS data.

QE parameters. The QE shock follows an AR(1) process, where $d_F = d_H = 0.2$ the share of long-term bonds purchased by the Central Bank is equal in both countries. The QE smoothing, ρ_s is set to 0.9 as in Cui and Sterk (2021).

Parameter	*Description*	*Value*	*Sources*
Households			
η_H	*Proportion of rule-of-thumb in core*	0.3 (0.25)	Bilbiie (2008), HFCS
η_F	*Proportion of rule-of-thumb in periphery*	0.3 (0.4)	Bilbiie (2008), HFCS
σ	*Inverse of intertemporal elasticity of substitution*	1	Standard calibration
φ	*Inverse of Frisch elasticity*	5	Standard calibration
β	*Discount factor*	0.99	Bilbiie (2008)
ϕ_H	*Resaleability constraint (core)*	0.8	Author's calculation
ϕ_F	*Resaleability constraint (periphery)*	0.8 (0.6)	Author's calculation
χ	*Long-term bond coupon*	0.975	Bond duration: 7–8 years
Production			
α	*labour share*	1/3	Standard calibration
$1-\alpha$	*Capital share*	2/3	Standard calibration
ψ	*Rotemberg adjustment cost*	42.68	3.5 quarters price duration
ε	*Elasticity of substitution*	6	Price markup = 20%
Trade			
γ	*Home bias*	0.66	Conventional
ω	*Core/periphery substitutability*	0.66	Standard calibration
n	*Country size*	1/2	Same size
Policy Block			
d_F, d_H	*Central bank bond holdings*	0.20	Author's calculations
$(b/y)^H$	*Debt-to-GDP (core)*	0.8	Author's calculations
$(b/y)^F$	*Debt-to-GDP (periphery)*	0.8 (1.1)	Author's calculations
ϑ_H	*Short/long-term debt ratio (core)*	0.3(0.25)	Kabaca et al. (2023)
ϑ_F	*Short/long-term debt ratio (periphery)*	0.3(0.4)	Kabaca et al. (2023)
$(g/y)^H, (g/y)^F$	*Gov. spending to GDP*	0.2	Galí et al. (2007a)
π	*Steady-state inflation*	1	Standard calibration
y^H, y^F	*Steady-state output*	1	Standard calibration
ρ_s	*QE smoothing*	0.9	Cui and Sterk (2021)
ρ_r	*Taylor rule persistence*	0.75	Standard calibration
ϕ_π	*Inflation response*	1.25	Standard calibration
ϕ_y	*Output response*	0	ECB mandate
$\rho_{\tau,b}$	*Tax elasticity to debt*	0.33	Galí et al. (2007a)
$\rho_{\tau,g}$	*Tax elasticity to spending*	0.1	Galí et al. (2007a)

Table 2: This table presents the calibration values used in the model. Parameters are based on conventional values and previous studies, with some calculated by the author. Values in parentheses refer to the alternative scenarios: *cross or within country heterogeneity*.

5 Quantitative Results

This section investigates the transmission channels of QE shock (the share of long-term bonds purchased by the Central Bank, d_t) in the monetary union. The analysis proceeds in three steps, which correspond to three different scenarios. In subsection 5.1, I conduct the analysis on a closed-economy TANK, where I do not introduce heterogeneity in the monetary union. In subsection 5.2, within-country heterogeneity is embedded. I assume that the share of rule-of-thumb households differs across countries. A higher share of households do not have access to financial market in periphery than in core, 0.4 and 0.25, respectively. Then, in subsection 5.3, I analyse the effects of QE in the presence of cross-heterogeneity, i.e. different debt profiles. Core economies exhibit structurally stronger public debt profiles, characterised by lower debt-to-GDP ratios, a smaller reliance on short-term sovereign issuance, and higher liquidity in long-term government bonds. All these exercises are conducted by solving the model for three steady states, with the same QE shock each time.

5.1 Closed-economy TANK

In this benchmark exercise, I simulate a 0.5% deviation from the steady state in the share of bonds purchased by the Central Bank in both the core and periphery regions. As noted previously, this scenario assumes the absence of cross-country heterogeneity within the monetary union, which can be considered a closed economy. The accompanying figures 2, 3, 4 plot the Impulse Response Functions (IRFs) for the entire monetary zone following this 0.5% deviation from the steady state.

The first set of results, presented in the benchmark scenario, reveals a symmetric response to Quantitative Easing (QE) in both the core and peripheral economies. This symmetry arises from the structural homogeneity embedded in the model, which abstracts from macroeconomic imbalances and assumes a uniform implementation of QE. In particular, the central bank is designed to purchase an identical share of public bonds in both regions.

The QE affects the economy through a set of well-established channels (Hohberger et al. (2020); Cantore and Meichtry (2024); Albertazzi et al. (2018); Cui and Sterk (2021). Following the central bank's purchase of long-term bonds, yields decline, prompting optimisers to rebalance their portfolios towards short-term debt, physical capital and investment. This shift, consistent with the

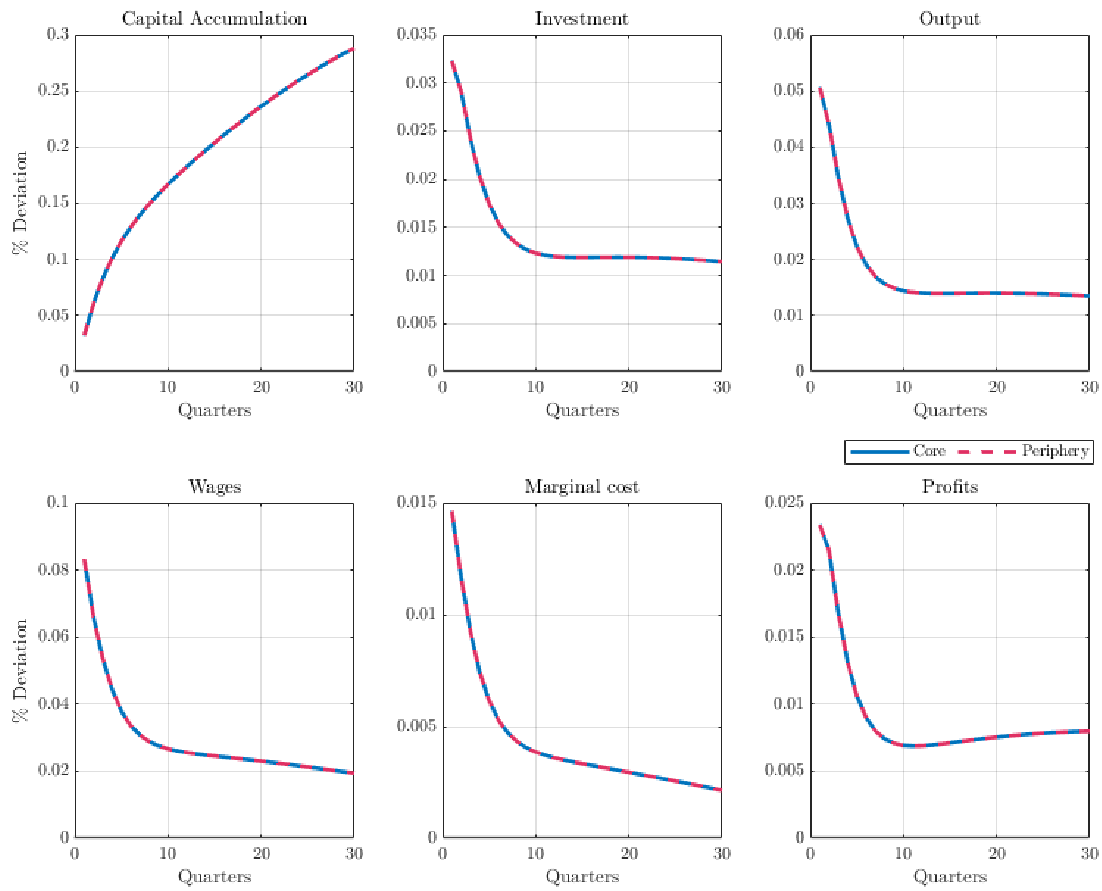


Figure 2: Production sector

(a) This figure displays the impulse response functions of production, investment, capital, marginal cost, wages and profits following a deviation of 0.5% of the bond purchased by the Central Bank. In this scenario, countries do not differ.

