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REM Working Paper 0259-2023

January 2023

REM – Research in Economics and Mathematics
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ISSN 2184-108X

REM – Research in Economics and Mathematics

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Balance Sheet Expansionary Policies in the Euro Area: Macroeconomic Impacts and a Vulnerable versus Non-Vulnerable Comparison - A Bayesian Structural VAR Approach*

Francisco Gomes Pereira$

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Abstract

Employing a Bayesian structural vector autoregressive (VAR) model, we estimate the impact of the European Central Bank's (ECB) balance sheet expansionary policies (BSEP) on a range of economic and financial variables including real GDP, inflation, long-term sovereign bond yields, systemic stress, unemployment, bank loans, and equity markets in the period from 2009:Q1 to 2021:Q4. The main conclusion from this study is that more vulnerable euro area countries had larger magnitudes in desirable impulse responses to BSEPs shocks. To reach this conclusion, we estimated the same model for 16 euro area countries and used maximum, minimum, and cumulative impulse responses to assess the heterogenous responses to BSEPs across member states. We then attempt to find correlations of impulse responses with measures of financial and economic vulnerability such as debt-to-GDP ratios, unemployment, GDP per capita (PPP), and tier 1 bank capital ratios. Our results suggest that the magnitude of the responses are more pronounced in countries with higher levels of vulnerability. These findings are akin to theoretical assumptions that suggest that unconventional monetary policies are most effective in periods of severe systemic stress.

Keywords: ECB, monetary policy, unconventional monetary policy, BVAR, euro area
JEL: C11, E02, E52, E58, G02

* This work was supported by the FCT (Fundação para a Ciência e a Tecnologia) [grant number 2021.06646.BD]. The opinions expressed herein are those of the authors and not necessarily those of their employers. Any remaining errors are the authors' sole responsibility

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1 Introduction

When quantitative easing (QE) policies were announced as a response to the global financial crisis by the Federal Reserve (Fed) in the US, there were different opinions in the public discourse relative to their appropriateness. In particular, there were fears of inflation and diminishing central bank independence (see for instance Hamilton (2009)). Some prominent economists downplayed the skepticism of QE and argued that the US economy was in a liquidity trap and the bigger concern at the time was deflation (see for instance the opinion pieces by Krugman (2008) and Blinder (2009)). After the fact, the Fed's QE programs were largely perceived as effective, despite lingering concerns regarding the long-term sustainability of these policies and the potential risks they could pose to the central bank's balance sheet. As a result, there was a more favorable attitude towards the use of asset purchases as a policy tool.

During the sovereign debt crisis in Europe, balance sheet expansionary policies (BSEPs), and in particular large scale asset purchases (LSAPs), was a tool the ECB was increasingly willing to employ to stabilize sovereign debt markets, improve credit transmission, and stimulate inflation. Currently, BSEPs are widely considered by central bankers to be an essential policy tool. Given that the use of such policies is likely to persist in the future — provided macroeconomic conditions justify — it is crucial to continue investigating and analyzing unconventional monetary policies (UMPs) to inform future policy decisions and determine the most effective methods for using these policies.

In this paper, we rely on a Bayesian structural vector autoregression (VAR) model with hierarchical prior selection and zero and sign restrictions with data spanning a period from 2009:Q1 to 2021:Q4. We aim to study the impacts of the ECB's BSEPs shocks on several macroeconomic variables, particularly real GDP, HICP inflation, long-term sovereign bond yields, the composite index of sovereign stress (CISS), unemployment, long-term bank interest rates, bank loans, and equity prices in the euro area. We test 6 different model variations before deciding on our main model to ensure the results obtained are comparable to prior studies and to different variable selections. Building upon the methodology of previous research, we not only examine peak impulse responses to balance sheet shocks, but also consider the cumulative impulse responses over an 8 quarter period following an innovation to the ECB balance sheet.

Contrary to studies by Boeckx et al. (2017) and Burriel and Galesi (2018), which find that peak impulse responses of real GDP to a balance sheet innovation are positively correlated with banks tier 1 capital ratio, we find the opposite. Our findings show that countries with a higher degree of financial and economic vulnerability had larger magnitude in more desirable impulse responses in several economic variables. As a further step, we undertake a vulnerable versus non-vulnerable emphasis. This comparison emphasis accentuates that the heterogeneity in monetary policy responses was driven, at least in part, by sovereign financial and economic vulnerability. We measure vulnerability by sovereign debt levels, GDP per capita, unemployment, and tier 1 bank capital ratios.

