Universidade de Lisboa
Instituto Superior de Economia e Gestão – ISEG
Lisbon School of Economics & Management

Essays in Monetary and Fiscal Policies

Francisco Costa Pereira Gomes Pereira

Orientador: Professor Doutor António Manuel Pedro Afonso

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Resumo

A presente dissertação reúne quatro artigos que examinam políticas monetárias e orçamentais na área do euro. Em específico, os dois primeiros artigos avaliam os impactos e a heterogeneidade das respostas macroeconómicas aos programas de compra de ativos em larga escala implementados pelo Banco Central Europeu (BCE). Os dois artigos subsequentes analisam as interações entre as políticas monetárias e orçamentais na área do euro. Na sequência do que foi referido anteriormente, são apresentados os resumos individuais de cada artigo que compõem a presente tese.

No primeiro artigo, é utilizado um conjunto de dados ao nível bancários e ao nível regional com o objetivo de estudar os impactos e a heterogeneidade dos programas de compra de ativos em larga escala do BCE na economia. Os resultados obtidos indicam que os bancos mais expostos a títulos de dívida pública registaram um maior crescimento de empréstimos do que os bancos menos expostos após o programa de compra de ativos denominado por *Asset Purchase Programme* (APP). No entanto, este resultado não é verificado para o programa denominado por *Pandemic Emergency Purchase Programme* (PEPP). Adicionalmente, os resultados obtidos demonstram que, após o programa APP, as regiões onde os bancos estão mais expostos a títulos de dívida pública apresentam resultados macroeconómicos mais favoráveis em comparação com regiões onde os bancos têm menor exposição, operando através do canal de transmissão de crédito bancário, ou *Bank Lending Channel*. Concluímos que a exposição dos bancos aos ativos alvo dos programas de compra de ativos em larga escala, assim como a sua localização geográfica, são fatores importantes na explicação da magnitude e heterogeneidade dos mecanismos de transmissão monetária.

O segundo artigo investiga os impactos e a heterogeneidade dos programas de compra de títulos de dívida pública da zona euro em larga escala pelo BCE no PIB real, inflação, rendimentos das obrigações de longo prazo, stress sistémico e taxa de desemprego. Neste artigo, foi estimado um modelo VAR Bayesiano (BVAR) estrutural com seis variáveis endógenas para 11 países da área do euro durante o período entre 2012:M1 e 2023:M12. Para robustez dos resultados, foi estimado um modelo BVAR estrutural com dados em painel, permitindo uma comparação direta entre um grupo de países vulneráveis e não vulneráveis. Os resultados sugerem que as magnitudes das respostas a um choque no *stock* de ativos de dívida pública da zona euro detidos no balanço dos bancos centrais nacionais pertencentes ao Eurosistema foram mais favoráveis nos países mais vulneráveis ao nível económico e financeiro. Os resultados obtidos sugerem que a fragilidade financeira e económica constitui uma das razões que explica a heterogeneidade nas respostas aos programas de compra de ativos em larga escala do BCE.

O terceiro artigo investiga a resposta das políticas monetárias do BCE face a projeções de défices orçamentais. O aumento contínuo do rácio dívida-produto de vários países do euro e o uso extensivo de políticas monetárias não convencionais pelo BCE levantam questões sobre a possibilidade de a política monetária estar a reagir à política orçamental, pondo em causa a independência do banco central. Esta questão é avaliada com um modelo VAR estrutural estimado com projeções de variáveis macroeconómicas. Lidamos com a incerteza quanto ao horizonte de previsão utilizando o método *thick modelling*, onde estimamos um total de 96 modelos e reportamos a mediana dos resultados. Concluímos que a política monetária do BCE reagiu principalmente a alterações de projeções da inflação e não a projeções de défices orçamentais, consistente com um regime de domínio monetário.

Por último, o quarto artigo investiga o impacto das políticas monetária do BCE na sustentabilidade orçamental de uma amostra de países da zona euro. Incrementamos uma função de reação orçamental com uma variável que descreve a política monetária do BCE. As conclusões são as seguintes: Primeiro, políticas monetárias contracionistas (expansionistas) tendem a levar a um aumento (diminuição) do saldo primário. Segundo, a posição da política monetária do BCE influencia significativamente o coeficiente da função de reação orçamental. Por outras palavras, uma política monetária contracionista induz um aumento maior dos saldos primários em resposta a um aumento do rácio dívida-produto do que se a política monetária for neutra ou expansionista. Os resultados obtidos sugerem que uma política monetária expansionista tem o potencial de ajudar a sustentabilidade orçamental. Por outro lado, uma política monetária demasiado contracionista pode agravar o esforço orçamental necessário para satisfazer a restrição orçamental do governo.

Classificação JEL: E02, E52, E58, E61, E62, E63, H62
Palavras-chave: Política Monetária, Programas de Compra de Ativos em Larga Escala, BCE, Política Orçamental, Sustentabilidade Orçamental

Abstract

This dissertation compiles four papers that examine the effects of monetary and fiscal policies in the euro area. Particularly, in the first two papers, this thesis focuses on the impacts and heterogeneity of macroeconomic responses to large scale asset purchase (LSAP) programs undertaken by the ECB. The last two papers explore the interactions of monetary and fiscal policies in the euro area. Individual abstracts for each paper that comprise this thesis are provided below.

In the first paper, a dataset of bank- and regional-level data is used to study the effectiveness and heterogeneity of the transmission mechanism of the ECB's LSAP programs to the real economy. Our results indicate that banks more exposed to government debt securities had higher growth of loans and loans relative to total assets than less exposed banks after the Asset Purchase Programme (APP). However, this effect was not observed after the Pandemic Emergency Purchase Programme (PEPP). Furthermore, our results demonstrate that regions where banks are more exposed to government securities exhibit more favorable macroeconomic outcomes after the APP in GDP, fixed capital formation, unemployment, and compensation of employees than regions with less exposed banks, operating via the bank lending channel. We argue that banks' exposure to LSAPs targeted assets and their geographical location is an important factor determining the magnitude and heterogeneity of the portfolio rebalancing and bank lending transmission mechanisms to the real economy.

The second paper investigates the impacts and heterogeneity of the ECB's LSAP programs of sovereign securities on real GDP, inflation, long-term sovereign bond yields, systemic stress, and the unemployment rate. A structural Bayesian VAR model with six endogenous variables was estimated for 11 euro area countries over the period from 2012:M1 to 2023:M12. To provide robustness to the results, a structural panel Bayesian VAR model is estimated, enabling a straightforward comparison of impulse responses of vulnerable and non-vulnerable countries. The results suggest that the magnitudes of impulse responses were more favorable in countries that were more economically and financially vulnerable. I conclude that financial and economic distress was a source of heterogeneity in the responses to LSAP programs in the euro area.

The third paper investigates whether the ECB's monetary policy is reacting to projected fiscal deficits. The increasing debt-to-GDP ratios of euro area member countries and the ECB's extensive use of unconventional monetary policies raise questions whether monetary policy is reacting to fiscal policy. We assess this question with a forward-looking structural VAR model using macroeconomic forecasts for the euro area. We address the uncertainty regarding the forecast horizon inherent to this research question by using a thick modelling approach, where we estimate a total of 96 models and report the median results. The results suggest that the ECB's monetary policy mostly reacted to projected inflation and was not impacted by changing projected fiscal deficits, consistent with a monetary dominance regime.

The fourth paper investigates the impact of monetary policy on fiscal sustainability in the euro area. Our sample includes 12 euro area countries and covers the period from 2003:Q1 to 2022:Q4. We extend a fiscal reaction function by including the monetary policy stance as an interaction term. Our findings are as follows: First, a contractionary (expansionary) monetary stance tends to lead to an increase (decrease) in the primary balance. Second, the ECB's monetary policy stance significantly influences the fiscal reaction function coefficient. In other words, contractionary monetary policy induces a larger increase in primary balances in response to an increase in the debt-to-GDP ratio than if monetary policy was neutral or expansionary. Our findings suggest that monetary policy has the potential to help fiscal sustainability and mitigate fiscal fatigue. Conversely, contractionary monetary policy can exacerbate the fiscal effort required to satisfy the governments' budget constraint.

JEL Classification: E02, E52, E58, E61, E62, E63, H62

Keywords: Monetary Policy, Large Scale Asset Purchases, ECB, Fiscal Policy, Fiscal Sustainability

Table of Contents

List of Figures

List of Tables

Appendix

Chapter 1: Introduction

During and after the turbulent period of the Global Financial Crisis (GFC) of 2008 and the European sovereign debt crisis, the challenges faced by the European Central Bank (ECB) became increasingly more pronounced. As the policy rates reached the zero lower bound (ZLB), the ECB was compelled to turn to unconventional monetary policies (UMP) to overcome deflationary pressures, reduce substantial sovereign yield differentials between member countries, and stimulate economic growth. Through the use of these policies, the ECB preserved the transmission of monetary policy to the real economy. This constituted a paradigm shift in the conduct of monetary policy in the euro area as it marked a departure from “conventional” policies to a broader set of tools. The use of UMPs sparked a lively debate amongst policymakers and academics about their appropriateness and effectiveness. At present, there are still lingering questions in the literature regarding the real impacts of these policies in the economy and through which channels of transmission they operate.[1]

Monetary and fiscal policies play an important role in stabilizing the macroeconomy, both in terms of cyclical output volatility and inflation. This macroeconomic stabilization function can be considered an important undertaking for sustained and sustainable economic growth and to mitigate other socio-economic impacts of recessions.[2] This topic is of particular importance for the European economy as the coordination of single monetary policy with fragmented fiscal policy decisions by individual governments has proved a hard endeavor. Furthermore, while the ECB’s single mandate is price stability, one can convincingly argue that the ECB can be prompted to act in extraordinary circumstances to pursue other macroeconomic outcomes and guarantee stability within the union. This focus became increasingly clear following the famous *“whatever it takes speech”* in 2012 by then president of the ECB, Mario Draghi. This speech signaled the ECB’s unwavering commitment to save the euro when faced with extraordinary circumstances. Even though this was an important undertaking for

[1] Bhattarai and Neely (2022) provide a detailed review of the UMP literature. Borio and Zabai (2018) and Bernanke (2020) provides an interesting after the fact analysis and discussion of UMPs.

[2] For references that provide arguments and discuss the importance of the macroeconomic stabilization function see, for instance, Musgrave (1973), Fischer (1993), Barro (1995). For an analysis on the negative socio-economic impacts of recessions see, for instance, Stuckler et al. (2009) and Hoynes et al. (2012).

stabilizing the European economy, it can also raise questions with regards to the independence of the central bank and the single mandate of price stability. Specifically, monetary policy could be reacting to fiscal developments and be further moving away from a pure rules-based approach. I believe that the study of monetary and fiscal policies today is an important undertaking to inform and guide the correct and effective use of the tools available to policymakers. This thesis explores the policies undertaken by the ECB since its creation until recent times. Specifically, this thesis focuses on the macroeconomic effects and heterogeneities of large scale asset purchase (LSAP) programs in the euro area (Chapters 2 and 3), and the interactions between monetary and fiscal policies (chapter 4 and 5). I hope that, with the writing of this thesis, I am able to provide a modest contribution to this strand of literature.

Chapter 2 investigates how the Asset Purchase Programme (APP) and the Pandemic Emergency Purchase Programme (PEPP) influenced credit supply in the euro area. The monetary policy transmission mechanism considered in this chapter is the so-called portfolio rebalancing channel. Through this transmission mechanism, banks reduce their exposures to LSAPs targeted assets (in this case, we consider government bonds) and increase their supply of credit to the real economy, one of the intended outcomes of the ECB. Our results suggest that banks more exposed to government securities had larger growth in credit supply than less exposed banks after the APP. However, this result was not verified for the PEPP. A persistent question in the literature is whether the ECB's UMPs generated a positive economic outcome. This question has proved challenging to investigate due to the difficulty in establishing a causational relationship at the country level. Against this backdrop, we investigate whether the increase in credit supply after the APP generated a positive macroeconomic outcome via the bank lending channel in geographies where banks are more exposed to government bonds. We answer this question with a dataset of regional macroeconomic data and with the use of a difference-in-differences methodology. We find that regions with banks more exposed to government securities had more favorable impacts in macroeconomic variables after the APP than regions with less exposed banks, consistent with the portfolio rebalancing and bank lending channels of monetary policy.

Chapter 3 asks whether structural differences between euro area member countries explained heterogenous responses to LSAP programs, in particular the Public Sector Purchase Programme (PSPP). Specifically, I hypothesize that more vulnerable member countries benefited more from LSAPs than less vulnerable countries in the euro area.

Vulnerable countries are defined as having larger debt-to-GDP, lower GDP per capita, a larger unemployment rate, and lower tier 1 bank capital ratios. Through the use of a structural Bayesian VAR model, I find that more vulnerable countries obtained more favorable impulse responses following a shock to the stock of euro area government bonds held by the Eurosystem national central banks (NCBs). The results obtained provide a quantitative assessment of the heterogenous impacts of the PSPP between member countries. I conclude that more vulnerable countries had more positive macroeconomic effects as a response to the ECB's LSAPs than less vulnerable countries.

Chapter 4 asks whether projected fiscal deficits influenced ECB policy making. Since the inception of the euro, many member countries reported large deficits and substantially increased their debt-to-GDP ratios to levels not seen prior. Aligned with unprecedented expansionary monetary policy by the ECB, a question could be raised regarding the monetary dominance regime in the euro area. In other words, is monetary policy accommodating fiscal policy? This situation is undesirable as it poses questions with regards to the independence of the ECB and its price stability mandate. This situation can lead to inflation and eventually default of government debt. In this chapter, we develop a structural VAR methodology estimated in a forward-looking fashion and with a thick modelling approach to study the question posed above. The results obtained suggest that the ECB is not reacting to projected fiscal deficits of euro area member countries. The ECB is reacting mostly to inflation projections, consistent with a monetary dominant regime.

Chapter 5 investigates how the ECB's monetary policies influenced fiscal and debt sustainability in the euro area. To answer this question, a Bohn's fiscal reaction function is extended with a monetary policy stance variable. We find that a contractionary monetary policy stance leads to an increase in the growth of primary balances, while an expansionary monetary policy stance leads to a decrease in the growth of primary balances. Furthermore, we find that if the monetary policy stance is contractionary, an increase in the debt-to-GDP ratio will lead to larger increases in the primary balance than if the monetary policy stance was expansionary or neutral. Given these results, we argue that fiscal policy, for the euro area countries considered in the analysis, acted "responsibly". It could also be argued that monetary policy is exerting a "disciplinary" effect on fiscal policy. Furthermore, the results obtained suggest that monetary policy helped member countries sustain fiscal solvency, while contractionary monetary policy exerted additional strain on public finances.

Together, these four papers provide a comprehensive analysis of the dynamic and complex effects of monetary and fiscal policies in the euro area. This dissertation aims to contribute to the ongoing debate about the appropriateness and effectiveness of these policies. I hope that the contributions and findings provide insights for policymaking, particularly on how to better employ these policies and to achieve sustainable economic outcomes in the euro area.

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Chapter 2: Unconventional Monetary Policy in the Euro Area. Impacts on Loans, Employment, and Investment*

2.1 Introduction

Unconventional Monetary policies (UMPs) played a prominent role in the response to the Global Financial Crisis (GFC) of 2008 and the European sovereign debt crisis. Additionally, their implementation became necessary when policy rates reached the zero lower bound (ZLB) to guarantee the transmission of monetary policy. This situation made UMPs a central topic, leading to a substantial body of research. The prevailing consensus in the literature is that UMPs are effective tools for macroeconomic stabilization, however there are still questions regarding the magnitudes of the impacts and through which channels they operate. It is reasonable to expect that central banks will consider the use of UMPs going forward, thus making the continued analysis of its impacts an important undertaking to better employ them in the future.

A central question to this debate, particularly for the euro area, is whether UMPs were effective at stimulating economic activity. This paper contributes to the literature by providing insights into this question. Specifically, we analyze the impacts of ECB's large scale asset purchases (LSAPs) on credit, GDP, gross fixed capital formation (GFCF), unemployment, and compensation of employees. We consider two monetary transmission mechanisms, namely the portfolio rebalancing channel and the bank lending channel. Given the nature of LSAPs in the euro area, we conjecture two research questions. (1) did banks with higher exposure to government securities experience a larger increase in credit supply following the Asset Purchase Programme (APP) and the Pandemic Emergency Purchase Programme (PEPP), acting via the portfolio rebalancing channel? And (2) did regions[1] with more exposed banks have larger favorable impacts on macroeconomic aggregates, acting via the bank lending channel? With these hypotheses, we intend to test the effectiveness and heterogeneity of LSAPs transmission mechanism to the real

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[1] At the NUTS 2 regional level.

economy in the euro area. To answer these questions, we rely on bank- and regional-level data from BankFocus and Eurostat respectively and employ a difference-in-differences methodology. We argue that our empirical design,[2] particularly the use of a more granular set of regional data, provides an effective method for identifying heterogeneities in macroeconomic responses to LSAP programs in the euro area.

The portfolio rebalancing channel posits that, following an LSAP program, holders of the targeted assets will reallocate their investments to other, perhaps higher yielding assets. As the LSAP programs increase the prices of the targeted assets, investors are incentivized to sell them. Facing a reinvestment decision, investors will consider allocations with better return profiles. For banks, we hypothesize that asset allocations will shift to private sector credit as a natural alternative. Furthermore, banks with larger exposure to the targeted assets could realize capital gains from increased mark-to-market valuations as well as improved overall capitalization. This, in turn, could also spur bank credit supply to the real economy. This mechanism is usually referred in the literature as the net-worth channel or stealth recapitalization.[3] Subsequently, in line with the bank lending channel, easier credit conditions will generate positive macroeconomic impacts in the regions these banks operate.

In this paper, we focus on sovereign securities for two main reasons. First, banks exhibit considerable variability in exposure to government debt securities. And second, government securities represent most of the purchases under the APP and the PEPP, more specifically under the Public Sector Purchase Programme (PSPP). In December 2018, The PSPP holdings amounted to 2.1 trillion euros, or 81.80% of all assets purchased under the APP. However, in theory, it could be argued that government securities are close to risk-free and banks' preferences between government securities and reserves should be similar. For instance, in the U.S., following QE2,[4] empirical studies reveal that there were no significant macroeconomic impacts apart from a decrease in interest rates. Arguably, the same result could have been accomplished with other methods, such as forward guidance.[5] In this paper, we argue that the case is different in the euro area because most sovereign securities are not perceived as riskless by the markets. This situation became increasingly apparent during the European sovereign debt crisis. In 2010 there was a shift

[2] Motivated in part by Rodnyansky and Darmouni (2017), and Luck and Zimmermann (2020).

[3] This transmission mechanism is discussed in Brunnermeier and Sannikov (2014), and Rodnyansky and Darmouni (2017).

[4] During QE2 the Fed only purchased U.S. treasuries.

[5] This result is discussed in Krishnamurthy and Vissing-Jorgensen, 2011, and Luck and Zimmermann, 2020.

in risk perceptions resulting in an increase in yields and a widening of spreads of euro area periphery countries vis-à-vis core countries. During this period, the European banks that were more exposed to sovereign securities restricted loan supply to the real economy. This effect generated a substantial negative macroeconomic impact at the firm level.[6] We suggest that the inverse effect occurred after the ECB's LSAPs. In particular, banks with higher exposure to sovereign securities increased the supply of credit in larger magnitude than banks with lower exposure.

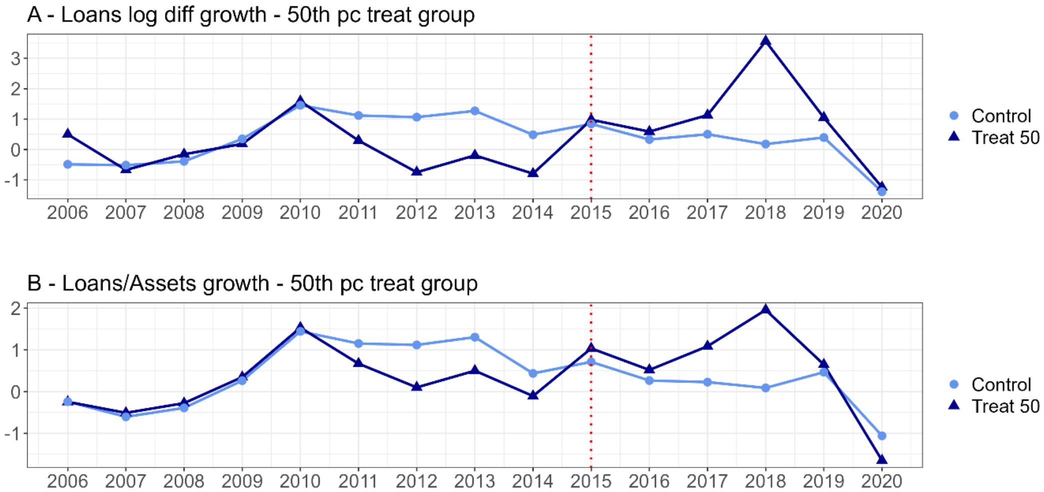
To substantiate the motivation for the hypotheses proposed, we conducted a preliminary analysis using a dataset with 370 banks.[7] This analysis, depicted in Figure 2.1, traces the growth of loans and loans relative to total assets (henceforth loans/assets) from 2006 to 2020 in the euro area. Figure 2.1 reveals that the growth of loans of all banks in the sample was very similar prior to 2010, that is, prior to the European sovereign debt crisis. After 2010, half of the banks that were more exposed to government securities[8] had a sharp decrease in the growth of loans and loans/assets. This divergence was sustained until the introduction of the APP in 2015. After 2015 the trend reversed, with more exposed banks exhibiting larger loan growth than less exposed banks. We considered that Figure 2.1 provides convincing support for the presence of the portfolio rebalancing channel in the euro area following the APP, justifying further research.

[6] These findings are reported and discussed in Popov and Van Horan (2015), Acharya et al. (2018), De Marco (2019), and Bottero et al. (2020).

[7] The sample was retrieved from BankFocus and includes a total of 370 banks in the euro area from year-end 2006 to year-end 2020.

[8] Exposure is measured as government securities over total assets in year-end 2014.

Figure 2.1: Preliminary analysis of loans and loans/assets growth



Notes: The "Treat 50" group is represented by the upper 50th percentile group of banks that were more exposed to government securities relative to total assets in year-end 2014. The remaining banks constitute the control group. The sample includes a total of 370 banks in the euro area. The vertical red dotted line represents year-end 2015, the first data point after the APP announcement. This figure reveals that prior to the European sovereign debt crisis, the growth of loans and loans/assets followed a similar trend. During the sovereign debt crisis, banks more exposed to sovereign securities significantly reduced loan growth compared to less exposed banks. This trend was reversed from 2015 to 2018, coinciding with the introduction of the APP programme.

The results obtained in our study confirm the first hypothesis proposed for the APP. That is, banks with higher exposure to government debt securities had, on average, larger growth of loans and loans/assets than less exposed banks. However, this finding was not confirmed for the PEPP. We propose several potential explanations for the differing results between programs. First, banks' exposure to government securities prior to the PEPP was substantially lower than prior to the APP. Less exposure indicates diminished capacity for banks to trade government securities for reserves. Second, the valuations of euro area government securities were substantially higher prior to the PEPP than the APP. This leads to fewer opportunities for capital gains from increased asset valuations. Third, the COVID-19 pandemic marked a period of considerable uncertainty, which might have sparked a flight to quality effect. Under a flight to quality scenario, banks have higher demand for safer assets such as government debt compared to private debt. And lastly, the period analyzed for the PEPP is much shorter than for the APP. Thus, a possible lag in responses may not be captured in our analysis.

Leaning on the previous conclusion — that banks more exposed to government securities supplied more credit to the real economy after the APP —, we hypothesize that geographies with more exposed banks, and thus larger credit supply growth on average, may have experienced more favorable macroeconomic impacts after the APP than regions with less exposed banks. In the literature, this transmission mechanism is commonly referred to as the bank lending channel. Since the first hypothesis was only confirmed for the APP but not the PEPP, this second analysis is only executed for the APP. To investigate the second hypothesis, we first calculate the weighted average exposure of banks to government securities for each NUTS 2 region. Then, we match this average exposure variable with macroeconomic data from Eurostat at the NUTS 2 regional level.

The results obtained for the second hypothesis indicate that regions with more exposed banks had, on average, more favorable macroeconomic impacts in GDP, GFCF, unemployment, and compensation of employees than regions with less exposed banks after the introduction of the APP. These findings suggest that the bank lending channel produced significant heterogeneous macroeconomic responses between regions. However, we recognize that our empirical strategy rests on a few assumptions that might not be met, for instance, the regionality of banks — banks only lend in the same region as the address of their headquarters. To overcome this limitation, we undertake a robustness exercise where we exploit a dataset with 61,755 bank branches to provide a more accurate regional exposure estimate and hence provide further validity to the results. This robustness exercise yielded the same overall results.

As an empirical exercise, the transmission of monetary policy to the real economy is difficult to isolate and measure due to the absence of a control group. The question of what could have happened if certain UMPs were not undertaken is a causational relationship that is generally hard to establish in a natural experiment setting at the country level as there are many dynamics at play. We argue that the increased granularity offered by regional-level data facilitates the identification of the underlying heterogeneous macroeconomic effects resulting from LSAP programs. By attributing an average bank exposure variable to regions, and then matching it with NUTS 2 macroeconomic data, we construct a dataset that enables us to perform a convincing and relevant counterfactual analysis.

This paper contributes to the literature with two main findings. First, banks more exposed to government securities in the euro area had larger growth in loans and loans/assets than less exposed banks operating via the portfolio rebalancing channel. Second, regions in the euro area where banks had a higher weighted average exposure to government securities had larger favorable impacts on macroeconomic variables such as GDP, GFCF, unemployment, and compensation of employees operating via the bank-lending channel. The results obtained in this study suggest that the balance sheet composition of banks is an important determinant for the magnitude and heterogeneity of banks' reactions to LSAP programs. This, in turn, leads to heterogeneous macroeconomic impacts depending on the geographical location of more exposed banks. Provided that banks perform the fundamental role of allocating capital for productive use, and much of monetary policy transmission acts through the banking sector, we suggest that close attention is warranted to the balance sheet composition of banks prior to the implementation of LSAP programs. Moreover, these findings have particular relevance for the European economy due to its large dependence on bank financing.

This chapter is organized as follows. Section 2.2 reviews the literature. Section 2.3 reviews the data and assumptions. Section 2.4 reviews the empirical strategy. Section 2.5 reports the results. Lastly, Section 2.6 concludes.

2.2 Related Literature

The present study follows closely on the literature strands of monetary policy transmission mechanisms, specifically the portfolio rebalancing channel and the bank lending channel. Banks play an important role in the intermediation of credit, thus the bank lending channel serves as one of the most direct transmission mechanisms for influencing the real economy (Bernanke & Blinder, 1988; Kashyap & Stein, 1994). Correspondingly, Bernanke and Blinder (1992) argue that a tightening of monetary policy, via the federal funds rate, results in a reduction of loans underwritten by banks, depressing the economy and increasing unemployment. Bernanke and Gertler (1995) also noted that the short-term federal funds rate has implications for the long-term output of durable goods and long-term rates. They further argue that the increased cost of funds reduces the bank supply of credit, harming predominantly bank dependent borrowers. Kashyap and Stein (2000) argue that the influence of monetary policy on banks' lending behavior is significantly more pronounced for banks with less liquid balance sheets.

The composition of banks' balance sheets is an important determinant of their responses to macroeconomic shocks. Recent empirical evidence suggests that during the European sovereign debt crisis, banks that were more exposed to government securities curtailed credit to a greater extent than less exposed banks. This effect generated worse real economic outcomes (i.e. employment and investment) for firms with relationships with more exposed banks (Popov & Van Horan, 2015; Acharya et al., 2018; De Marco, 2019; Bottero et al., 2020). Similarly for the U.S., Chodorow-Reich (2014b) argues that reduced firm credit was a principal factor in explaining unemployment in the U.S. following the GFC. Workers from industries with high external finance dependence were the most impacted (Duygan-Bumpa et al., 2015). A contraction in credit and private investment, in turn, can detrimentally impact GDP (Afonso & St. Aubyn, 2019). Overall, a sudden reduction in credit supply can exacerbate a downturn.

Monetary policies and incentives for credit creation can promote macroeconomic stabilization during recessions. However, when the policy rates reach the ZLB, central banks face significant challenges in influencing the economy through conventional policy. Therefore, at the ZLB, UMPs become necessary. Interestingly, in a theoretical framework, Eggertsson and Woodford (2003) argue that central banks cannot influence macroeconomic outcomes through open market operations at the ZLB. However, this result is disputed empirically as many studies find evidence of macroeconomic impacts from open market operations. There are many UMPs transmission mechanisms discussed in the literature. Specifically in this paper, we consider the portfolio rebalancing channel. In more detail, the portfolio rebalancing channel posits that, following LSAP programs, holders of the targeted assets will reallocate their investments to other, perhaps higher yielding assets (Gambetti & Musso, 2017; Koijen et al., 2017; Albertazzi et al., 2018; Paludkiewicz, 2021). Empirical evidence on recent LSAPs suggests that these programs can effectively impact the real economy. For instance, Eser and Schwaab (2013) find that the ECB's Securities Markets Programme (SMP) was successful in decreasing yields and spreads of targeted sovereign securities.[9] Furthermore, findings by Koetter (2020) indicate that German banks that were more exposed to targeted SMP securities had larger growth in credit supply than less exposed banks, the impact being more significant for commercial lending. Blattner et al. (2021) investigates bank credit supply in Portugal and argue that LSAP programs were more effective at reducing banks' exposure to sovereign debt and stimulating credit supply than other signaling events (e.g. OMT). Findings by Rodnyansky and Darmouni (2017) for the U.S. economy, indicate that banks more exposed to MBS loaned more following QE1 and QE3. In another U.S. centric study, Luck and Zimmermann (2020) argue that the Fed's QE programs affected real economic outcomes via the bank lending channel, specifically reducing unemployment. The authors

[9] The SMP targeted government debt from Greece, Ireland, Italy, Portugal, and Spain only. The operations were "sterilized" with regards to money supply.

argue that this effect was more pronounced in geographical areas where banks held more troubled assets, particularly MBS. Chodorow-Reich (2014a) argues that the Fed's LSAP programs benefited financial institutions by raising the value of legacy assets. Paludkiewicz (2021), using a dataset of bank security holdings in Germany, finds evidence of a yield induced portfolio rebalancing channel. Through this transmission channel, banks that had a larger average yield decline in their securities portfolio increased lending to the real sector more substantially after the APP. The decrease in yields resulting from LSAPs could induce investors to buy riskier assets to meet a particular return, a mechanism called search for yield or the risk-taking channel (Adrian & Shin, 2010; Borio & Zhu, 2012; Dell'Ariccia et al., 2017). This mechanism usually works in tandem with the portfolio rebalancing channel. In the case of banks, private credit yields could become an increasingly attractive asset allocation versus LSAP targeted assets (i.e. government bonds).

The practice of influencing long term interest rates by reenforcing the central bank's commitment to its policies is usually referred to as forward guidance (McKay et al., 2016) and the signaling channel (Bauer & Rudebusch, 2014; Bhattarai et al., 2015). Monetary policy announcements, either conventional or unconventional, usually have significant impacts on interest rates and sovereign yields. For instance, Afonso et al. (2018) argues that the ECB's Outright Monetary Transactions (OMT) program had a significant effect on the yields and spreads of European government bonds, particularly on periphery countries. Under the OMT, the ECB declared that it was willing to do *"whatever it takes"* to support the euro. However, there was no immediate massive purchase of assets in the market. Arce et al. (2017) argues that announcements can have larger effects on yields than asset purchases. Krishnamurthy and Vissing-Jorgensen (2011) highlight that the Fed's QE2 did not have significant impacts apart from a reduction of the yields of safer assets. The authors argue that the same effect could have been achieved without purchasing assets in the market, thereby avoiding placing the Fed's balance sheet at risk. Nevertheless, one can convincingly argue that asset purchases reinforce the commitment by the central bank to maintain the expansionary stance for longer (Bhattarai et al., 2015).

The refinancing channel (Beraja et al., 2019; Di Maggio et al., 2020) is frequently argued to be a consequence of expansionary monetary policy shocks. The lowering of the short-term central bank policy rate places downward pressure on interbank interest rates (e.g. euribor), and by extension commercial bank interest rates. The reduction of benchmark rates provides debtors with additional disposable income, either through refinancing or, in the case of flexible interest rate loans, reduced monthly payments without refinancing. The increase in disposable income can, in turn, induce aggregate demand growth (Di Maggio et al., 2020). An important takeaway from this result is that an increased flow of bank lending directed towards refinancing older liabilities is not necessarily a bad outcome in the short term. Empirical evidence suggests that the refinancing channel was active in the U.S. after the first round of QE (Rodnyansky & Darmouni, 2017; Luck & Zimmermann, 2020). This channel can positively affect aggregate macroeconomic variables without necessarily increasing the outstanding stocks of private debt.