portfolio rebalancing channel, boosts investment and capital accumulation, raising output in both countries. As production expands, labour demand increases, leading to higher wages and hours worked. The response is heterogeneous across households: rule-of-thumb agents, who rely solely on labour income, increase their labour supply more strongly than optimising households, who benefit from rising asset returns and face less incentive to work more—an effect that operates through the *labour market channel*. Higher wages raise total income for both types of households, though the composition differs—optimising households consume only part of their additional income, while rule-of-thumb agents consume it all (see Figure 3). As consumption picks up, inflation rises, reducing the real value of nominal assets held by optimising households—implying

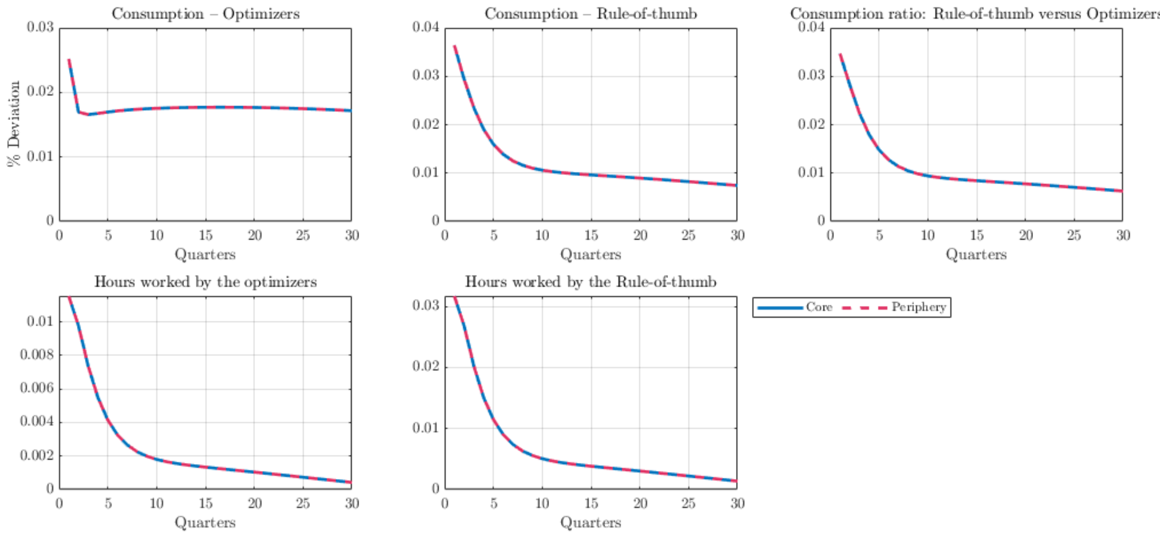


Figure 3: Hours worked and consumption

(a) This figure displays the impulse response functions of consumption and hours worked for both households – optimisers and rule-of-thumb – and the consumption ratio following a deviation of 0.5% in bond purchases by the Central Bank. In this scenario, countries do not differ.

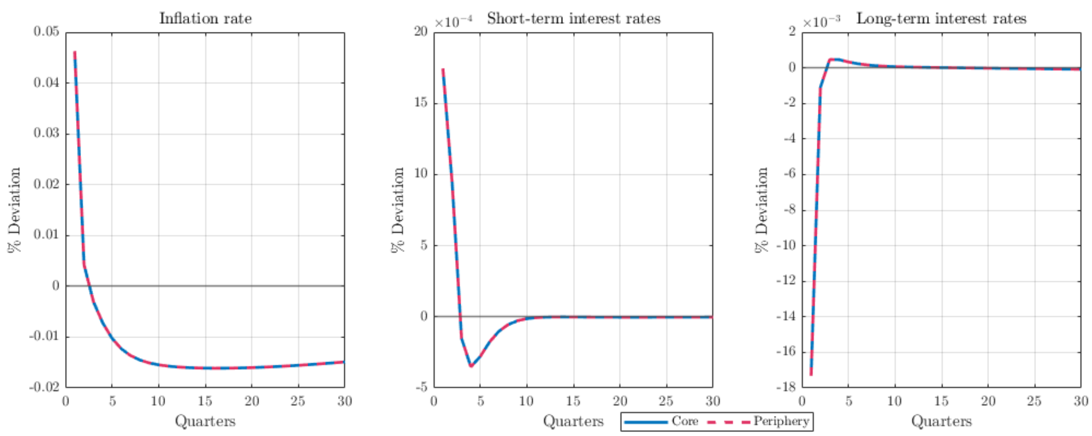


Figure 4: Prices and Interest rates

(a) This figure displays the responses of inflation, short-term and long-term interest rates following a deviation of 0.5% of the bond purchased by the Central Bank. In this scenario, countries do not differ.

a loss in their bond wealth. This effect operates through the *inflation channel*, and while rule-of-thumb households are also exposed to higher prices, their losses are partially offset by rising wages. Over time, inflation pressures subside as the central bank raises short-term interest rates. On the fiscal side, the purchases of long-term bonds by the Central Bank leads to an increase of nominal public debt (long-term and short-term debt) and tax revenues due to several reasons like in Cantore and Meichtry (2024) Hohberger et al. (2019). First, purchases are financed by either government new bond issuance or through tax revenues. Then, following the rise of wages and the number of hours worked, the tax revenues increases. While disposable income initially falls due to this *fiscal channel*, the rise in wages and hours worked more than offsets the effect, resulting in net income gains. Taken together, these mechanisms deliver a temporary boost to aggregate demand and output. In distributional terms, QE modestly reduces inequality in the short run, as rule-of-thumb households benefit disproportionately from the labour market response. However, this effect fades over time as asset returns begin to dominate income dynamics, leading to a neutral impact in the medium run.

In this scenario where both countries are exactly the same, i.e. one-country monetary union, I show that QE leads to an expansion of output (Figure 2) and a reduction of income inequalities only in the short run (Figure 3), through several transmission channels.

5.2 The Share of rule-of-thumb (optimisers) matters

Now, I relax the assumption regarding the shares of households. I assume that the share of rule-of-thumb in periphery country is larger than in the core, 0.4 and 0.25, respectively.