Our analysis is confined to the period of monetary expansion implemented by the ECB from 2009:Q1 to 2021:Q4 in order to more effectively isolate the effects of expansionary BSEPs. This period is also characterized by the suppression of interest rates to a degree that required the ECB to utilize unconventional policies. By restricting our analysis to this time frame, we can more accurately disentangle the impacts of expansive unconventional policies, particularly BSEPs, from the potential cofounding effect of decreases in policy rates. Furthermore, the beginning in 2022 is characterized by a winding down of expansionary policies and supply side inflationary pressures which could generate conflicting results and hence we exclude this period from our analysis. As a potential pitfall of our chosen time frame, we recognize that naively incorporating macroeconomic time series during the COVID pandemic period could generate inaccurate results (Cascaldi-Garcia, 2022). To ensure our results are robust, we estimate the same model from 2009:Q1 to 2019:Q4, excluding the pandemic period. Since we obtained the same general conclusions, we maintained the inclusion of the pandemic period in our main analysis.

Our empirical approach begins with the estimation of a simple model for the euro area to examine the overall effects of BSEPs in the European Monetary Union (EMU). In the second stage, to understand transmission heterogeneity, we implement the same model individually for 16 euro area countries. We correlate the maximum, minimum, and cumulative impulse responses with country economic and financial vulnerability variables such as debt-to-GDP, GDP per capita (PPP), unemployment rate, and bank tier 1 capital ratios. The results from the second stage suggest that countries with higher levels of debt-to-GDP and unemployment, and lower levels of GDP per capita (PPP) and tier 1 bank capital ratios have stronger positive economic responses to BSEPs shocks. More specifically, more vulnerable countries had higher peaks in the impulse responses of real GDP and more pronounced troughs in the impulse responses of unemployment, CISS, and long-term interest rates derived from sovereign rates. In the third stage, we average the variables of vulnerable and non-vulnerable countries for each time period[1]. We estimate two additional Bayesian VAR models, one for vulnerable countries and a second for the non-vulnerable. By juxtaposing the results, the same conclusions were reached, that is, more vulnerable countries had stronger positive economic responses to BSEPs shocks. These results are relevant because prior studies that use multiple time series models to study UMP in the euro area (for instance Boeckx et al. (2017) and Burriel and Galesi (2018)) find that more vulnerable countries did not have larger reactions to UMP, therefore our results are contrasting in this regard and are more akin to theoretical considerations as in Curdia and Woodford (2011) and Gertler and Karadi (2011) and empirical findings of conventional monetary policy as in Ciccarelli et al. (2013).

Prior research on similar topics has placed significant emphasis on tier 1 bank capital, with findings suggesting that countries with more highly capitalized banks tend to experience more positive responses to BSEP through the bank lending channel. Our study also finds evidence of larger transmission though bank lending in countries with better capitalized banks. However, in contrast to previous research, we did not observe larger impulse responses of real GDP in these countries. This result suggests that the credit channel did not overpower other channels of transmission. Other channels of transmission could be easier and cheaper access to financing by the government, less systemic stress, and larger consumer and investor confidence. Given the results obtained, we conclude that financial and economic vulnerability, such as higher debt-to-GDP and unemployment, and lower GDP per capita, contributed to the magnitude of reactions to ECB's BSEPs. Our study confirms that the assertions previously valid for conventional monetary policy are also valid for the unconventional counterpart, that is, they are strongest during financial and economic fragility periods. An important caveat to acknowledge is the potential unsustainability of these results going forward with the increasing discrepancy of debt-to-GDP ratios of vulnerable versus non-vulnerable countries and the possible policy insolvency of the ECB in the event the balance sheet generates significant losses, even though this is a highly disputed issue.

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[1] We classify as vulnerable countries: Greece, Italy, Portugal, and Spain. We consider as non-vulnerable countries: Austria, Belgium, Finland, France, Germany, Ireland, Netherlands, Cyprus, Luxembourg, Malta, Slovakia, and Slovenia. Latvia and Lithuania were not included because they only joined the euro area in 2014 and 2015 respectively. Estonia was not included due to missing data, particularly long-term interest rates.