Despite the positive macroeconomic effects from UMPs described above, it should also be underscored that some researchers expressed concerns about conceivable long-term implications of UMPs. The most often voiced being deflationary pressures experienced in the years following the programs (Andrade et al., 2016; Dell'Ariccia et al., 2018), the muted response of the macroeconomy (Acharya et al., 2019), zombie lending (Acharya et al., 2020; Bonfim et al., 2023), interest rates near the ZLB for prolonged periods (Bikker & Vervliet, 2018), diminishing effectiveness of UMPs (Borio, 2020), and increased risk taking under the search for yield mechanism (Jiménez et al., 2014).

2.3 Data Overview and Assumptions

In this section we outline the data used, provide summary statistics, and detail the empirical strategy used. To conduct this study, a sample of banks was retrieved from the Bureau van Dijk BankFocus database. BankFocus is a highly comprehensive database that offers standardized financial statement data for a large number of public and private banks. To the best of our knowledge, this database has not been used to investigate the hypotheses posed in this paper. For the regional analysis, we first use a BankFocus dataset to calculate the average exposure of banks to government securities for each NUTS 2 region. Next, we match this regional exposure variable with macroeconomic variables retrieved from the Eurostat database, at the corresponding NUTS 2 regional code.

2.3.1 Bank-level data

For the bank-level analysis, a sample of euro area banks was retrieved at yearly frequency from BankFocus. Using the attribution of specialization (or bank business model) by the data provider, we kept in our analysis only credit granting institutions, specifically: commercial banks, cooperative banks, savings banks, specialized governmental credit institutions, and real estate and mortgage finance institutions. We removed banks with consolidated statements that also had unconsolidated statements from subsidiaries thus avoiding duplication. We maintained a balanced panel by only retaining institutions that have the necessary variables available for all time periods. We retrieved data on total assets, total liabilities, equity, loans, return on assets (ROA), customer deposits, interbank funding, and government securities. We removed outliers by trimming the sample relative to the growth of loans.[10] The final sample is comprised by 663 banks from 15 euro area countries[11] and spanned a period from 2012 to 2020.

We further subdivided the sample into two time periods, one for the APP and one for the PEPP. We decided to make this distinction because, under the APP, asset purchases grew steadily from 2015 until 2018, after which the growth significantly decelerated. Asset purchases resumed in 2020 in response to the COVID-19 pandemic under the PEPP. This distinction will allow us to assess the effectiveness of the two programs separately. For the APP analysis, the chosen period spans from year-end 2012 to year-end 2018. Provided that the PSPP was announced in early 2015, we consider year-end 2012 to year-end 2014 as the pre-treatment period and year-end 2015 to year-end 2018 as the post-treatment period.[12] For the PEPP, only two time periods are considered, specifically year-end 2019 and year-end 2020. Year-end 2019 constitutes the pre-treatment period and year-end 2020 the post-treatment period. The motivation behind the shorter time span for the PEPP was to isolate the impacts of this program and minimize other potential effects that could still be present from the APP. However, a shorter time window has some disadvantages. First, it will not be possible to test the parallel trends hypothesis as done for APP period. Second, the impact of the PEPP could be delayed and

[10] We removed outliers by trimming observations that deviated by more than 3 standard deviations from the mean. This was done because banks' balance sheets could have been impacted by mergers, acquisitions, or other events that would make the log growth of loans susceptible to outliers.

[11] The sample includes banks from Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia, and Spain. Banks from Latvia and Lithuania were not included because our study predates their inclusion to the euro area. Banks from Estonia and Ireland were not included due to non available data.

[12] It could be argued that pre-signalling effects could have prompted some banks to act before the announcement of the PSPP. As a robustness check, we considered banks' exposure to government securities in year-end 2013, that is, more than one year prior to the PSPP announcement. The results and conclusions did not change qualitatively, therefore we conclude that pre-signalling did not materially affect the results. Further details about this robustness exercise are available under the robustness section.

might not be fully captured in 2020. Nevertheless, we argue that keeping these caveats in mind, the results still provide relevant insights with regards to the short-term impacts of the PEPP.

For each analysis, to test whether exposure to government securities explained variability in the supply of credit, banks were divided into two treatment groups and their respective control groups. The treatment groups are comprised by the upper 50th and 75th percentile of banks more exposed to government debt securities relative to total assets in year-end 2014 for the APP analysis and year-end 2019 for the PEPP analysis. The control groups will be the respective remaining banks from each group. Particularly, they will be comprised of the lower 50th and 75th percentile groups of banks. Even though the banks in both analyses are the same, the exposure could have changed from 2014 to 2019. Therefore, we reassign the treatment groups for each program as more exposed banks could have re-weighted their balance sheets by reducing exposure to government securities after the APP.

The motivation behind the choice of treatment and control groups follows convention and serves as a robustness exercise. We first chose to divide the dataset of banks in two — the upper and lower 50th percentile groups. This is the most common approach in studies with similar empirical designs. To provide further validity to the results, we conjecture that if the upper 75th percentile group has a larger coefficient than the upper 50th percentile group, it provides further validity to our hypothesis. That is, more exposed banks had larger growth in credit supply after the LSAP program.

Table 2.1 presents descriptive statistics of our sample for all time periods (2012-2020). From this table we conclude that there is significant heterogeneity between banks regarding size and asset composition. Table 2.1 also shows that the exposure to government securities in 2019 decreased, on average, by 1.8% compared to 2014. This decline is possibly explained by the portfolio rebalancing effects of the APP.

Table 2.1: Summary statistics for bank-level data

Summary Statistics (2012-2020)
Bank-level data – 663 Banks

Variable	Obs.	Banks	Mean	Std. Dev.	p10	p90
Total Assets (in millions)	5967	663	21,676.68	95,940.65	180.35	23,475.19
Loans (in millions)	5967	663	9,990.16	35,964.25	107.88	15,104.30
Loans/Total Assets (in %)	5967	663	62.50	15.01	41.43	79.00
Δln(Loans) (in %)	5967	663	4.62	6.99	(1.48)	10.93
Δ(Loans/Total Assets) (in %)	5967	663	0.42	3.32	(2.99)	3.70
Equity/Assets (in %)	5967	663	8.95	3.40	5.34	12.40
ROA (in %)	5967	663	0.25	0.43	0.05	0.60
Deposits/Assets (in %)	5967	663	16.51	15.08	2.83	32.90
GovSec/Assets (2014) (in %)	663	663	5.87	8.16	0.45	13.71
GovSec/Assets (2019) (in %)	663	663	4.07	4.49	0.32	9.75

Data source: BankFocus and authors' calculations

Notes: This table provides summary statistics for the bank-level panel data from 2012 to 2020. Specifically, it reports the mean, standard deviation, the 10^{th} percentile, and the 90^{th} percentile. Total assets and Loans are in millions of EUR. The remaining variables are expressed as percentages.

Panel A and B from Table 2.2 reports arithmetic means of the treatment and control groups for the two time periods corresponding to each program — the APP and the PEPP respectively. An important detail from this table is that the treatment groups' average exposure to government securities changed substantially from 2014 to 2019. For instance, the upper 50^{th} percentile group reduced the average exposure from 10.39% to 6.86%. Lower exposure leads to the expectation that the portfolio rebalancing channel is less likely to occur for the PEPP than for the APP as banks have less securities to trade. Moreover, opportunities for capital gains resulting from asset appreciations would also be diminished. Banks comprising the treatment groups exhibit, on average, significantly more assets than their respective control groups. Conversely, the control groups exhibit, on average, larger loans/assets, deposits/assets, and equity/assets. This difference reveals that banks from the control group are smaller and exhibit more conservative business models. Given these differences, in our main specifications, we control for bank fixed effects and other bank-level controls that capture these idiosyncrasies.

Table 2.2: Summary statistics for bank-level data by LSAP program and treatment group

Bank-level data – 663 Banks (50th and 75th treatment and respective control groups)

50th perc. and respective control group	Mean	75th perc. and respective control group	Mean
Panel A: APP – Summary Statistics (2012-2018)			
50th perc. and respective control group	Mean	75th perc. and respective control group	Mean
Avg. exposure to gov. securities in year-end 2014 (50th perc.) (in %)	10.39	Avg. exposure to gov. securities in year-end 2014 (75th perc.) (in %)	16.22
Avg. exposure to gov. securities in year-end 2014 (Control) (in %)	1.36	Avg. exposure to gov. securities in year-end 2014 (Control) (in %)	2.41
Δln(Loans) (50th perc.) (in %)	3.95	Δln(Loans) (75th perc.) (in %)	4.15
Δln(Loans) (Control) (in %)	4.63	Δln(Loans) (control) (in %)	4.34
Δ(Loans/Total Assets) (50th perc.) (in %)	0.71	Δ(Loans/Total Assets) (75th perc.) (in %)	0.65
Δ(Loans/Total Assets) (Control) (in %)	0.73	Δ(Loans/Total Assets) (Control) (in %)	0.74
Total Assets (50th perc.) (in millions)	34,436.17	Total Assets (75th perc.) (in millions)	48,901.83
Total Assets (Control) (in millions)	7,833.90	Total Assets (Control) (in millions)	11,834.06
Loans/Total Assets (50th perc.) (in %)	58.37	Loans/Total Assets (75th perc.) (in %)	55.59
Loans/Total Assets (Control) (in %)	65.82	Loans/Total Assets (Control) (in %)	64.27
Equity/Assets (50th perc.) (in %)	8.61	Equity/Assets (75th perc.) (in %)	8.36
Equity/Assets (Control for 50th) (in %)	9.11	Equity/Assets (Control) (in %)	9.03
ROA (50th perc.) (in %)	0.21	ROA (75th perc.) (in %)	0.19
ROA (Control) (in %)	0.29	ROA (Control) (in %)	0.28
Deposits/Assets (50th perc.) (in %)	65.29	Deposits/Assets (75th perc.) (in %)	62.60
Deposits/Assets (Control) (in %)	69.75	Deposits/Assets (Control) (in %)	69.17
Interbank/Liabilities (50th perc.) (in %)	16.30	Interbank/Liabilities (75th perc.) (in %)	15.79
Interbank/Liabilities (Control) (in %)	17.59	Interbank/Liabilities (Control) (in %)	17.34
Panel B: PEPP – Summary Statistics (2019-2020)			
50th perc. and respective control group	Mean	75th perc. and respective control group	Mean
Avg. exposure to gov. securities in year-end 2019 (50th perc.) (in %)	6.86	Avg. exposure to gov. securities in year-end 2019 (75th perc.) (in %)	9.85
Avg. exposure to gov. securities in year-end 2019 (Control) (in %)	1.29	Avg. exposure to gov. securities in year-end 2019 (Control) (in %)	2.14
Δln(Loans) (50th perc.) (in %)	5.47	Δln(Loans) (75th perc.) (in %)	5.79
Δln(Loans) (Control) (in %)	6.05	Δln(Loans) (control) (in %)	5.75
Δ(Loans/Total Assets) (50th perc.) (in %)	(0.68)	Δ(Loans/Total Assets) (75th perc.) (in %)	(0.48)
Δ(Loans/Total Assets) (Control) (in %)	(0.54)	Δ(Loans/Total Assets) (Control) (in %)	(0.66)
Total Assets (50th perc.) (in millions)	30,120.09	Total Assets (75th perc.) (in millions)	44,663.49
Total Assets (Control) (in millions)	17,184.68	Total Assets (Control) (in millions)	16,621.58
Loans/Total Assets (50th perc.) (in %)	60.84	Loans/Total Assets (75th perc.) (in %)	57.41
Loans/Total Assets (Control) (in %)	66.92	Loans/Total Assets (Control) (in %)	66.05
Equity/Assets (50th perc.) (in %)	9.06	Equity/Assets (75th perc.) (in %)	8.96
Equity/Assets (Control) (in %)	9.44	Equity/Assets (Control) (in %)	9.35
ROA (50th perc.) (in %)	0.18	ROA (75th perc.) (in %)	0.23
ROA (Control) (in %)	0.26	ROA (Control) (in %)	0.22
Deposits/Assets (50th perc.) (in %)	69.05	Deposits/Assets (75th perc.) (in %)	65.75
Deposits/Assets (Control) (in %)	70.64	Deposits/Assets (Control) (in %)	71.22
Interbank/Liabilities (50th perc.) (in %)	14.67	Interbank/Liabilities (75th perc.) (in %)	14.96
Interbank/Liabilities (Control) (in %)	15.32	Interbank/Liabilities (Control) (in %)	15.00

Data source: BankFocus and authors' calculations

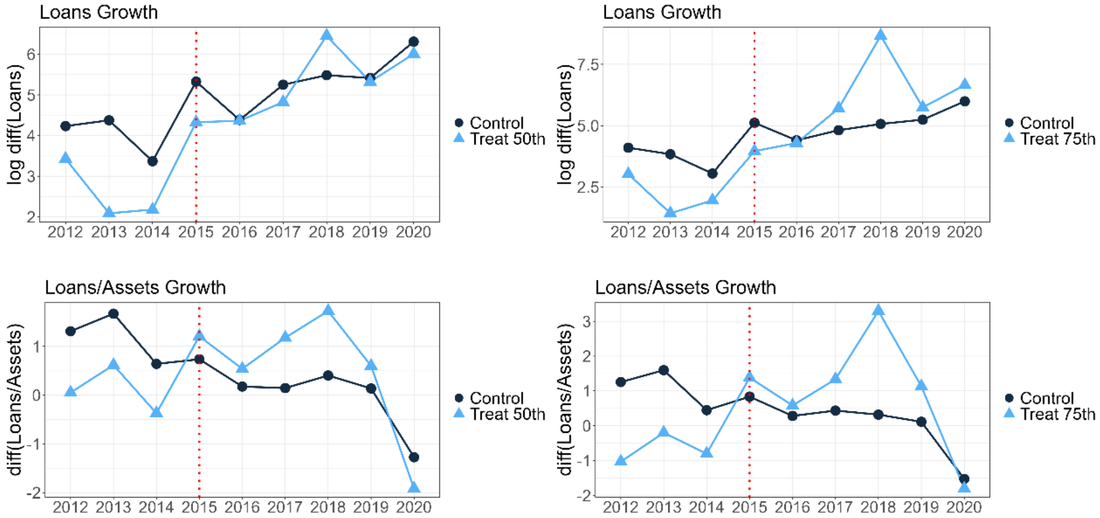
Notes: This table reports the arithmetic means of the variables belonging to the treatment and control groups for time periods corresponding to the APP and the PEPP. APP exposure is taken from year-end 2014 and the PEPP exposure is taken from year-end 2019. The treatment groups are the upper 50th and 75th percentile groups of banks more exposed to government securities. The control groups are the lower 50th and 75th percentile groups respectively.

To guarantee the validity of the difference-in-differences research design used in this paper, the confirmation of the parallel trends' assumption between the treatment and control groups is necessary. Specifically, we need to verify that the trend in the growth of loans and loans/assets between the treatment and control groups were similar during the pre-treatment period.[13] Figure 2.2 shows the average log differences growth of loans and first differences growth of loans/assets for all treatment and control groups. This illustration provides visual evidence that the parallel trends assumptions hold. The relationship seems more robust for loans/assets than for the direct growth of loans, where this assumption is harder to establish. The European sovereign debt crisis presents added difficulty for the confirmation of this assumption. As suggested by Figure 2.1 previously, there was a divergence in credit growth between more and less exposed banks between 2010 and 2015.

Figure 2.2 suggests that, after the introduction of the APP, the growth of loans demonstrates a more delayed reaction than loans/assets. This figure also provides some visual evidence that, in the pre-treatment period, the growth of loans and loans/assets was lower for the treatment groups. That is, banks that were more exposed to government securities curtailed the supply of loans in larger magnitude than less exposed banks during this period. This trend started to reverse around 2015-2016, coinciding with the introduction of the APP and the PSPP. Moreover, the data reveals that in 2018 there was a sharp spike in the growth of loans and loans/assets for the treatment group. Possibly, this indicates a delayed impact of the APP or, perhaps, banks repositioned their balance sheets as a response to the announced winding down of the APP by the ECB, which was to take place during 2018. The treatment groups' growth of loans and loans/assets dropped again in 2019. Both groups' growth of loans and loans/assets is similar in 2020. Therefore, the plots suggests that the short-term effects of the PEPP were ineffective at spurring bank credit.

[13] In the results section, we conduct a difference-in-differences event study that tests the parallel trends assumption for the pre-treatment period in a more formal manner. Results from this specification indicate that the parallel trends hold.

Figure 2.2: Average growth of loans and loans/assets for the treatment and control groups.



Notes: This figure reports the average log differences growth of loans and the first differences growth of loans/assets for the 50th and 75th percentile treatment groups of banks more exposure to government debt securities at year-end 2014 compared to the control groups. The red dotted line represents year-end 2015, the first data point after the introduction of the APP.

2.3.2 Regional-level data

We make use of a regional dataset from Eurostat to test whether regions where banks are more exposed to government securities had more favourable macroeconomic impacts via the bank lending channel after the APP. To investigate this question, we exploit a new BankFocus dataset with 1,834 banks to estimate an exposure variable to NUTS 2 geographical regions in year-end 2014.[14] A weighted average exposure of banks to government securities was assigned to 124 NUTS 2 regions.[15] We then matched this variable with regional macroeconomic data from Eurostat. NUTS 2 regions were chosen because it is large enough to assume that borrowing households and firms would be in the same location as the lending bank and still offer enough granularity to identify potential heterogeneity in macroeconomic aggregates arising from the portfolio rebalancing and bank lending channels.

The outcome variables in this analysis will be the growth of GDP at current market prices, GFCF, unemployment rate, and compensation of employees. All growth variables are expressed as log first differences, except unemployment rate growth, which is

[14] Provided that we need less bank-level variables for this analysis — we only need bank name, specialisation, location, government debt securities, and total assets — we retrieved a larger sample of banks to increase representativeness and improve the estimation of regional exposure. The specialisation of banks used in this analysis is the same as before.

[15] The specific calculation of the regional exposure variable is explained in more detail under the Empirical Strategy section for the regional-level analysis.

expressed using first differences. Table 2.3 reports summary statistics for the entire regional-level panel. The average bank exposure to government securities for all regions in 2014 is 9.5%. On average, the growth of GDP was 2.24% and the decrease in unemployment was 0.2%, indicating an expansionary period overall. Furthermore, this table reveals sizable variability between regions. This motivated the inclusion of economic and demographic regional controls along with regional and country fixed effects in our main specification. The controls included are GDP, GDP per capita, population, and unemployment.

Table 2.3: Summary statistics for regional-level data

Summary Statistics (2012-2018)
Regional-level data – 124 Regions

Variable	Obs.	Regions	Mean	Std. Dev.	p10	p90
Regional bank exposure in 2014 (in %)	124	124	9.50	10.15	25.13	1.61
GDP (in millions of EUR)	868	124	75,853.21	79,572.49	17,405.7	156,266.3
Δlog(GDP) (in %)	868	124	2.34	2.19	-0.06	4.62
Population (in thousands)	868	124	2,342.53	1,950.55	554.6	4,909.81
Unemployment (in %)	868	124	9.01	5.91	3.27	18
ΔUnemployment (in %)	868	124	-0.20	1.23	-1.5	1.2
ΔGFCF (in %)	868	124	2.18	8.37	-6.42	9.94
ΔCompensation Employees (in %)	868	124	2.48	2.5	-0.31	4.77
GDP per capita (in thousands of EUR)	868	124	32.18	11.55	20.28	46.31

Data source: Eurostat and authors' calculations

Notes: This table reports summary statistics for the regional analysis comprising 124 NUTS 2 regions. We report the mean, standard deviation, 10^{th} percentile, and 90^{th} percentile values for the entire panel.

Similar to the bank-level analysis, regions were assigned to treatment groups. As before, the treatment groups consist of the upper 50^{th} and 75^{th} percentile groups of regions with more exposed banks. The respective remaining banks were classified as the control groups. Table 2.4 reports summary statistics for the treatment and control groups separately. From this table, it can be inferred that there is some variability between groups. The treatment exhibits lower growth of GDP, GFCF, compensation of employees, and higher unemployment. Table A1 (in the Appendix) discriminates the number of regions and banks per country used to assign the regional exposure variable. Due to the structure of the financial system and size of some countries, most of the regions with an attributable exposure variable are from Germany, France Italy, Spain, and Austria.

Table 2.4: Summary statistics for regional level data by treatment group

Regional-level data -124 Regions (50th and 75th treatment and respective control groups)

Summary Statistics (2012-2018)			
50th perc. and respective control group	Mean	75th perc. and respective control group	Mean
Avg. regional exposure in year-end 2014 (50th perc.) (in %)	16.00	Avg. regional exposure in year-end 2014 (75th perc.) (in %)	23.69
Avg. regional exposure in year-end 2014 (Control) (in %)	3.00	Avg. regional exposure in year-end 2014 (Control) (in %)	4.77
GDP (50th perc.) (in millions of EUR)	85,047.73	GDP (75th perc.) (in millions of EUR)	67,998.03
GDP (Control) (in millions of EUR)	66,658.69	GDP (Control) (in millions of EUR)	78,471.60
Δlog(GDP) (50th perc.) (in %)	2.31	Δlog(GDP) (75th perc.) (in %)	1.94
Δlog(GDP) (Control) (in %)	2.37	Δlog(GDP) (Control) (in %)	2.48
Population (50th perc.) (in thousands)	2,566.56	Population (75th perc.) (in thousands)	2,397.38
Population (Control) (in thousands)	2,118.50	Population (Control) (in thousands)	2,324.25
Unemployment (50th perc.) (in %)	9.64	Unemployment (75th perc.) (in %)	11.36
Unemployment (Control) (in %)	8.37	Unemployment (Control) (in %)	8.23
ΔUnemployment (50th perc.) (in %)	-0.16	ΔUnemployment (75th perc.) (in %)	-0.07
ΔUnemployment (Control) (in %)	-0.24	ΔUnemployment (Control) (in %)	-0.24
ΔGFCF (50th perc.) (in %)	1.93	ΔGFCF (75th perc.) (in %)	1.19
ΔGFCF (Control) (in %)	2.43	ΔGFCF (Control) (in %)	2.51
ΔCompensation Employees (50th perc.) (in %)	2.31	ΔCompensation Employees (75th perc.) (in %)	1.75
ΔCompensation Employees (Control) (in %)	2.66	ΔCompensation Employees (Control) (in %)	2.72
GDP per capita (50th perc.) (in thousands of EUR)	32.85	GDP per capita (75th perc.) (in thousands of EUR)	28.58
GDP per capita (Control) (in thousands of EUR)	31.52	GDP per capita (Control) (in thousands of EUR)	33.38

Data source: Eurostat and authors' calculations

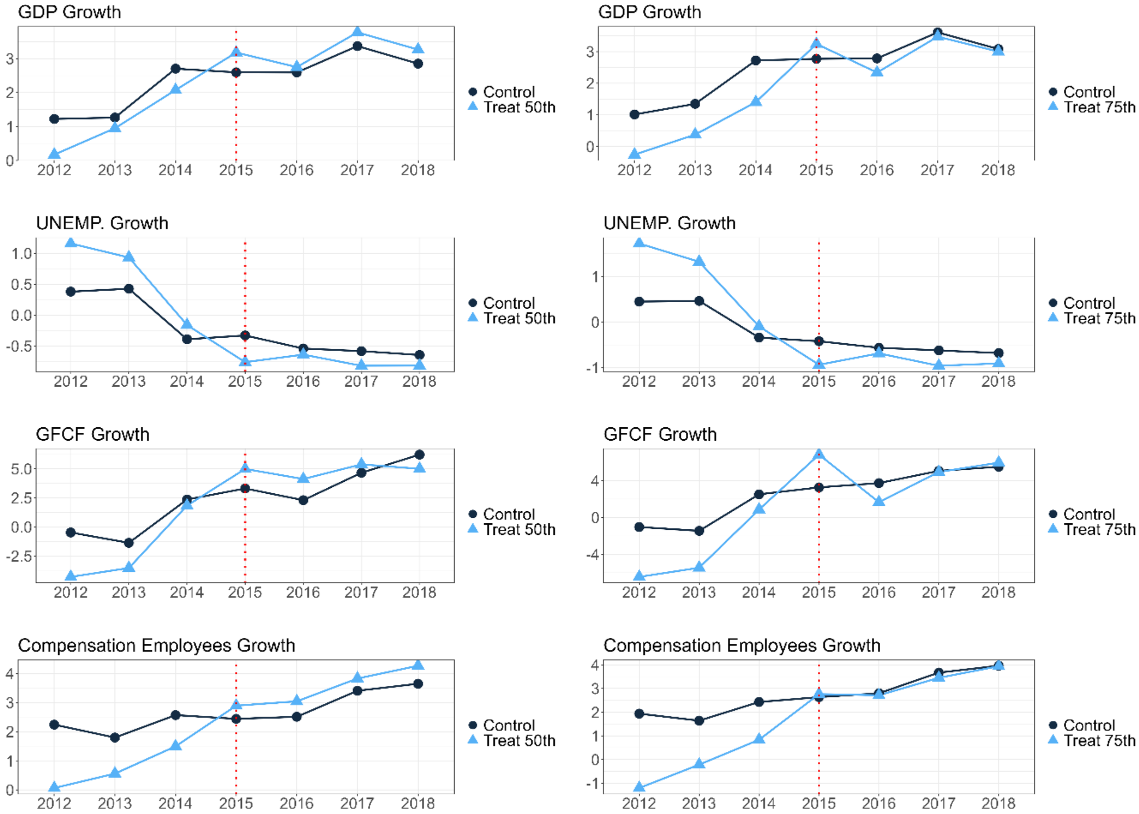
Notes: This table reports summary statistics for the regional analysis comprised of 124 NUTS 2 regions. The treatment groups are the upper 50th and 75th percentile groups of regions where banks are more exposed to government securities. The control groups are the lower 50th and 75th percentile groups respectively.

To guarantee the validity of our difference-in-differences methodology, the parallel trends assumption needs to be confirmed as previously discussed for the bank-level analysis. Figure 2.3 reports the average values per year for the treatment and control groups. This figure suggests similar trends from 2012 to 2014 for most of the variables considered.[16] However, similar to the former analysis with the bank-level data, the European sovereign debt crisis exerted some macroeconomic divergence between regions which constitutes a challenge for the confirmation of the parallel trends assumption. Furthermore, the treatment groups' growth is particularly subdued in the pre-treatment period but seems to improve more than the controls after 2015. In summary, Figure 2.3 seems to align with our second hypothesis, that is, regions where banks are more exposed to government securities generally experienced more favourable economic impacts

[16] The parallel trends are also tested with a difference-in-differences event study reported under the Results section for the regional-level analysis.

following the introduction of the APP. Another intriguing observation is that the impact seems to be immediate. The biggest positive impact for the treatment groups for most variables is year-end 2015, the first observation after the introduction of the APP. In the bank level analysis, the impact was sustained for the duration of the program. This difference could indicate that the favourable macroeconomic conditions were a result of immediate eased financing conditions.

Figure 2.3: Regional growth of macroeconomic variables for the treatment and control groups.



Notes: This figure reports the average growth of GDP, unemployment rate, GFCF, and total employee compensation for the upper 50th and 75th treatment groups of regions where banks are more exposed to government debt securities relative to total assets compared to their respective control groups.

2.4 Empirical Strategy

2.4.1 Bank-level analysis

We start this analysis by calculating each bank's exposure to government securities. This variable is calculated as per the below equation where $Bank\_Exposure_b^{(j)}$ is a time invariant variable that equals the proportion of government debt securities relative to total assets of each individual bank b for program j where $j = \{APP, PEPP\}$. For $j = APP$, we use the values from year-end 2014 while for $j = PEPP$ we use the values from year-end 2019.

$$Bank\_Exposure_b^{(j)} = \left(\frac{Gov.Debt\ Securities}{Total\ Assets}\right)_b^{(j)}$$

The $Bank\_Exposure_b^{(j)}$ variable will allow us to distribute the banks into treatment and control groups. As discussed in the previous section, we define the treatment groups as the upper 50th and 75th percentile groups of banks more exposed to government securities. The respective remaining banks will be classified as the control groups. Under this methodological framework, it is relevant to note that that both the treatment and the control groups receive "treatment". In other words, both groups are exposed to government securities but to varying degrees. Therefore, the banks near the bottom of the treatment group and at the top of the control group should exhibit similar exposure. However, we conceive that the average effects for each group will still allow us to obtain relevant results.

Equations 1, 2, and 3 represent the main specifications of the bank-level analysis. Equation 1 represents an event study analysis, where year-end 2014 is used as the reference point. This specification will allow us to strengthen the evidence supporting the parallel trends assumption. Equation 1 is only estimated for the APP because the PEPP only considers two time periods, thus making it unfeasible to test the parallel trends hypothesis. Equation 2 represents the difference-in-differences analysis where the results provide a comparison between the pre-treatment and post-treatment periods. Lastly, Equation 3 uses the time invariant bank exposure variable directly. This circumvents possible group selection bias problems. We estimate the following equations:

$$y_{bct} = \sum_{k=2012,k\neq 2014}^{2018} \beta_k \left(Treat_b^{(j)} \times Period_k\right) + \theta X_{bt}^{(n)} + \Gamma(Country_c \times Time_t) + \lambda_b + \tau_t + \epsilon_{bct} \quad (1)$$

$$y_{bct} = \beta\left(Treat_b^{(j)} \times LSAP_t^{(j)}\right) + \theta X_{bt}^{(n)} + \Gamma(Country_c \times Time_t) + \lambda_b + \tau_t + \epsilon_{bct} \quad (2)$$

$$y_{bct} = \beta\left(Bank\_Exposure_b^{(j)} \times LSAP_t^{(j)}\right) + \theta X_{bt}^{(n)} + \Gamma(Country_c \times Time_t) + \lambda_b + \tau_t + \epsilon_{bct} \quad (3)$$

where y_{bct} is the outcome variable and it will take the form of the log differences growth of loans and the first differences growth of loans/assets of bank b in country c at time t. $Treat_b^{(j)}$ represents a binary variable equal to 1 for the treatment group and zero otherwise for program j. $Period_k$ will equal 1 if we are in time period k and zero otherwise.[17] For Equation 1, the coefficient for year-end 2014 will be specified to zero, the remaining β_k coefficients will be compared to this reference point. $LSAP_t^{(j)}$ is a binary variable equal to 1 for the period after the announcement of program j and 0 otherwise. For the APP, $LSAP_t^{(APP)}$ will equal 0 from year-end 2012 to 2014 and it will equal 1 from year-end 2015 to 2018. For the PEPP, we only include two time periods, year-end 2019

[17] Where k = {2012,2013,2015,2016,2017,2018}. Year-end 2014 is not included as this will be the reference point.

and 2020. $LSAP_t^{(PEPP)}$ will equal 0 in 2019 and it will equal 1 in 2020. $X_{bt}^{(n)}$ are n bank-level controls for bank b at time t, specifically the natural logarithm of total assets, deposits/assets, return on assets (ROA), equity/assets, and interbank funding/liabilities. These controls are necessary because the exposure to government securities is not random, it reflects banks' business models and preferred asset habitats and thus could impact their propensity to lend to households and firms. The validity of our identification strategy rests on the assumption that loan supply shocks are orthogonal to loan demand factors. To control for potential loan demand factors (Khwaja & Mian, 2008), we follow Kok et al. (2023), and include the interaction $\text{Country}_c \times \text{Time}_t$. Country_c represents a country dummy variable and Time_t represents a year dummy variable. To erase any further potential confounding factors, we include bank and time fixed effects — λ_b and τ_t respectively.

2.4.2 Regional-level analysis

To undertake the regional-level analysis, we start by calculating a variable that captures the exposure of banks to government securities in each NUTS 2 region. Since we need less bank-level variables for this analysis — we only need bank name, specialization, location, government debt securities, and total assets — we retrieved a larger sample of banks from BankFocus to increase representativeness and obtain a more accurate regional exposure variable. We retrieve a total of 1,834 banks from 16 euro area countries.[18] We removed banks with consolidated statements that also had unconsolidated statements from subsidiaries in our sample and thus avoiding duplication. Using the country, city, address, and post code information, each bank location was matched to its respective NUTS 2 region. We define the regional exposure variable as per below.

$$Regional\_Exposure_r = \sum_{b \epsilon r} \omega_{br} \left(\frac{Gov.Sec.}{Total\ Assets} \right)_b, \qquad where\ \omega_{br} = \frac{Total\ Assets_{b,r}}{\sum_{b \epsilon r} Total\ Assets_b}$$

where $Regional\_Exposure_r$ will represent a time invariant weighted average exposure of banks to government debt securities in region *r* in year-end 2014, where *r* represents NUTS 2 regions. ω_{br} will represent the weight of each bank within its respective region.