Allowing for heterogeneity in the share of rule-of-thumb (RoT) households across the core and the periphery alters the strength, not the sign of QE transmission. Relative to the benchmark case, in which both regions are assumed to have a uniform RoT share of 0.3, increasing the prevalence of RoT households in the periphery amplifies the dynamic responses following a quantitative easing (QE) shock. The mechanism operates through the consumption dynamics of rule-of-thumb households. In the periphery, where a larger fraction of households consume their entire earned income rather than smoothing consumption intertemporally, the income effects generated by QE translate more forcefully into aggregate demand. Consequently, the periphery experiences a stronger expansion in consumption and output compared to the core. This amplification is consistent with Galí et al. (2007b) and Bilbiie (2008), who show that the presence of rule-of-thumb consumers magnifies the transmission of monetary policy through a more immediate consumption response.

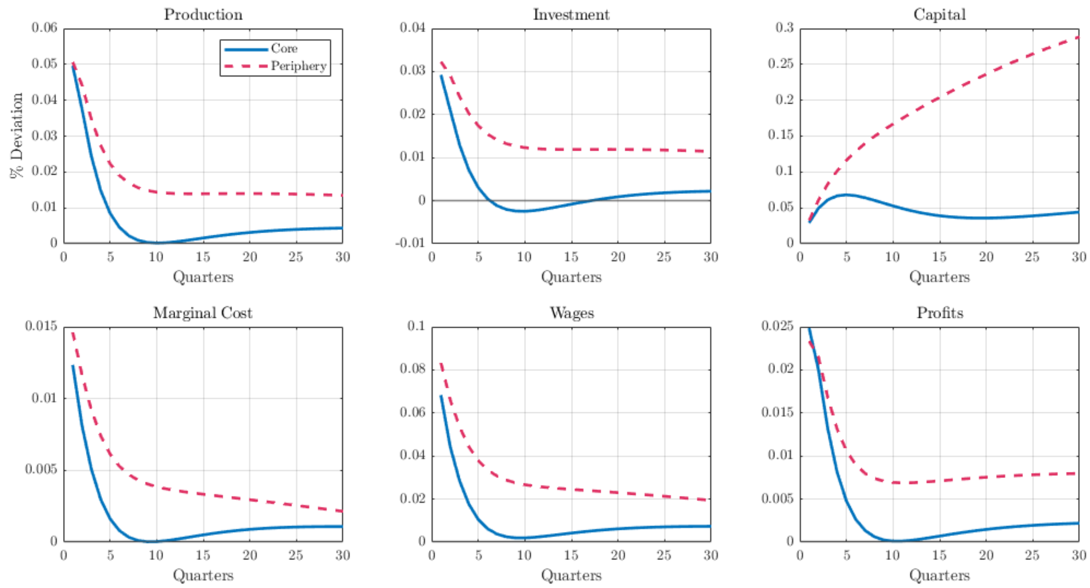


Figure 5: Production sector

(a) This figure displays the impulse response functions of production, investment, capital, marginal cost, wages and profits following a deviation of 0.5% of the bond purchased by the Central Bank. In this scenario, countries differ by the share of rule-of-thumb households – 0.25 in core and 0.4 in periphery.

Distributional Implications

As depicted in Figure 6, income inequality declines more sharply in the periphery, where the share of RoT households is larger. The underlined mechanism is the following. The QE shock raises disposable income primarily through higher labor income generated by stronger aggregate demand and lower firms' financing costs. Since RoT households consume all of their current income and do not smooth consumption intertemporally due to their lack of access to credit markets, they translate these income gains directly and immediately into consumption. This stronger consumption response among lower-income RoT households leads to a compression of the income distribution, thereby producing more pronounced distributional effects in the periphery.

Within-country heterogeneity, i.e. different access to financial market for households; affects the transmission of QE. It drives the amplitude of both output and income inequalities dynamics. A

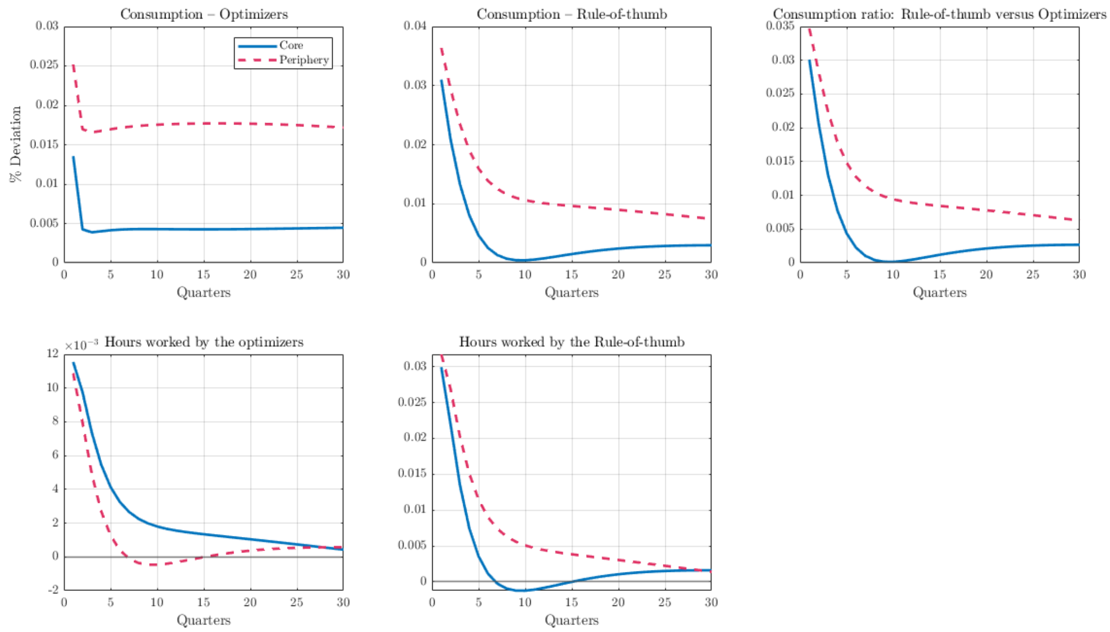


Figure 6: Hours worked and consumption

(a) This figure displays the impulse response functions of consumption and hours worked for both households – optimisers and rule-of-thumb and consumption ratio following a deviation of 0.5% of the bond purchased by the Central Bank. In this scenario, countries differ by the share of rule-of-thumb households – 0.25 in core and 0.4 in periphery.

larger prevalence of rule-of-thumb households (do not have access to financial market) amplifies the transmission of QE via income channel.

5.3 Liquidity and debt decomposition in portfolio reallocation channel

In this third scenario, I introduce cross-country heterogeneity, i.e. divergence in public debt composition and liquidity of the public debt between core and periphery. The periphery is assumed to have a higher debt-to-GDP ratio, a relative greater reliance on short-term debt, and less liquid long-term bonds (see Table 3).

Parameter	*Description*	*Value*
$(b/y)^c$	*Debt-to-GDP (core)*	0.8
$(b/y)^p$	*Debt-to-GDP (periphery)*	1.2
ϑ^c	*Short-term to Long-term debt (core)*	0.25
ϑ^p	*Short-term to Long-term debt (periphery)*	0.4
ϕ_H	*Resaleability constraint (core)*	0.8
ϕ_F	*Resaleability constraint (periphery)*	0.6

Note: Key fiscal and debt parameters used in the calibration.