Lastly, turning to the limitations of our empirical strategy. First, we only take into consideration ECB balance sheet growth. While this approach is convenient, it is not possible to disentangle effects coming from the announcement and the actual purchase of assets. Additionally, the ECB's balance sheet incorporates very different programs and hence the combined responses might not represent the exact outcome of one specific program. The results represent generically balance sheet expansions during a specific point in time and not the exact response of any particular program. This makes it unfeasible to pinpoint which programs were successful at which periods as they overlap in time. Also, the ECB programmes' scope and size is usually announced prior to the actual implementation of the programmes, and hence some responses could have started to happen prior to the programme actual implementation.

The rest of the paper is structured as follows: Section 2 reviews the literature relevant to our study. Section 3 details the methodology and data used. Section 4 presents the results obtained. Lastly, section 5 concludes.

2 Literature

The literature on the macroeconomic impacts of monetary policy is vast. In this section we provide some important highlights of this literature in the scope of our paper along with some theoretical and modelling considerations.

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 and Watson, 2001). In this paper, we rely on a Bayesian structural VAR model with hierarchical priors as in Giannone et al. (2015) and with zero and sign restrictions as in Arias et al. (2018) to provide further empirical evidence of macroeconomic reactions to BSEPs shocks.

The ECB's mandate states price stability as its main (and only) objective, however, the European community treaty gives authority to the ECB to *"support general economic policies"* (Ioannidis et al., 2021; Treaty on the Functioning of the European Union, Article 127 (1)) and hence it is common to find in ECB's issued press releases stated support for other objectives such as promoting employment, stabilizing markets, and easing financing conditions to the private sector. In 2010, the ECB introduced the Securities Market Programme (SMP). Directly quoting from the ECB press release from May 10th, the ECB had the stated intent "*to address the severe tensions in certain market segments which are hampering the monetary policy transmission mechanism and thereby the effective conduct of monetary policy oriented towards price stability in the medium term"*. Granted, this first undertaking was relatively small in scale, being sterilised and only comprising sovereign debt issued by Greece, Italy, Ireland, Portugal, and Spain. In a further effort, in 2014 the ECB introduced the Asset Purchase Programme (APP). This program was larger in scope, comprising many asset classes, and running intermittently from 2014 until 2019. In 2020 the ECB introduced the Pandemic Emergency Purchase Programme (PEPP) as a response to the COVID-19 pandemic. Asset purchases are important in the scope of our study as they comprise the majority of the ECB's balance sheet. Other BSEPs undertaken by the ECB were the longer-term refinancing operations (LTRO and TLTROs) whereby the ECB finances banks with the more targeted objective to spur commercial credit activity.

Since the ECB's increased reliance on unconventional monetary policies, motivated in large part by reaching the ZLB, much interest has been directed towards measuring its macroeconomic impacts. VARs (or some variation of multiple time series models) have been routinely used for this purpose. Examples of recent papers that rely on a VAR framework to measure UMP for the European case are Gambacorta et al. (2014), Kremer (2014), Wieladek and Garcia Pascual (2016), Gambetti and Musso (2017), Ghysels et al. (2017), Boeckx et al. (2017), and Burriel and Galesi (2018). This is by no means an exhaustive list — it catalogs prominent papers that use similar methodology for measuring UMP shocks and responses of macroeconomic variables in the euro area. A summary of the models used, and the general impulse response results of these papers are summarized in Table I. These studies consistently find that an increase in 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 outcomes coincide with the intentions of the ECB prior to implementing these programs, hence deeming them successful according to much of the results obtained empirically. These results are analogous to reactions stemming from conventional monetary policy shocks (setting the central bank short-term policy rate) hence it being commonly argued that UMPs are an appropriate tool while at the ZLB. UMPs are also credited by the literature with the ability to stabilize markets. A testimony of this power was shown during the 2007-2008 great recession and the euro sovereign debt crisis. Additional to these conclusions, Burriel and Galesi (2018), using a global VAR, also note that spillovers account for a significant part of UMP transmission in the euro area, suggesting that economic inter-dependencies are important.

The use of UMP by the ECB, notably LSAPs, generated criticism. Particularly, the continuous use of these policies. Gertler and Karadi (2011), Curdia and Woodford (2011), Quint and Rabanal (2017), Kiley (2018), and Borio and Zabai (2018) argue their used should be reserved for specific period, such as during the ZLB and during financially and economic fragile periods, hence UMP should not become a permanent fixture for central banks. An additional consideration 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).