[18] Latvia and Lithuania were not included due to adopting the euro in January 2014 and January 2015 respectively. Ireland was not included due to unavailable data. The specialisation of banks used in the regional-level analysis was the same as in the bank-level analysis.

This weight is calculated by dividing each bank's total assets over the sum of the assets of all banks in that same region. By considering bank size, we can better gauge the real effect each bank could have had in each region. The new sample of banks allowed us to attribute an exposure to 124 NUTS 2 regions from 16 different euro area countries. From the regional exposure variable calculated above, we create two treatment groups and the respective control groups. Similar to the bank-level analysis, the treatment groups will be the upper 50th and 75th percentiles of regions with banks more exposed to government debt securities. The control groups will be the remaining regions.

To understand if regions with more exposed banks experienced more favourable macroeconomic impacts, we estimate Equations 4, 5, and 6

$$y_{rct} = \sum_{k=2012,k\neq 2014}^{2018} \beta_k (Treat_r^{(APP)} \times Period_k) + \theta X_{rt}^{(n)} + \phi_c + \lambda_r + \tau_t + \epsilon_{rct} \quad (4)$$

$$y_{rct} = \beta\left(Treat_r^{(APP)} \times LSAP_t^{(APP)}\right) + \theta X_{rt}^{(n)} + \phi_c + \lambda_r + \tau_t + \epsilon_{rct} \quad (5)$$

$$y_{rct} = \beta\left(Regional\_Exposure_r^{(APP)} \times LSAP_t^{(APP)}\right) + \theta X_{rt}^{(n)} + \phi_c + \lambda_r + \tau_t + \epsilon_{rct} \quad (6)$$

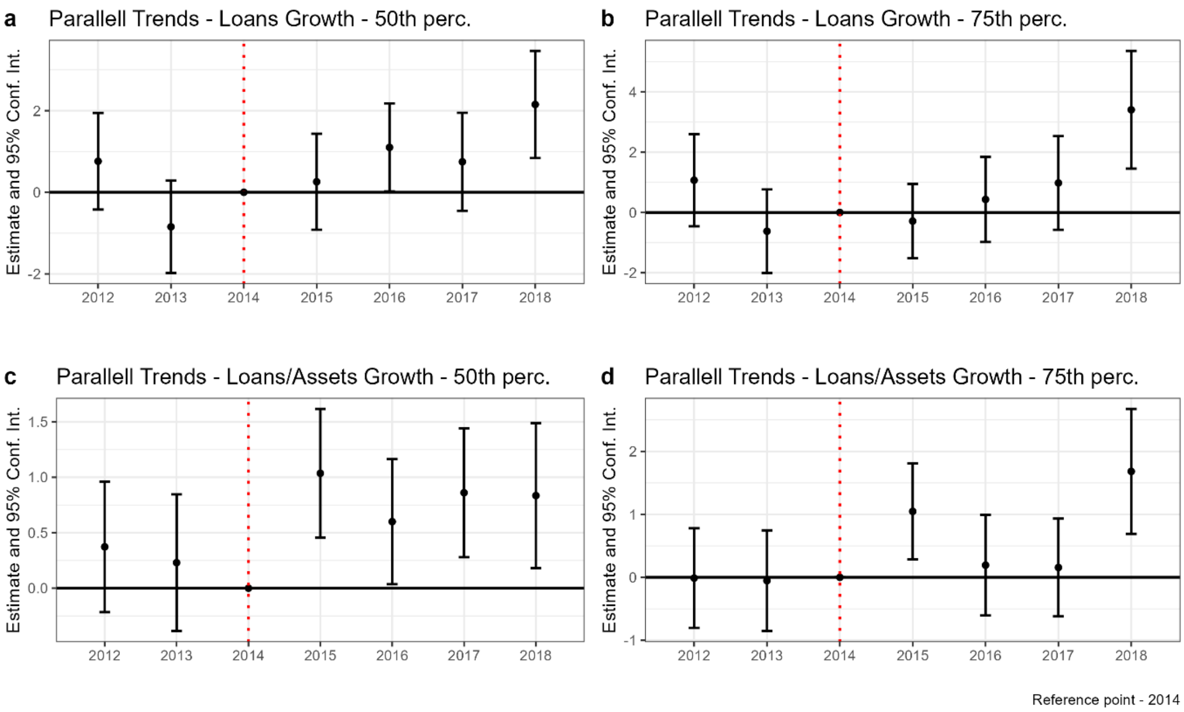
where the outcome variables, y_{rct}, for this analysis are the log differences of GDP, GFCF, and total compensation of employees, and the first differences of the unemployment rate. GFCF growth will be a proxy for regional investment. The unemployment rate and the total compensation of employees will test general employment impacts, as this could be materialized via new hirings or increased remuneration of employees. $Treat_r^{(APP)}$ equals 1 for the treatment group and zero otherwise. The controls, $X_{rt}^{(n)}$, are the natural logarithm of population, the natural logarithm of GDP, the natural logarithm of GDP per capita, and unemployment. These controls are included because the demographic and economic conditions of each region could be important factors to explain the reaction of macroeconomic aggregates to a credit supply shock. We include country (ϕ_c), regional (λ_r), and time (τ_t) fixed effects to remove any potential confounding factors affecting the results. Equation 4 constitutes the event study. Equation 5 constitutes the difference-in-differences analysis. Equation 6 estimates the model with the time invariant $Regional\_Exposure_r$ variable to circumvent any potential treatment group selection bias and parallel trends violations.

2.5 Results

2.5.1 Bank-level analysis – APP

The estimated coefficients from the event study (Equation 1) are reported in Figure 2.4. The coefficients depicted reveal that the log differences growth of loans and the first differences growth of loans/assets for the treatment and control groups are not significantly different than zero during the pre-treatment period. This result is desirable as it suggests that the parallel trends assumption is satisfied. In the post-treatment window, the coefficients of the upper 50th percentile group for the growth of loans are positive and statistically significant in 2016 and 2018. In contrast, the upper 75th percentile group only exhibits statistical significance in the 2018 coefficient. Regarding loans/assets, all the coefficients for the upper 50th percentile group are positive and statistically significant in the post-treatment window. For the upper 75th percentile group, only 2015 and 2018 display statistical significance. Overall, the growth of loans/assets exhibits more statistically significant and robust results. We assume that loans/assets more accurately represent the portfolio rebalancing channel than the direct growth of loans. The growth of the stock of loans can be affected by balance sheet adjustments and other consolidations. We control for this issue by removing outliers, however small consolidations might not be captured. When considered collectively, the results from this specification suggest the confirmation of our first hypothesis. However, the coefficients are not statistically significant for every year the APP was active.

Figure 2.4: Event study with bank-level data



Notes: This figure reports the estimation of the event study described in Equation 1. The coefficients are not statistically significant in the pre-treatment period, which confirms the parallel trends assumption. The results are more robust for the growth of loans/assets.

The regression results of Equation 2 and 3 for the period from 2012 to 2018, covering the APP, are reported in Columns 1 through 6 in Table 2.5. The first noteworthy point to underscore is that all of the coefficients of interest are positive and statistically significant. The results obtained indicate that the treatment groups of banks more exposed to government debt securities had larger growth in loans and in loans/assets in the post-treatment period relative to the pre-treatment period than their respective control groups. This provides support for the portfolio rebalancing hypothesis. As discussed in the Empirical Strategy section, to mitigate confounding factors from loan demand, we include a country and time interaction[19] as in Kok et al. (2023). The results in Table 2.5 reveal that the inclusion of loan demand (Columns 4 through 6) improves statistical significance and exerts substantial influence on the magnitude of the coefficients, particularly for loans/assets. Nevertheless, the sign and overall conclusion are equivalent. Regarding loan growth, the coefficients for the upper 50th and 75th percentile groups are 1.316 and 1.477 respectively, and their statistical significance is at the 0.1% and 5% level respectively. Concerning loans/assets, banks from the upper 50th and 75th percentile treatment groups

[19] This is represented by $Country_t \times Year_t$ in Equations 2 and 3 and in Table 5.

exhibit a difference-in-differences coefficient of 0.7256 and 1.037 respectively. Both coefficients are statistically significant at the 0.1% level. The coefficients for the loans/assets display increased significance, a result already suggested by the event study reported previously. This table also reveals that the coefficients for the bank exposure variable (Columns 1 and 4 in Panels A and B) are positive and highly statistically significant. This supports the assertion that the difference-in-differences results are not attributable to treatment group selection but rather to banks' exposure to government securities. The exposure coefficients indicate that the portfolio rebalancing impact is sizable. For each 1% increased exposure to government securities relative to total assets, banks increased the growth of loans by about 0.21% and loans/assets by 0.176%. Furthermore, the fact that the 75th percentile coefficient was larger than the 50th percentile for both outcome variables reinforces the suitability of banks' exposure as an explanatory variable for increased credit supply after the introduction of the APP.

The estimated results from this analysis suggest, with a high level of confidence, that banks more exposed to government securities increased their stock of loans and loans/assets following the APP, providing strong evidence of a portfolio rebalancing mechanism. As discussed, this mechanism incentivizes banks to sell government securities and materialize capital gains. Faced with a reinvestment decision, banks allocate funds to private sector credit. However, the effectiveness of LSAPs could be conditional on the level of distress of the targeted assets. The effectiveness of the APP could perhaps be attributable to risk repricing and subsequent devaluations of euro area debt securities following the European sovereign debt crisis. The APP improved the valuation of these securities and diminished uncertainty and risk perceptions. Without improved asset valuations, the yield induced portfolio rebalancing (Paludkiewicz, 2021), stealth recapitalization, and net worth channels (Brunnermeier & Sannikov, 2014) will have a diminished impact on credit supply. Consequently, we underscore that the confirmation of the APP's effectiveness does not necessarily imply LSAP programs will always achieve this outcome, as will be discussed in the next sub-section covering the PEPP.

Table 2.5: Impact of the APP on the growth of loans and loans/assets

Panel A

Dependent Variable:	Δlog(Loans)					
Model:	1	2	3	4	5	6
Bank Exposure in 2014 × $LSAP_t^{(APP)}$	0.1470***			0.2103***		
	(0.0271)			(0.0434)		
Treat 50th × $LSAP_t^{(APP)}$		1.029**			1.316***	
		(0.3862)			(0.3916)	
Treat 75th × $LSAP_t^{(APP)}$			1.449**			1.477*
			(0.4998)			(0.5877)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
$Country_t$ × $Year_t$	No	No	No	Yes	Yes	Yes
Fit statistics						
Observations	4,641	4,641	4,641	4,641	4,641	4,641
R^2	0.37429	0.36961	0.37012	0.43375	0.42913	0.42871
Within R^2	0.07771	0.07081	0.07156	0.16536	0.15854	0.15792

Panel B

Dependent Variable:	Δ(Loans/Assets)					
Model:	1	2	3	4	5	6
Bank Exposure in 2014 × $LSAP_t^{(APP)}$	0.2220***			0.1760***		
	(0.0168)			(0.0209)		
Treat 50th × $LSAP_t^{(APP)}$		1.267***			0.7256***	
		(0.2061)			(0.1717)	
Treat 75th × $LSAP_t^{(APP)}$			2.197***			1.037***
			(0.3105)			(0.2467)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
$Country_t$ × $Year_t$	No	No	No	Yes	Yes	Yes
Fit statistics						
Observations	4,641	4,641	4,641	4,641	4,641	4,641
R^2	0.25963	0.20413	0.21432	0.38724	0.36839	0.36900
Within R^2	0.14439	0.08026	0.09204	0.29187	0.27008	0.27079

Clustered (bank) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, . :0.10*

Notes: Panel A and B report the regression results of Equations 2 and 3 for the growth of loans and loans/assets using bank-level data, covering the APP period (2012-2018). The treatment groups are the upper 50th and 75th percentile groups of banks more exposed to government securities. The control groups constitute the remaining banks. The exposure variable represents the ratio of government debt securities to total assets in year-end 2014.

2.5.2 Bank-level analysis – PEPP

The same exercise done for the APP is also undertaken for the PEPP. We kept the same sample of banks but changed the treatment groups by considering government debt exposure relative to total assets in year-end 2019. We considered this re-assignment necessary because banks' exposures changed substantially from 2014 to 2019. This is explained by the portfolio rebalancing channel and subsequent reduction in exposures during the APP. The analysis is conducted for two periods, year-end 2019 and year-end 2020. Year-end 2019 represents the period before the treatment and year-end 2020 the period after the treatment.

Table 2.6 reports the regression results of Equations 2 and 3. Columns 1 through 3 report the results with controls, bank fixed effects, and time fixed effects. Columns 4 through 6 report the results including demand for bank credit. As before, bank credit influences the magnitude of the coefficients, but the overall conclusions are equivalent. The main conclusion from Table 2.6 is that banks with a higher proportion of government securities in their balance sheet, contrary to the APP, did not have a larger growth of loans and loans/assets in the post-treatment period compared to the pre-treatment period. In fact, the sign and statistical significance of the coefficients for the upper 50^{th} and 75^{th} percentile groups for loans/assets suggest the opposite — a reduction in loans/assets by more exposed banks. We propose four potential explanations for these results. First, the COVID-19 pandemic represented a period of great uncertainty, during which a flight-to-quality mechanism could have occurred (Papadamou et al., 2021). Under a flight-to-quality scenario, there is an increased appeal for safer assets such as government securities. This could explain the statistically significant negative coefficients. Increased demand for these assets can diminish the portfolio rebalancing channel effectiveness. Second, euro area sovereign securities maintained relatively stable valuations before and after the PEPP. This implies that there were fewer opportunities for capital gains, resulting in diminished effectiveness of the net-worth and stealth recapitalization channels. Third, as shown in Table 2.1 and Table 2.2, banks' exposure to government securities significantly decreased in 2019. Hence, banks had less government securities to trade. And lastly, the period analysed for the PEPP is substantially shorter than for the APP. As a result, a possible lag in responses may not be captured in this analysis.

Table 2.6: Impact of the PEPP on the growth of loans and loans/assets

Panel A

Dependent Variable:	Δlog(Loans)					
Model:	1	2	3	4	5	6
Bank Exposure in 2019 × $LSAP_t^{(PEPP)}$	-0.0185			-0.0658		
	(0.0502)			(0.0548)		
Treat 50th × $LSAP_t^{(PEPP)}$		-0.5824			-0.6127	
		(0.5007)			(0.4719)	
Treat 75th × $LSAP_t^{(PEPP)}$			-0.2787			-0.6655
			(0.6606)			(0.6520)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
$Country_t$ × $Year_t$	No	No	No	Yes	Yes	Yes
Fit statistics						
Observations	1,326	1,326	1,326	1,326	1,326	1,326
R^2	0.75677	0.75714	0.75673	0.77073	0.77043	0.77029
Within R^2	0.21157	0.21279	0.21143	0.25682	0.25587	0.25540

Panel B

Dependent Variable:	Δ(Loans/Assets)					
Model:	1	2	3	4	5	6
Bank Exposure in 2019 × $LSAP_t^{(PEPP)}$	-0.0314			-0.0262		
	(0.0365)			(0.0405)		
Treat in 50th × $LSAP_t^{(PEPP)}$		-0.7391*			-0.5339*	
		(0.3003)			(0.2590)	
Treat in 75th × $LSAP_t^{(PEPP)}$			-0.7717.			-0.6087.
			(0.4376)			(0.3597)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
$Country_t$ × $Year_t$	No	No	No	Yes	Yes	Yes
Fit statistics						
Observations	1,326	1,326	1,326	1,326	1,326	1,326
R^2	0.67215	0.67379	0.67321	0.69756	0.69847	0.69816
Within R^2	0.20995	0.21390	0.21251	0.27119	0.27338	0.27264

Clustered (bank) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1, . :0.10*

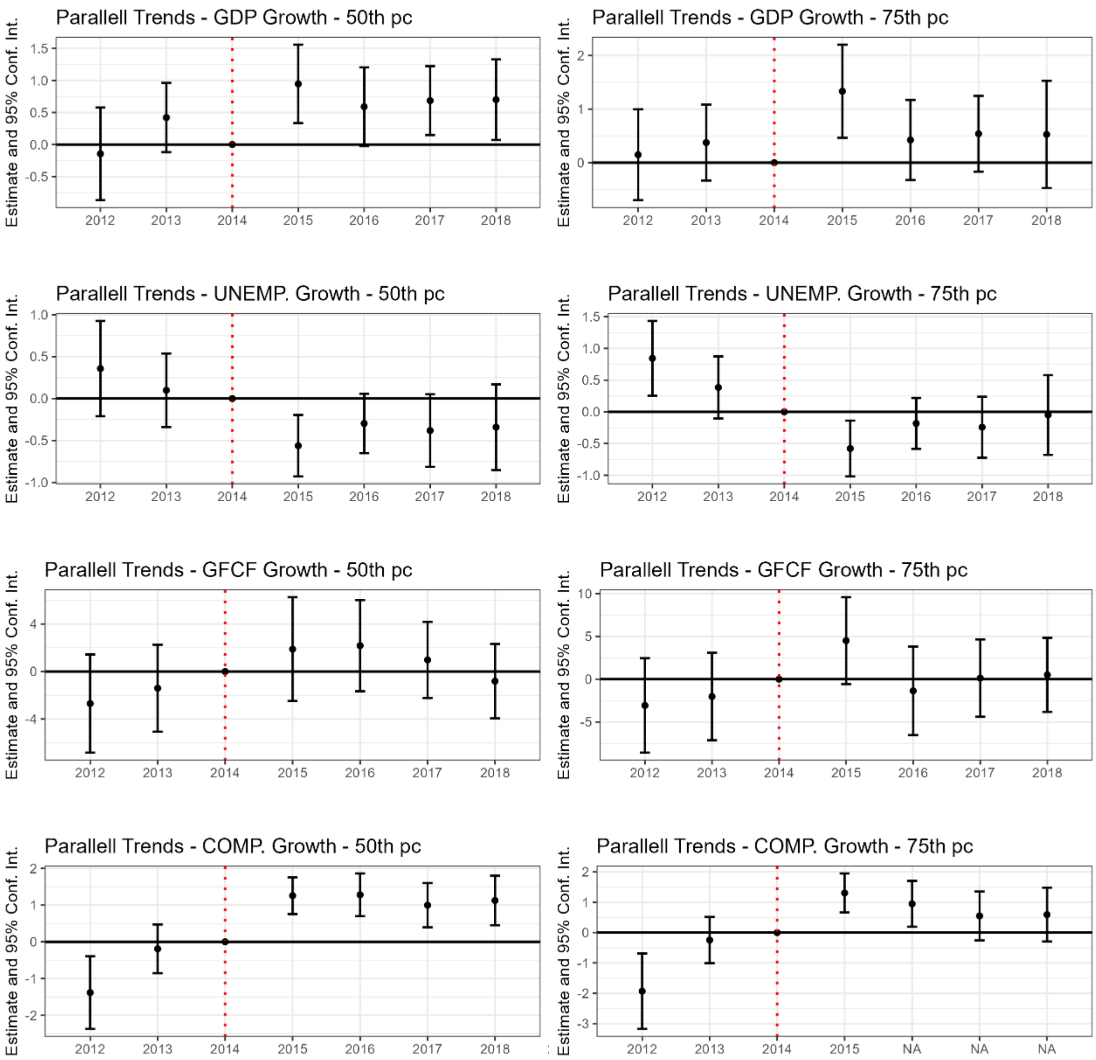
Notes: Panel A and B report the regression results of Equations 2 and 3 for the PEPP period (2019-2020) using bank-level data. The treatment groups are the 50th and the 75th percentile of banks with the largest exposure of government securities relative to total assets in year-end 2019. Panel a reports the results for the log differences growth of loan and Panel b reports the results for the first differences growth of loans/assets.

2.5.3 Regional-level analysis – APP

In this section, we explore whether regional variation in banks' exposure to government securities generated heterogeneous macroeconomic responses. Given that banks more exposed to government securities supplied more credit after the APP, we posit that geographies with more exposed banks could have had more favourable macroeconomic impacts than regions with less exposed banks, acting via the bank lending channel.

Figure 2.5 shows the coefficients obtained from Equation 4. These results indicate that the parallel trends assumption is not met in three cases. Specifically, the 50th and the 75th percentile treatment groups of employee compensation growth and the 75th percentile group of the unemployment rate growth. However, in all instances, only the 2012 coefficient is significantly different from zero, while the remaining pre-treatment coefficients are not significant. The violation of the parallel trends assumption in these three cases is perhaps attributable to lingering effects from the European sovereign debt crisis. During 2012, more exposed banks may have still been unwilling or unable to supply credit than less exposed banks. Despite possible explanatory factors, these results inform that the difference-in-differences coefficients will be biased upwards. Therefore, for these cases, we will conduct a robustness exercise removing the 2012 from the analysis. The remaining variables have statistically insignificant coefficients in for the entire pre-treatment period. Regarding the impacts of the program, the coefficients for GDP, compensation of employees, and the unemployment rate in the post-treatment window suggest a positive and significant impact after the introduction of the APP. The most impactful coefficient appears to be 2015, the first period after the introduction of the APP.

Figure 2.5: Event study with regional-level data



Notes: This figure reports the coefficients from the estimation of Equation 4 using NUTS 2 regional data to test the parallel trends assumption. The coefficients are compared to the 2014 coefficient, shown by the red vertical line. The coefficients in the pre-treatment period are not significant for the growth of GDP and GFCF. There are 3 cases where the parallel trends assumption is not confirmed. Specifically, the 2012 coefficient for the 75th percentile treatment group of unemployment growth and the 50th and 75th percentile groups of compensation of employees' growth. The remaining coefficients are not statistically significant at the 95% confidence interval, which suggests that the parallel trends assumption holds.

Table 2.7 reports the regression results of Equations 5 and 6 for the regional analysis for the period from 2012 to 2018 covering the APP. Most coefficients of interest are significant and in line with ex-ante expectations. The coefficients obtained are positive for the growth of GDP, GFCF, and employee compensation, and negative for unemployment. All of the coefficients are statistically significant at the 0.1% level. Overall, these results suggest that regions with more exposed banks in year-end 2014 had more favourable impacts for all variables than regions with less exposed banks following the introduction of the APP. A 1% increase in the aggregate average exposure of banks corresponds to an increase of 0.04% of GDP, an increase of 1.13% in GFCF, and a -0.03% decrease in unemployment. To overcome the parallel trends violation by the 75th percentile group of unemployment and both treatment groups of compensation of employees, we conduct a robustness analysis where we estimate Equations 5 and 6 from year-end 2013 to year-end 2018, removing the 2012 observation. The results are shown in Table A2 (in the Appendix). The estimated coefficients are smaller, but they continue to exhibit high statistical significance. The total compensation of employees exhibits a 50th and 75th treatment group coefficient of 1.36 and 1.23 respectively. Both coefficients are statistically significant at the 0.1% level. The results obtained are congruent with the hypothesis that heterogeneous macroeconomic impacts can arise from central bank asset purchases. These findings indicate that, during the APP period, the bank lending channel effectively impacted real economic variables, providing evidence that LSAPs can significantly influence the real economy through credit transmission. Regions with banks that are more exposed to government securities had more favourable impacts. However, an important caveat to underscore, similar to the bank-level analysis, is that these results could be conditional on the distress level of the targeted assets and its contagion to the real economy. Also, these results provide a relatively short-term analysis of these programs. They do not consider potential long-term implications of asset purchases, such as risks posed to the balance sheet of the ECB.

Table 2.7: Regression results using NUTS 2 regional data

Panel A

Dependent Variable:	Δlog(GDP)			Δunemp.		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Regional Exposure in 2014 × $LSAP_t^{(APP)}$	0.0408^{***}			-0.0346^{***}		
	(0.0120)			(0.0080)		
Treat 50^{th} × $LSAP_t^{(APP)}$		0.7721^{***}			-0.5981^{***}	
		(0.2900)			(0.1346)	
Treat 75^{th} × $LSAP_t^{(APP)}$			0.7258^{**}			-0.7395^{***}
			(0.2967)			(0.1816)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
NUTS2 FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	868	868	868	868	868	868
R^2	0.62343	0.62301	0.62058	0.56280	0.55912	0.56097
Within R^2	0.16032	0.15937	0.15396	0.32673	0.32106	0.32391

Panel B

Dependent Variable:	Δlog(GFCF)			Δlog(Comp. Employees)		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Regional Exposure in 2014 × $LSAP_t^{(APP)}$	1.1267^{**}			0.0833^{***}		
	(0.0557)			(0.0180)		
Treat 50^{th} × $LSAP_t^{(APP)}$		2.681^{***}			1.683^{***}	
		(0.9826)			(0.2996)	
Treat 75^{th} × $LSAP_t^{(APP)}$			2.982^{***}			1.571^{***}
			(1.068)			(0.3760)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
NUTS2 FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	868	868	868	868	868	868
R^2	0.26378	0.26467	0.26420	0.70242	0.70420	0.69511
Within R^2	0.04627	0.04741	0.04680	0.30534	0.30949	0.28827

Clustered (bank) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .:0.1*

Notes: This table reports the regression results using NUTS 2 regional-level data. The sample includes a total of 124 regions. To attribute the exposure to each region, a sample of 1,834 banks was used. Outcome variables are the log differences of GDP, GFCF, and employee compensation growth, and first differences of the unemployment rate.

2.5.4 Robustness

In this section, we undertake various robustness exercises to provide further validity to the main specifications. With regards to banks' exposure to government securities, it could be argued that pre-signalling effects could have influenced the results as the ECB's PSPP could have been anticipated by banks in late 2014. To address this issue, we conduct a similar bank-level analysis (estimation of Equations 2 and 3) but consider exposure at year-end 2013, and thereby avoiding possible anticipation by the banks. The results are shown in Table A3 (in the Appendix). With regards to the growth of loans/assets, the difference-in-differences coefficients for the upper 50th and 75th percentile groups are statistically significant. The only coefficient not statistically significant is the upper 75th percentile for the growth of loans. Similar to the main specification, the results for the growth of loans/assets are more robust than the direct growth of loans. Considered as a whole, the results obtained are qualitatively similar to the main specifications, thus reinforcing their validity and informing that pre-signalling rebalancing was not a significant confounding factor.

Another possible confounding issue is related with the influence some banks could have over the balance sheets of subsidiaries. This would constitute a violation of the stable unit treatment value assumption (SUTVA) as the exposure of one bank might influence the decisions of a subsidiary that is also included in the sample. In our main specification, we assume that banks have full autonomy over their balance sheet allocations, which we considered a reasonable assumption. However, there could still be ownership dependencies influencing some decisions. To address this potential issue, we conduct a robustness analysis controlling for subsidiary dependencies. We identified and mapped all subsidiary interdependencies for all banks in our sample. We removed all banks that exhibited any interdependency, thereby removing any potential influence banks could have exerted over other banks in the sample. We then estimate Equations 2 and 3 for the APP and the PEPP. The results are shown in Table A4 (in the Appendix). The overall conclusions are equivalent to the main analysis, hence reinforcing the validity of the results reported previously.

In the main regional-level analysis, we assume that banks operate solely in their region. In other words, we assume that banks only lend in the same region as the address of their headquarters. This assumption is not realistic under all scenarios as some banks can have national and international presences and conduct their operations through a distribution of branches. To overcome this limitation, we retrieved a new dataset from BankFocus comprised of bank branches in the euro area. Our dataset includes a total of 61,755 bank branches. By examining the country, city, and post code, we match each branch location to a NUTS 2 region. We consider that the exposure of the branch is the same as the exposure of the parent bank, as it is uncommon for branches to have independent asset allocation decisions. Thus, we assume that the parent bank credit supply decisions are homogenous across all branch locations. We attribute an exposure variable to each NUTS 2 region by averaging the exposure of all the branches in each region. Relying on this new methodology, we were able to attribute an exposure variable to 146 regions in total. We argue that this approach avoids the issue of large banks extending their activity over the location of their headquarters and provides a more accurate regional exposure estimation. The validity of this analysis is dependent on the assumption that the sample of branches is representative of the entire population in each region, which we consider a reasonable assumption as the number of branches in our sample is large. However, to avoid small sample bias, we only consider regions that have 10 branches or more. Table A5 (in the Appendix) reports the number of regions, number of branches, and the average exposure per country. The regression results are reported in Table A6 (in the Appendix). Overall, the sign and significance of the coefficients obtained are equivalent to the main analysis, substantiating its validity.

Next, we examine if there is agreement between the two methodologies for estimating regional exposure. There are 118 regions that are common both to the banks and the branches analysis. We difference the regional exposure obtained from the branches analysis from the regional exposure obtained from the banks analysis for each of the 118 common regions to assess the agreement of the exposure variable. The differences are plotted in the histogram illustrated in Figure A1 (in the Appendix). The mean difference in regional exposure between the banks and the branches analysis is -1.38% and the median is -0.23%. Given this, we consider that both methodologies exhibit consistency in estimating exposure. Figure A1 reveals some outliers, particularly in the left side of the histogram. We take an agnostic approach regarding which analysis provides the true exposure, therefore, we remove the outliers. We remove all regions that have an absolute difference larger than 5% and maintain only the regions where there is relative agreement in exposure between the two methods. We are left with 91 regions. Next, we estimate Equation 6 considering only the 2014 regional exposure attributed in the banks and the branches analysis and compare the results, which are reported in Table A7 (in the Appendix). The results obtained are congruent with results previously obtained for the main analysis. The exposure coefficient from the branches' analysis is slightly higher for the growth of GDP, GFCF, and compensation of employees than the exposure coefficient obtained from the banks analysis. The branches' exposure coefficients are also more statistically significant for GDP and GFCF than the coefficient from the banks' exposure which, perhaps, reveals a more accurate measure of the real regional banking exposure.

2.6 Conclusion

There is considerable debate whether the ECB's LSAP programs (i.e. APP and PEPP) were effective at stimulating economic activity in the euro area. In a preliminary analysis using a sample of individual banks from 2006 to 2020, we document that credit supply appears to be explained by banks' exposure to government securities relative to total assets. This observation is in accordance with the portfolio rebalancing channel hypothesis, where banks more exposed to LSAP targeted assets will increase their supply of loans in greater magnitude than less exposed banks after these programs. Given this backdrop, we conjecture two hypotheses. First, considering the portfolio rebalancing channel, we assess if banks' exposure to government securities explains the magnitude and variability in the supply of credit following the ECB's APP and PEPP. Second, conditional on the confirmation of the first hypothesis, we posit that responses of macroeconomic variables could be heterogeneous depending on the geographical location (at the NUTS 2 regional level) of exposed banks, operating via the bank lending channel. We argue that these research questions are relevant because, given the increased reliance on UMPs in recent years, their continued analysis is important to enhance our understanding of the mechanisms of monetary transmission.

Regarding the first hypothesis, our results indicate that banks more exposed to government debt securities had higher growth of loans and loans/assets than less exposed banks after the introduction of the APP. We find significant heterogeneity in credit supply responses depending on banks' exposure to government securities, suggestive of an active portfolio rebalancing channel. The overall results remained consistent to various robustness tests. Undertaking the same exercise for the PEPP, the same relationship was not found, suggesting that the portfolio rebalancing channel was not active after the PEPP.

Regarding the second hypothesis, our results indicate that regions with more exposed banks exhibit more favourable outcomes in GDP, GFCF, unemployment, and compensation of employees following the APP than regions with less exposed banks. Overall, our results underscore the importance of regional variation in the average composition of banks' balance sheets to explain variability in LSAP macroeconomic impacts. In summary, regions with a higher proportion of banks that are more exposed to the targeted assets could benefit more through the portfolio rebalancing and bank lending channels.

Even though there is considerable consensus in the literature regarding improved bank credit conditions following the ECB's APP, there is less agreement concerning the impacts to the real economy. Thus, the relevance of our contribution resides in the direct link established between the APP and positive impacts on variables that describe the real economy, such as GDP, employment, and investment. We demonstrate that the magnitude and heterogeneity of the impacts are highly dependent on the balance sheets of banks and on their geographical location. Heterogeneous asset exposures create significant variability in responses and thus should constitute an important consideration when assessing the implementation appropriateness and forecasting the impacts of these programs. Furthermore, we argue that the regional empirical setting used in this paper provides a good basis for a counterfactual analysis and allows for more comprehensive insights than an analysis at the country level. Lastly, these results do not seem to be generalizable for all LSAP programs and appear to be dependent on the distress level of the targeted assets and the economy.