Table 3: Debt Composition and Liquidity

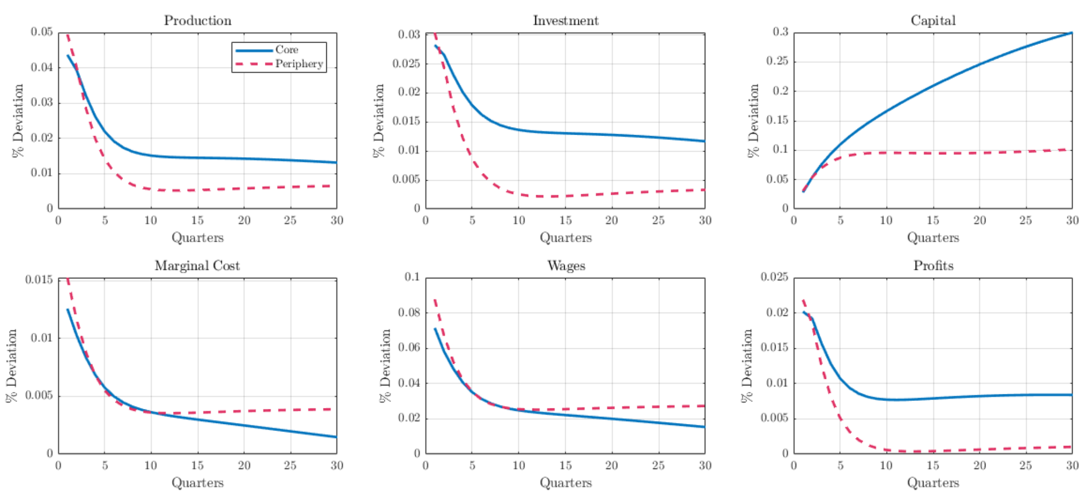


Figure 7: Production sector

(a) This figure displays the impulse response functions of production, investment, capital, marginal cost, wages and profits following a deviation of 0.5% of the bond purchased by the Central Bank. In this scenario, countries differ by debt decomposition and liquidity

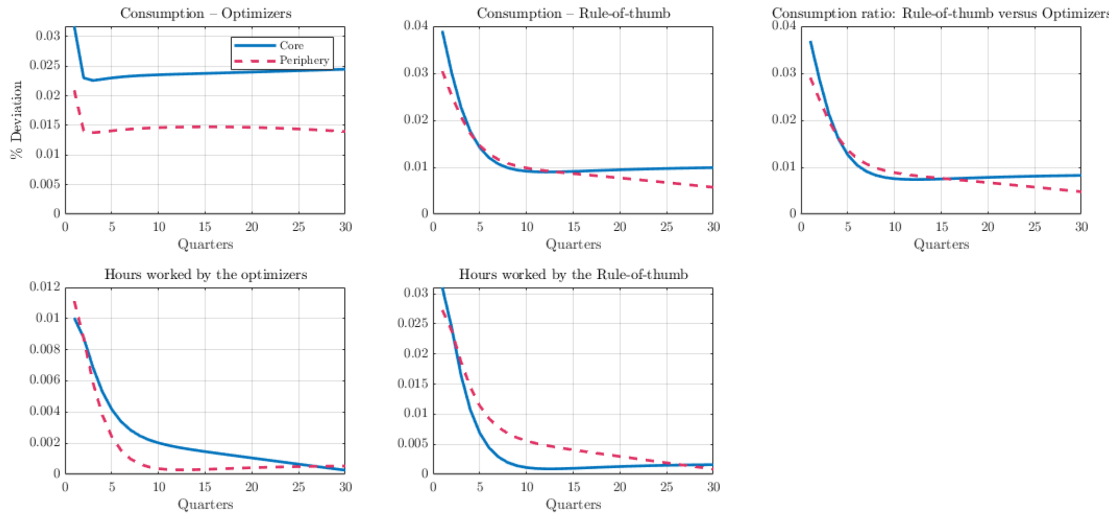


Figure 8: Hours worked and consumption

(a) This figure displays the impulse response function of consumption and hours worked for both households – optimisers and rule-of-thumb and consumption ratio – following a deviation of 0.5% of the bond purchased by the Central Bank. In this scenario, countries differ by debt decomposition and liquidity

Introducing heterogeneity in public debt profiles sheds light on the role of *portfolio reallocation* in the transmission of Quantitative Easing (QE). In particular, I show how differences in the structure and liquidity of sovereign debt affect both the *magnitude* and the *direction* of portfolio adjustments following QE. Compared with the existing literature, I identify two additional determinants of the portfolio rebalancing channel: (i) the short-term to long-term debt ratio, and (ii) the liquidity of long-term government bonds.

The short-term to long-term debt ratio governs the direction of portfolio reallocation.

Following a QE shock, the yields on long-term bonds decline, prompting optimising households in both the core and the periphery to rebalance their portfolios across others assets—namely, short-term debt, physical capital, and investment. As in Scenarios 1 and 2, QE leads to an expansion in nominal public debt through increased issuance of both short- and long-term debt. However, because long-term yields fall, the demand for short-term bonds rises. The extent to which this demand translates into broader portfolio shifts depends on the composition of public debt. In the *core*, where governments rely more heavily on long-term debt, the increase in public debt following QE is primarily concentrated in long-term maturities. The demand for long-term bonds (from the optimisers) is lower that the supply for short-term bonds (from the government) Consequently, optimisers in the core shift relatively more towards capital accumulation and investment, as they are less constrained by short-term refinancing needs. In contrast, in the *periphery*, government issues a relatively larger share of short-term debt compared to the core. As a result, optimisers there rebalance their portfolios more evenly across all assets—capital, investment, and short-term bonds.Thus, the maturity composition of public debt shapes both the direction and intensity of portfolio reallocation after QE.

The liquidity of long-term bonds determines the amplitude of portfolio reallocation.

The liquidity of long-term bonds measures how easily these bonds can be resold or used as collateral. Higher liquidity implies that a smaller fraction of bonds must be retained in investors' portfolios, facilitating more flexible asset reallocation. In this scenario, I assume that core bonds are more liquid than those issued by the periphery, based on Eurozone data. This difference in liquidity magnifies cross-country asymmetries in the transmission of QE. When the yields on long-term bonds fall, core optimisers can sell or refinance their bond holdings more easily, allowing them to redirect funds toward physical capital and investment. Peripheral optimisers, by contrast, face tighter resale constraints and must retain a larger share of illiquid long-term bonds, limiting their capacity to rebalance. Consequently, bond-market liquidity amplifies the portofolio reallocation following QE in the core while attenuating it in the periphery.

Taken together, differences in debt profiles imply a modified portfolio rebalancing channel that directly shapes the magnitude of the expansionary effects of QE. The results show a stronger expansion in the core relative to the periphery, reflecting the more limited ability to reallocate portfolios of the periphery. In peripheral economies – a higher reliance on short-term debt and lower bond liquidity– constrain the rebalancing process toward productive assets, leading to a more muted output response compared to the core.

Distributional Implications

Turning to the *distributional consequences*, the introduction of heterogeneity in debt profiles does not substantially alter the distributional transmission of QE. Based on Scenarios 1 and 2, one would expect that stronger economic expansion in the core should translate into larger increases in labour supply for both types of households. However, this pattern does not materialise here. The large output expansion observed in the core stems primarily from greater *capital accumulation and investment*, rather than from stronger labour responses. When comparing labour supply dynamics across countries, the responses of both optimising and rule-of-thumb households remain relatively similar to those in the previous scenarios, with no pronounced divergence between the core and the periphery. Consequently, differences in debt structure and bond liquidity—while important for the *magnitude of output expansion*—do not generate additional redistributional effects. In both regions, the trajectories of income inequality follow similar dynamics, implying that *heterogeneity in debt profiles affects the aggregate strength of QE but not its redistributive impact*.