Under certain scenarios, other monetary policy tools can be used to achieve similar results as asset purchases. 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 and Woodford, 2003). Krishnamurthy and Vissing-Jorgensen (2011) argue that, after QE2 in the US, yield reduction from the purchase of treasuries does not carry over to riskier assets, such as lower grade corporate securities and mortgages, hence suggesting that the same outcome could have been achieved via forward guidance - decisively and transparently communicating Fed future intention of keeping interest rates lower for longer. In the European case, following Mario Draghi's *"whatever it takes"* speech, the yields of government debt yields decreased (Afonso, Arghyrou, et al., 2018) and averted a possible dire scenario for the debt sustainability of more vulnerable euro area members, however no securities were purchased in the market. Some may argue that the actual purchase of assets by the central bank strongly underscores this commitment, however, it puts its balance sheet at risk. With the purchase of long maturity securities, there is a fear that, when interest rate rise, the central bank will incur losses. Such considerations are usually downplayed because central banks have different objectives than commercial banks and therefore, they could continue to operate normally while incurring losses (Archer, Moser-Boehm, et al., 2013). A more concerning issue would be if the central bank becomes policy insolvent (Del Negro and Sims, 2015; Cardoso da Costa, 2022) or if it needs fiscal transfers (Reis, 2017).

Before the implementation of the European monetary union, and during the conceptualization phase, it was recognized that countries with high stocks of debt could pose a stability problem. Grilli et al. (1991) argues that the challenges from a common currency implementation in Europe would come from highly indebted members. They additionally argue that imposing fiscal rules that guarantee the solvability of these countries would increase the credibility of the euro area, a problem still being tackled and discussed at present. Figure 5 reports that differences in debt levels relative to GDP are increasing for the more vulnerable euro area members, which could be interpreted as concerning in accordance with sustainability consideration. In addition to financial stability, Afonso and Jalles (2013) and Panizza and Presbitero (2013) argue that a negative link between high public debt and economic growth appears to be present, however, it is difficult to decisively identify a causal relationship. Arguably, without the concerted effort of fiscal policy, it is unfeasible to expect monetary policy to single handed accomplish all of the macroeconomic objectives it proposes itself in a sustainable fashion

(Sims, 2013; Corsetti et al., 2019). Theoretically, fiscal spending multipliers are larger when at the ZLB (Christiano et al., 2011; Eggertsson, 2011), however this claim is disputed (Ramey and Zubairy, 2018). The political feasibility of such efforts is usually pointed as an obstacle to its realization.

Despite dissenting viewpoints, UMP have become mainstays in Europe since 2010. The opinions regarding the appropriate use and goals of monetary policy are far from being resolute. The consensus today by central bankers and most economists is that monetary policy can be used appropriately to deal with economic and financial crisis. It is established that the causes of the 1929 great depression was a reduction in the money supply (Friedman and Schwartz, 1963) and credit (Bernanke, 1983). Another potential question that we can ask today is if the central bank can indeed significantly influence the money supply through balance sheet expansions and asset purchases. The relationship between the creation of new bank reserves and the generation of new credit appears to be complicated and inconclusive, particularly in instances where the preferences of banks for liquidity is high (Dow, 2017). Nevertheless, it was the study and lessons taken from the great depression of 1929 in the US that influenced much of the course taken in more recent years. Indeed, as clearly stated in the memoir of former US Fed chairman Ben Bernanke: *"My reading and research impressed on me some enduring lessons of the depression for central bankers and other policymakers. First, in periods of recession, deflation, or both, monetary policy should be forcefully deployed to restore full employment and normal levels of inflation. Second, policymakers must act decisively to preserve financial stability and normal flows of credit"* (Bernanke, 2015). Despite their ubiquitous use, the degree of the magnitude and extent of the programmes remains a challenging and uncertain area of estimation (Borio and Zabai, 2018). An added complexity for the execution of monetary policy in the euro area is the heterogeneity observed in the response to unconventional monetary policy (Ciccarelli et al., 2013; Weale and Wieladek, 2016; Wieladek and Garcia Pascual, 2016; Boeckx et al., 2017; Burriel and Galesi, 2018), an issue this paper attempts to address.

Unconventional monetary policy is a burgeoning topic, for a very thorough analysis of the entire spectrum of this topic Papadamou et al. (2020) and Bhattarai and Neely (2022) provides an additional and very comprehensive survey of the literature and of empirical findings.