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2.8 Appendix

Table A1: Overview of regional banks' exposure to government securities

	Regional analysis with Banks		
	Nr. Banks	Nr. Regions	Mean Exposure (in %)
FR	106	25	2.82
DE	1,045	38	4.9
IT	290	19	25.05
NL	18	4	7.94
ES	24	10	10.57
BE	19	5	19.48
AT	256	9	5.09
PT	9	3	18.28
EL	4	1	3.73
LU	19	1	10.12
FI	8	3	6.02
CY	7	1	9.24
SK	11	2	21.71
EE	3	1	2.52
MT	7	1	12.73
SI	8	1	9.58
Total	1834	124	10.61

Notes: This table reports the number of banks, regions, and average exposure to government securities.

Table A2: Robustness – Regional-level data analysis for the APP without 2012

APP (2013-2018)

Dependent Variable:	Δlog(Comp. Employees)			Δunemp.		
Model:	1	2	3	4	5	6
Regional Exposure in 2014 × $LSAP_t^{(APP)}$	0.0658***			-0.0278***		
	(0.0132)			(0.0071)		
Treat 50^{th} × $LSAP_t^{(APP)}$		1.361***			-0.4493**	
		(0.2633)			(0.1416)	
Treat 75^{th} × $LSAP_t^{(APP)}$			1.233***			-0.5853***
			0.3109			(0.1568)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
NUTS2 FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	744	744	744	744	744	744
R^2	0.73809	0.74016	0.73199	0.55847	0.55405	0.5564
Within R^2	0.25671	0.26257	0.23939	0.26506	0.2577	0.26163

Clustered (bank) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .:0.1*

Notes: This table reports the regression of Equations 5 and 6 from 2013 to 2018. 2012 was removed because this coefficient exhibited statistical significance in the pre-treatment period, challenging the parallel trends assumption. The treatment groups are the upper 50^{th} and the 75^{th} percentile group of banks more exposed to government securities. The control groups constitute the remaining banks. The exposure variable represents the ratio of government debt securities to total assets in year-end 2014.

Table A3: Robustness – Regression results controlling for pre-signalling effects

APP (2012-2018)

Dependent Variable:	Δlog(Loans)			Δ(Loans/Assets)		
Model:	1	2	3	1	2	3
Bank Exposure in 2013 × $LSAP_t^{(APP)}$	0.2058***			0.1765***		
	(0.0514)			(0.0255)		
Treat 50th × $LSAP_t^{(APP)}$		1.622***			0.7047***	
		(0.4177)			(0.1761)	
Treat 75th × $LSAP_t^{(APP)}$			0.6813			0.7755**
			(0.6087)			(0.2474)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
$Country_t \times Year_t$	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	4,410	4,410	4,410	4,410	4,410	4,410
R^2	0.42750	0.42557	0.42315	0.38063	0.36682	0.36614
Within R^2	0.16123	0.15840	0.15486	0.28815	0.27228	0.27150

Clustered (bank) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .:0.1*

Notes: This table reports the regression results of Equations 2, and 3 controlling for pre-signalling effects. The treatment groups are the upper 50th and the 75th percentile group of banks more exposed to government securities in year-end 2013. The control groups constitute the remaining banks. The exposure variable represents the ratio of government debt securities to total assets in year-end 2013.

Table A4: Robustness – Controlling for subsidiaries in the sample of banks

APP (2012-2018)

Dependent Variable:	Δlog(Loans)			Δ(Loans/Assets)		
Model:	1	2	3	1	2	3
Bank Exposure in 2014 × $LSAP_t^{(APP)}$	0.1812**			0.1129***		
	(0.0582)			(0.0215)		
Treat 50^{th} × $LSAP_t^{(APP)}$		1.172**			0.7171***	
		(0.4031)			(0.1705)	
Treat 75^{th} × $LSAP_t^{(APP)}$			1.050.			0.8671***
			(0.6247)			(0.2424)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
$Country_t$ × $Year_t$	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	4,088	4,088	4,088	4,088	4,088	4,088
R^2	0.42760	0.42546	0.42457	0.34349	0.3387	0.3378
Within R^2	0.13421	0.13097	0.12962	0.21396	0.20822	0.20715

PEPP (2019-2020)

Dependent Variable:	Δlog(Loans)			Δ(Loans/Assets)		
Model:	1	2	3	1	2	3
Bank Exposure_2019 × $LSAP_t^{(PEPP)}$	0.0091			-0.0102		
	(0.0475)			(0.0319)		
Treat_50 × $LSAP_t^{(PEPP)}$		-0.3412			-0.4936.	
		(0.4696)			(0.2581)	
Treat_75 × $LSAP_t^{(PEPP)}$			-0.5561			-0.5983
			(0.6370)			(0.3734)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
$Country_t$ × $Year_t$	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	1,168	1,168	1,168	1,168	1,168	1,168
R^2	0.76400	0.76393	0.77924	0.71139	0.71289	0.71260
Within R^2	0.22321	0.22298	0.27337	0.26817	0.27199	0.27125

Clustered (bank) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .:0.1*

Notes: This table reports regression results of Equations 2, and 3 controlling for subsidiaries in the sample of banks. The treatment groups are the upper 50^{th} and the 75^{th} percentile group of banks more exposed to government securities. The control groups constitute the remaining banks. The exposure variable represents the ratio of government debt securities to total assets in year-end 2014.

Table A5: Regional bank branches' exposure to government securities

Country	Total Nr. Regions	Total Nr. Branches	Mean Exposure (in %)
FR	26	18,944	4.91
BE	11	1,417	13.90
IT	21	18,990	17.93
PT	7	2,770	12.11
LU	1	181	10.28
DE	38	7,393	3.85
NL	11	452	6.48
AT	9	2,579	4.18
ES	17	8,910	13.45
SK	1	15	13.41
FI	4	104	5.01
Total	146	61,755	9.59

Notes: This table reports the number of regions, number of branches, and average exposure for the analysis with bank branches per country.

Table A6: Robustness – Regional exposure using brank branches

Panel A

Dependent Variable:		Δlog(GDP)			Δunemp.	
Model:	1	2	3	1	2	3
Regional Exposure in 2014 × $LSAP_t^{(APP)}$	0.1113***			-0.0488***		
	(0.0205)			(0.0125)		
Treat 50th × $LSAP_t^{(APP)}$		1.056***			-0.4859***	
		(0.2289)			(0.1423)	
Treat 75th × $LSAP_t^{(APP)}$			1.016***			-0.4199**
			(0.2538)			(0.1553)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
NUTS2 FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	1,022	1,022	1,022	1,022	1,022	1,022
R^2	0.61669	0.61197	0.60953	0.58883	0.58699	0.58460
Within R^2	0.24440	0.23511	0.23030	0.33351	0.33053	0.32665

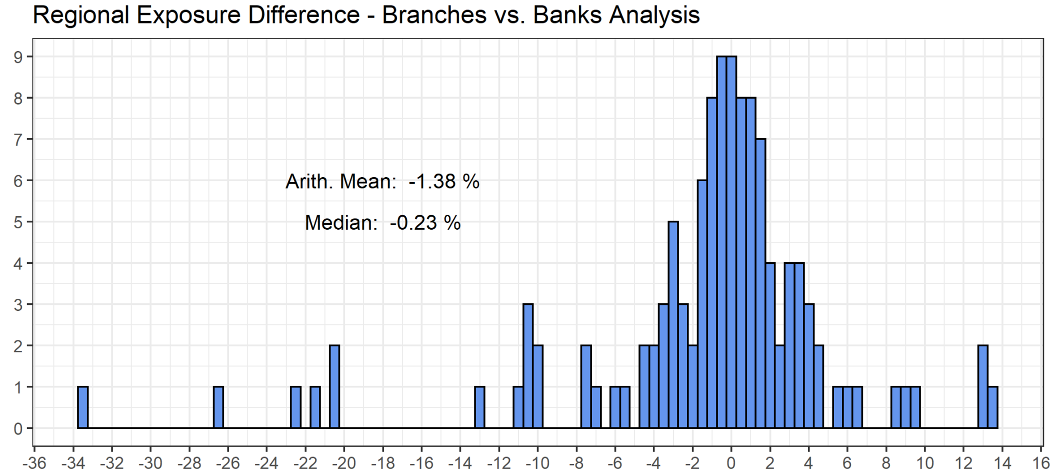
Panel B

Dependent Variable:		Δlog(GFCF)			Δlog(Comp. Employees)	
Model:	1	2	3	1	2	3
Regional Exposure in 2014 × $LSAP_t^{(APP)}$	0.3109***			0.1710***		
	(0.0755)			(0.0210)		
Treat 50th × $LSAP_t^{(APP)}$		2.898**			1.852***	
		(0.9206)			(0.2427)	
Treat 75th × $LSAP_t^{(APP)}$			2.355.			1.474***
			(1.261)			(0.2902)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
NUTS2 FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	1,022	1,022	1,022	1,022	1,022	1,022
R^2	0.28581	0.28360	0.28149	0.69666	0.69450	0.68245
Within R^2	0.07274	0.06987	0.06714	0.38524	0.38086	0.35643

Clustered (bank) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

Notes: This table reports the regression results using NUTS 2 regional data. The regional exposure variable was calculated using a sample of 61,755 bank branches. The sample includes a total of 146 regions. Outcome variables are the log differences of GDP, GFCF, and employee compensation growth, and first differences of the unemployment rate.

Figure A1: Regional Exposure difference between branches and banks



Notes: Histogram reporting the difference of regional exposure between the branches analysis and the banks analysis.

Table A7: Robustness – Comparison of regression banks and branches

Panel A

Dependent Variable:	Δlog(GDP)		ΔUnemp.	
Model:	(1)	(2)	(3)	(4)
Exposure(Banks Analysis) × $LSAP_t^{(APP)}$	0.0693^{**}		-0.0342^{*}	
	(0.0329)		(0.0193)	
Exposure(Branches Analysis) × $LSAP_t^{(APP)}$		0.1129^{***}		-0.0289^{*}
		(0.0306)		(0.0165)
Controls	Yes	Yes	Yes	Yes
NUTS2 FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Fit statistics				
Observations	637	637	637	637
R^2	0.53584	0.54364	0.49137	0.48984
Within R^2	0.14718	0.16150	0.31954	0.31750

Panel B

Dependent Variable:	Δlog(GFCF)		Δlog(Comp. Employees)	
Model:	(1)	(2)	(3)	(4)
Exposure(Banks Analysis) × $LSAP_t^{(APP)}$	0.1453^{*}		0.1794^{***}	
	(0.0747)		(0.0330)	
Exposure(Branches Analysis) × $LSAP_t^{(APP)}$		0.1607^{**}		0.1956^{***}
		(0.0751)		(0.0350)
Controls	Yes	Yes	Yes	Yes
NUTS2 FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Fit statistics				
Observations	637	637	637	637
R^2	0.18301	0.18318	0.69044	0.69338
Within R^2	0.03390	0.03409	0.30853	0.31509

Clustered (bank) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .:0.1*

Notes: This table reports the regression results of Equations 6 with 91 regions. Comparison of exposure variable attributed using the banks and the branches analysis.

Chapter 3: Balance Sheet Expansionary Policies in the Euro Area: Macroeconomic Impacts and a Vulnerable versus Non-Vulnerable Comparison*

3.1 Introduction

When quantitative easing (QE) policies were announced as a response to the global financial crisis by the Federal Reserve (Fed) in the U.S., there were different opinions in the public discourse relative to their appropriateness. In particular, there were fears of diminishing central bank independence and inflation (Hamilton, 2009). Other prominent economists downplayed the criticism of QE and argued that the U.S. economy was in a liquidity trap and the bigger concern at the time was deflation (Krugman, 2008; Blinder, 2009).

During the European sovereign debt crisis and the zero lower bound period that followed, balance sheet expansionary policies (BSEPs), and in particular large scale asset purchases (LSAPs), were policies the ECB was increasingly willing to employ to stabilize sovereign debt markets, improve credit transmission, and stimulate inflation. However, structural asymmetries between member countries posed challenges to the conduct of monetary policy, particularly heterogenous government indebtedness levels, uncoordinated fiscal policy, and dissimilar economic structures. Given the likelihood of the ECB considering unconventional monetary policies (UMPs) in the future, it is necessary to continue scrutinizing the effects of these policies to inform future policy decisions. Despite their ubiquitous use, the magnitude and extent of UMPs remains a challenging and uncertain area of estimation (Borio & Zabai, 2018).

In this paper, we study the impacts and heterogeneity of the ECB's LSAPs shocks on several macroeconomic variables, specifically real GDP, inflation, long-term sovereign bond yields, the composite indicator of sovereign stress (CISS), and the unemployment rate. Typically, monetary policies are most effective during financial turbulent periods (Mishkin, 2009; Ciccarelli et al., 2013). In particular, monetary policy is shown to be effective for macroeconomic stabilization and alleviating the adverse

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feedback loops of crisis. However, euro area countries exhibit structural nuances that may give rise to heterogenous responses to monetary policies, potentially leading to various degrees of effectiveness across member states. Recent papers[1] argue that the transmission of the ECB's unconventional monetary policies were more effective in less vulnerable countries, contradicting the conventional understanding of these policies. Given this contradictory backdrop, the question we pose in this paper is whether countries under more financial and economic stress (classified in this paper as vulnerable countries) benefited more from expansionary LSAPs than non-vulnerable countries in the euro area.

To undertake the analysis, a Bayesian structural vector autoregression (BVAR) model is used.[2] The identification is done via zero and sign restrictions, with data spanning from 2012:M1 to 2023:M12. For robustness, the same model is estimated for the period from 2012:M1 to 2019:M12, removing the COVID-19 and the inflationary periods that followed. The overall conclusions were the same, however the robustness model displayed more significant results. The empirical strategy of this paper consists of, first, estimating the impulse response functions (IRFs) of several macroeconomic variables given an unexpected innovation to each national central bank's (NCB's) balance sheet holdings of euro area sovereign securities. Second, the peak, trough, and cumulative impulse responses over a 24-month period are calculated. Lastly, these values are correlated with variables that capture the economic and financial vulnerability of each member country. Specifically, the vulnerability variables considered are debt-to-GDP, the unemployment rate, GDP per capita, and tier 1 bank capital ratios. As a robustness exercise, a panel structural BVAR model where vulnerable and non-vulnerable countries are grouped is undertaken with the same overall conclusions.

This study concludes that the magnitudes of impulse responses were more favorable in countries with greater vulnerability. I argue that this result is relevant to the literature because recent studies that use multiple time series models to study UMPs in the euro area have opposite findings. For instance, Boeckx et al. (2017) and Burriel and Galesi (2018) find that more vulnerable countries did not have larger impulse responses to BSEP, exhibiting the opposite correlations reported in this paper. The authors argue that better capitalized banks enhance monetary policy transmission through the credit channel. Given that banks in non-vulnerable countries exhibit more robust tier 1 capital

[1] In particular Wieladek and Garcia Pascual (2016), Boeckx et al. (2017), and Burriel and Galesi (2018).
[2] The model implementation follows Giannone et al. (2015), Arias et al. (2018), and Kuschnig and Vashold (2021).

ratios, this explains the different macroeconomic effects. Furthermore, this study presents some innovations compared to past papers. For instance, the entire ECB's APP and PEPP programs are included in the estimation window. Prior to 2015, most of the balance sheet programs undertaken by the ECB were specialized financing programs designed to stimulate bank credit, which could have generated different impacts than LSAPs (i.e. LTROs, and TLTROs[3]). In this study, the holdings of euro area sovereign bonds by each individual NCB are considered instead of the entire ECB balance sheet. I argue that this methodology is preferable because it provides a more accurate representation of the actual sovereign securities purchased in the market by the central bank for each member country. Therefore, the responses to the shocks are more targeted to each member country and have less ambiguity. The results obtained in this paper are consistent with conventional theoretical understandings of the effectiveness of monetary policy (Mishkin, 2009), UMP modelling considerations (Curdia & Woodford, 2011; Gertler & Karadi, 2011) and empirical findings for conventional monetary policy (Ciccarelli et al., 2013).

The rest of the paper is structured as follows: Section 3.2 reviews the relevant literature. Section 3.3 details the methodology, the data, and the empirical strategy. Section 3.4 presents the results. Lastly, section 3.5 concludes.

3.2 Literature Review

Given the ECB's increased reliance on UMP, particularly in response to the zero lower bound (ZLB), there is significant interest in quantifying its macroeconomic impacts in the literature. This is often achieved with the use of multiple time series models. Examples of recent papers that rely on a VAR type framework to measure UMP for the European case are Gambacorta et al. (2014), Kremer (2016), Wieladek and Garcia Pascual (2016), Gambetti and Musso (2017), Ghysels et al. (2017), Boeckx et al. (2017), and Burriel and Galesi (2018). These papers measure the responses of macroeconomic variables following UMP shocks in the euro area. A summary of the models used in these papers, and the general impulse response results are summarized in Table 3.1. These studies consistently find that an increase in the ECB's balance sheet translates into a reduction of sovereign debt yields, a reduction in systemic stress levels, an increase in real GDP, and an increase in prices. These results are analogous to reactions stemming from conventional monetary policy shocks – changes in the central bank's short-term

[3] Longer-term refinancing operations (LTROs) and targeted longer-term refinancing operations (LTROs).

policy rate. UMPs are also credited with the ability to stabilize financial markets. In the context of the euro area, the impact of LSAP programs significantly reduced sovereign premiums (Eser & Schwaab, 2016; Krishnamurthy et al., 2018; Altavilla et al., 2021). An example of this efficacy was apparent during the GFC of 2008 and the European sovereign debt crisis where unconventional monetary policies effectively mitigated the risk of a more profound crisis (Mishkin, 2009; Afonso et al., 2018).

The heterogeneity observed in the responses to UMPs is a source of complexity for the effective implementation of monetary policy in the euro area (Ciccarelli et al., 2013). Boeckx et al. (2017) and Burriel and Galesi (2018) underscore that bank capitalization is an important variable when considering monetary transmission. They argue that better capitalized banks were in a more favorable position to lend to the real economy. Provided that less vulnerable countries have better capitalized banks, macroeconomic responses in these countries were larger. However, the relationship that better capitalized banks have larger credit growth after expansionary monetary shocks than less capitalized banks is not well established in the literature and is subject to debate. Van den Heuvel (2002) argues that, following an expansionary monetary policy shock, lending by banks with low capital exhibit a delayed credit reaction which is then amplified relative to well capitalized banks. Grosse-Rueschkamp et al. (2019) finds that more constrained banks (i.e. banks with lower tier 1 ratios and higher non-performing loans) were more likely to extend credit to private firms following the ECB's Corporate Sector Purchase Programme (CSPP). In an opposite view, Gambacorta and Shin (2018) and Altavilla et al. (2020) suggest that banks with higher capital ratios will extend more credit following expansionary monetary policies.

Ciccarelli et al. (2013) argues that countries with high sovereign and financial stress had larger responses to ECB conventional monetary policy. Heterogeneities in monetary policy transmission can also be influenced by factors such as financial structure, labor market rigidities, industry mix, and competition in the banking sector (Barigozzi et al., 2014; Georgiadis, 2014; Georgiadis, 2015; Mandler et al., 2022). The asynchronization of business cycles of euro area member countries poses a significant challenge for the ECB's single monetary policy framework. The euro area is built around frictionless flow of factors of production between countries, which can help induce positive correlations of the business cycles. This alignment is a desirable condition for an optimum currency area (Eichengreen, 1991; Frankel & Rose, 1998). However, at present, there are still some structural differences that can present challenges for synchronization.

The continuous use of LSAP programs and their appropriateness is still a source of debate. Gertler and Karadi (2011), Curdia and Woodford (2011), Quint and Rabanal (2017), Kiley (2018), and Borio and Zabai (2018) argue their use should be reserved for specific periods, such as during the ZLB and during financially and economic fragile periods. Thus, UMP should not become a permanent policy for central banks. Another factor to consider is that asset purchases exert strong influence on sovereign debt yields, which in turn could result in political pressure and a threat to central bank independence (Hamilton, 2009; Cobham, 2012), which is considered an important determinant for guaranteeing appropriate inflation targeting (Alesina and Summers, 1993; Grilli et al., 1991). Fabo et al. (2021) provides a comparison across several QE studies. The authors conclude that central bank research tends to report larger and more favorable impacts of QE. This should constitute a caveat to be aware of when analyzing studies that focus on the effectiveness of UMPs.

It could be argued that, under certain scenarios, alternative monetary policy tools other than LSAPs can be used to achieve similar results. For instance, forward guidance could be used to reduce long-term sovereign debt yields and can be a powerful tool when at the ZLB (Eggertsson & Woodford, 2003). This consideration potentially raises some concerns for estimations that use backward looking variables, as expectations play a role for the responses of macroeconomic variables. Krishnamurthy and Vissing-Jorgensen (2011) argue that, after QE2 in the U.S., yield reduction from the purchase of treasuries did not carry over to riskier assets, such as lower grade corporate securities and mortgages. This suggests that the same outcome achieved by LSAP programs could have been obtained with forward guidance and hence with less risk for the Fed. In the European case, after Mario Draghi's *"whatever it takes"* speech, the yields of government debt yields decreased substantially (Afonso et al., 2018) and averted a serious debt sustainability situation, particularly for the more indebted and vulnerable euro area members. Even though securities were not purchased in the market, it could logically be argued that the actual purchase of assets by the central bank strongly underscores the expansionary commitment. However, the purchase of securities raises the concern that, when interest rates rise, the central bank will incur losses. Such considerations are usually downplayed because central banks could continue to operate normally with losses (Archer & Moser-Boehm, 2013). A more concerning issue would be if the central bank becomes policy insolvent (Del Negro & Sims, 2015; Cardoso da Costa, 2022) or if it needs fiscal transfers (Reis, 2017).

Grilli et al. (1991) argued that the challenges of a common currency implementation in Europe would come from highly indebted members. The authors underscored that imposing fiscal rules that guarantee fiscal solvency would increase the credibility of the euro area. Afonso and Jalles (2013) and Panizza and Presbitero (2013) argue that there is a negative relationship between high public debt and economic growth. However, the authors recognize the difficulty to decisively identify a causal relationship. Without the concerted effort of fiscal policy, it is unfeasible to expect monetary policy to single-handedly accomplish all the macroeconomic objectives necessary in a sustainable fashion (Sims, 2013; Corsetti et al., 2019). Theoretically, and of particular importance for the period under consideration, fiscal spending multipliers are larger when at the ZLB (Christiano et al., 2011; Eggertsson, 2011), however this claim is disputed (Ramey & Zubairy, 2018).

Despite the issues discussed above, UMP have become mainstays in the ECB's policy toolbox since 2010. The consensus today by central bankers and most economists is that monetary policy should be used when needed to deal with economic and financial crisis. The study of past recessions informs us that that a reduction in money supply and credit can unnecessarily exacerbate a crisis (Bernanke, 1983; Bernanke et al., 1994). A more relevant question to ask today is whether the central bank can effectively influence credit supply when banks preference for liquidity is high (Dow, 2017). This consideration could pose questions about the effectiveness of the bank lending channel.

Table 3.1: Overview of Literature Results

Paper	Model	Data Results	Results
Gambacorta et al. (2014)	Panel SVAR	Monthly Data - 2008:M1 to 2011:M6	A positive, one-standard deviation structural shock to the ECB balance sheet (around 3%) generates a peak impulse response of real GDP between 0.05% and 0.15% (16th and 84th bootstrap percentile bands at month 6 horizon). The peak impulse response of prices is between 0.01% and 0.04% at month 6 horizon.
Kremer (2016)	SVAR	Monthly Data - 1999:M1 to 2013:M12	A positive, one-standard deviation structural shock to the ECB balance sheet (around 4%) represents a peak mean impulse response of real GDP of about 0.2% at month 15 horizon. The peak mean impulse response of prices is around 0.05% at month 20 horizon.
Wieladek and Garcia Pascual (2016)	Bayesian SVAR	Monthly Data - 2012:M6 to 2016:M6	A 1% structural shock to the ECB balance sheet expansion announcement represents a peak of 0.11% increase in real GDP at around month 18 horizon. The peak impulse response of prices is about 0.75% at around month 18 horizon.
Gambetti and Musso (2017)	TVP-VAR	Quarterly Data - 2009Q3 to 2016:Q4	The APP shock (2015:Q1) generated a peak impulse response of real GDP of 0.18% on impact. 4 Quarters after the initial shock the impulse response of real GDP was around 0.16%. The HICP impulse response peaked 8 quarters after the initial shock at 0.36%.
Boeckx et al. (2017)	Bayesian SVAR	Monthly Data - 2007M1 to 2014:M12	A 1.5% positive structural shock to the ECB balance sheet generates a peak impulse response of real GDP of 0.1% at around month 8 horizon. The peak impulse response of prices was 0.09% at around month 10 horizon.
Burriel and Galesi (2018)	Global VAR	Monthly Data - 2007:M1 to 2015:M9	A 1% positive structural shock to the ECB balance sheet represents a peak impulse response of real GDP of 0.08% at month 4 horizon. A 1% shock to the ECB balance sheet generates a peak impulse response of prices of 0.03% at month 5 horizon.

Notes: Summary of results of a selection of papers that use multiple time series models to analyze unconventional monetary policies in the euro area. Some values are approximations as they were taken from IRF plots depicted in the mentioned papers as the exact response magnitudes were not detailed.

3.3 Methodology, data, and empirical strategy

VAR models, since their introduction by Sims (1980), have been extensively used and adapted in the empirical economics literature, particularly for monetary policy and more recently for UMPs. Much of their popularity is attributed to their simple formulation, flexibility, and intuitive outputs (Watson, 1994; Stock & Watson, 2001). In this paper, a Bayesian Vector Autoregression (VAR) model is used. The estimation is executed based on code developed by Kuschnig and Vashold (2021),[4] which is based on the model by Giannone et al. (2015). Hence, the model uses a hierarchical prior modelling approach to draw inference regarding the informativeness of the prior distribution and reduce its ambiguity.[5] That is, hyperparameters are treated as additional parameters to be estimated. This strategy has the potential to improve naïve benchmarks of flat priors. As defined by Giannone et al. (2015), the model considers a combination of conjugate priors, specifically the Minnesota prior, the sum-of coefficients prior (soc), the single-unit-roots prior (sur). The sur and soc priors will reduce the importance of the deterministic component of the series in case of possible non-stationarity. A metropolis hastings algorithm is used to obtain the posterior distribution with 100,000 iterations and 50,000 burned draws. The structural identification is done with zero and sign restrictions as in Arias et al. (2018). We resort to this identification because it allows for greater modelling flexibility, and it requires fewer necessary restrictions than a standard structural VAR model with a lower triangular matrix of restrictions. Imposing zero and sign identifying restrictions provides structure to the model and, arguably, more realistic impulse responses. However, a common criticism is that the restrictions are often chosen arbitrarily by the model builder, which can induce bias. The restrictions imposed in this paper follow convention and are grounded in generally accepted economic theory. The restrictions applied are summarized in Table 3.2.

The model used in this paper is written as follows:

$$A_0 y_t = c + \sum_{i=1}^{2} A_i y_{t-i} + \varepsilon_t \quad where \quad \varepsilon_t \sim N(0, \Sigma) \tag{1}$$

where y_t is an M × 1 vector of endogenous variables, c is an M × 1 intercept vector, A_i (i = 1, 2) are M × M coefficient matrices, and ε_t is an M × 1 vector of exogenous Gaussian

[4] I am thankful to Kuschnig and Vashold (2021) for making their R implementation code available through CRAN.

[5] This model considers the Minnesota prior, the sum-of-coefficients (soc) prior, and single-unit-root (sur) prior. The calibration of the hyperpriors is based on the recommended settings as defined in Kuschnig and Vashold (2021). The implementations and calibration of this model will be made available upon request.

shocks with zero mean and variance-covariance matrix Σ. The benchmark models considered in this paper are of lag length 2 and include 6 endogenous variables[6] (M = 6).

The variables considered are the NCBs' holdings of euro area general government debt securities, long-term sovereign rates,[7] the composite indicator of systemic stress, real GDP, the inflation rate (measured by the HICP), and the unemployment rate. All variables are sourced in monthly frequency except real GDP. A Chow-Lin interpolation was estimated with industrial production to obtain a monthly output series. The variables are transformed to year-over-year (y-o-y)[8] growth rates to assess annual growth and avoid potential seasonality in the data. This way, we can evaluate the long-term performance and trends of the impulse responses, smoothing out possible short-term fluctuations. Furthermore, past studies use this method for calculating growth rates, hence, by using this transformation, we can maintain comparability. The variables used, their sources, and their transformations are described in Table B1 in the Appendix.

Table 3.2 summarizes the model's variables and the imposed restrictions. We assume that a positive innovation in the NCBs' holdings of sovereign securities does not contemporaneously impact real GDP, the inflation rate, and the unemployment rate. On the other hand, it is assumed that it negatively impacts the long-term sovereign rates and the composite indicator of systemic stress contemporaneously. The baseline specification and the variables included builds on papers of similar methodological nature, specifically Gambacorta et al. (2014), Wieladek and Garcia Pascual (2016), Gambetti and Musso (2017), Boeckx et al. (2017), and Burriel and Galesi (2018).

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[6] For robustness, we estimated the model with various lag lengths and different variables and obtained the same general results.

[7] As described by the ECB, the variable long-term interest rate is derived from long-term government bonds denominated in Euro. In the case that long-term government bond yields are not available, the values are derived from private sector bond yields or other interest rate indicators. (https://www.ecb.europa.eu/stats/financial_markets_and_interest_rates/long_term_interest_rates/html/index.en.html).

[8] Log value from each month subtracted by the log value of the same month in the previous year.

Table 3.2: Baseline Structural BVAR model and restrictions

Structural BVAR Model						
Variables	1	2	3	4	5	6
	NCB BS	LTIR	CISS	Real GDP	HICP	UNE

Contemporaneous restrictions following a shock to NCB BS						
	NCB BS	LTIR	CISS	GDP	HICP	UNE
NCB BS Shock	>0	<0	<0	0	0	0

Notes: This table summarizes the baseline model where the NCB BS represents the individual NCB's balance sheet, specifically the holdings of euro area general government debt securities. LTIR represents the long-term interest rate derived from sovereign bond yields and is provided by the ECB. HICP represents the harmonized index of consumer prices, and it is used as an indicator for measuring inflation. CISS represents the composite indicator of systemic stress. UNE is the unemployment rate. All the variables enter the model in either y-o-y differences or log differences as described in Table B1. The above table also summarizes the restrictions applied following a shock to the NCB balance sheet. It is assumed that a positive innovation in the NCB balance sheet does not impact real GDP, the inflation rate, and the unemployment rate contemporaneously. On the other hand, it is assumed that it negatively impacts the LTIR and the CISS contemporaneously.

The econometric model discussed above is estimated for 11 individual euro area countries[9] with the objective of understanding the heterogeneity in macroeconomic responses following balance sheet expansionary shocks. The empirical strategy used in this paper consists of, first, estimating the impulse response functions of all variables given an unexpected innovation to each NCB balance sheet holdings of euro area sovereign securities. Second, the peak, trough, and cumulative impulse responses over a 24-month period are calculated. These values are then correlated with variables that capture economic and financial vulnerability of each member country. As for indicators of vulnerability, first we consider the debt-to-GDP ratio. ECB's LSAPs — and in particular the Public Sector Purchase Programme (PSPP) — can impact the yields of sovereign debt and influence the ability of governments to conduct fiscal policy. Thus, debt-to-GDP serves as a relevant variable within this framework, capturing the vulnerability of more indebted countries. As a second indicator, we consider the unemployment rate as it may influence the response of inflation, according to the Phillips curve. If unemployment is low (high), one expects inflation responses to be higher (lower) following an expansionary monetary shock. Furthermore, the unemployment rate can also

[9] Due to data availability, we include 11 countries in our analysis. Countries included are Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain.

serve as an indicator of economic distress as it reveals unused capacity in the economy. The third vulnerability variable considered is GDP per capita, which can also be conceptualized as a measure of productivity. Thus, this indicator could be relevant in the context of the euro area convergence. At the inception of the euro, it was expected for all euro area member states to achieve convergence of per capita income (Franks et al., 2018). One would predict that countries with lower GDP per capita should experience faster growth arising from more opportunities for investment in productivity and efficiency. Moreover, some literature suggests that expansionary policies could positively influence productivity (Colciago & Silvestrini, 2022). The fourth vulnerability variable considered is bank tier 1 capital ratios. The inclusion of this variable is justified by the recent findings that banks with higher capitalization experienced more effective monetary transmission via the bank lending channel. Therefore, countries with more capitalized banks experienced more pronounced macroeconomic effects via the bank lending channel. In the main analysis, we use the vulnerability variables described above as the averages for the entire period.