Main results. In this section 5, I investigate how Quantitative Easing (QE) transmits in heterogeneous monetary union. I derive from the three scenario, three main results. Firstly, in all the cases QE is expansionary and reduces income inequalities in the short run. Second, within-country heterogeneity, i.e. the share of rule-of-thumb acts as an amplifier of these effects. Finally, the main result of this present paper is that cross-country heterogeneity i.e. debt profiles, affects the amplitude of the expansion between core and periphery via differences in portfolio reallocation channel (direction and amplitude). Countries relying relatively more on long-term debt that is more liquid experience greater economic expansion.

6 Empirical Motivations

In this section, I provide evidence on the role of cross and within-country heterogeneity in the transmission of Quantitative Easing in the EA. I employ the Jordà (2005) local projection (LP) method, which estimates the dynamic response of a variable to an exogenous shock at each forecast horizon[3]. Identification of QE shocks follows Altavilla et al. (2019) and De Luigi et al. (2023), who use high-frequency yield changes around ECB policy announcements to construct externally valid monetary surprises. The maintained assumption is that these high-frequency surprises shift expectations about the scale of asset purchases but are orthogonal to contemporaneous country-level macroeconomic shocks.

6.1 Data and Descriptive Statistics

The empirical sample covers 13 euro area countries, divided into *core*[4] and *periphery*[5] from 2014Q1 to 2020Q1. The dataset combines household survey evidence, inequality indicator, macroeconomic aggregates, and externally identified QE shocks.

Income inequality. Inequality is measured using the Income Gini index that summarises overall dispersion in the income distribution.

Rule-of-thumb shares. The prevalence of hand-to-mouth (HtM) households is estimated using the Eurosystem HFCS microdata. Following Kaplan et al. (2014) and Almgren et al. (2022), I distinguish between *poor HtM* households, with near-zero or negative net assets, and *wealthy HtM* households, who hold illiquid assets (e.g., housing, pensions) but little liquidity. This classification allows me to compute the aggregate RoT share at the country level, capturing differences in marginal propensities to consume consistent with the model.

[3]LPs are well suited here for three reasons: (*i*) they avoid imposing a full autoregressive structure as in VARs, (*ii*) they allow flexible horizon-specific inference and robustness to model misspecification, and (*iii*) they accommodate heterogeneous country responses in a panel setting.

[4]Austria, Belgium, Finland, France, Germany, Netherlands

[5]Greece, Ireland, Italy, Portugal, Slovakia, Slovenia, Spain

Bond liquidity. To proxy sovereign bond market liquidity, I use the roll1984simple spread, which infers effective bid–ask spreads from the negative autocovariance of price changes. Formally,

$$\text{RollSpread}_t = 2\sqrt{-\text{Cov}(\Delta P_t, \Delta P_{t-1})}, \tag{52}$$

where P_t denotes the 10-year government bond price. Higher values indicate lower liquidity. I compute this measure using LSEG transaction data; debt ratios and maturities are obtained from Eurostat.

Real GDP. The real GDP is obtained on Eurostat data.

I report in Table 4, the means of RoT shares, Income Gini, debt-to-GDP, 10-y yield and Roll spread for both groups – core and periphery:

Variable	**Core**	**Periphery**
Rule-of-thumb share	0.189	0.378
Income Gini	0.430	0.450
Debt-to-GDP (%)	60.974	88.516
10-year yield (%)	0.550	1.993
Roll spread	2.560	5.660

Table 4: Descriptive statistics. Core vs. periphery averages.

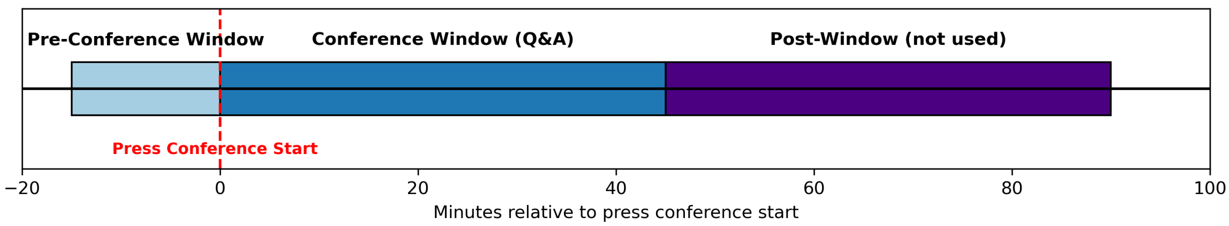
Periphery countries are characterized by higher RoT shares, larger public debt burdens, higher sovereign yields, and less liquid bond markets, while inequality levels (Income Gini index) are comparable across the two groups. These patterns closely mirror the macroeconomic asymmetries highlighted in the theoretical model.

6.1.1 Identifiying Quantitative Easing shocks

QE surprises are identified using a quarterly version of the methodology of Altavilla et al. (2019) by De Luigi et al. (2023).

Methodology – Press Conference and Press Release Conference Windows Their approach relies on ultra-narrow windows around Governing Council communication events, which are the primary source of new information about unconventional policy. Their analysis exploits the so-called 'conference window', defined as the 15 minutes before and the 45 minutes following the start of the ECB's post-meeting press conference, during which the President delivers prepared remarks and answers questions from the press.

Figure 9: Timing Press Conference window



This window is deliberately chosen to isolate policy surprises, as the majority of market-moving content on the scale, composition, and signalling of asset purchases is revealed during this stage, rather than at the release of the policy statement itself. Within this high-frequency window, changes in a broad set of asset prices, sovereign yields across the maturity spectrum, corporate bond spreads, equity indices, and exchange rates, are interpreted as clean measures of unexpected QE news, abstracting from confounding macroeconomic or geopolitical developments. Aggregating these surprise components across all QE-related events yields an estimate of the cumulative announcement effect, while allowing the decomposition of channels through which QE operates, including compression of duration premia, reduction of sovereign and corporate risk premia, and portfolio rebalancing into riskier assets. I measure asset-price changes within the press-release and press-conference windows, with the latter spanning the 15 minutes before to 45 minutes after the start of the press conference. Surprise components are extracted from intraday yield-curve movements via a small-factor setup that isolates target/FG/timing/QE dimensions, and these continuous shocks are used to quantify announcement effects.

Updated QE factor. The QE factor extracted from Altavilla et al. (2019) are daily data. The identification of Quantitative Easing shocks follows the procedure in De Luigi et al. (2023), who adapts the high-frequency factors of Altavilla et al. (2019) to lower-frequency macroeconomic data. The starting point is QE factor obtained from the EA-MPD dataset, which captures daily financial-market surprises around ECB policy announcements. Intraday yield changes across maturities are subjected to principal component analysis with varimax rotation to recover economically interpretable factors; I focus on the QE component, which isolates asset-purchase announcements from policy rate or forward guidance surprises. The first step is to construct a *cumulative daily series* of the QE factor, such that shocks accumulate over time rather than reset each day[6]. From this cumulative series, monthly averages are then calculated, producing a smoother monthly shock measure that retains the cumulative information while attenuating day-to-day noise. In a final step, the monthly series is aggregated to the quarterly frequency, either by averaging or summing, to match the periodicity of macroeconomic outcomes such as output, prices, or wealth. To control for other monetary policy dimensions, the analysis also incorporates the *timing* and *target* factors of Altavilla et al. (2019), transformed analogously to monthly and quarterly frequency.