Paper	Model	Data	Results
Gambacorta, Hofmann, and Peersman (2014)	SVAR	Monthly Data (2008:M1 to 2011:M6)	A positive one-standard deviation structural shock to the ECB balance sheet represents: A peak response of GDP from 0.05% to 0.15% (16th and 84th percentiles at month 3 horizon), and Prices from 0.05% to 0.010% (16th and 84th percentiles at month 5 horizon).
Kremer (2016)	SVAR	Monthly Data (1999:M1 to 2013:M12)	A positive one-standard deviation structural shock to the ECB balance sheet represents a peak of 0.23% and 0.05% in real GDP growth (at month 16 horizon) and prices (at month 20 horizon) respectively.
Wieladek and Garcia Pascual (2016)	Bayesian SVAR	Monthly Data (2012:M6 to 2016:M6)	1% positive structural shock to the ECB balance sheet announcement represents a peak of 0.11% rise in real GDP (at month 20 horizon) and a rise of 0.075% in prices (at month 18 horizon). This being the average of all identification schemes.
Gambetti and Musso (2017)	TVP-VAR	Quarterly Data (2009Q3 to 2016Q4)	The APP shock (2015:Q1) represented a 0.18% response of real GDP on impact and represented a 0.06% response of HICP one quarter after the shock. The HICP IRF peaked at 0.36% 8 quarters after the shock.
Boeckx, Dossche, and Peersman (2017)	Bayesian SVAR	Monthly Data (2007:M1 to 2014:M12)	1.5% positive structural shock to ECB Balance sheet represents a peak of 0.1% rise in real GDP (at month 8 horizon) and a 0.09% rise in prices (at 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 of 0.08% growth in real GDP (at month 4 horizon) and a 0.03% rise in prices (at month horizon 5).

TABLE *I: This table summarizes the results of a selection of papers that use multiple time series models to analyze unconventional monetary policy in the Euro area. Values are approximations as they were taken from IRF graphs depicted in the mentioned papers*

3 Methodology

To undertake the study we proposed ourselves, we rely on a Bayesian structural VAR with hierarchical prior selection and zero and sign restrictions. We resort to this model 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.

The baseline Bayesian structural VAR model is represented as follows:

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

where y_t is an M × 1 vector of endogenous variables, c is an M × 1 intercept vector, A_i (i = 1, … , N) are M × M coefficient matrices, and ε_t is an M × 1 vector of exogenous Gaussian shocks with zero mean and variance-covariance matrix Σ. Our model uses a hierarchical prior modelling approach in the spirit of Giannone et al. (2015)[2]. The Bayesian approach to estimating VAR models is growing in use mostly attributed to the ability to increase the number of parameters of estimation and greater structural flexibility. Prior informativeness and selection is a topic that receives much interest in the Bayesian statistics literature as it can significantly impact the posterior distribution. Flat priors are often used as a form of uninformed prior, however they might lead to inadmissible estimators. Flat uninformed priors may generate inaccurate out-of-sample predictions, hence, it is arguably more appropriate to use correctly informed priors, such as hierarchical prior setup herein used. This approach is particularly appropriate for large scale models, however, hierarchical Bayesian VARs can also improve inference for small scale models (Giannone et al., 2015). Imposing zero and sign restrictions (Arias et al., 2018) can help provide structure to the model. However, it is important to recognize that they are chosen arbitrarily by the model builder, nevertheless, they are grounded in generally accepted theory. The restrictions imposed in the models used are similar to the restrictions used in similar prior studies, hence maintaining the comparability of results. The calibration of the algorithm and priors are left to the standard parameters as defined in Kuschnig and Vashold, 2021.

[2] We are thankful to Nikolas Kuschnig and Lukas Vashold for making their R code available online through CRAN (Kuschnig and Vashold, 2021) that enables the estimation of the model in the spirit of Giannone et al. (2015) and zero and sign restrictions as outlined in Arias et al. (2018).

The main model for the euro area is of lag length 2 and includes 4 endogenous variables: The ECB balance sheet, long-term interest rates (derived from sovereign yields produced by the ECB[3]), real GDP, and inflation (measured by the HICP)[4]. To add further conclusions to our analysis, we extend our baseline model by including a 5th variable to uncover potential channels of transmission. Specifically, 5th variable will be the CISS, bank loan volumes, bank interest rates, unemployment, and stock market prices.

The baseline model and the variables included builds on papers of similar nature, specifically Gambacorta et al. (2014), Wieladek and Garcia Pascual (2016), Gambetti and Musso (2017), Boeckx et al. (2017), and Burriel and Galesi (2018). Prior to settling on a definitive methodology we experimented with various configurations of model variables — the different models used and variable configurations are outlined in table IV — and obtained similar maximum, minimum, and cumulative impulse responses. As a result, we settled on a simpler model with an interest rate variable, specifically, the long-term interest rates derived from sovereign yields from the ECB database. The variables used, their sources, and their transformations are described in table VIII in appendix.