The analysis is confined to the period of ECB's balance sheet expansion driven by asset purchases undertaken, particularly during the period from 2012:M1 to 2023:M12. This period is characterized by the reduction of policy rates to a degree that required the ECB to resort to unconventional policies. By restricting our analysis to this time frame, we can more accurately disentangle the impacts of LSAPs from the potential confounding effect of decreases in policy rates. For robustness, and to avoid possible confounding effects from the aftermath of COVID-19, the same analysis is conducted for the period from 2012:M1 to 2019:M12, excluding the pandemic period. The overall conclusions for both models were the same albeit with slight differences in magnitudes and significance.

3.4 Results

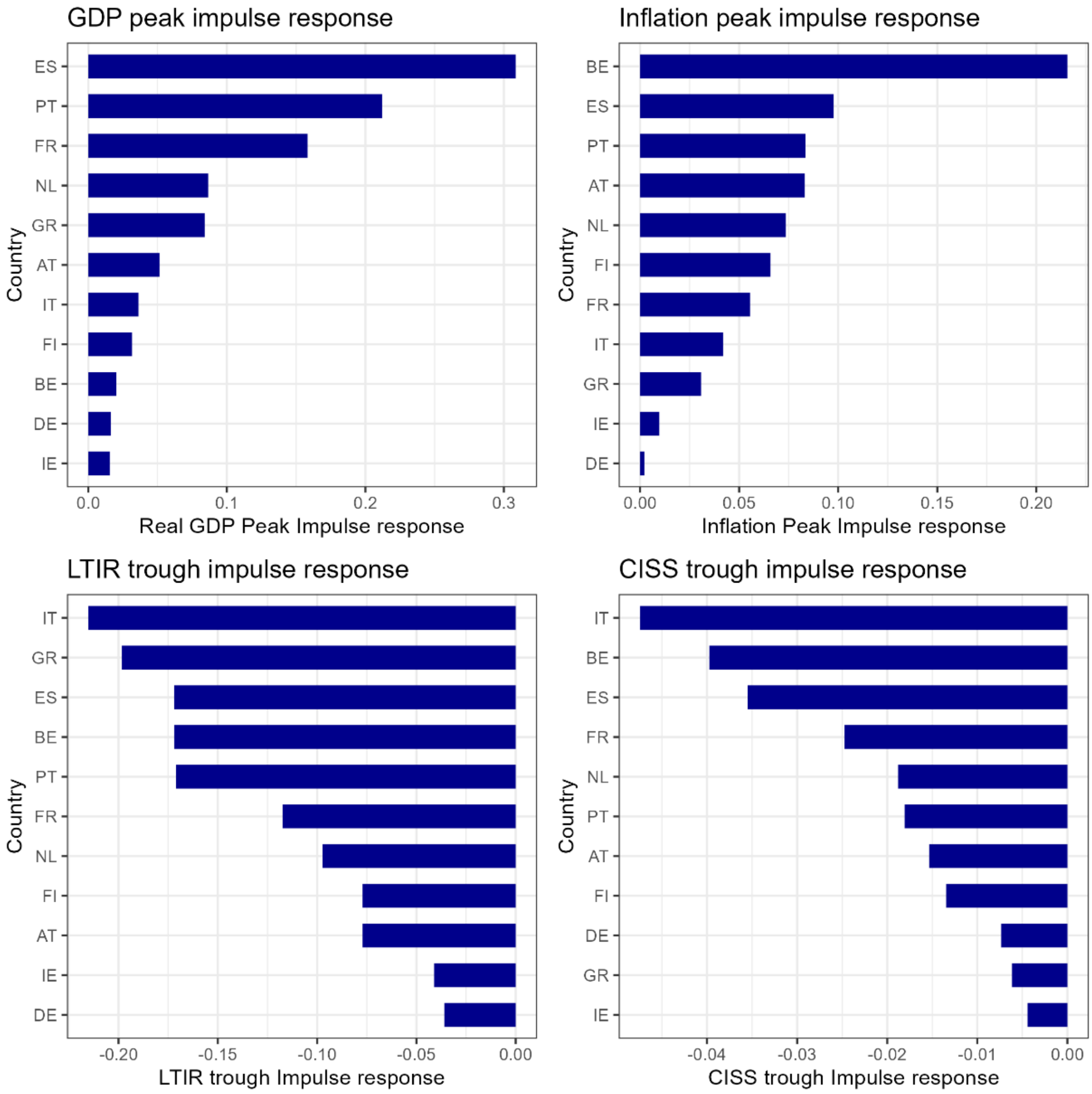
3.4.1 Individual Country Analysis

Figure 3.1 reports the magnitudes of the maximum and minimum impulse responses following a 1% shock to the central banks' balance sheet.[10] Upon first glance, it becomes apparent that the magnitudes of the impulse responses exhibit substantial heterogeneity between member states. Particularly, more vulnerable countries exhibit larger magnitudes in the impulse responses of real GDP and lower responses in long-term interest rates. For

[10] These results are also reported in Table B2 and Table B3 in the Appendix.

instance, Spain and Portugal have the largest magnitudes of output response. Italy, Greece, Spain, Belgium, and Portugal have the lowest minimum responses of long-term interest rates. Belgium is included in this group, possibly due to its high debt-to-GDP ratio during the period under analysis. All the countries exhibited positive maximum responses of real GDP and inflation, and negative minimum responses of long-term interest rates and CISS. These results are consistent with expectations and, arguably, provide credibility to the estimated models. Furthermore, the estimated magnitudes are consistent with those documented in previous studies (presented in Table 3.1) providing justification for comparability. Some cumulative impulse responses exhibit mixed results, particularly for inflation. This is possibly explained by the infectiveness of LSAPs in stimulating inflation or due to the so-called price puzzle common to monetary policy VARs (Sims, 1992; Hanson, 2004).

Figure 3.1: Estimated maximum and minimum impulse responses



Notes: This figure reports the estimated magnitudes of the maximum and minimum impulse responses following a 1% shock in the holdings of euro area government bonds by each NCB for real GDP, HICP inflation, long-term interest rates derived from sovereign yields (LTIR), and the composite index of systemic stress (CISS).

Figure B1 in the Appendix reports the output impulse responses following a 1% shock to each NCBs' holdings of euro area government securities. Only Greece, Portugal, and Spain exhibit statistically significant[11] output responses, with maximum values of 0.084%, 0.212%, and 0.309%, respectively. The significance of these results underscores the effectiveness of asset purchases in stabilizing output in some of the countries impacted by the European sovereign debt crisis. However, Italy remains an exception with a peak impulse response of 0.035%, not crossing the threshold of significance. Given that Italy's

[11] The median, the $16^{th,}$ and the 84^{th} percentile bands are reported and considered for statistical significance.

GDP growth rates were substantially lower than those of the other vulnerable countries during this period, and the euro area's average, this outcome is consistent with observed data. This result suggests that other factors may have hampered the effectiveness of asset purchases for output stabilization.

Figure B2 in the Appendix reports the HICP inflation impulse responses. Only the impulse responses of Portugal and Greece cross the threshold of significance. Portugal exhibits a peak impulse response of 0.084%, and Greece of 0.031%, following a 1% shock to the NCB's holdings of euro area sovereign securities. However, these magnitudes are modest compared to the results for the remaining countries. The largest median peak response was Belgium, which exhibited a maximum impulse response of 0.2%. This particular result is consistent with the observation that Belgium had substantially larger inflation than the euro area average during the period under analysis, specifically after 2015. Even though euro area average inflation was close to zero in 2015 and 2016, Belgium's inflation was around 0.56% and 1.97%, respectively.[12] The magnitudes of the inflation responses from the model spanning from 2012:M1 to 2019:M12, estimated for robustness and excluding the COVID-19 period, are significantly lower than those of the main model up to 2023:M12. Nevertheless, Belgium maintains the largest maximum response of inflation at around 0.10%. The same is not verified for Spain, which reports a significantly lower maximum response of 0.002%. In the case of Germany, there is deflation following an expansionary balance sheet shock. This could, perhaps, be explained by the so-called price puzzle along with the low effectiveness of BSEPs to stimulate inflation, particularly in most of the non-vulnerable countries.

Figure B3 and Figure B4 in the Appendix report the impulse responses of LTIR and CISS, respectively. Italy, Greece, Spain, Portugal, and Belgium reported the largest troughs in the responses of long-term interest rates. These results are aligned with expectations, as most of these countries were significantly impacted by the sovereign debt crisis. However, there is considerable variability in the reversion of the responses back to zero, some countries exhibiting more persistence than others. Unexpectedly, the impulse responses of the CISS, at first glance, do not reveal any specific discernable pattern between vulnerable and non-vulnerable countries.

In the next step, the IRF magnitudes are correlated with the average of the vulnerability variables considered for this study. All the correlations obtained are reported

[12] This analysis is based on data from the World Bank, source: https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG.

in Table 3.3 and Table 3.4. Figure 3.2 reports the correlation plots for a better visualization and interpretation of the result. Generally, the correlations indicate that more vulnerable countries, characterized by higher debt-to-GDP, higher unemployment rates, lower GDP per capita, and lower tier 1 capital ratios exhibit the largest increases in real GDP and the lowest decreases in long-term interest rates and unemployment rates, indicating a favorable economic outcome. The correlations obtained for the inflation rate and CISS are comparatively lower. This suggests that the responses of inflation and CISS following a shock in euro area sovereign bond purchases by NCBs were not correlated with the vulnerability variables considered. Not surprisingly, the largest correlations were observed for the magnitudes of long-term interest rates. Specifically, a correlation of -0.83 was found with debt-to-GDP, 0.75 with GDP per capita, -0.65 with the unemployment rate, and 0.58 with tier 1 capital ratios. Given that the shock variable considered is the NCBs' holdings of euro area sovereign securities, it is expected for a positive shock to significantly reduce the yields of the most affected countries. Furthermore, a positive shock to the purchase of euro area sovereign bonds also yields relevant correlations for output growth and a reduction in the unemployment rate, albeit with weaker correlations. These results suggest that NCB sovereign bond purchases were more effective at stimulating economic activity in more vulnerable member countries.

For robustness, the same analysis was undertaken for the period from 2012:M1 to 2019:M12, excluding the COVID-19 pandemic and the inflationary events that followed as they could have influenced the results. Table 3.4 reports the correlations of the robustness model. The results obtained confirm the general conclusion of the main model ending in 2023:M12. However, the results for the robustness period are more significant and provide stronger support for the hypothesis proposed in this paper. Specifically, it reports a higher correlation between the minimum response of long-term interest rates and debt-to-GDP of 0.91. The lower correlations in the main model are perhaps explained by the COVID-19 and inflationary periods. Furthermore, during the pandemic period, extraordinary fiscal and public policies could have played a significant role in the variation of output, inflation, and unemployment.

Table 3.3: Correlations IRF magnitudes with structural variables.

Correlations Table - 2012:M1 to 2023:M12				
	DTG	GPC	UNE	T1
GDP Max	0.2364	-0.5275	0.5540	-0.6561
GDP Cumul.	0.2110	-0.4545	0.6014	-0.6129
INF Max	0.0064	-0.1457	-0.0686	0.0223
INF Cumul.	0.1690	-0.1582	0.2140	0.0059
LTIR Min.	-0.8298	0.7463	-0.6498	0.5786
LTIR Cumul.	-0.0593	0.1086	0.0776	-0.1823
CISS Min.	-0.2111	0.2901	-0.0928	0.3389
CISS Cumul.	-0.1976	0.2059	-0.1498	0.3298
UNE Max.	-0.2093	0.4024	-0.6422	0.5525
UNE Cumul.	-0.1908	0.3796	-0.6533	0.5580

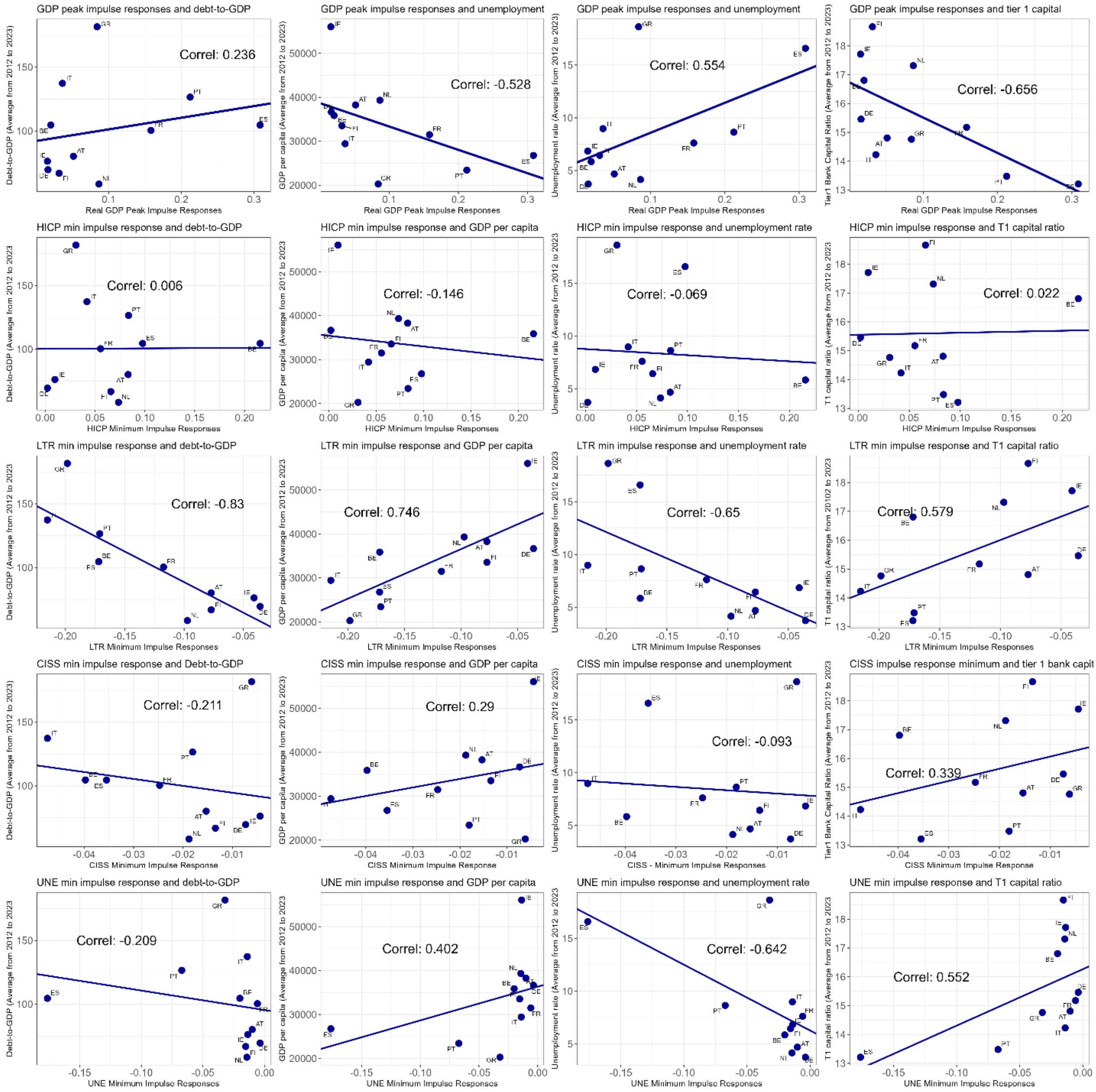
Notes: This table reports the correlations of maximum, minimum, and cumulative impulse responses with country characteristics. DTG represents the debt-to-GDP ratio. GPC represents GDP per capita PPP. T1 represents the banking industry tier 1 capital ratio. UNE represents the unemployment rate. Max represents the maximum of the median impulse responses. Min represents the minimum of the median impulse responses. Cumul. represents the cumulative of the median impulse response in a 24-month horizon.

Table 3.4: Correlations of IRF magnitudes with structural variables for the robustness model ending in 2019:M12

Correlations Table - 2012:M1 to 2019:M12				
	DTG	GPC	UNE	T1
GDP Max	0.4251	-0.4129	0.5473	-0.2657
GDP Cumul.	0.5483	-0.5504	0.8619	-0.6220
INF Max	-0.0424	-0.0340	-0.2807	0.2946
INF Cumul.	-0.3760	0.3038	-0.6803	0.3028
LTIR Min.	-0.9083	0.7113	-0.8081	0.2057
LTIR Cumul.	-0.6988	0.5173	-0.6968	-0.0291
CISS Min.	-0.4752	0.4614	-0.3455	0.5669
CISS Cumul.	-0.1428	0.1288	-0.0146	0.5241
UNE Max.	-0.4770	0.5918	-0.8930	0.4471
UNE Cumul.	-0.4722	0.5743	-0.8954	0.4302

Notes: This table reports the correlations of maximum, minimum, and cumulative impulse responses for the robustness model from 2012:M1 to 2019:M12. DTG represents the debt-to-GDP ratio. GPC represents GDP per capita PPP. T1 represents the banking industry tier 1 capital ratio. UNE represents the unemployment rate. Max represents the maximum of the median impulse responses. Min represents the minimum of the median impulse responses. Cumul. represents the cumulative of the median impulse response in a 24-month horizon.

Figure 3.2: Correlation plots



Notes: This figure plots the correlations between IRF magnitudes and vulnerability variables. The correlations reported are calculated from the model spanning from 2012:M1 to 2023:M12.

3.4.2 Panel Structural BVAR

In this section, we estimate a panel structural BVAR model for robustness and to provide a basis for comparison of results. By incorporating more observations, a panel model can produce more generalizable and robust estimations. Additionally, this strategy will allow the grouping of countries and provide a straightforward basis for the comparison of IRFs between vulnerable and non-vulnerable countries. The estimation is conducted using the ECB's BEAR application for MATLAB (Dieppe et al., 2016). The model considered is a pooled estimator.[13] For the identification, the same variables and restrictions are used as before (Table 3.2) with the purpose of maintaining comparability.

Under this panel setting, two models are estimated, one for vulnerable countries (Greece, Italy, Portugal, and Spain) and a second for non-vulnerable countries (Austria, Belgium, Germany, Finland, France, Ireland, and the Netherlands). Figure 3.3 reports the IRFs for the model from 2012:M1 to 2023:M12. Figure 3.4 reports the results for the model from 2012:M1 to 2019:M12. As previously, the impulse responses report the impact after a 1% innovation to the NCB's holdings of euro area sovereign debt securities. From Figure 3.3, it can be concluded that the magnitudes and statistical significance of the impulse responses are more pronounced for the vulnerable countries across all variables, except the CISS.

The response of real GDP reaches a peak of 0.08% for the vulnerable countries, and of 0.051% for the non-vulnerable countries. For the model ending in 2019:M12, the response of output reaches a peak of 0.071% for the vulnerable countries, and of 0.02% for the non-vulnerable countries, a larger difference. Moreover, and particularly for the robustness model, the figures reveal that the impact on output displays more persistence for the non-vulnerable countries. This result is consistent with correlations of cumulative responses in the individual country analysis. That is, the peak impulse response is larger for vulnerable countries, but the shock persistence is more significant for non-vulnerable countries.

The response of the inflation rate reaches a peak of 0.034% for the vulnerable countries, and of 0.02% for the non-vulnerable countries. This response shows a significant price puzzle for the group of non-vulnerable countries. However, the response

[13] The parameters were calibrated according to the recommended settings as decribed by Dieppe et al. (2016). Specifically, the hyper paramenters used are: autoregressive coefficients (ar) - 0.8, overall tightness (lambda1) - 0.1; lag decay (lambda3) - 1; exogenous variable tightness (lambda4) - 100. The model was run with 50,000 replications with 20,000 burn-in. Further details on this estimator is found in section 6.3 in Dieppe et al. (2016).

eventually turns positive after 19 months of the initial shock. In the robustness model ending in 2019:M12, inflation does not turn positive for the group of non-vulnerable countries, suggesting the ineffectiveness of asset purchases in stimulating inflation for this group of countries in this period.

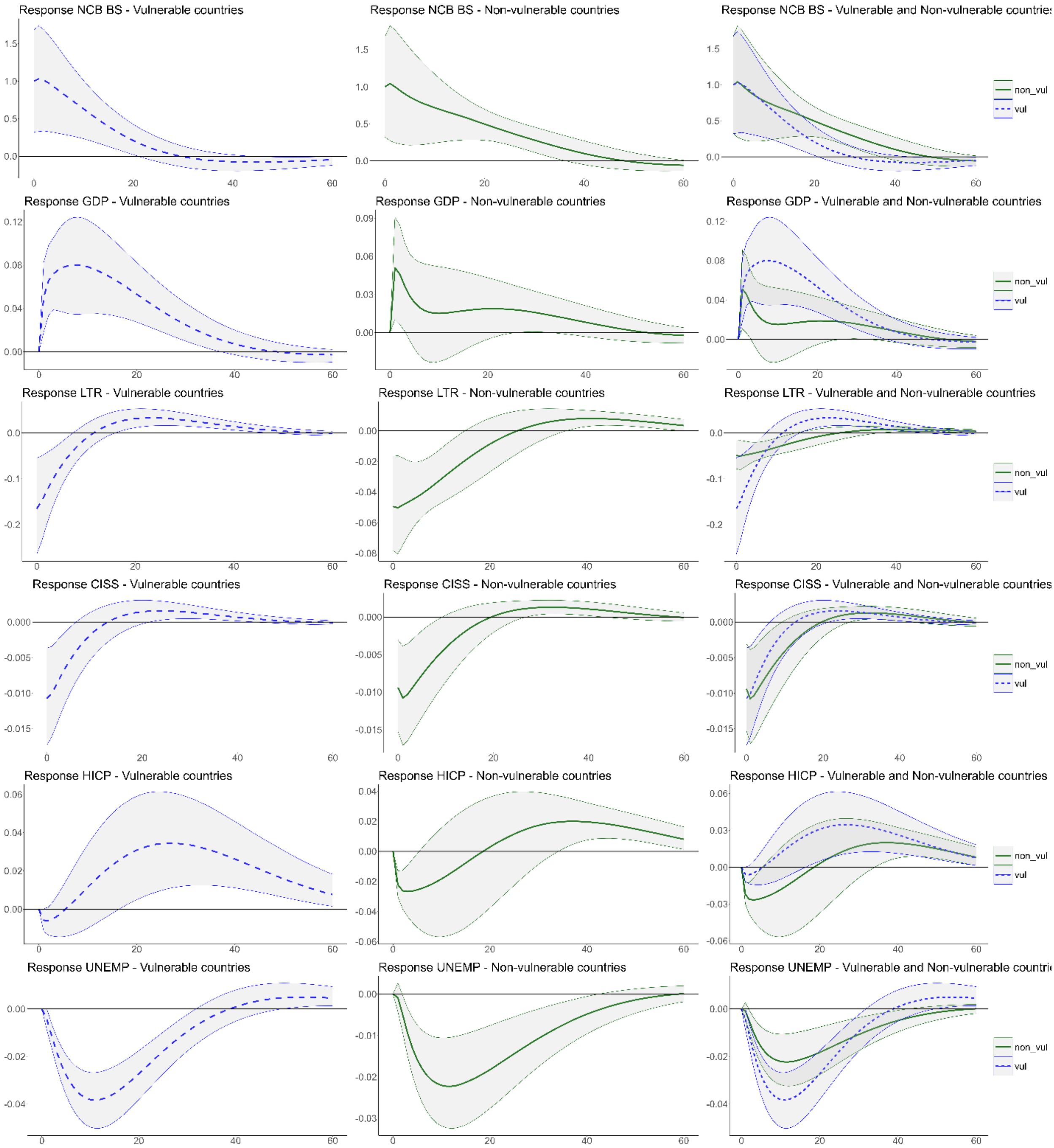
In the main model ending in 2023:M12, the response of the long-term interest rate reaches a minimum of -0.16% for the vulnerable countries, and -0.05% for the non-vulnerable countries. Again, the duration and persistence of the responses tends to be more sustained in non-vulnerable countries. The magnitude of the impact is larger for the vulnerable countries, but quickly goes back to zero. The IRF becomes slightly positive roughly 12 months after the initial shock. This suggests that market participants adjusted the price of the bonds in the months following the shocks. Perhaps the BSEPs were not as impactful as anticipated by the market. This result is consistent with the lower correlation value reported in Table 3.3 for the cumulative responses of long-term interest rates and debt-to-GDP. Although the magnitudes are smaller for non-vulnerable countries, it takes longer for the impact to subside back to zero.

In the main model ending in 2023:M12, the minimum responses of the CISS, for both the vulnerable and the non-vulnerable countries, reaches a minimum of around -0.1%. In the robustness model, the response of the CISS reaches a minimum of -0.02% for the vulnerable countries, and -0.007% for the non-vulnerable countries. As with the individual country analysis, it is harder to establish evidence of large heterogeneity in the response of this variable to BSEPs. However, the panel model for the robustness period ending in 2019:M12 suggests that vulnerable countries had slightly more favorable responses.

In the main model ending in 2023:M12, the minimum responses of the unemployment rate reach a minimum of -0.038% for the vulnerable countries, and -0.022% for the non-vulnerable countries. In the robustness model, the response of unemployment reaches a minimum of -0.041% for the vulnerable countries, and -0.016% for the non-vulnerable countries. The vulnerable countries obtained more favorable responses, however, similar to the previous IRFs, unemployment displays more persistence in the non-vulnerable group of countries.

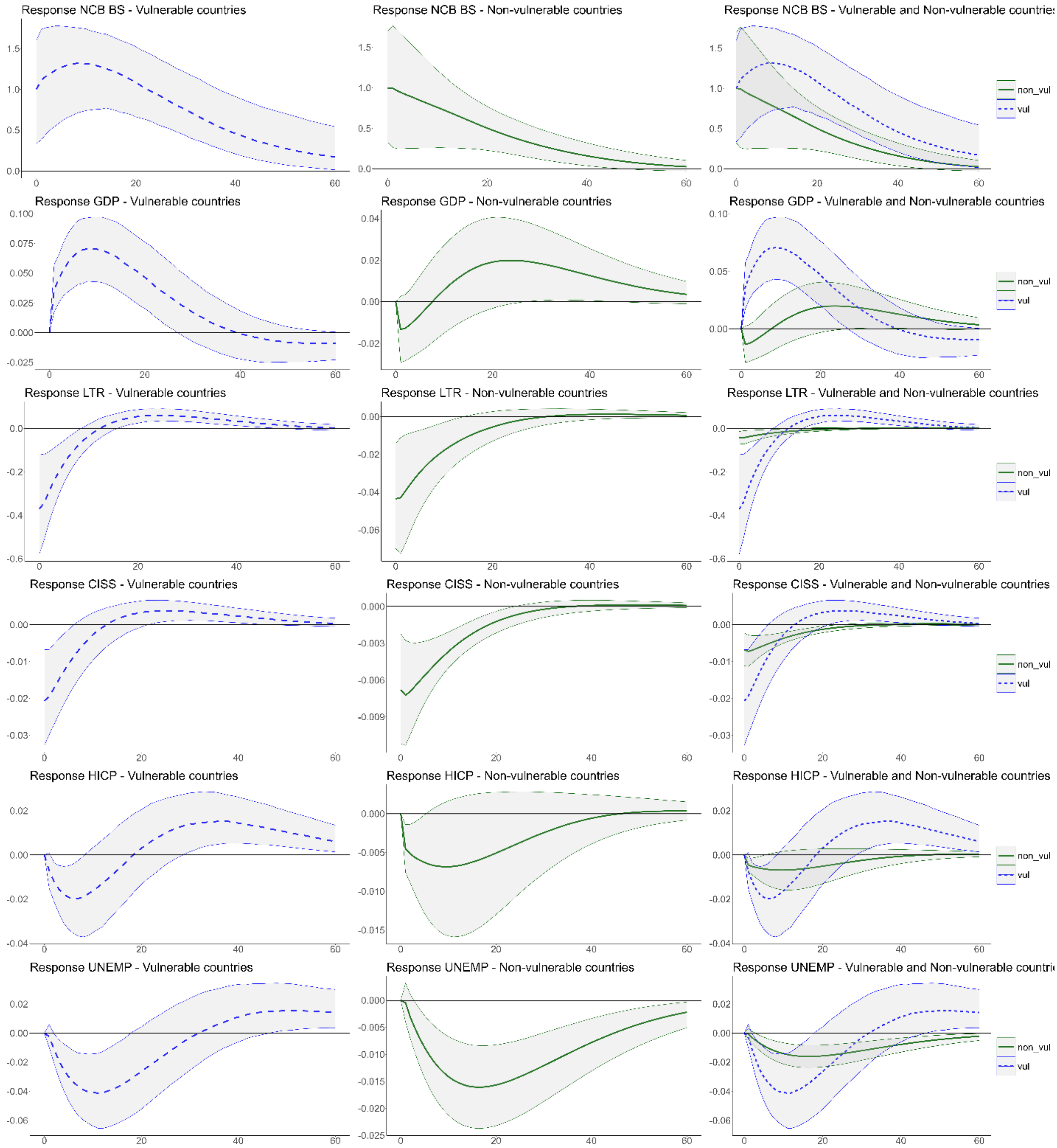
The Panel BVAR models estimated provide the same general conclusions as the analysis with the individual countries. This strategy suggests the presence of more favorable impacts on inflation and CISS for the vulnerable group of countries, which was harder to establish in the individual country analysis. One of the main benefits of undertaking this analysis is the direct comparison of IRFs between these two groups of countries. This exercise provides compelling evidence in support for the hypothesis that more vulnerable countries benefited more from ECB's LSAP programs.

Figure 3.3: Comparison of IRFs for the panel model (2012:M1-2023:M12)



Notes: This figure plots the IRFs given a 1% shock to the NCBs holdings of euro area sovereign debt securities. The model considered is a structural panel BVAR. Vulnerable countries are Greece, Italy, Portugal, and Spain. Non-vulnerable countries are Austria, Belgium, Germany, Finland, France, Ireland, and the Netherlands. The model considered spans the period from 2012:M1 to 2023:M12. The right most column shows the overlap of IRFs using the same scale for comparison.

Figure 3.4: Comparison of IRFs for the panel model (2012:M1-2019:M12)



Notes: This figure plots the IRFs given a 1% shock to the NCBs holdings of euro area sovereign debt securities. The model considered is a structural panel BVAR. Vulnerable countries are Greece, Italy, Portugal, and Spain. Non-vulnerable countries are Austria, Belgium, Germany, Finland, France, Ireland, and the Netherlands. The model considered spans the period from 2012:M1 to 2019:M12. The right most column shows the overlap of IRFs using the same scale for comparison.

3.4.3 Limitations and avenues for future research

Turning to the limitations of our empirical strategy. First, we only take into consideration NCB's holdings of euro area sovereign securities. While this approach is convenient, it is not possible to disentangle effects coming from the announcements and the actual purchase of assets. Second, the ECB undertook different programs and hence the estimated responses might not represent the exact outcome of a specific programme. For instance, the corporate sector purchase programme (CSPP) was undertaken simultaneously with the PSPP, and hence the results could prove hard to disentangle. Third, several of the countries in this study were subject to financial assistance during the period under analysis, which may have introduced bias and potentially skewing some of the results. Fourth, even though the correlations reported (Table 3.3 and Table 3.4) present an intuitive way of looking at the research question proposed, it is not an exceedingly robust exercise, as it is based on only 11 member countries. Furthermore, the vulnerability variables are based on averages for the entire period, which show considerable variation.

For future research, extending the model herein used by considering fiscal variables could prove valuable. Fiscal policies could provide further explanations regarding the macroeconomic stabilization and recovery of some member countries, particularly during the COVID-19 period. Additionally, investigating the distinct effects of the APP and PEPP, which were designed with different objectives and undertaken under different macroeconomic contexts, could provide interesting findings about the effectiveness of LSAP programs.

3.5 Conclusion

This paper estimates a structural BVAR model for 11 euro area countries over the period from 2012:M1 to 2023:M12. The purpose of this study was to investigate the heterogenous responses of macroeconomic variables to ECB's LSAP programs. The monetary policy variable considered is the NCB's holdings of euro area sovereign debt securities. Overall, this paper finds that more vulnerable euro area countries had larger magnitudes in desirable impulse responses after an LSAP shock than non-vulnerable countries. This conclusion is reached by, first, calculating the maximum, minimum and cumulative impulse responses of several macroeconomic variables following an LSAP shock. Then, the impulse responses are correlated with vulnerability variables, specifically debt-to-GDP, the unemployment rate, GDP per capita, and tier 1 bank capital ratios. This study finds that vulnerable countries exhibited larger peak impulse responses of real GDP, and lower minimum impulse responses in long-term sovereign yields, and the unemployment rate. The results were particularly significant for the impulse responses of long-term sovereign rates. The cumulative impulse responses exhibit lower correlations, suggesting that the long-term impact is less significant and it is harder to establish a causational relationship with LSAPs.