This procedure yields a quarterly QE shock series that are plotted in Appendix **??**. These factors can be either positive or negative. A *positive* QE factor can be interpreted as QE tightening surprise since long-term rates go up and *negative* QE factor as QE easing surprise since long-term rates go down. I focus solely on negative QE factor, i.e. monetary easing. From 2014Q1 to 2020Q1, monetary easing episodes represent 75% of QE episodes.

6.2 Specification

I estimate impulse responses using panel LPs of the form in both country group, namely the core and periphery:

$$Y_{i,t+h} - Y_{i,t-1} = \alpha_{i,h} + \gamma_{t,h} + \beta_h QE_t + \sum_{l=1}^{L} \Gamma_l^h X_{i,t-l} + u_{i,t+h}, \quad h = 0, \ldots, H, \tag{53}$$

where $Y_{i,t}$ corresponds to the Income Gini index and the real GDP for group of country i, QE_t is the identified QE surprise, and $X_{i,t-l}$ denotes controls (public spending, tax rates, and three lags of Y). Horizon-specific country and time fixed effects, $\alpha_{i,h}$ and $\gamma_{t,h}$, absorb unobserved heterogeneity and common shocks. Standard errors are clustered at the country level, and inference follows the methodology of Jordà et al. (2013). The horizon is $H = 12$ quarters. Confidence intervals

[6] This transformation, advocated by Romer and Romer (2004), ensures comparability with standard interest rate or bond yield shocks, which typically enter regressions in levels

are computed using clustered standard errors at the country level within the local projection framework. At each horizon h, the interval is given by

$$\hat{\beta}_h \pm 1.64 \times SE(\hat{\beta}_h) \,, \tag{54}$$

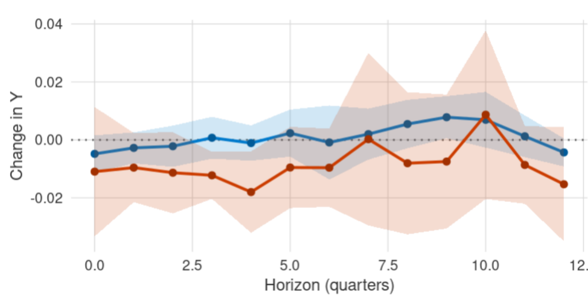
generating the 90% confidence bands.

I proceed in three steps: (i) a benchmark specification without heterogeneity controls, (ii) an extension including debt characteristics (debt-to-GDP, maturity structure, liquidity) to capture financial asymmetries and then (iii) an extension including Rule of thumb shares.

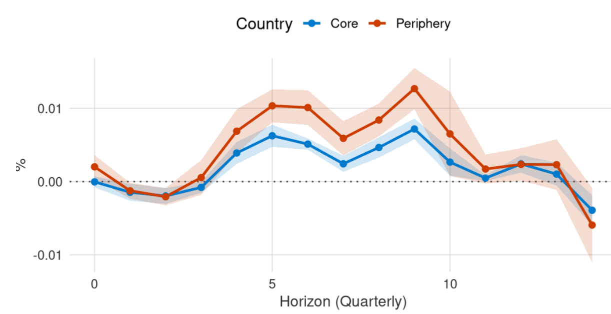
6.2.1 Benchmark Results

Figure 10 reports the benchmark impulse responses of Income Gini index and real GDP to a QE shock, estimated over 2014Q1–2020Q1 for both country groups: core and periphery.[7]

Figure 10: LP responses of Income Gini and real GDP to a monetary easing shock (negative QE shock)



(a) LP responses of **Income Gini index** for core and periphery to a negative QE shock (monetary easing). Solid lines denote point estimates, shaded areas 90% confidence bands. Orange line = periphery; blue line = core.



(b) LP responses of **real GDP** for core and periphery to a negative QE shock (monetary easing). Solid lines denote point estimates, shaded areas 90% confidence bands. Orange line = periphery; blue line = core.

As illustrated in Figure 10, the transmission of quantitative easing (QE) exhibits notable heterogeneity between core and periphery economies. In panel 10a, the Income Gini index in core countries shows little to no reaction following QE shocks, suggesting a limited direct effect on income inequality. In contrast, the periphery displays a marked decline in the Gini index lasting up to eight quarters, pointing to a temporary equalizing impact of QE.

[7]Starting in 2014 ensures that QE shocks are not confounded with the earlier SMP or OMT interventions. Results are robust to extending the sample to 2009.

Turning to output dynamics (Panel 10b), both groups experience comparable cyclical patterns and similar peak magnitudes of expansion. However, from roughly the fourth to the eleventh quarter, the periphery's expansion is visibly stronger. Overall, these results indicate that while QE generates qualitatively similar responses across the euro area, the magnitude and persistence of its effects differ between core and periphery economies.

6.2.2 Debt Profiles

Now, based on stylised facts and the theoretical model, I introduce cross-country heterogeneity, i.e. debt profiles. I extend the baseline local projection framework by interacting the QE shocks with country-specific measures of debt-to-GDP and bond-market liquidity [8]. Formally, the estimating equation is

$$
\begin{aligned}
Y_{i,t+h} - Y_{i,t-1} = {} & \alpha_{i,h} + \gamma_{t,h} + \beta_h \, QE_t + \phi_h^{(\text{debt})} \left(QE_t \times z_{i,t}^{\text{debt}} \right) + \phi_h^{(\text{liq})} \left(QE_t \times z_{i,t}^{\text{liq}} \right) \\
& + \sum_{\ell=1}^{L} \Gamma_{h,\ell} \, Y_{i,t-\ell} + \sum_{\ell=0}^{L} \Theta_{h,\ell} \, QE_{t-\ell} + \sum_{\ell=0}^{L} \Delta_{h,\ell}^{(\text{debt})} \, z_{i,t-\ell}^{\text{debt}} + \sum_{\ell=0}^{L} \Delta_{h,\ell}^{(\text{liq})} \, z_{i,t-\ell}^{\text{liq}} \\
& + \sum_{l=1}^{L} \Gamma_l^h X_{i,t-l} + u_{i,t+h}, \qquad h = 0, \ldots, H.
\end{aligned} \tag{55}
$$

where $Y_{i,t}$ denotes the outcome of interest (Gini, or Palma), QE_t is the identified QE shock (common across countries), $z_{i,t}^{\text{debt}}$ and $z_{i,t}^{\text{liq}}$ are standardized measures of debt-to-GDP and bond-market (il)liquidity (Roll spread), $\alpha_{i,h}$ and $\gamma_{t,h}$ are country and time fixed effects, $X_{i,t-l}$ denotes controls (public spending, tax rates and $L = 3$ lags are included). The specification is estimated by OLS separately for each horizon h, with standard errors clustered at the country level.