The model restrictions applied are described in table II. We assume that a positive innovation in the eurosystem balance sheet does not impact GDP and inflation contemporaneously and negatively impacts the long-term interest rate contemporaneously. We assume that an increase in the long-term interest rates does not impact GDP and inflation contemporaneously. We leave the contemporaneous response of eurosystem balance sheet unrestricted to a shock of the long-term interest rate. Table III summarizes the contemporaneous restrictions applied to the 5th variable, while maintaining the previous restrictions from the baseline model with 4 variables. Particularly, we assume that a positive innovation to the ECB balance sheet and to the long-term interest rate has a zero contemporaneous response in loans to the private sector and unemployment. A positive innovation to the ECB balance sheet has a contemporaneous negative response of CISS and a positive contemporaneous response in stock prices, the inverse being true for a shock to the

[3] As described by the ECB, the long-term interest rates are derived from long-term government bonds denominated in Euro. Where no long-term government bond yields are 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).

[4] For robustness, we estimated the model with various lag lengths and different variables. For instance, we estimated the model with 1 lag and obtained the same general results. In addition, we estimated the model using the ECB debt securities holdings instead of the entire asset side of the balance sheet for the euro area and obtained similar results. Instead of the long-term interest rate we also used the shadow interest rate and bank interest rates.

long-term interest rate. The structural design used in this paper is akin to much of the research in the topic and of similar papers on monetary policy impacts mentioned previously and outlined in table I.

Shock	ECB BS	LTR	GDP	Inflation
ECB BS shock	>0	<0	0	0
LTR shock (+)	?	>0	0	0

TABLE *II: This table summarizes the contemporaneous restrictions applied. ECB BS represents European Central Bank balance sheet and SR represents shadow rate.*

Shock	CISS	Stock Prices	Loans	Unemp-loyment
ECB BS shock	<0	>0	0	0
LTR shock (+)	>0	<0	0	0

TABLE *III: This table summarizes the contemporaneous restrictions applied to the fifth variables*

The data used is summarized in table VIII. We use quarterly data from 2009:Q1 to 2021:Q4. We decided to start in 2009 because policy rates were already at considerably low levels and the ECB started to consider unconventional monetary policies. In the first quarter of 2009, the ECB's deposit facility rate (DFR) was at 0.5% and the main refinancing operations (MRO) rate was at 1.5%. For perspective, a year prior, the DFR was at 3% and the MRO was at 4%. In 2021:Q4, the DFR was at -0.5% and the MRO was at 0.5%, a relatively small decrease since 2009:Q1. We decided to end our sample in 2021 to avoid potential contamination of inflation stemming from supply side shocks, which could be unrelated to the variables in our model. The variables enter the model in log differences and first differences in the case of rates, in order to guarantee stationarity. We tested the stationarity of the variables with the augmented dickey fuller and the phillips perron test confirming that our transformed variables are stationary.

4 Results

4.1 Euro Area Analysis

This section summarizes the results obtained for the models described previously for euro area aggregated data. We take an agnostic approach with regards to the variables in our model and start by estimating six different models with a different mix of variables (table IV). Model 1 is a simplistic model with only 3 variables, the eurosystem balance sheet, real GDP, and the HICP inflation. We consider this model an appropriate starting point because the ECB policy rates during this period were at a very low level (close to the ZLB) as described in the previous section, and hence exerting a small impact on macroeconomic variables. Model 2, 3, and 4 are extensions of the previous model 1 but include an interest rate component. Model 2 includes the shadow interest rate (Krippner, 2013). The shadow interest rate is commonly used in the literature to measure monetary policy impacts at the ZLB. Model 3 includes the long-term interest rate. The long-term interest rates are retrieved from the ECB's database and is derived from long-term government bond yields. This approach is similar to Gambetti and Musso (2017) who also utilizes this variable. Model 4 includes long-term bank interest rates. Bank interest rates are faced by the real economy, and hence could be a good proxy for transmission, particularly the credit channel. Model 5 and 6 follow the approach used by Boeckx et al. (2018) and Burriel and Galesi (2018). We settle for a lag length of 2 after checking the usual lag length criteria (lag length checks are described in table IX). Some criteria suggests 1 lag is also appropriate. We also estimated the models with 1 lag and the results were similar to using 2 lags, while the results of 3 lags exhibits some overfitting.