For robustness, and to enhance the comparability of the results, two panel structural BVAR models are estimated. One model is estimated for vulnerable member countries (Greece, Italy. Portugal, and Spain), and a second model is estimated for non-vulnerable countries (Austria, Belgium, Germany, Finland, France, Ireland, the Netherlands). The impulse responses of the vulnerable countries exhibit a larger magnitude in output, and inflation, and lower magnitude in the long-term interest rate, and the unemployment rate. Furthermore, the impulse responses of vulnerable countries exhibit larger magnitudes, but the impulse responses of non-vulnerable countries are more persistent, which is consistent with the correlation results obtained for the cumulative IRFs of individual countries.

This paper provides several contributions to the literature. First, the results obtained contrast with recent empirical findings from studies with similar methodology. In particular, past papers suggest that non-vulnerable countries had more favorable magnitudes in IRFs than vulnerable countries following a shock to the ECB's balance sheet. In this study, the opposite result is reported. Second, the NCBs' holdings of euro area sovereign debt securities is used as the monetary policy variable instead of the consolidated ECB balance sheet. Arguably, the methodology used in this paper provides a more accurate identification of LSAP shocks for each member state. Third, the results reported in this study are consistent with theoretical considerations of monetary policy models and with empirical findings of conventional monetary policy. From the results obtained in this study, it is argued that financial and economic vulnerability contributed to the magnitude of reactions to ECB's LSAPs. More vulnerable euro area member countries benefited more from sovereign bond purchase programs than non-vulnerable member countries.

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3.7 Appendix

Table B1: Summary of data sources and transformations

Variable	Source	Data Source Code	Transformation
Chow-Lin interpolation of Real GDP and industrial production	Eurostat	namq_10_gdp (na_item: B1GQ, unit: CLV10_MEUR, s_adj: SCA) and sts_inpr_m (unit: I15, a_adj: SCA, nace_r2: B-D)	2
Harmonized Index of Consumer Prices (HICP) Inflation**	ECB SDW	ICP.M.CC*.N.000000.4.ANR	N/A
Long-term interest rate derived from sovereign bond yields (LTIR)	ECB SDW	IRS.M.CC*.L.L40.CI.0000.EUR.N.Z	1
National central banks' (NCBs) balance sheet holdings of euro area general government debt securities.	ECB SDW	BSI.M.CC*.N.N.A30.A.1.U2.2100.Z01.E	2
Composite Indicator of Systemic Stress (CISS)	ECB SDW	CISS.M.CC*.Z0Z.4EEC.SOV_CLIDX	1
Unemployment rate (UNE)	Eurostat	lfsq_urgan (age: Y15-74, citizen: TOTAL, sex: T)	1
Debt-to-GDP (DTG)	ECB SDW	GFS.A.N.CC*.W0.S13.S1.C.L.LE.GD.T._Z.XDC_R_B1GQ._T.F.V.N._T	N/A
GDP Per Capita PPP (GPC)	Eurostat	nama_10_pc (na_item: B1GQ, unit: CP_PPs_EU27_2020_HAB	N/A
Tier 1 Capital Ratio (T1)	ECB SDW	SUP.Q.CC*.W0._Z.I4002._T._Z._Z._Z._Z.PCT.C	N/A

Notes: This table reports the data and transformations used in the BVAR model.

*CC represents the country code (i.e. AT, BE, FI, FR, DE, GR, IE, IT, NL, PT, ES)

** Inflation is seasonally adjusted using X-13ARIMA-SEATS. This was done with the R package software *seas* available through CRAN.

Transformations: 1 – y-o-y differences; 2 – y-o-y log differences

Table B2: IRF magnitudes individual countries - model from 2012:M1 to 2023:M12

Country	GDP Max	GDP Cumul.	INF Max	INF Cumul.	LTIR Min	LTIR Cumul.	CISS Min	CISS Cumul.	UNE Max.	UNE Cumul.
AT	0.0513	0.3154	0.0831	-0.4292	-0.0771	-1.0003	-0.0153	-0.0799	-0.0100	-0.0814
BE	0.0203	-0.9093	0.2157	2.4394	-0.1720	-2.5135	-0.0397	-0.3924	-0.0200	0.1485
DE	0.0163	0.1272	0.0022	-0.7385	-0.0359	-0.8093	-0.0074	-0.1043	-0.0036	-0.0711
ES	0.3085	5.9286	0.0977	1.2670	-0.1721	-1.1224	-0.0355	-0.3663	-0.1762	-3.3153
FI	0.0316	0.3044	0.0658	0.1222	-0.0772	-1.4814	-0.0135	-0.0663	-0.0154	-0.1831
FR	0.1583	0.3901	0.0555	-1.1892	-0.1173	-1.8402	-0.0247	-0.3077	-0.0058	0.0731
GR	0.0840	1.2480	0.0308	0.4408	-0.1984	-0.9530	-0.0061	-0.0561	-0.0321	-0.5499
IE	0.0156	0.2912	0.0097	0.1329	-0.0411	-0.4631	-0.0044	-0.0799	-0.0137	-0.2352
IT	0.0362	-0.0794	0.0419	-0.2653	-0.2152	-1.6756	-0.0474	-0.3945	-0.0140	-0.1963
NL	0.0866	0.8064	0.0736	0.8145	-0.0972	-0.8867	-0.0188	-0.1293	-0.0143	-0.1895
PT	0.2122	3.7395	0.0835	1.3146	-0.1711	-0.2049	-0.0181	-0.1081	-0.0672	-1.1006

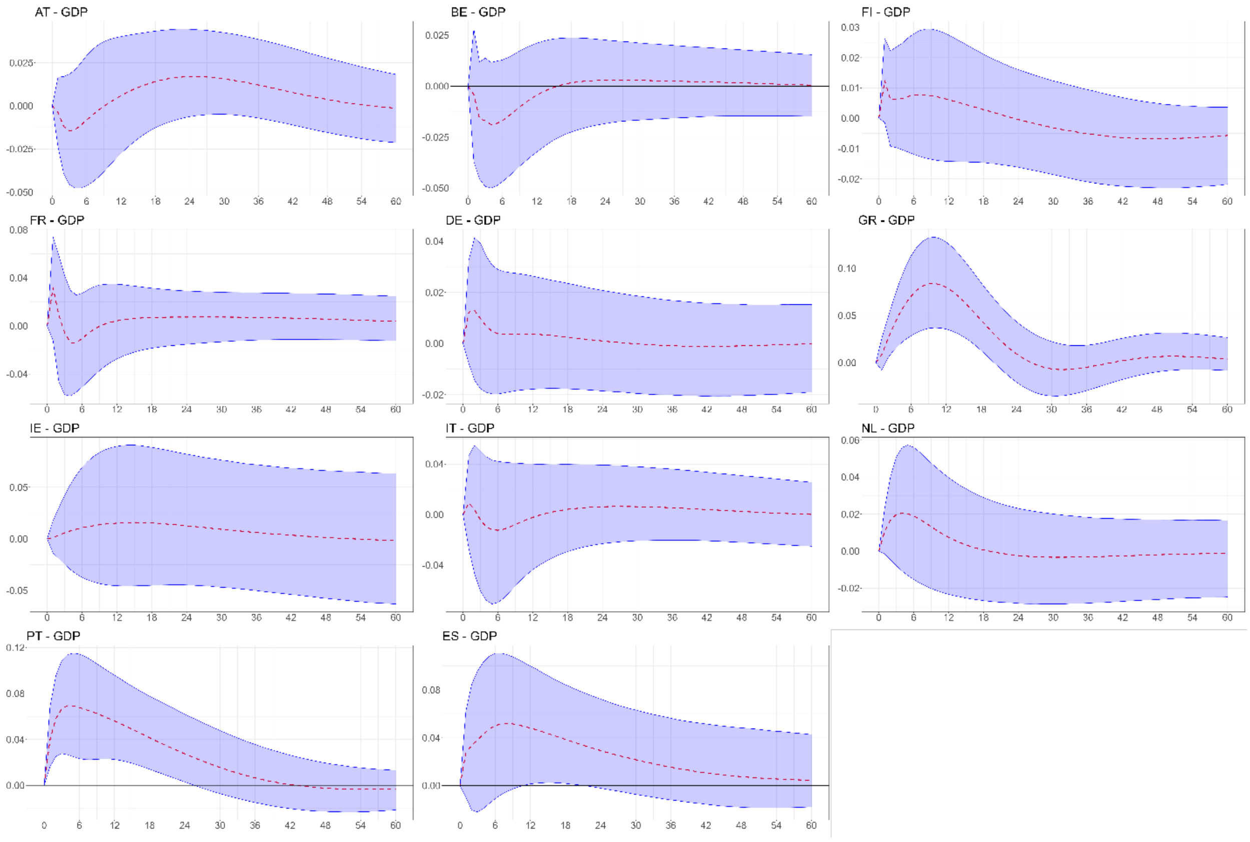
Notes: This table reports the maximum, minimum, and cumulative impulse responses following a 1% innovation to each individual NCB balance sheet. GDP represents real GDP. INF represents HICP inflation. LTIR represents long-term interest rates derived from sovereign bond yields. CISS represents the composite index of systemic stress. UNE represents unemployment. The sources and transformations of these variables are described in Table B1.

Table B3: IRF magnitudes individual countries - model from 2012:M1 to 2019:M12

Country	GDP Max	GDP Cumul.	INF Max	INF Cumul.	LTIR Min	LTIR Cumul.	CISS Min	CISS Cumul.	UNE Max.	UNE Cumul.
AT	0.0218	0.0142	0.0192	0.3171	-0.0595	0.2688	-0.0148	-0.1481	-0.0111	-0.0401
BE	0.1348	-0.3817	0.1014	2.0245	-0.1583	-0.6334	-0.0369	-0.3521	-0.0075	-0.0391
DE	0.0000	-0.3468	0.0008	-0.0039	-0.0219	-0.2839	-0.0029	-0.0332	0.0000	0.0389
ES	0.1230	2.4830	0.0021	-0.8322	-0.1613	-1.0474	-0.0371	-0.3740	-0.1421	-2.8400
FI	0.0000	-0.6605	0.0422	0.4952	-0.0615	-1.3328	-0.0083	-0.0425	-0.0032	-0.0099
FR	0.0819	0.6886	0.0370	0.7366	-0.1163	0.6485	-0.0208	-0.1995	-0.0307	-0.4870
GR	0.0853	1.3952	0.0100	-1.1122	-0.6993	-3.3512	-0.0180	0.0683	-0.0944	-1.8030
IE	0.0170	0.3098	0.0000	-0.0768	-0.0390	-0.4847	-0.0039	-0.0845	-0.0020	-0.0383
IT	0.0040	0.0614	0.0103	-0.1260	-0.2180	-2.0436	-0.0496	-0.5908	-0.0040	0.0239
NL	0.0000	-0.6265	0.0180	0.3491	-0.0664	-0.3148	-0.0119	-0.0967	0.0000	0.2468
PT	0.0486	0.8392	0.0307	0.5264	-0.2020	-0.3038	-0.0207	-0.1785	-0.0247	-0.3790

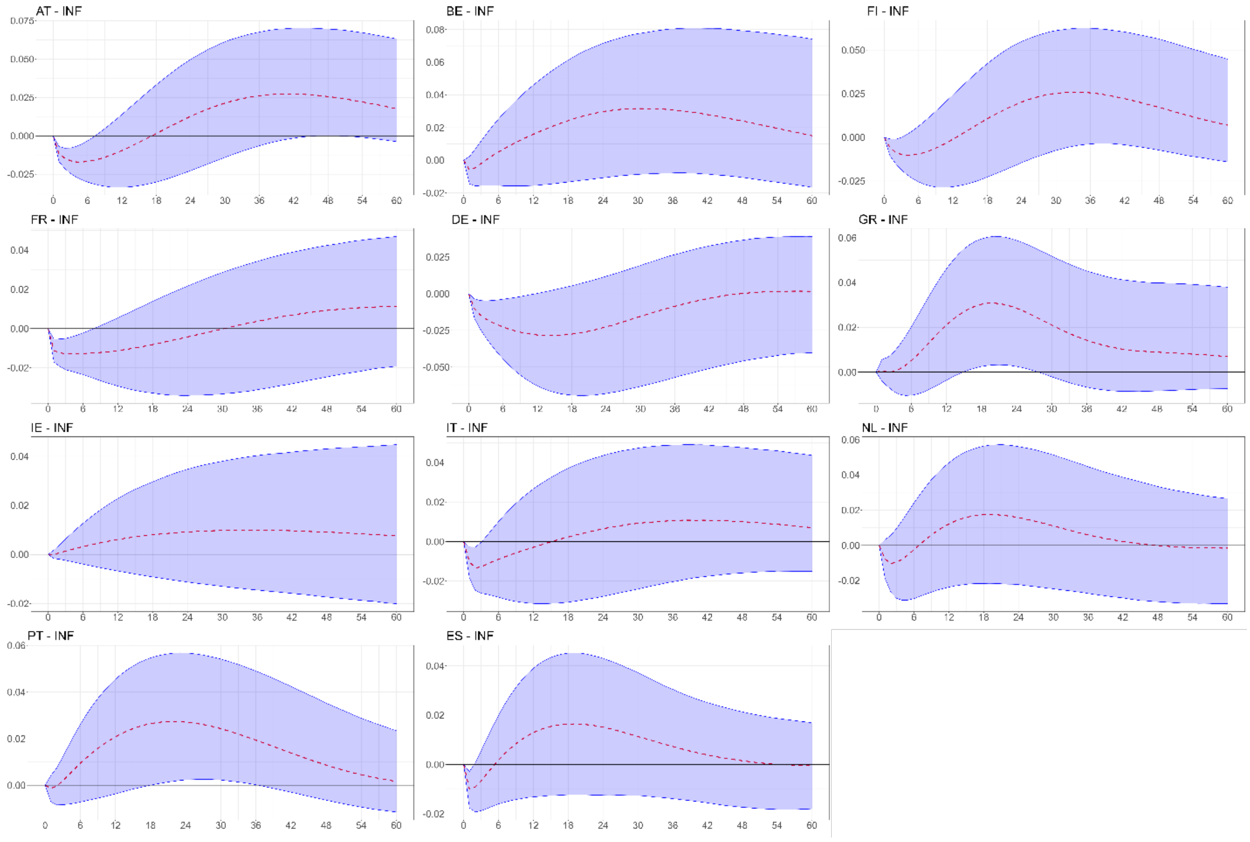
Notes: This table reports the maximum, minimum, and cumulative impulse responses following a 1% innovation to each individual NCB balance sheet. GDP represents real GDP. INF represents HICP inflation. LTIR represents long-term interest rates derived from sovereign bond yields. CISS represents the composite index of systemic stress. UNE represents unemployment. The sources and transformations of these variables are described in Table B1.

Figure B1: Individual IRFs of real GDP



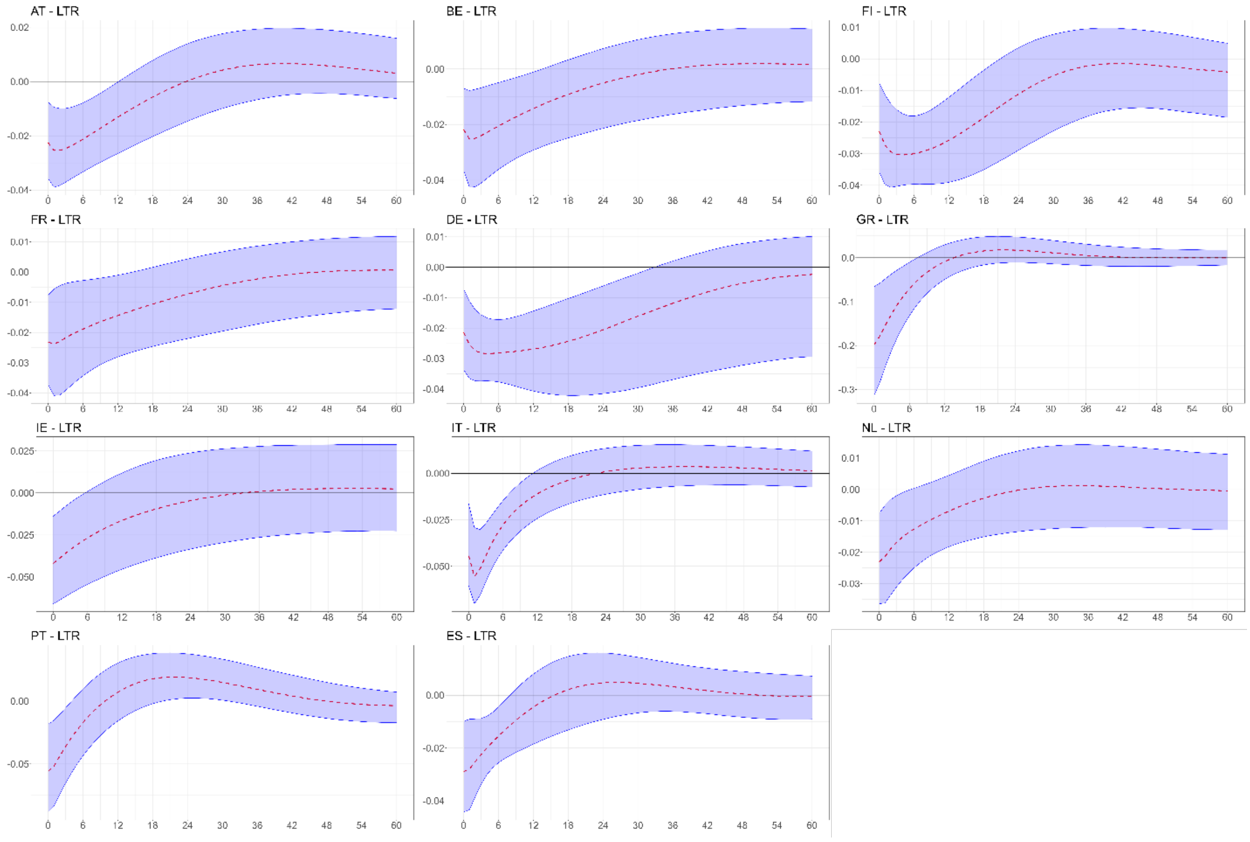
Notes: Individual countries impulse responses of real GDP following a 1% shock to the NCBs' balance sheet holdings of euro area government securities. The median, 84th, and 16th percentile bands are reported.

Figure B2: Individual IRFs of HICP



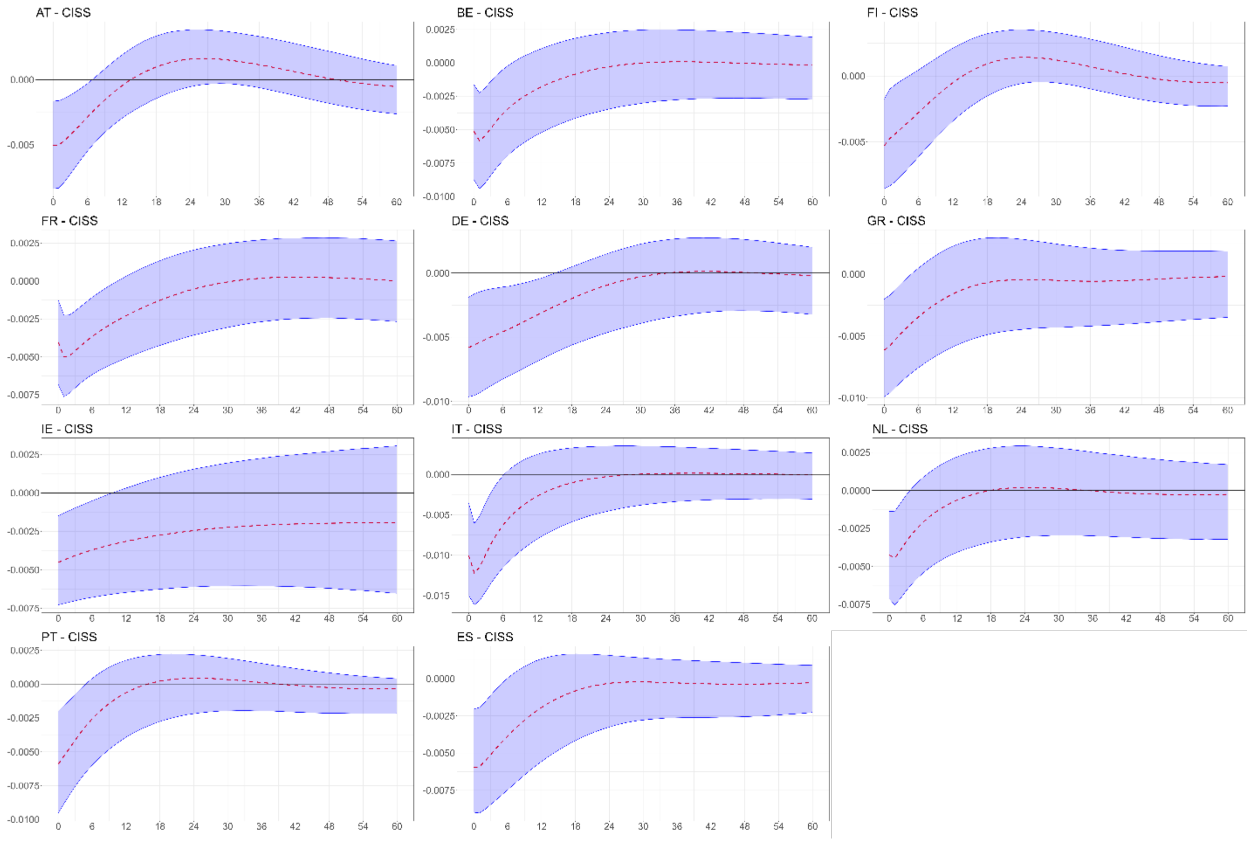
Notes: Individual countries impulse responses of HICP inflation following a 1% shock to the NCB's balance sheet holdings of euro area government securities. The median, 84th, and 16th percentile bands are reported.

Figure B3: Individual IRFs of LTIR



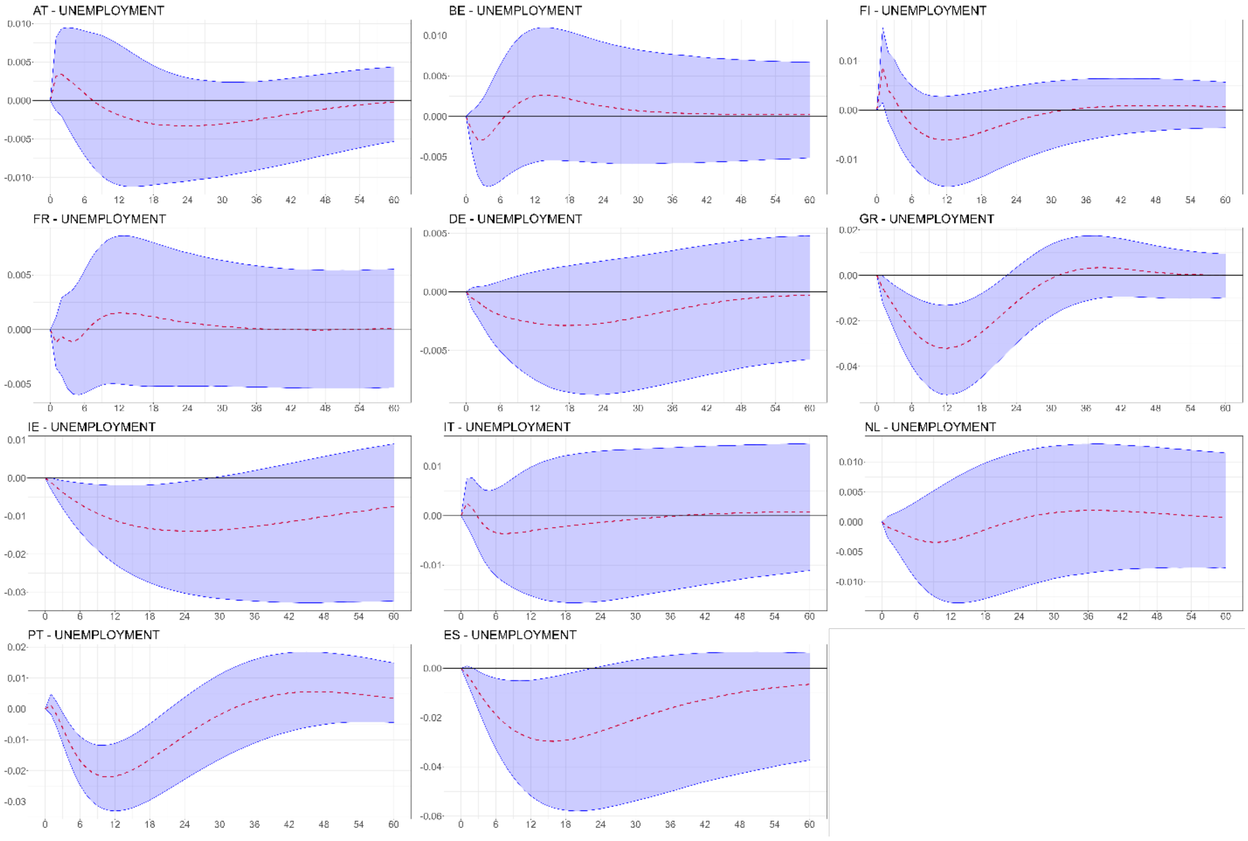
Notes: Individual countries impulse responses of long-term interest rates following a 1% shock to the NCB's balance sheet holdings of euro area government securities. The median, 84th, and 16th percentile bands are reported.

Figure B4: Individual IRFs of CISS



Notes: Individual countries impulse responses of CISS following a 1% shock to the NCB's balance sheet holdings of euro area government securities. The median, 84th, and 16th percentile bands are reported.

Figure B5: Individual IRFs of unemployment



Notes: Individual countries impulse responses of the unemployment rate following a 1% shock to the national central bank's balance sheet holdings of euro area government securities. The median, 84th, and 16th percentile bands are reported.

Chapter 4: Do Fiscal Policy Projections Influence ECB Decisions? A Forward-Looking SVAR Analysis*

4.1 Introduction

Central bank independence is generally considered a desirable institutional device to guarantee price stability.[1] Research suggests that countries with independent central banks have lower rates of inflation.[2] This finding is explained by the fact that central bankers are often exposed to significant political pressure. In the short term, monetary easing (tightening) has the potential to improve (deteriorate) economic activity, increase (decrease) tax income, and decrease (increase) interest rates on public debt. Therefore, from a political perspective, loose monetary policy is more desirable than contractionary monetary policy, particularly during election years. Generally, central bank heads are appointed by political actors, and hence their decisions could be motivated by political objectives and not solely by the central bank mandate. Specifically for the euro area, the ECB could be motivated to take actions to correct macroeconomic imbalances as an effort to avoid bailouts and fragmentation issues that could pose a threat to the currency area. Even though the single mandate of the ECB is price stability, one might argue convincingly that the macroeconomic environment and irresponsible fiscal policies by member countries can prompt the ECB to act.

Since the introduction of the euro, there have been rising fiscal deficits and debt-to-GDP ratios in most member countries of the euro area. Furthermore, the ECB has increased its balance sheet to unprecedented levels as a response to the GFC of 2008, the European sovereign debt crisis, and the COVID-19 pandemic. Arguably, the Mario Draghi's *"whatever it takes"* speech and the QE programs that followed allowed the euro area countries, particularly the more indebted members, to continue obtaining financing in the markets at low costs and to preserve the solvency of their fiscal policy. The purchase of large quantities of government bonds in the secondary market by the ECB could be understood as an effective monetary tool at the zero lower bound (ZLB), but

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[1] For a thorough review of central bank independence, see Eijffinger and De Haan (1996).

[2] See for instance Alesina (1988); Grilli et al., (1991); Alesina and Summers (1993).

also, potentially, as an indirect mechanism for monetizing the debt. If the latter case is the motivation behind such policies, this would be consistent with a fiscal policy dominance regime which is highly undesirable from a long-term sustainability perspective.

Given this backdrop, in this paper we ask whether euro area projected fiscal deficits have influenced ECB monetary policy decisions in the period between 2001:Q1 and 2022:Q2. To answer this question, we use a forward-looking Taylor rule estimated in a structural vector autoregression (SVAR) fashion with the inclusion of forecasts of euro area output, inflation, and fiscal deficits. For the proxy of the monetary policy stance, we use two shadow rates, one developed by Krippner (2015) and one developed by Kortela (2016). Our results suggest that the ECB's monetary policy mostly reacted to inflationary shocks, but not to fiscal deficits, consistent with a monetary dominance regime. The impulse response function (IRF) of the monetary policy stance following an exogenous shock to the projection of fiscal deficit suggests a slight (although statistically insignificant) contemporaneous decrease. Nevertheless, this IRF increases over time, and never crosses the threshold of significance. Furthermore, the forecast error variance decomposition (FEVD) of the monetary policy stance suggests that fiscal deficit projection shocks have very low explanatory power for monetary policy with the inflation indicator being the dominant variable.

Our contributions to the literature are as follows. First, we explore the question posed above using a SVAR model, which to the best of our knowledge, was not undertaken in the literature before in this context. Second, we augment a standard Taylor rule with a fiscal variable. This extension is not common in the literature, particularly for the euro area. Third, we use the so-called monetary policy shadow rates to account for unconventional monetary policies, enabling us to extend the analysis period and include the ZLB. Fourth, we use macroeconomic projections instead of past values. This approach is justified as the ECB is likely reacting to forecasts rather than past values of inflation, output, and fiscal deficits. Fifth, we employ a so-called thick modelling approach where we refrain from making assumptions regarding which forecast horizon or concrete indicator the central bank is considering for policy decisions. To overcome this variable selection uncertainty, we estimate a total of 96 model variations with different forecast horizon combinations and report the median results obtained.

Our paper is structured as follows. Section 4.2 provides a brief review of the relevant literature. Section 4.3 describes the data used. Section 4.4 details the methodology. Section 4.5 reports the results. Finally, section 4.6 concludes.

4.2 Literature Review

The monetary decision maker is usually appointed by a political figure, which could place doubt on the de facto central bank independence (Buchanan & Wagner, 1977). Some evidence suggests that even legally independent central banks are exposed to political power as described, for instance, in Eijffinger and De Haan (1996) and Blinder (2022). This concern arises from the well-known government failure, the political business cycle (Nordhaus, 1975; Alesina, 1988). Political business cycles and the influence of political power in monetary policy decisions can give rise to fiscal policy dominance and monetary policy passive regimes. In a fiscal policy dominance regime, monetary policy reacts to the changes in fiscal deficits and government debt (Sargent & Wallace, 1981; Leeper, 1991). Under this regime, there is a risk of a spiral of increasing fiscal deficits, government debt, and inflation. Eventually, this can lead to debt monetization and even repudiation. On the other hand, in a monetary dominance regime, fiscal policy reacts to the changes in monetary policy. Central bankers often address the issue of independence by emphasizing the benefits that an independent monetary policy brings to the economy (Mersch, 2020).

The seminal work by Kydland and Prescott (1977) underscores that discretionary policies can fail in the long term because the incentives of policymakers can change over time. They argue that policy should be set with rules rather than discretion. It could be argued that the recent unconventional monetary policies undertaken by the ECB are discretionary and not fully rules based. This could raise questions with regards to the time consistency of policy. Alesina (1988), Grilli et al. (1991), and Alesina and Summers (1993) argue that legal independence is usually correlated with price stability. However, as argued by Fisher (1995), a central bank can sometimes be too independent. A central bank that is solely focused on price stability can potentially be insensitive to output stabilization or other macroeconomic objectives. This argument could provide some justification for discretion in monetary policy actions.

Taylor (1993) showed, in a simple formulation, that the Fed policy rate closely follows a simple relationship of inflation and the output gap. However, one criticism of the classic Taylor rule is its reliance on past data. One could argue that monetary authorities are making decisions based on macroeconomic forecasts. In this regard, Clarida et al. (2000) underscores the importance of using forward-looking variables to enhance this relationship. They estimate a forward-looking model where the Fed funds rate is a function of the expected deviation of inflation and output from their respective target levels. Paloviita et al. (2021) argues that the forecast horizon for the estimation of a forward-looking Taylor type rule could significantly affect the estimation results. Also, econometric models of a two-variable rule try to simplify the reality and thus are too simplistic to mimic the actual behavior of policymakers. While inflation and economic growth are common targets of monetary authorities, they are also greatly concerned with developments in the financial sector and other areas of the economy (Agnello et al., 2020). There is an apparent lack of studies that test whether the fiscal stance is being considered for monetary policymaking, providing motivation for this study.