Impulse responses. The key parameters of interest are β_h, $\phi_h^{(\text{debt})}$, and $\phi_h^{(\text{liq})}$. While β_h captures the average response to a QE shock across all countries of a group, the interaction terms allow the effect to vary systematically with debt and liquidity conditions. The conditional impulse response

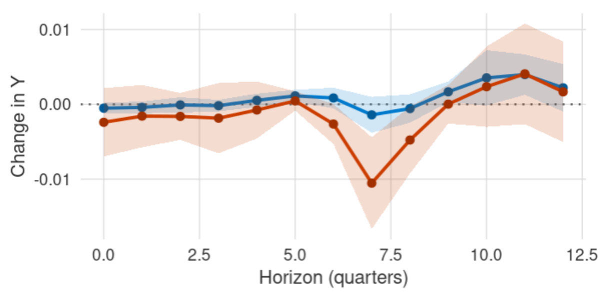
[8] This strategy directly builds on the state-dependent policy evaluation literature as auerbach show that fiscal multipliers are substantially larger in recessions than in expansions, while Jordà et al. (2013) document that monetary policy effects are amplified in periods of high private leverage. Following this tradition, I extend the framework to the euro area by conditioning inequality responses to QE shocks on cross-country differences in debt burdens and bond market liquidity. This provides a transparent and empirically tractable way to assess how structural fiscal and financial heterogeneity shapes the effectiveness of unconventional monetary policy.

of Y to a QE shock at horizon h for a given debt level z^{debt} and liquidity level z^{liq} is:

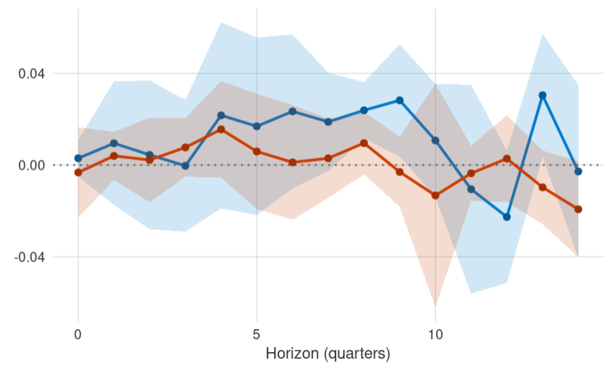
$$IRF_h(z^{\text{debt}}, z^{\text{liq}}) = \beta_h + \phi_h^{(\text{debt})} z^{\text{debt}} + \phi_h^{(\text{liq})} z^{\text{liq}}. \tag{56}$$

Figure 11 analyses how cross-country heterogeneity, i.e. different debt profiles across core and

Figure 11: Conditional LP responses of Income Gini and real GDP to a monetary easing shock (negative QE shock), interacted with cross-country heterogeneity.



(a) Conditional LP responses of **Income Gini index** for core and periphery to a negative QE shock (monetary easing) with debt profiles. Solid lines denote point estimates, shaded areas 90% confidence bands. Orange line = periphery; blue line = core.



(b) Conditional LP responses of **real GDP** for core and periphery to a negative QE shock (monetary easing) with debt profiles. Solid lines denote point estimates, shaded areas 90% confidence bands. Orange line = periphery; blue line = core.

periphery, influences the transmission of quantitative easing (QE) across euro area economies. In this specification, QE shocks are interacted with country-specific measures of debt-to-GDP ratios and bond market liquidity. Panel 11a demonstrates that the evolution of the Income Gini index is broadly similar between core and periphery economies, except for a slight divergence between the sixth and eighth quarters. Regarding output responses (Panel 11b), the results indicate a stronger and more persistent expansion in the core, whereas the periphery exhibits a more subdued reaction.

Overall, these findings suggest that differences in public debt profiles shape the strength of the QE transmission mechanism. Countries with more liquid and lower debt typically in the core, benefit from a more pronounced expansion.

6.2.3 Rule-of-thumb

In this last specification, I introduce the share of rule-of-thumb. Do countries with a higher share of rule-of-thumb experience a decline of income inequalities and or higher economic expansion?

$$Y_{i,t+h} - Y_{i,t-1} = \alpha_{i,h} + \gamma_{t,h} + \beta_h \, QE_t + \phi_h^{(\mathrm{rot})} \left(QE_t \times zRoT_{i,t}\right) + \sum_{\ell=1}^{L} \Gamma_{h,\ell} \, Y_{i,t-\ell} + \sum_{\ell=0}^{L} \Theta_{h,\ell} \, QE_{t-\ell}$$
$$+ \sum_{\ell=0}^{L} \Delta_{h,\ell}^{(\mathrm{rot})} \, zRoT_{i,t-\ell} + \sum_{l=1}^{L} \Gamma_l^h X_{i,t} + u_{i,t+h}, \quad h = 0, \ldots, H \tag{57}$$

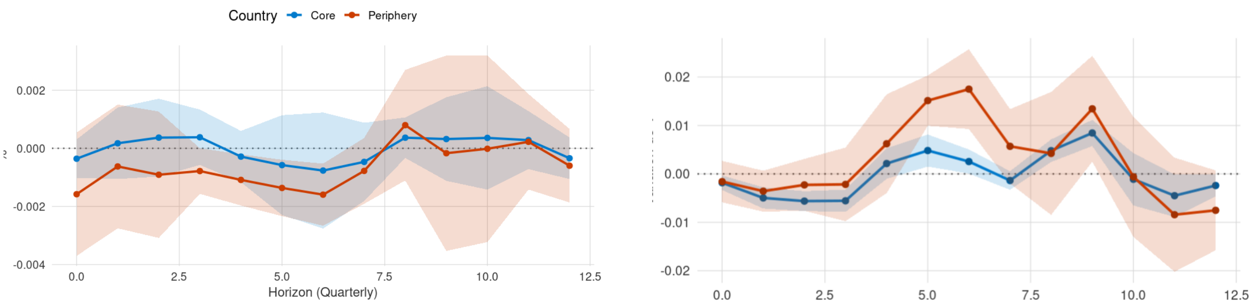
As in Section 6.2.2, $Y_{i,t}$ denotes the outcome of interest (Income Gini and real GDP), QE_t is the identified QE shock (common across countries), $zROT_t$ are the standardized share of rule-of-thumb $\alpha_{i,h}$ and $\gamma_{t,h}$ are country and time fixed effects, $X_{i,t}$ denotes controls (public spending, tax rates and $L = 3$ lags are included). The specification is estimated by OLS separately for each horizon h, with standard errors clustered at the country level.

Impulse responses. The key parameters of interest are β_h and $\phi_h^{(\mathrm{rot})}$. While β_h captures the average response to a QE shock across all countries of a group, the interaction terms allow the effect to vary systematically with the share of rule-of-thumb. The conditional impulse response of Y to a QE shock at horizon h for a given share of rule-of-thumb z^{rot} is:

$$IRF_h(z) \;=\; \beta_h \;+\; \phi_h^{(\mathrm{rot})} \, z, \tag{58}$$

Figure 12 shows that only peripheral countries experience a decline in inequality—measured by the Income Gini index indice—when QE is interacted with the share of rule-of-thumb households. The reduction is stronger in economies with a larger proportion of such households, consistent with their higher marginal propensity to consume. This pattern aligns with recent work on QE and inequality, and suggests that once household heterogeneity is taken into account, peripheral countries in the EMU benefit more from QE in distributional terms. Looking at the responses of real GDP, I against can see difference across core and periphery. While both countries experience an economic expansion, the latter seems to be more pronounced in the periphery. This confirms theoretical predictions presented in section 5.2.

Figure 12: Conditional LP responses of Income Gini and real GDP to a monetary easing shock (negative QE shock), interacted with the share of rule-of-thumb.



(a) Conditional LP responses of **Income Gini index** for core and periphery to a negative QE shock (monetary easing). Solid lines denote point estimates, shaded areas 90% confidence bands. Orange line = periphery; blue line = core.