A summary of the maximum, minimum, and cumulative impulse response functions for all the six models is summarized in table V. The results obtained are consistent across all models. The arithmetic mean peak median impulse response to a 1% increase in the ECB balance sheet is 0.0539% for real GDP and 0.012% for inflation. These values are close to the values obtained in prior studies as summarized in table I. For the euro area baseline model we settle on a simpler model with an interest rate component - model 2 and 3 including the shadow interest rate and the long-term interest rate respectively. For the individual country analysis in the next section, we settle on model 3 — taking into account long-term interest rates for individual countries.

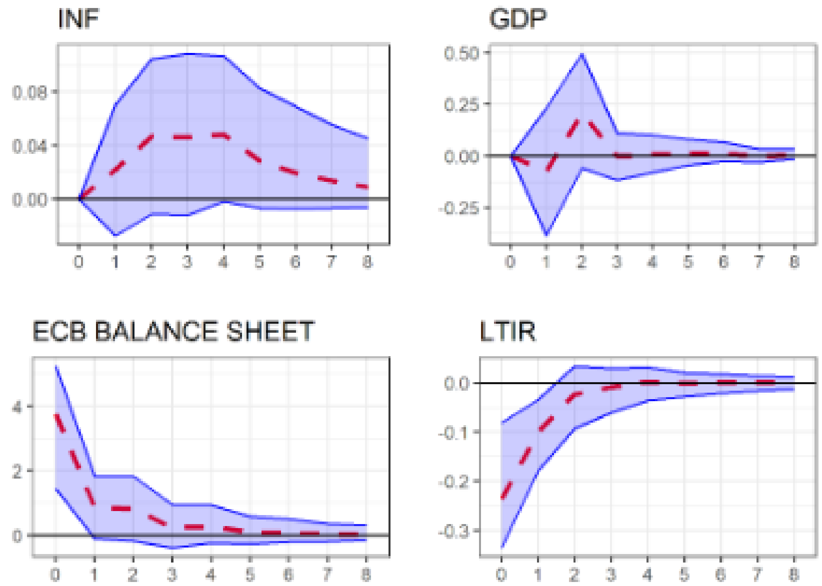
Euro area BVAR models						
Models	Var 1	Var 2	Var 3	Var 4	Var 5	Var 6
Model 1	EBS	real GDP	HICP			
Model 2	EBS	real GDP	HICP	SIR		
Model 3	EBS	real GDP	HICP	LTIR		
Model 4	EBS	real GDP	HICP	BIR		
Model 5	EBS	real GDP	HICP	MLF	EONIA - MLF	
Model 6	EBS	real GDP	HICP	MLF	EONIA - MLF	CISS

TABLE *IV: This table summarizes the 6 models estimated for the Euro area where EBS is the eurosystem balance sheet, SIR is the shadow interest rate, LTIR is the long term interest rate, BIR is the interest rate of new loans over 1 year to non-financial corporations and households, MLF is the ECB marginal lending facility, EONIA-MLF is the spread between the EONIA rate and the marginal lending facility, and the CISS is the composite index of systemic stress. All variables enter the model in either differences or log differences. Details regarding the variables as well as their source and transformations are summarized in table VII.*

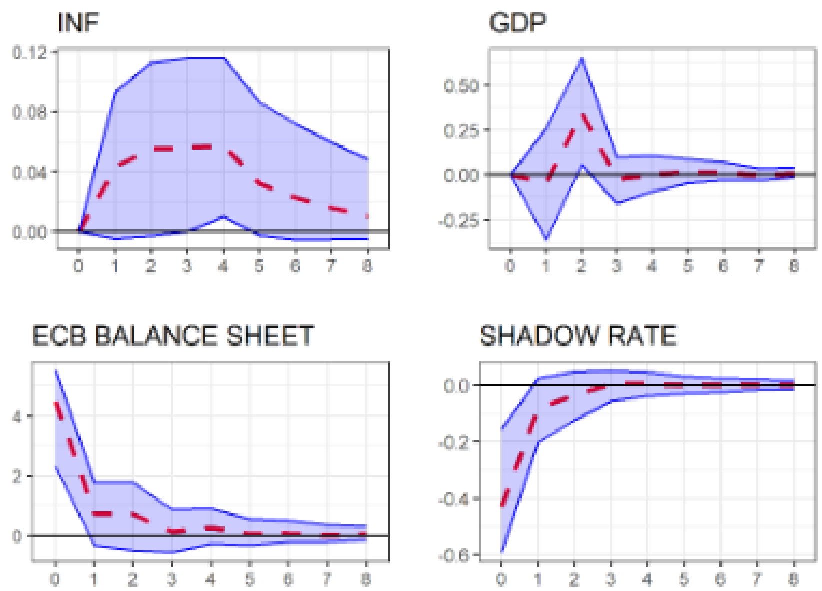
Models	Max GDP	Cumul GDP	Max HICP	Cumul HICP
Model 1 (3 var)	0.0494	0.0530	0.0128	0.0664
Model 2 (4 Var SIR)	0.0808	0.0725	0.0128	0.0640
Model 3 (4 var LTR)	0.0584	0.0473	0.0122	0.0588
Model 4 (4 var BIR)	0.0340	0.0185	0.0125	0.0672
Model 5 (5 var)	0.0373	0.0197	0.0077	0.0379
Model 6 (6 var)	0.0634	0.1751	0.0139	0.0718
Arith. mean	0.0539	0.0644	0.0120	0.0610