4.3 Data

The main SVAR model used in this paper consists of 4 variables at quarterly frequency. Specifically, we use the monetary policy stance indicator and projections for the fiscal deficit, real output growth, and inflation gap. For the monetary policy stance indicator, we use the so-called shadow rate as it accounts for unconventional monetary policies, thereby allowing us to include the ZLB period. Specifically, we use the shadow rate variables developed by Krippner (2015) and Kortela (2016). The Krippner (2015) rate is based on a two-factor arbitrage-free Nelson Siegel model (i.e., level and slope state factors) and a time-varying lower bound. The Kortela (2016) rate is based on a multi-factor shadow rate term structure model and a time varying lower bound.

For the inflation gap we subtract inflation projections from the inflation target. For the inflation target, we use 1.9% until July 2021 and 2% afterwards.[3] Regarding inflation projections, we use four different time series indicators: (i) The ECB's average projected year-over-year (y-o-y) inflation for the full remaining projection horizon from the projection date; (ii) The ECB's average projected y-o-y inflation after Q3 (from the projection date) until the end of the projection horizon; (iii) The ECB's projected y-o-y inflation at Q3 after the projection date; (iv) The SPF (Survey of Professional Forecasters) projected y-o-y inflation at Q3 after the projection date. With regards to output growth, we use three different projection variables. Specifically, we use: (i) The ECB's projected y-o-y GDP growth at Q2 after the projection date; (ii) The ECB's average projected y-o-y GDP growth from the projection date until the end of the projection horizon; (iii) The SPF projected y-o-y GDP growth at Q2 after the projection date. Regarding projected fiscal deficit, we use four indicator variables: (i) The EC projected government deficit for

[3] This was motivated by Paloviita et al. (2021) where the authors suggests that the inflation target for the ECB has been below 2% since its inception ("close, but below 2 percent").

the current year, in % of GDP; (ii) The EC projected net borrowing by government for the next year, in % of GDP; (iii) The ECB's projected average general government budget balance for the full projection horizon (since the projections date until the end of the projection horizon), in % of GDP; (iv) The ECB's projected general government budget balance for the next year, in % of GDP.

We estimate our model using combinations of all the different variables described above, totaling 96 model variations. As central banks analyze a large variety of indicators, it would be too simplistic and naive to pick only one indicator for each group. Therefore, the thick modelling approach helps to reduce the selection bias and increase the robustness of the results.

4.4 Methodology

We build a straightforward SVAR model to test our hypothesis in the style of Bernanke and Blinder (1992), Stock and Watson (2001), Clarida (2001), and Choi and Wen (2010). These authors designed a SVAR model based on a Taylor rule and argued that this methodology provides a logical alternative for the analysis of a central bank reaction function in the context of unexpected disturbances in macroeconomic variables. The main argument for the usage of a SVAR model in this setting rests on the assumption that the typical macroeconomic variables in a classic monetary model are endogenous and, unlike a single-equation model, a SVAR can uncover dynamic variable interactions (Lütkepohl, 2005). Therefore, the SVAR model herein proposed can provide additional insights regarding the behavior of the central bank, in our case of the ECB, and investigate whether a fiscal stance indicator influences monetary policy behavior. We take a neutral approach with regards to which forecast horizon is considered for monetary policy setting, therefore we use many combinations of forecasted indicator variables and estimate a total of 96 models. We report the median coefficients and trace the impulse response functions of the ECB monetary policy given an unexpected innovation in macroeconomic projections, and thereby obtain a quantitative estimate of the ECB's response. Our SVAR model takes the following form:

$$BY_t = \Gamma_0 + \sum_{j=1}^{n} \Gamma_j Y_{t-j} + \varepsilon_t \tag{1}$$

We estimate the reduced form representation of the structural model:

$$Y_t = B^{-1}\Gamma_0 + \sum_{j=1}^{n} B^{-1}\Gamma_j Y_{t-j} + B^{-1}\varepsilon_t \tag{2}$$

$$Y_t = A_0 + \sum_{j=1}^{n} A_j Y_{t-j} + u_t \quad (3)$$

where $A_0 = B^{-1}\Gamma_0$ and $A_j = B^{-1}\Gamma_j$ and $u_t = B^{-1}\varepsilon_t$

A_0 is a $K \times 1$ vector of intercepts; A_j is a $K \times K$ matrix of coefficients; u_t is a $K \times 1$ vector of disturbances; and Y_t is a vector with 4 endogenous variables, specifically:

$$Y_t = [\Delta y_{t+k}, fd_{t+n}, inf_{t+h}, i_t]'$$

where:

- Δy_{t+k} – projected y-o-y real GDP growth after period *k*.
- fd_{t+n} – projected fiscal deficits after period *n*.
- inf_{t+h} – projected inflation gap after period h (π_{t+h} - π^*).
    - π_{t+h} – y-o-y HICP projected inflation after period h.
    - π^*– inflation target (1.9% until 2021 July, 2% afterwards).
- i_t – shadow rate at time *t*.

We estimate the model with 1 lag.[4] We are mostly interested in the model's policy reaction function equation:

$$i_t = c + \sum_{j=0}^{1} \beta_{j,1} fd_{t+n-j} + \sum_{j=0}^{1} \beta_{j,2} \Delta y_{t+k-j} + \sum_{j=0}^{1} \beta_{j,3} inf_{t+h-j} + \beta_{1,4} i_{t-1} + \varepsilon_t \quad (4)$$

The primary purpose of estimating the above model is to assess the dynamic response of the ECB monetary policy stance in response to innovations in macroeconomic projections, mostly through the examination of IRFs. The identification of structural shocks is based on a recursive Cholesky identification. The basic layout described above is based on a conventional SVAR methodology, albeit via a forward-looking approach due to the medium-term orientation of ECB.

Our main SVAR model is specified with the variable ordering as outlined above, i.e., first projections of the output growth, followed by projections of the fiscal deficit, followed by projections of the inflation gap, and finally the shadow rate. We assume that the shadow rate is impacted by contemporaneous projections of all three variables. We consider this assumption realistic because monetary policymakers base their decisions on the most recent projections available to them. Inflation projections will be impacted by contemporaneous values of projected output growth and the fiscal deficit. Fiscal deficit

[4] For robustness, we estimated the same model with 2 and 3 lags and the results were qualitatively similar.

projections will be impacted by contemporaneous projections of output. Lastly, output will only react to lagged values of itself and the remaining variables. Whether fiscal deficit projections are determined based on contemporaneous projections of output and inflation is something that is difficult to ascertain, and many narratives can be constructed to support specific orderings. We selected the aforementioned ordering as it appeared to be the most logical choice from an economic perspective. Nevertheless, recognizing the disadvantage of not using a systematic mechanism for determining the ordering – this being a well-known issue in SVAR models – we conducted a robustness exercise by estimating several models with different orderings, as suggested by Lütkepohl (2005). The qualitative results and general responses were similar, albeit with varying levels of magnitudes.

4.5 Results

We start the analysis of the results by reporting the median coefficients obtained for the monetary policy reaction function and their respective statistical significance as they can provide an initial insight into the behavior of the ECB (Table 4.1). The 1-period lagged value of shadow rate is very persistent, with a coefficient of 0.96, meaning that central banks change their policy rates very gradually. Unsurprisingly, the contemporary coefficients of inflation gap and output growth are larger and more statistically significant than their respective lagged variables – monetary policymakers consider the most recent projections. The inflation gap projection is by far the most influential coefficient, with a magnitude of around 2.35 and with high statistical significance. This means that the ECB mostly takes into account inflation projections rather than other indicators for monetary policy setting. For output growth, we obtained a positive and statistically significant coefficient of 0.43, consistent with countercyclical monetary policy. For the contemporaneous impact of fiscal deficit projections, we obtained a slightly positive coefficient of 0.08, although it is statistically insignificant. Interestingly, the 1-period lagged fiscal deficit coefficient exhibits a positive value of 0.05 with 5% significance. This suggests that fiscal deficit projections could induce a contractionary monetary policy response later. One hypothesis for this result is that increased fiscal deficits could lead to higher aggregate demand, contributing to higher inflationary pressures, which would lead to higher policy rates and more restrictive monetary policy.

Table 4.1: SVAR model median coefficients

Variables	Coefficient	Std. Error	t value	P(>|t|)
Intercept	-0.28328478	0.18905873	-1.52924843	1.384554e-01
Shadow Rate(−1)	0.95641060***	0.03556086	26.89509333	7.969679e-42
Inflation gap(0)	2.3546788***	0.1084652	21.7090659	2.823502e-35
Inflation gap(−1)	-0.01269468	0.17414518	-0.07737535	9.385319e-01
Output growth(0)	0.4287708***	0.1115166	3.8449063	2.408613e-04
Output growth(−1)	0.07964357	0.05296900	1.92766403	1.568218e-01
Fiscal deficit(0)	0.0754472	0.1096485	0.6880825	4.933912e-01
Fiscal deficit(−1)	0.04802548**	0.02316476	2.07315718	4.138382e-02

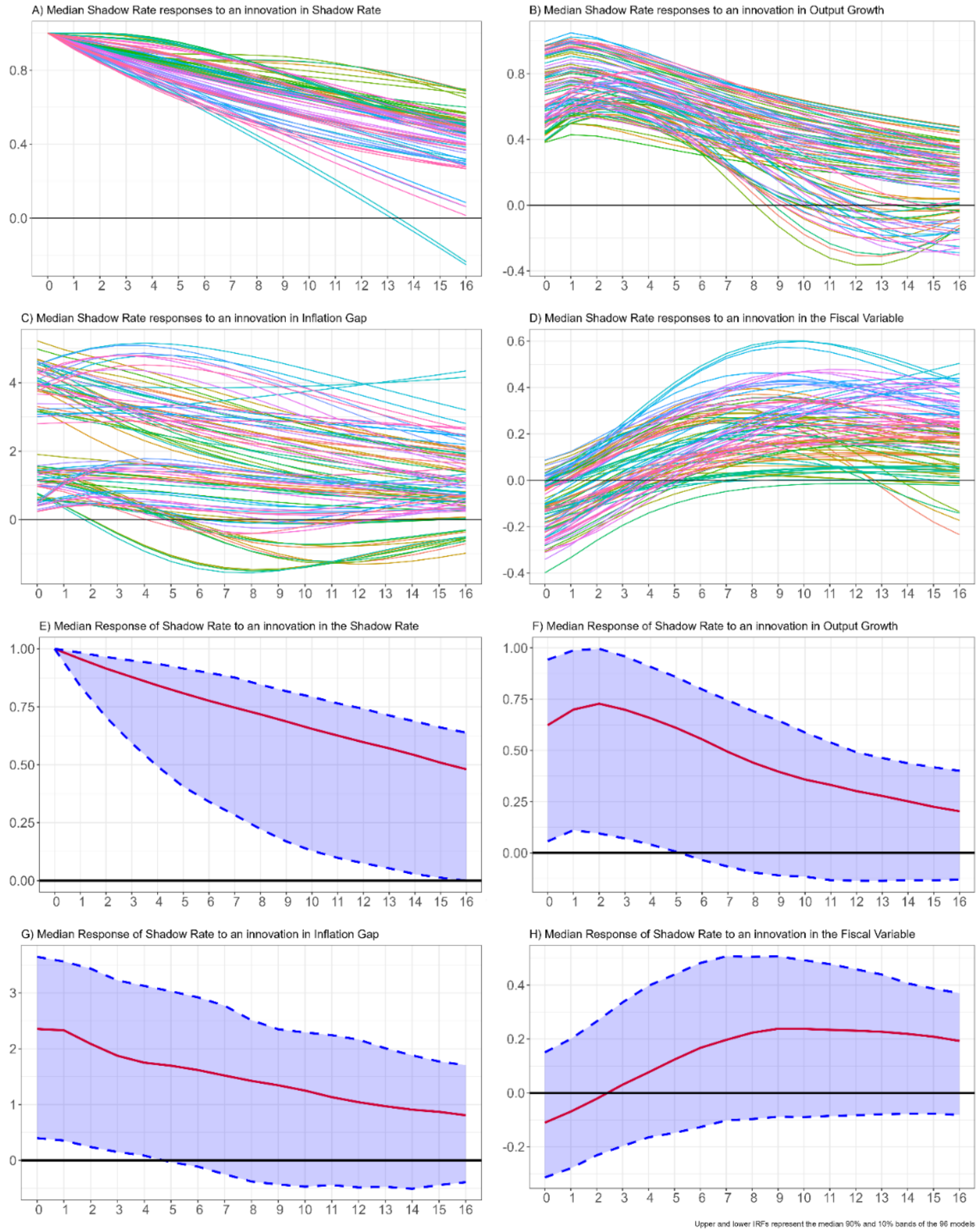
Notes: Asterisks after coefficients indicate the statistical significance of the median value at the 5% (**) and 1% (***) significance levels.

Figure 4.1 reports the IRFs of the shadow rate given an unexpected innovation in the projected inflation gap, output growth, and the fiscal deficit. The top four panels (A–D) report the distribution of the IRFs. The bottom four panels (E–H) report the median values of the IRFs and the median 90% confidence intervals of the different model specifications for each time horizon. An unexpected innovation in the projected inflation gap generates a positive and statistically significant response of shadow rates up to 4 quarters after the initial shock (panel G), again confirming the direct reaction of monetary policy to inflation developments. However, the distribution of the results exhibits significant variability (panel C). This is possibly explained by the fact that the response of the shadow rate is sensitive to the projected period and the combination of variables. At time horizon 0, all the estimated shadow rate impulse response functions are above zero and range between 0.24% and 5.22% for a 1% unexpected innovation in projected inflation. Regarding the economic activity (panels B and F), the response of the shadow rate at horizon 0 following a 1% innovation in output growth ranges between 0.38% and 1%, and the median is 0.62%. This result suggests the ECB follows countercyclical monetary policy. Furthermore, the impulse responses for the output growth exhibit less variability than the inflation shock impulse responses of the shadow rate.

The primary IRF of interest for this study is the response of the shadow rate to a 1% unexpected innovation in the projected fiscal deficit, presented in panels D and H. Panel D demonstrates a consistent distribution across impulse responses. At horizon 0, the values range between −0.40% and 0.09%, and the median is -0.11%. Even though the median impulse response is negative at time horizon 0, it is statistically insignificant as the median 90% confidence bands do not cross the 0 threshold. We assume that this insignificant result is possibly related to the fact that the ECB is likely not actively considering projections of fiscal variables. The shadow rate could thus respond when the fiscal deficit materializes or becomes more certain. Therefore, it is possible that the impulse response at the earlier horizons may not fully reflect the actual response of monetary policy due to the nature and timing of the projected fiscal deficit indicator. After the initial response, this impulse response increases gradually up until 9 quarters, with the impulse response distribution now ranging between -0.02% and 0.60%, and the median at around 0.24%. As the projected fiscal spending is realized over time (i.e., during the projection horizon), the shadow rate eventually increases, indicating a contractionary stance taken by the central bank. It is likely that increased fiscal spending and/or increased output will lead to inflationary pressures later, which could explain the delayed and restrictive response of the monetary policy stance indicator. However, the median 90% confidence bands never cross the threshold of significance.

The method of estimating many different SVAR models in a thick modelling approach catches a wide net of possible results. Each model's variable composition may vary in terms of their credibility. Therefore, we expect some results to make less intuitive sense than others. This seems particularly true for the responses of the shadow rate to an innovation in projected inflation, as there is significant dispersion (panel C). Nevertheless, given the numerous variables that central bankers must consider and the uncertainty regarding the appropriate variable selection choice, we expect that the median of the results at each time horizon can provide a reasonable approximation of the true parameters and the actual central banks reaction.

Figure 4.1: IRFs of shadow rate following innovation in projection variables



Notes: Panels A–D report all the impulse responses of the shadow rate given an unexpected innovation in the projection variables according to the model described in Equation (2) using a thick modelling approach. Panels E–H represent the median value of the impulse responses and 90% confidence intervals based on bootstrapping replications at each given horizon. The thick modelling approach has 2 shadow rates, 4 projected inflation indicators, 3 projected output growth measures, and 4 projections of fiscal deficit, producing a total of 96 impulse responses. We report a horizon of 16 quarters.

Table 4.2 reports the median of the FEVD results. The FEVDs report the contribution of each individual shock to explaining variable response variation (Lütkepohl, 2005). We report the FEVDs up to 10 steps ahead. In the first step, around 74% of the error variance of the shadow rate is accounted for by inflation gap innovations, and around 14% for own innovations. In subsequent steps, the contributions to shadow rate variation remain relatively stable, with projected inflation gap innovations continuing to be the most significant factor at around 75% by step 10. Additionally, innovations in the fiscal deficit is the factor that contributes the least to variations in the shadow rate response, being close to zero. The results of this analysis indicate that most of the influence of innovations on the response of the shadow rate is attributable to the inflation gap, with a smaller (close to zero) contribution from fiscal deficit innovations. This finding reinforces the result against the fiscal dominance regime – that is, monetary policy decisions are not being influenced by fiscal deficits, but mostly by the inflationary developments

Table 4.2: Shadow rate forecast error variance decomposition (FEVD)

Period	Output Growth	Fiscal Deficit	Inflation Gap	Shadow Rate
0	0.0677	0.0011	0.7401	0.1438
1	0.0771	0.0009	0.7389	0.1399
2	0.0857	0.0016	0.7419	0.1447
3	0.0852	0.002	0.7463	0.1508
4	0.0845	0.0022	0.75	0.157
5	0.0835	0.0028	0.754	0.1627
6	0.0823	0.0033	0.7537	0.166
7	0.0823	0.0037	0.7529	0.1694
8	0.0832	0.004	0.7519	0.1726
9	0.0764	0.0042	0.7507	0.1756
10	0.073	0.0048	0.7493	0.1729

Notes: This table reports the forecast error variance decomposition (FEVD) for the shadow rate. The FEVD values reported are the medians for each horizon.

For robustness and to provide an alternative model to compare the results, we estimate a similar model with three endogenous variables, omitting the fiscal deficit variable: $Y_t = [\Delta y_{t+k}, inf_{t+h}, i_t]'$. We report the impulse responses obtained from this model in Figure C1 in the Appendix. The overall dynamics do not change when compared with the previously estimated four-variable model. The main driver of the response in the shadow rate continues to be a shock in the inflation gap. The response of the shadow rate exhibited a median magnitude of approximately 2.5% following a 1% innovation in the inflation gap – only slightly larger than the four-variable model. As the results are very similar, we conclude that inclusion of the projected fiscal deficit variable does not substantially change the main results of the standard three-variable model.

4.6 Conclusion

Since the introduction of the euro, fiscal deficits and debt-to-GDP ratios of euro area member countries have significantly increased, along with a substantial expansion of the ECB balance sheet. This backdrop raises questions about whether monetary policy is reacting to fiscal policy changes. Therefore, in this paper, we assess whether the ECB's monetary policy responded to fiscal deficit forecasts in the euro area. In other words, we ask whether the ECBs monetary policy was active or passive. We answer this question with a forward-looking SVAR model with four variables. Specifically, we use the monetary policy stance proxied by the so-called shadow rate, and forecasts of output growth, inflation gap, and the fiscal deficit. To mitigate model selection uncertainty, we use a so-called thick modelling approach where we estimate many combinations of variables (totaling 96 models) and report the median coefficients and IRFs.

Overall, our results suggest that the ECB is not reacting to fiscal policy. The IRFs reveal that, contemporaneously, there is a slight loosening of the monetary policy stance after an exogenous fiscal deficit projection shock. However, the monetary stance variable quickly reverses and becomes contractionary in a sustained manner. Importantly, this IRF never crosses the threshold of significance consistent with a monetary dominance regime. Furthermore, the FEVDs reveal that the fiscal projections have little explanatory power for the monetary policy stance variable. As expected, the inflation projections have the strongest and direct link with the ECB monetary policy stance, showing strong adherence to the price stability mandate. Based on these results, we argue for the presence of a monetary dominance regime in the euro area during the period from 2001:Q1 to 2022:Q2.

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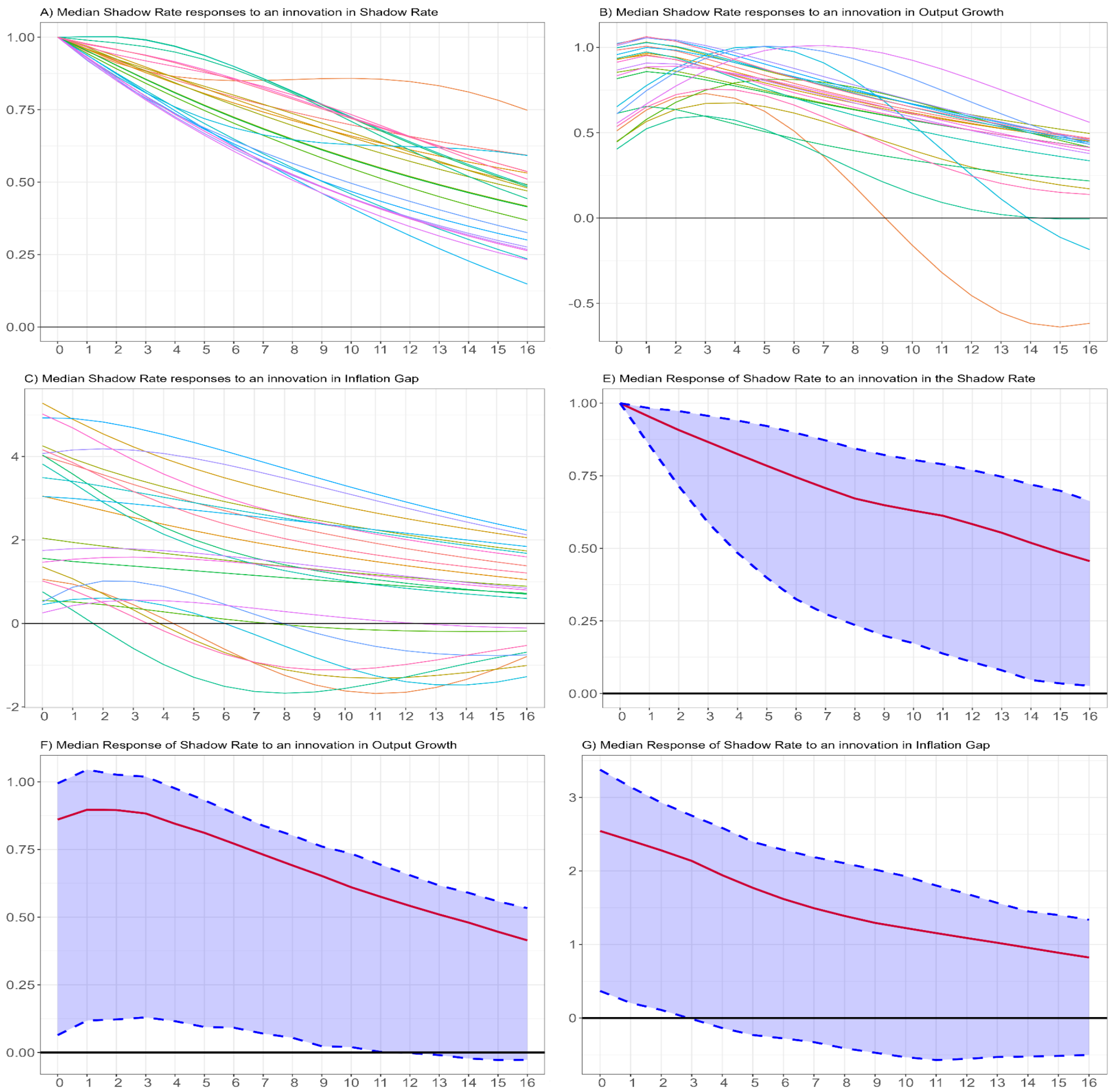
4.8 Appendix

Figure C1: Robustness – IRFs 3 variable model



Notes: This figure reports the distribution and median impulse responses of a 3-variable model $Y_t = [\Delta y_{t+k}, inf_{t+h}, i_t]$, without the inclusion of a fiscal projection variable. The plots represent the response of the shadow rate given an unexpected shock to output growth and inflation gap. Panels A-C reports the distribution of all IRFs obtained, while panels D-F represent the median values and 90% confidence intervals at each given horizon. The thick modelling approach has 2 shadow rates, 4 projected inflation indicators, and 3 projected output growth measures, producing a total of 24 impulse responses. We report a horizon of 16 quarters.

Chapter 5: Does monetary policy influence euro area fiscal sustainability?*

5.1 Introduction

How did the ECB's monetary policies influence fiscal sustainability in the euro area? While the ECB's mandate is price stability, fiscal policy reacts to shifts in monetary policy, which subsequently affects fiscal sustainability. In this paper, we contribute to the literature by exploring empirically how the ECB's monetary policy influenced debt sustainability. Specifically, we extend a fiscal reaction function (Bohn's rule) with a monetary policy stance interaction moderator term. When monetary policy is expansionary, it might allow governments to maintain a lower primary balance and potentially reduce fiscal fatigue. On the other hand, if monetary policy is contractionary, primary balances need to increase to maintain the debt trajectory sustainable.

The aftermath of the Global Financial Crisis (GFC) of 2008 and the European sovereign debt crisis left euro area countries with large debt-to-GDP ratios from an historical perspective. This situation raised concerns regarding the fiscal sustainability of several member countries, particularly those with the highest levels of sovereign indebtedness. These concerns were further amplified by the relatively subdued economic growth in several euro area countries compared to other developed nations and the lack of convergence. Arguably, the difficulty in addressing the large debt levels stems from the European economic and monetary union (EMU) framework of common monetary policy and decentralized fiscal policy. This provides a significant challenge for achieving policy coordination. This issue is relevant because fiscal and monetary policies play a pivotal role in managing fluctuations inherent in the business cycle as they are the main tools of macroeconomic stabilization (Musgrave, 1973). Hence, fiscal sustainability becomes of particular importance under this framework. The occurrence of self-fulfilling debt crisis and adverse feedback loops underscores the necessity of maintaining coordinated policies.

Under the analysis of debt sustainability by Bohn (1998), a sustainable government will increase the primary balance to satisfy the intertemporal government budget constraint (IGBC). Specifically, an increase in the governments' debt-to-GDP

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ratio should be matched with future increases in the primary balance. Although the original fiscal reaction function model proposed by Bohn does not include monetary policy, we argue that this variable is an important component for these dynamics. The rate at which the debt is discounted could significantly influence the present value of the primary balance. Similarly to government debt, if the central bank's policy rate increases, a fiscally sustainable government will increase the primary balance to remain solvent. Under this scenario, and assuming fiscal policy acts "responsibly", monetary policy can exert a "disciplinary" effect on fiscal policy. Alternatively, expansionary monetary policy can increase the sustainable level of debt and ease the pressure on fiscal policy. However, in the later situation, there could be questions regarding debt monetization and potentially place doubt on the independence and price stability mandate of the central bank.[1] There is a clear moral hazard issue if monetary policy is complacent with governments' increase in debt. However, monetary policy that is too restrictive can place unnecessary difficulty for governments repaying debt (De Grauwe, 2011).

The results obtained in this study, for 12 euro area countries, in the period frequency from 2003:Q1 to 2022:Q4, indicate that contractionary (expansionary) ECB's monetary policy stance tends to lead to an increase (decrease) in the primary balance of member countries. Furthermore, the interaction between the debt-to-GDP ratio and the monetary policy stance in the extended fiscal reaction function exhibits statistically significant coefficients. That is, when monetary policy is contractionary, primary balances increased more following an increase in the debt-to-GDP ratio than when monetary policy is neutral or expansionary. Conversely, when monetary policy is expansionary, the increase in primary balances is not as pronounced following an increase in the debt-to-GDP ratio. These results suggest that contractionary monetary policy exerts a "disciplinary" effect on fiscal policy, while expansionary monetary policy goes together with more relaxed fiscal constraints. Overall, these results suggest that euro area countries conducted fiscal policy in a "responsible" manner, and are indicative of a Ricardian fiscal regime, or a monetary dominant regime. However, regarding the magnitude and significance of the coefficients obtained, our results show that expansionary monetary policy has larger and more significant results than contractionary monetary policy.

[1] This is linked to the possibility of non-Ricardian regimes, where money and prices would need to adjust to the level of government debt to guarantee the fulfilment of the government intertemporal budget constraint (passive monetary policy), see Buiter (2002).

As a general understanding of these results, monetary policy that is more contractionary than necessary following an increase in the debt ratio could induce an unnecessary burden in public finances. On the other hand, expansionary monetary policy has the potential to increase the level of sustainable debt and decrease the risk of fiscal fatigue. As argued by Willems and Zettelmeyer (2022), these dynamics are possible provided the central bank enjoys a certain degree of credibility. However, this power by the monetary authorities can give rise to conflicts of interest if the independent goals are not well defined or are perceived to have changed. If monetary policy is too expansionary, then public finances are allowed be less sustainable and could raise questions of goal independence.

This paper is organized as follows. Section 5.2 reviews the literature. Section 5.3 details the data used. Section 5.4 details the econometric specifications. Section 5.5 reports the results. Lastly, section 5.6 concludes.

5.2 Literature Review

This paper is related to the literature strands of fiscal sustainability, government debt sustainability, fiscal reaction functions, and fiscal-monetary policy interactions. In this strand of literature, governments are often characterized as following a Ricardian or a non-Ricardian fiscal regime (Aiyagari & Gertler, 1985; Woodford, 1995; Afonso, 2008). Under a Ricardian fiscal regime, the government guarantees the sustainability of its interest-bearing obligations by increasing the primary balance through increased tax revenue or reduced spending. In other words, government finances satisfy the intertemporal government budget constraint (IGBC). On the other hand, under a non-Ricardian fiscal regime, the level of government debt will have no influence in fiscal policy decisions. Another interpretation of this concept is classifying regimes as monetary dominant and fiscal passive, or vice versa (see for instance Sargent & Wallace, 1981; Leeper, 1991; Sims, 1994). Simply put, under a dominant monetary and passive fiscal regime, monetary policy is set to maintain inflation at a pre-determined level, independent of fiscal policy decisions and government debt levels. Consequently, fiscal policy adjusts to the constraints of monetary policy. Under a fiscal dominant regime, fiscal policy is determined irrespective of monetary policy. Under this regime, monetary policy and the price level will have to adjust to sustain higher levels of fiscal deficits and debt. This situation is not desirable it often leads to inflation and, eventually, to default.

Fiscal reaction functions are a common method for assessing government debt sustainability. Under this framework, it is a common empirical exercise to regress primary balances on government debt as percentage of GDP (Bohn, 1998; Canzoneri et al., 2001; Afonso, 2008). This method is usually referred to as the Bonh's rule. This methodology allows for the evaluation of fiscal sustainability from the perspective of debt accumulation. It explains how governments react to the accumulation of debt and asks whether governments take corrective measures and act "responsibly". In this paper, we extend this analysis by including the monetary policy stance variable as an interaction term. In this line of literature, another important detail is the difference between the interest rate on public debt (r) and the real growth of the economy (g). Blanchard (2019) suggests that when r<g means that governments can run primary deficits indefinitely and still maintain debt sustainability. The sustainability of debt is guaranteed by GDP growth.

Many researchers have proposed that expansionary monetary policy can be used to maintain fiscal sustainability and avoid self-fulfilling debt crisis. Bacchetta et al. (2018) discusses how monetary policy can impede self-fulfilling sovereign debt crisis through inflation surprises, output growth, and lower interest rates. Roch and Uhlig (2018) Proposes an actuarily bailout agency to restore sovereign yields back to fundamentals and avoid sunspot driven defaults. Alberola et al. (2022) argues that unconventional monetary policy, in particular the Pandemic Emergency Purchase Programme (PEPP), substantially improved debt sustainability in the euro area for the countries with higher debt stock. For the case of Japan, Alberola et al. (2023) shows that unconventional monetary policy lowered sovereign funding costs, which, in turn, help improve debt sustainability. Cavalcanti et al. (2018), in a DSGE setting, argue that contractionary monetary policy increases public debt interest payment, therefore government need to have increasingly positive budget balances to guarantee debt sustainability. Afonso et al. (2023), using a fiscal reaction function for 35 OECD countries, in the period from 1980 to 2021, report that higher inflation rates contribute positively to fiscal sustainability.

Interestingly, in the literature there are not many extensions of the Bohn's rule that include a monetary policy variable. One exception is the study by Dascher-Preising and Greiner (2023), in which the authors estimate a fiscal reaction function incorporating a monetary policy variable to investigate its impacts on primary balances. Their findings indicate that monetary policy exerts a "disciplining" effect on fiscal policy, as primary balances increase following contractionary monetary policy. Willems and Zettelmeyer (2022) explore the link between government debt sustainability and central bank credibility and provide a comprehensive summary of this literature. The authors highlight that credible central banks have the ability to expand the boundary of sustainable debt and fiscal deficits and avoid self-fulfilling debt crisis. A credible central bank can influence macroeconomic variables such as the public debt interest rate and promote sustainability at higher levels of debt-to-GDP ratios. If a central bank has enough credibility, it can alleviate debt vulnerabilities when needed. Indeed, this assumption is a precondition for the hypothesis posed in this paper.