(b) Conditional LP responses of **real GDP** for core and periphery to a negative QE shock (monetary easing). Solid lines denote point estimates, shaded areas 90% confidence bands. Orange line = periphery; blue line = core.

7 Policy Implications

The analysis in this paper yields two main policy implications for the conduct of Quantitative Easing within a structurally heterogeneous monetary union.

First, while Quantitative Easing delivers expansionary effects at the union level and reduces short-term consumption inequality, its transmission is strongly shaped by country-specific structural characteristics. Countries with a higher prevalence of liquidity-constrained households exhibit amplified demand responses to QE, while economies with higher debt burdens and less liquid sovereign bond markets experience attenuated benefits from central bank asset purchases. The latter implies that uniform monetary interventions can have different (in terms of amplitude) and reinforce initial divergences across member states.

Second, the results suggest that the design of QE programs should explicitly account for the differences between countries. Relying solely on proportional bond purchases based on capital key allocations may be suboptimal when cross and within country persist. Instead, a more effective approach may involve tailoring asset purchase strategies to debt liquidity and maturity structures across countries, or combining QE with fiscal instruments aimed at redistributing stimulus effects. Such considerations are particularly relevant for the euro area, where structural divergences between core and peripheral countries remain salient.

More broadly, this paper contributes to the ongoing debate on optimal monetary policy design in currency unions with persistent heterogeneity between countries. The results underscore that heterogeneity across and within countries are not passive background conditions, but actively influence both the transmission mechanisms of policy interventions. The findings reinforce the case for explicitly considering divergences when assessing the effects of union-wide monetary interventions.

8 Conclusion

This present paper presents a model of a heterogenous monetary union, with two types of heterogeneity: across and within countries. The analysis reveals that both types have implications on the effects of Quantitative Easing and income inequalities dynamics. Unequal access to financial market across households (within heterogeneity) condition both, the aggregate output response and the distributional effects of QE. Peripheral countries with a more unequal access to the financial market experience larger expansion and greater reduction of income inequalities in the short-run, compared to core. Across countries, I show that debt profiles also shape the magnitude of QE effects, but solely on output. This effect relies on modification of the portfolio rebalancing channel. Liquidity and short-term to long-term debt are drivers of this modification. Liquidity drives the amplitude of the reallocation – how much households may reallocate their assets following the decline of long-term debt yields. The short-term to long-term debt ratio drives the direction of the reallocation. I prove that in core countries (higher debt liquidity and lesser reliance on short-term debt) tend to experience a greater output response following QE, compared to periphery countries. This finding suggest that divergence between core and periphery increases compared to pre QE period.

Taking together, these results underscore the need for embedding such divergences in the design of monetary policy. This can involve tailoring asset purchase strategies to debt liquidity and maturity structures across countries, or combining QE with fiscal instruments aimed at redistributing stimulus effects.

For future research, an extension of this framework evolves: (i) the consideration of other heterogeneity in the EMU, such as external imbalances, including the net foreign asset position and trade balance, (ii) the addition of the Zero Lower Bound in the Taylor rule. I use a Taylor rule in what we call ’normal times’, which may not be the best option regarding QE, where the Zero Lower Bound was achieved. Thus, integrating the ZLB in the Taylor Rule is appealing.

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Appendix

8.1 Equilibrium

Here are the equilibrium conditions for the core:

$$(c_t^o)^{-\sigma} = \lambda_t$$

$$\zeta (l_t^o)^{\varphi} = \theta w_t (c_t^o)^{\sigma}$$

$$1 = \beta \mathbb{E}_t \left[\frac{r_t^s}{\pi_{Ht+1}} \right]$$

$$1 = \mathbb{E}_t \beta_t \frac{1}{\pi_{Ht+1}} \left[\frac{\lambda_{t+1} r_t^l + (1-\phi)\mu_{t+1}}{\lambda_t + \mu_t} \right]$$

$$1 = \mathbb{E}_t \beta_t \frac{s_{t+1}}{s_t} \frac{1}{\pi_{Ft+1}} \left[\frac{r_t^{l*} \lambda_{t+1} + (1-\phi)\mu_{t+1}}{\lambda_t + \mu_t} \right]$$

$$1 = \mathbb{E}_t \beta_t \left[\frac{\lambda_{t+1}}{\lambda_t} \left(\frac{q_{t+1}(1-\delta) + r^k_{t+1}}{q_t} \right) \right]$$

$$1 = q_t \left[1 - \frac{\kappa_I}{2} \left(\frac{i_t}{i_t - 1} - 1 \right)^2 - \kappa_I \left(\frac{i_t}{i_{t-1}} \right) \left(\frac{i_t}{i_t - 1} - 1 \right) \right] + \kappa_I \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t} q_{t+1} \left[\left(\frac{i_{t+1}}{i_t} \right)^2 \left(\frac{i_{t+1}}{i_t} - 1 \right) \right] \right]$$

$$k^o_t = (1-\delta) k^o_{t-1} + \left[1 - \frac{\kappa_I}{2} \left(\frac{i^o_t}{i^o_{t-1}} - 1 \right)^2 \right] i^o_t$$

$$(c^r_t)^{\frac{1}{\sigma}} = \lambda_t,$$

$$w_t = \frac{1}{\theta} (c^r_t)^{\frac{1}{\sigma}} \zeta^r (l^r_t)^{\varphi}.$$

$$Y_{Ht}(i) = a_t k_t(i)^{\alpha} l_t(i)^{1-\alpha}$$

$$r^k_t = \alpha m c_t \frac{Y_{Ht}}{k_{t-1}}$$

$$w_t = (1-\alpha) m c_t \frac{Y_{Ht}}{l_t}$$

$$\pi_t(\pi_t - \bar{\pi}) = \beta \mathbb{E}_t \left[\pi_{t+1}(\pi_{t+1} - \bar{\pi}) \frac{Y_{Ht+1}}{Y_{Ht}} \right] + \frac{\varepsilon}{\kappa_p} \left(m c_t - \frac{\varepsilon - 1}{\varepsilon} \right)$$

$$\pi_{Ht} = \frac{p_{Ht}}{p_{Ht-1}} \pi_{Ht}$$

$$\Gamma_t = p_{Ht} Y_{Ht} - \theta w_t l_t - r^k_t k_{t-1} - \phi (\pi_{Ht} - \bar{\pi})^2 Y_{Ht} p_{Ht}$$

$$gdp_t \left[1 - \frac{\kappa_p}{2} (\pi_{Ht} - \bar{\pi})^2 \right] = c_t + i_t + g_t + TB_t$$

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R} \right)^{\rho_r} \left[\left(\frac{n \pi_{Ht} + (1-n) \pi_{Ft}}{\bar{\pi}} \right)^{\phi \pi} \left(n \frac{Y_{Ht}}{Y_{Ht-1}} + (1-n) \frac{Y_{Ft}}{Y_{Ft-1}} \right)^{\phi y} \right]^{1-\rho_r}$$

$$gdp_t = p_{Ht} Y_{Ht}$$

$$1 = (1-\gamma)(p_{Ht})^{1-\omega} + \gamma (p_{Ft})^{1-\omega}$$

$$r^r_t = \frac{r_t}{\mathbb{E}_t(\pi_{t+1})}$$

$$log(a_t) = (1-\rho_a) log(\bar{a}) + \rho_a log(a_{t-1}) + v_a.$$

$$log(d_t) = (1-\rho_d) log(\bar{d}) + \rho_d log(d_{t-1}) + v^d_t$$