5.3 Data

The data for this study was retrieved from the Eurostat and the ECB databases. We retrieved data for 12 euro area countries[2] at quarterly frequency from 2003:Q1 to 2022:Q4. We selected these 12 countries because most of them introduced the euro in January 2001 (except Greece that introduced the euro in January 2002). Therefore, this selection of countries will allow us to extend the period of our analysis. For the series available at monthly and daily frequency, we transform it to quarterly frequency by averaging the values that belong to each specific quarter. Government expenditure, total government revenues, and the primary balance, exhibit significant seasonality. To deal with this issue, we employ the same methodology as in Afonso and Coelho (2023) and average the variables in a 4-quarter rolling window. The rolling windows approach is calculated as follows $Y_{t,rw} = \frac{1}{4}\sum_{i=0}^{3} X_{t-i}$. To maintain consistency with this transformation, we employ the rolling windows approach to all variables. We use output gap as a control variable calculated using the Hendrick-Prescott filter with the smoothing parameter set to 1600. For the monetary policy stance, we use Krippner's shadow rate (Krippner, 2015) and the MRO rate. We considered the Krippner's shadow rate as an appropriate measure of monetary policy stance, as it includes the zero lower bound (ZLB) period and accounts for unconventional monetary policies. The list of variables, their source, and their transformations are reported in Table D1 in the Appendix. The primary balance as % of GDP is obtained by using the following calculation: PB = TR – TE + IE. Where the primary balance as % of GDP (PB) is equal to total government revenues as % of GDP (TR) minus total government expenses as % of GDP (TE) plus and total government interest expense as % of GDP (IE).

[2] The countries included are Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain.

5.4 Specifications

To undertake our analysis, we extend the Bohn's rule by incorporating a monetary policy stance variable. With this approach, we study the influence of monetary policy on the primary balance and on the debt sustainability coefficient. We use a panel with 12 euro area countries and estimate a fixed effects model, specifically considering country fixed effects. To ensure the stationarity of the variables, we use the first differences of the primary balance, debt-to-GDP, and the monetary policy stance. Furthermore, using growth rates addresses potential baseline differences among countries. We estimate the following fiscal reaction function:

$$\Delta PB_{it} = \beta_1 \Delta GD_{it-4} + \beta_2 \Delta MPS_{t-s} + \beta_3 outgap_{it} + C_i + \varepsilon_{it} \qquad (1)$$

where i represents the country and t represents quarters. PB represents the primary balance as % of GDP, *outgap* represents the output gap. *GD* represents the debt-to-GDP ratio. C_i represents country fixed effects. *MP*S represents the monetary policy stance. As discussed, we consider two variables to capture the monetary policy stance, MPS. For conventional monetary policy, we use the MRO rate for the period from 2003:Q1 to 2015:Q4. We decided to end the period in 2015:Q4 because the MRO reached the ZLB in the beginning of 2016. For unconventional monetary policies we use Krippner's shadow rate for the period from 2003:Q1 to 2022:Q4. In the regression equations we include monetary policy at t=0 (s=0), at t-2 (s=2), at t-4 (s=4), and the average monetary policy stance from the change in the debt level to the current period, calculated as $\Delta MPS_{t,average} = \frac{1}{4}(\sum_{t=0}^{3} \Delta MPS_{t-i})$. These different approaches were used because the timing of changes in monetary policy can influence the response of the primary balance.

To understand how monetary policy interacted with the government debt, we estimate the following model:

$$\Delta PB_{it} = \beta_1 \Delta GD_{it-4} + \beta_2 \Delta MPS_{t-s} + \beta_3 outgap_{it} + \beta_4 (\Delta GD_{it-4} \times \Delta MPS_{t-s}) + C_i + \varepsilon_{it} \qquad (2)$$

In Equation 2, we are mostly interested in the coefficients β_2 and β_4, which we expect to be positive. In other words, if monetary policy is contractionary and fiscal policy is "responsible", then we expect the primary balance to increase in larger magnitude following an increase in the debt-to-GDP ratio than if monetary policy is neutral or expansionary.

To provide further evidence of this mechanism, we define dummy variables for expansionary and contractionary monetary policy events. This approach enables us to distinguish the behavior of primary balances following an expansionary and a contractionary policy event as the impacts may be different. In other words, the response to monetary policy may not be symmetric. Given these hypotheses, we estimate the following equation:

$$\Delta PB_{it} = \beta_1 \Delta GD_{t-4} + \beta_2 MPS_t^e + \beta_3 MPS_t^c + \beta_4(\Delta GD_{t-4} \times MPS_t^e) + \beta_5(\Delta GD_{t-4} \times MPS_t^c) + \beta_6 outgap_t + C_i + \varepsilon_{it} \quad (3)$$

where MPS_t^e represents expansionary monetary policy events and MPS_t^c represents the contractionary monetary policy events. As before, the $MPS_t^{e,c}$ variables will take the form of the shadow rate ($SR\_av4_t^{e,c}$) for unconventional monetary policy and the marginal refinancing operations rate ($MRO\_av4_t^{e,c}$) for conventional monetary policy. For reasons of parsimony, we will only consider the average monetary policy stance since the change in debt to the current period as defined above ($\Delta MPS_{t,average}$).[3] These variables will be equal to one if the monetary policy stance crosses a defined threshold. We define two thresholds for our analysis. The first threshold is defined as a scenario where the change in the monetary policy stance is less than 0%. Using this threshold, we introduce an expansionary dummy variable as follows:

$$\Delta MPS_t^{E,<0\%} = \begin{cases} 1, if \ \frac{1}{4}(\sum_{t=0}^{3} \Delta MPS_{t-i}) < 0 \\ 0 \ Otherwise \end{cases}.$$

With this approach, we wish to test whether expansionary monetary policy events are related with lower primary balances compared to neutral and contractionary monetary policy.

To further explore the effects of monetary policy on the primary balance, we define a second threshold where a contractionary monetary policy event is defined as when the average quarterly change in the monetary policy stance changes are greater than or equal to 0.10%. Further, we define an expansionary monetary policy event if the monetary policy stance changes by less than or equal to -0.10%. These dummy variables

[3] The variable is calculated as follows $\Delta MPS_{t,average} = \frac{1}{4}(\sum_{t=0}^{3} \Delta MPS_{t-i})$.

will be compared to neutral monetary policy which is defined as when ΔMPS is smaller than 0.10% or larger than -0.10%. Specifically, we define a contractionary monetary policy event as follows:

$$\Delta MPS_t^{C,\geq\, 0.10\%} = \begin{cases} 1, if\ \frac{1}{4}\left(\sum_{t=0}^{3} \Delta MPS_{t-i}\right) \geq 0.10\% \\ 0\ Otherwise \end{cases},$$

And we define an expansionary monetary policy event as follows:

$$\Delta MPS_t^{E,\leq -\, 0.10\%} = \begin{cases} 1, if\ \frac{1}{4}\left(\sum_{t=0}^{3} \Delta MPS_{t-i}\right) \leq -0.10\% \\ 0\ Otherwise \end{cases}.$$

With these dummy variables, we wish to test whether the changes in primary balances differ in periods following expansionary and contractionary monetary policy events compared to neutral monetary policy.

5.5 Results

In our analysis, Pesaran CD tests confirmed the presence of cross-sectional dependence in the estimated models. Additionally, the Breusch-Godfrey test confirmed the presence of serial correlation. Consequently, we used Driscoll Kray robust standard errors (Driscoll & Kraay, 1998).

Table 5.1, column 1, reports the fiscal reaction function with the debt ratio only, without the inclusion of a monetary stance variable. The results suggest that the euro area countries followed a Ricardian fiscal regime. That is, as the debt ratio increased, the primary balance also increased to guarantee debt sustainability. Columns 2-6 report the results with the inclusion of the monetary policy stance, in this case the shadow rate. The monetary policy stance exhibits a positive coefficient. In other words, the primary balance exhibits a positive (negative) reaction to a contractionary (expansionary) monetary policy. These results suggest that fiscal policy behaved in a "responsible" manner with respect to monetary policy. The contemporaneous shadow rate ($\Delta \mathrm{SR}_t$) is the only coefficient that is not statistically significant, which suggests that monetary policy influences fiscal policy with a lag. The output gap exhibits a positive coefficient which is aligned with the ex-ante expectations that governments collect more taxes and pay less in social transfers and other expenditures during growth periods.

Table 5.1: Impact of monetary policy on primary balance

Model: Fixed Effects **Period:** 2003:Q1-2022:Q4 **Dep. Variable:** Change in Primary Balance (ΔPB_t)	1	2	3	4	5
ΔGD_{it-4}	0.223404***	0.219867***	0.227408***	0.234819***	0.2241***
	(0.041605)	(0.043273)	(0.040827)	(0.040224)	(0.041261)
ΔSR_t		0.214093			
		(0.174198)			
ΔSR_{t-2}			0.461138***		
			(0.155006)		
ΔSR_{t-4}				0.391552***	
				(0.14151)	
ΔSR_av4_t					0.511949**
					(0.211237)
$outgap_t$	0.213991***	0.202645***	0.190852***	0.198878***	0.187794***
	(0.034283)	(0.04157)	(0.035531)	(0.032327)	(0.038408)
Country FE	Yes	Yes	Yes	Yes	Yes
Observations	960	960	960	960	960
Countries	12	12	12	12	12
Quarters	80	80	80	80	80
rsq	0.28634	0.28977	0.29948	0.29461	0.29835
adjrsq	0.27653	0.27924	0.2891	0.28416	0.28795

*, ** and *** represent statistical significance at 10%, 5%, and 1% levels, respectively. Driscoll Kray standard errors in parentheses.

Notes: This table reports the influence of the monetary policy stance, measured by the shadow rate, on the primary balance. The dependent variable is the primary balance (ΔPB_t).

Table 5.2: Interaction between unconventional monetary policy variable and primary balance

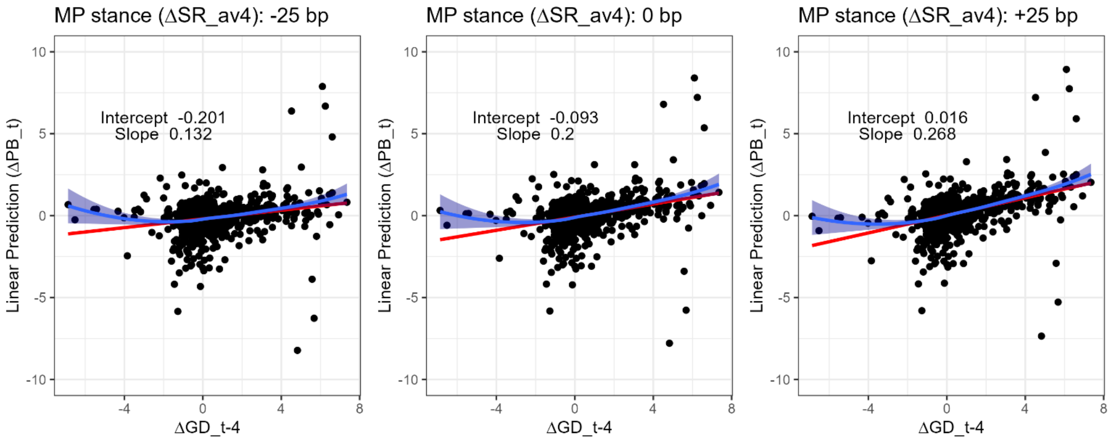
Model: Fixed Effects **Period:** 2003:Q1-2022:Q4 **Dep. Variable:** Change in Primary Balance (ΔPB_t)	1	2	3	4
ΔGD_{it-4}	0.221785***	0.251669***	0.2352172***	0.241446***
	(0.044161)	(0.039508)	(0.0412638)	(0.042813)
ΔSR_t	0.200558			
	(0.164984)			
ΔSR_{t-2}		0.347234**		
		(0.156086)		
ΔSR_{t-4}			0.3881797**	
			(0.1673495)	
ΔSR_av4				0.435029**
				(0.18158)
$\Delta GD_{it-4} \times \Delta SR_t$	0.109152			
	(0.087974)			
$\Delta GD_{it-4} \times \Delta SR_{t-2}$		0.287263**		
		(0.116745)		
$\Delta GD_{it-4} \times \Delta SR_{t-4}$			0.0040723	
			(0.0862277)	
ΔGD_{it-4} × ΔSR_av4				0.270617**
				(0.135963)
$outgap_t$	0.221785***	0.251669***	0.2352172***	0.241446***
	(0.044161)	(0.039508)	(0.0412638)	(0.042813)
Country FE	Yes	Yes	Yes	Yes
Observations	960	960	960	960
Countries	12	12	12	12
Quarters	80	80	80	80
rsq	0.29421	0.31752	0.29698	0.31201
adjrsq	0.28299	0.30668	0.28581	0.30108

*, ** and *** represent statistical significance at 10%, 5%, and 1% levels, respectively. Driscoll Kray standard errors in parentheses.

Notes: This table reports the impact of the monetary policy stance on the primary balance, including the interaction between the debt ratio and the monetary policy stance. The dependent variable is the primary balance (ΔPB_t).

Table 5.2 reports the results of Equation 2, that is the fiscal reaction function including the interaction between the government debt ratio and the shadow rate. Similar to Table 5.1, the results from Table 5.2 indicate that an increase in the debt ratio with a lag of 4 quarters (ΔGD_{it-4}) leads to an increase in primary balances, suggestive of a Ricardian regime. Generally, an increase in the monetary policy stance will also lead to an increase in the primary balance. Furthermore, if the monetary policy stance is expansionary (contractionary), the debt sustainability coefficient (ΔGD_{it-4}) is smaller (larger). These results suggest that during periods of debt accumulation, accommodative monetary policy can significantly reduce the necessity of governments to increase primary balances to maintain debt sustainability and thus reduce the risk of fiscal fatigue. Conversely, if monetary policy is contractionary during periods of debt accumulation, it could place a greater strain on fiscal policy.

Figure 5.1: Prediction of the primary balance given different monetary policy stances



Notes: This figure plots the interaction between the debt ratio and the monetary policy stance (Krippner's shadow rate) from Equation 2. The red line represents a linear regression between the debt ratio at t-4 and the linear prediction of the primary balance. The blue line represents a loess curve with span parameter set to 0.9.

Figure 5.1 helps to understand the effects of monetary policy on the growth of the primary balance following an increase in the deb-to-GDP ratio. Figure 5.1 shows the interaction between the debt ratio and the monetary policy stance, and their combined effect on the primary balance. When the monetary policy stance, in this case the shadow rate,[4] is -25 basis points, then the slope of the regression line is 0.13. That is, when the government debt increases by 1%, primary balance increases by 0.13%. The slope increases as the monetary policy becomes contractionary. When monetary policy is +25 basis points, the primary balance increases by 0.27% following an increase in the debt ratio of 1%. Another interesting observation is that the linear relationship appears to break down when there is a significant reduction in the debt ratio. The loess curves (in blue in Figure 5.1) exhibit nonlinearity when the change in the debt ratio is very negative. This suggests that the primary balance does not become negative when there is significant decrease in the debt ratio, instead it remains balanced.

[4] Calculated as $SR\_av4_t = \frac{1}{4}(\sum_{t=0}^{3} \Delta SR_{t-i})$.

Table 5.3: Impact of the MRO rate on the primary balance

Model: Fixed Effects **Period:** 2003:Q1-2015:Q4 **Dep. Variable:** Change in Primary Balance (ΔPB_t)	1	2	3	4
ΔGD_{it-4}	0.224408***	0.256561***	0.258864***	0.252239***
	(0.051508)	(0.04958)	(0.05283)	(0.04796)
ΔMRO_t	0.922184***			
	(0.205163)			
ΔMRO_{t-2}		0.683186***		
		(0.203734)		
ΔMRO_{t-4}			0.329115**	
			(0.166169)	
ΔMRO_av4				0.950438***
				(0.238014)
$outgap_t$	0.131619***	0.157133***	0.181434***	0.14342***
	(0.035092)	(0.036407)	(0.039823)	(0.034402)
Country FE	Yes	Yes	Yes	Yes
Observations	624	624	624	624
Countries	12	12	12	12
Quarters	52	52	52	52
rsq	0.2225	0.21157	0.19841	0.21936
adjrsq	0.20462	0.19344	0.17998	0.20142

*, ** and *** represent statistical significance at 10%, 5%, and 1% levels, respectively. Driscoll Kray standard errors in parentheses.

Notes: This table reports the influence of the monetary policy stance, measured by the MRO rate, on the primary balance. The dependent variable is the primary balance (ΔPB_t).

Table 5.3 reports the results with the MRO rate to account for conventional monetary policy. These results are similar to the results including the shadow rate as the monetary policy stance. However, the estimated MRO coefficients are larger, which suggests that the MRO rate influenced primary balances in a more substantial manner than the shadow rate. Monetary policy either induces the government to generate larger primary balances or allows governments to maintain lower primary balances in the case of expansionary monetary policy. The positive and statistically significant coefficients for the debt ratio and the MRO rate suggest that during this period, fiscal policy also acted in a “responsible” manner.

Table 5.4: Interaction between conventional monetary policy variable and primary balance

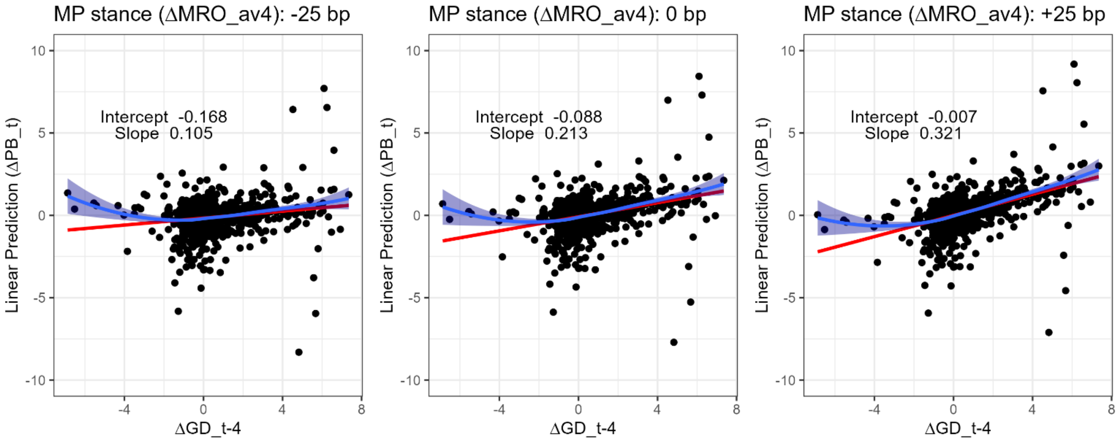
Model: Fixed Effects **Period:** 2003:Q1-2015:Q4 **Dep. Variable:** Change in Primary Balance (ΔPB_t)	1	2	3	4
ΔGD_{it-4}	0.253325***	0.287738***	0.283816***	0.297684***
	(0.055776)	(0.050674)	(0.053609)	(0.048178)
ΔMRO_t	0.864995***			
	(0.197906)			
ΔMRO_{t-2}		0.358394		
		(0.241356)		
ΔMRO_{t-4}			-0.012199	
			(0.223036)	
ΔMRO_av4				0.644152**
				(0.251805)
ΔGD_{it-4} x ΔMRO_t	0.456484*			
	(0.23967)			
ΔGD_{it-4} x ΔMRO_{t-2}		0.354871**		
		(0.163045)		
ΔGD_{it-4} x ΔMRO_{t-4}			0.266781**	
			(0.106442)	
ΔGD_{it-4} x ΔMRO_av4				0.506696***
				(0.19089)
$outgap_t$	0.1298***	0.152623***	0.17162***	0.138048***
	(0.456484)	(0.037542)	(0.041429)	(0.03548)
Country FE	Yes	Yes	Yes	Yes
Observations	624	624	624	624
Countries	12	12	12	12
Quarters	52	52	52	52
rsq	0.23451	0.22597	0.20918	0.23916
adjrsq	0.21562	0.20687	0.18967	0.22039

*, ** and *** represent statistical significance at 10%, 5%, and 1% levels, respectively. Driscoll Kray standard errors in parentheses.

Notes: This table reports the influence of the monetary policy stance, measured by the MRO rate, on the primary balance and interacts the debt ratio with the monetary policy stance. The dependent variable is the primary balance (ΔPB_t).

Table 5.4 reports the results of Equation 2, that is the fiscal reaction function including the interaction between the debt-to-GDP ratio and the MRO rate, accounting for conventional monetary policy. The results obtained in this table are similar to the results obtained including the shadow rate as the monetary policy stance. However, one notable difference is that the estimated coefficients have larger magnitude. This suggests that changes in the MRO rate were more effective as either a disciplinary tool for fiscal policy, or it provided greater relief for fiscal policy during the period under analysis (2003:Q1 to 2015:Q4).

Figure 5.2: Prediction of the primary balance given MRO rate stance.



Notes: This figure plots the interaction between the debt ratio and the monetary policy stance (MRO rate) from Equation 2. The red line represents a linear regression between the debt ratio at t-4 and the linear prediction of the primary balance. The blue line represents a loess curve with span parameter set to 0.9.

Figure 5.2 plots the interaction between the debt ratio and the MRO rate. When the monetary policy stance variable[5] is -25 basis points, then the regression line is 0.10. As monetary policy becomes increasingly contractionary, the slope increases and primary balances become increasingly positive. When the monetary policy is +25 basis points, the slope becomes 0.32, which predicts that the primary balance as percentage of GDP would increase by 0.32% following an increase of 1% of debt-to-GDP ratio. Similar to the results with the shadow rate in Figure 5.1, this linear relationship appears to break down when there is a significant reduction in the debt ratio. The loess curves (in blue in Figure 5.2) exhibits nonlinearity when the change in the debt ratio is very negative.

[5] Calculated as $MRO\_av4_t = \frac{1}{4}(\sum_{t=0}^{3} \Delta MRO_{t-i})$

Table 5.5: Results for unconventional monetary policy events

Model: Fixed Effects **Period:** 2003:Q1-2022:Q4 **Dep. Variable:** Change in Primary Balance (ΔPB_t)	1	2	3	4
ΔGD_{it-4}	0.224501***	0.339756***	0.220842***	0.261199***
	(0.040332)	(0.077)	(0.039798)	(0.060106)
$\Delta SR\_av4_t^{E,<0\%}$	-0.296345***	-0.217301***		
	(0.089268)	(0.076035)		
$\Delta SR\_av4_t^{E,\leq -0.10\%}$			-0.211782**	-0.155871
			(0.097101)	(0.098352)
$\Delta SR\_av4_t^{C,\geq 0.10\%}$			0.149682*	0.131065*
			(0.087788)	(0.076847)
$\Delta GD_{it-4} \times \Delta SR\_av4_t^{E,<0\%}$		-0.192114**		
		(0.088814)		
$\Delta GD_{it-4} \times \Delta SR\_av4_t^{E,\leq -0.10\%}$				-0.129014*
				(0.076862)
$\Delta GD_{it-4} \times \Delta SR\_av4_t^{C,\geq 0.10\%}$				0.052181
				(0.100389)
outgap_t	0.198719***	0.193525***	0.195475***	0.188972***
	(0.034988)	(0.036077)	(0.034743)	(0.034885)
Country FE	Yes	Yes	Yes	Yes
Observations	960	960	960	960
Countries	12	12	12	12
Quarters	80	80	80	80
rsq	0.3063	0.32792	0.30708	0.32255
adjrsq	0.29602	0.31725	0.29606	0.31032

*, ** and *** represent statistical significance at 10%, 5%, and 1% levels, respectively. Driscoll Kray standard errors in parentheses.

Notes: This table reports the influence of the shadow rate expansionary and contractionary dummy variable events, on the primary balance. The dependent variable is the primary balance (ΔPB_t).

The analyses thus far, though useful, were not able to inform whether the primary balance is more responsive to contractionary or expansionary monetary policy. We argue that this distinction is important in this context to understand whether monetary policy exerts a disciplinary effect or a relief effect on fiscal policy. It could be the case that primary balances are more reactive to expansionary monetary policy than contractionary monetary policy, or vice versa.

From Table 5.5, column 1, we can conclude that when the change in monetary policy is less than zero, on average, the primary balance growth is significantly lower than when the shadow rate is greater than or equal to zero. From column 2, we see that the interaction term between the debt ratio and the shadow rate is negative and statistically significant. These results suggest that expansionary monetary policy can ease fiscal constraints and allows governments to maintain lower primary balances given increases in the debt-to-GDP ratio. When monetary policy is expansionary, an increase in the government debt results in lower growth of the primary balance compared to when monetary policy is neutral or contractionary. In columns 3 and 4, we only consider expansionary or contractionary events if the monetary policy stance variable is greater than or equal to 10 basis points or less than or equal to -10 basis points respectively. In column 3, the coefficient for expansionary monetary policy is negative while it is positive for contractionary monetary policy. However, the coefficients exhibit larger magnitude and significance for expansionary monetary policy. Altogether, this suggests that expansionary monetary policy was more effective at alleviating fiscal constraints than contractionary monetary policy at "disciplining" fiscal policy. In column 4, only the contractionary dummy variable and the interaction between the expansionary dummy variable and the debt-to-GDP ratio exhibit statistical significance. From this, we can conclude that expansionary monetary policy only affected the growth in primary balance when there is an interaction with the debt-to-GDP ratio and not independently. These results suggest that expansionary monetary policy can improve fiscal sustainability and eventually decrease the risk of fiscal fatigue during periods of debt accumulation. The contractionary dummy variable is also statistically significant, which suggests that primary balances increase following contractionary monetary policy events. However, using less restrictive standard errors, such as Newey-West standard errors for instance, we obtain statistically significant for most coefficients.

Table 5.6: Results for conventional monetary policy events

Model: Fixed Effects **Period: 2003:Q1-2015:Q4** **Dep. Variable:** Change in Primary Balance ($\Delta \mathrm{PB_t}$)	1	2	3	4
$\Delta \mathrm{GD_{it-4}}$	0.255555***	0.344205***	0.2330383***	0.278527***
	(0.046402)	(0.078745)	(0.0486399)	(0.066714)
$\Delta MRO\_av4_t^{E,<0\%}$	-0.298887***	-0.236336***		
	(0.080266)	(0.084073)		
$\Delta MRO\_av4_t^{E,\leq -0.10\%}$			-0.3507685***	-0.247685*
			(0.1119139)	(0.131627)
$\Delta MRO\_av4_t^{C,\geq 0.10\%}$			0.0029082	0.035497
			(0.0857471)	(0.089493)
$\Delta \mathrm{GD_{it-4}} \times \Delta MRO\_av4_t^{E,<0\%}$		-0.122978		
		(0.093889)		
$\Delta \mathrm{GD_{it-4}} \times \Delta MRO\_av4_t^{E,\leq -0.10\%}$				-0.123479
				(0.103322)
$\Delta \mathrm{GD_{it-4}} \times \Delta MRO\_av4_t^{C,\geq 0.10\%}$				-0.089792
				(0.122904)
outgap_t	0.176698***	0.178357***	0.1528577***	0.15446***
	(0.033595)	(0.034713)	(0.0369754)	(0.03574)
Country FE	Yes	Yes	Yes	Yes
Observations	624	624	624	624
Countries	12	12	12	12
Quarters	52	52	52	52
rsq	0.21264	0.21964	0.21534	0.22262
adjrsq	0.19454	0.20039	0.19598	0.20081

*, ** and *** represent statistical significance at 10%, 5%, and 1% levels, respectively. Driscoll Kray standard errors in parentheses.

Notes: Influence of the MRO rate expansionary and contractionary dummy variable events, on the primary balance. The dependent variable is the primary balance (ΔPB_t).

Table 5.6 uses the MRO rate to account for conventional monetary policy. From column 1 and 2, we can conclude that monetary policy events that are lower than 0 basis points generate statistically significant lower primary balances, similar to the results reported in Table 5.5. However, when this variable is interacted with government debt (column 2) the coefficient is negative but not statistically significant. This could indicate that monetary policy did not significantly explain changes in primary balances following changes in government debt during this shorter period. Possibly, this result could be explained by the fact that prior to the sovereign debt crisis, sovereign debt risk was possibly less correlated with fiscal and debt sustainability and therefore did not exert a large influence on fiscal policy. Only the expansionary monetary policy dummy variable by itself exhibits statistical significance. The remaining dummy variables in columns 4 are not statistically significant. The interaction between the debt ratio and contractionary monetary policy events even suggests a negative value but is very close to zero. Likewise, this could indicate that contractionary monetary policy did not exert much pressure on fiscal policy solvency during this period.

5.6 Conclusion

In this paper we have assessed how monetary policy influenced debt sustainability in the euro area, through the estimation of a fiscal reaction function (Bohn's rule) with the inclusion of a monetary policy stance variable. For conventional monetary policy, we use the MRO policy rate and considered the period from 2003:Q1 to 2015:Q4. For unconventional monetary policy we used the shadow rate (Krippner, 2015) and considered the period from 2003:Q1 to 2022:Q4.

Our results suggest that contractionary (expansionary) monetary policy induces an increase (decrease) in the growth of primary balances. Under the classic analysis of debt sustainability, this first result is intuitive as the sustainability of public finances is affected by the rate at which primary balances are discounted. Given this backdrop, monetary policy can exacerbate the fiscal effort required to satisfy the government intertemporal budget constraint. Secondly, we find that the ECB's monetary policy stance significantly influences the fiscal reaction function coefficient. When we interact the change in the debt-to-GDP ratio with the change in the monetary policy stance, our findings indicate that contractionary monetary policy induces a larger increase in primary balances in response to an increase in the debt-to-GDP ratio than if monetary policy was neutral or expansionary. This underscores the potential of monetary policy to reduce the fiscal effort needed to promote fiscal sustainability and decrease the risk of fiscal fatigue, particularly during periods of debt accumulation. Thirdly, our results seem to suggest that the impact on the primary balance is more significant for expansionary than for contractionary monetary policy. In other words, the primary balances decrease by a greater magnitude and significance following an expansionary monetary policy change than increase following a contractionary monetary policy change. This result is noteworthy as it suggests that in the euro area, monetary policy exerted a "disciplining" effect on fiscal policy, but its influence was greater in providing relief for fiscal policy. With regards to policy implications, the results obtained suggest that monetary policy has the potential to reduce the fiscal effort needed to guarantee debt sustainability, and therefore reduce rollover risk and avoid self-fulfilling debt crisis. Conversely, if monetary policy is more contractionary than necessary, it might place undue burdens on fiscal policy and increase these risks. However, we should underscore that this result might not be valid if there is a belief that the central bank is not credible, in other words, there is a conviction that the goals of the central bank are not independent, but could be influenced by political reasons.

5.7 References

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5.8 Appendix

Table D1: Data Sources and Transformations

Variables	Source	Source Code	Transformations/Own calculations
Krippner's Shadow Rate	https://www.ljkmfa.com/	N/A	Monthly data transformed to quarterly by averaging the values for the months that belong to each quarter. After that, a rolling windows approach was used.
Main Refinancing Operations (MRO) rate	ECB	FM.D.U2.EUR.4F.KR.MRR_RT.LEV	Daily data transformed to quarterly by averaging the values of each day that belong to each quarter. After that, a rolling windows approach was used.
Government debt (% of GDP)	Eurostat	Data code - gov_10q_ggdebt Sector - S13 Unit - PC_GDP na_item - GD	Rolling windows approach
Output gap	Eurostat	Data code - namq_10_gdp s_adj - SCA na_item - B1GQ Unit - CLV15_MEUR	Output gap calculated as the rolling windows of the log of output minus the rolling windows of the log of the output trend. Output trend is calculated with the Hodrick-Prescott filter with the smoothing parameter set to 1600.
Total Revenues (% of GDP)	Eurostat	Data code - gov_10q_ggnfa s_adj - NSA Sector - S13 Unit - PC_GDP na_item - TR	Rolling windows approach
Total Expenditures (% of GDP)	Eurostat	Data code - gov_10q_ggnfa s_adj - NSA Sector - S13 Unit - PC_GDP na_item - TE	Rolling windows approach
Interest Expenditures (% of GDP)	Eurostat	Data code - gov_10q_ggnfa s_adj - NSA Sector - S13 Unit - PC_GDP na_item - D41PAY	Rolling windows approach
Primary Balance (% of GDP)	Eurostat	N/A	Total Revenue - Total Expenditure + Interest Expenditure.

Notes: The rolling windows approach is calculated as follows: $Y_{t,rw} = \frac{1}{4}\sum_{i=0}^{3} X_{t-i}$.