TABLE *V: This table summarizes the peak and cumulative median impulse responses estimated for real GDP and HICP standardized to a 1% increase in the eurosystem balance sheet for the 6 different models. SIR represents the shadow interest rate, LTR the long-term interest rate, BIR the bank interest rate. All the variables, their sources, and their transformations are described in table VII.*

The Impulse response functions for our baseline models (model 2 and 3), are shown in figure 1. Model 3 is shown in the top 4 plots (which includes the eurosystem balance sheet, long-term interest rate, the real GDP and the HICP). We report the median, the 16th percentile, and the 84th percentile bands. Considering the median impulse response responses, a 1% positive shock to the ECB's balance sheet represents a peak of 0.0473% response in GDP at quarter 2 horizon and a 0.0122% response in inflation at quarter 4 horizon. The real GDP impulse response quickly drops after quarter 3. For inflation, the impulse response function exhibits persistence, a finding commonly reported in this line of literature. Overall, considering the 16th and 84th percentile bands, the results are not statistically significant. The model that uses the shadow interest rate instead of the long-term interest rate (the bottom 4 plots of Figure 1) shows that GDP response become statistically significant 2 quarters after the balance sheet shock while inflation response becomes statistically significant 4 quarters after the initial shock.



Variables in this model: Euro system balance sheet, long-term interest rate, real GDP, inflation



Variables in this model: Euro system balance sheet, shadow rate rate, real GDP, inflation

FIGURE 1: *Impulse responses to a one standard deviation shock to the ECB's balance sheet. The structural BVAR includes sign and zero restrictions as described in table II. The lower bands represents the 16^{th} percentile and the upper bands represent the 84^{th} percentile. The red dashed lines are the 50^{th} percentile bands. Variables included in this model are the quarterly growth of Euro system balance sheet, the quarterly growth of long term interest rate (LTIR), the quarterly growth of the shadow rate, the quarterly growth of real GDP, and the quarterly growth of inflation (HICP)*

As described in the methodology section, we extend our baseline model (model 3) and include a fifth variable. Figure 2 shows the impulse response functions of the 5th variable of the extended model to a one standard deviation shock of the ECB balance sheet. Considering the median impulse response function, the figures suggest that a one standard deviation positive shock to the ECB balance sheet decreases the CISS significantly and persistently which suggests that UMP is a capable stabilization tool.

Long-term interest rates on new bank loans to non-financial corporations and households (variable named BIR) shows a significant negative impact and persistence. However, bank loans to non-financial corporations also have a negative impact, which is a puzzling result. A possible explanation could be a substitution effect of sources of financing by non-financial corporations. The impact on loans to households is not significant and remains inconclusive. Despite the low interest rate environment, data from the ECB reveals that the amount of loans to non-financial corporations decreased during most of the period under analysis, perhaps explaining this result, while loans to households increased moderately. Easing financing conditions was one of the stated objectives of the ECB prior to launching balance sheet expansion programs hence these results being difficult to interpret.

A shock to the ECB balance sheet has a positive impact on the eurostoxx600 stock index as expected. The impact is immediate and quickly subsides to zero. Unemployment shows an insignificant and inconclusive impact. These results are congruent with the common finding that, even though BSEP improved financial conditions (such as lower CISS, lower interest rates, etc.), the response of aggregate macroeconomic variables such as GDP and unemployment could be considered muted for the aggregated euro area.

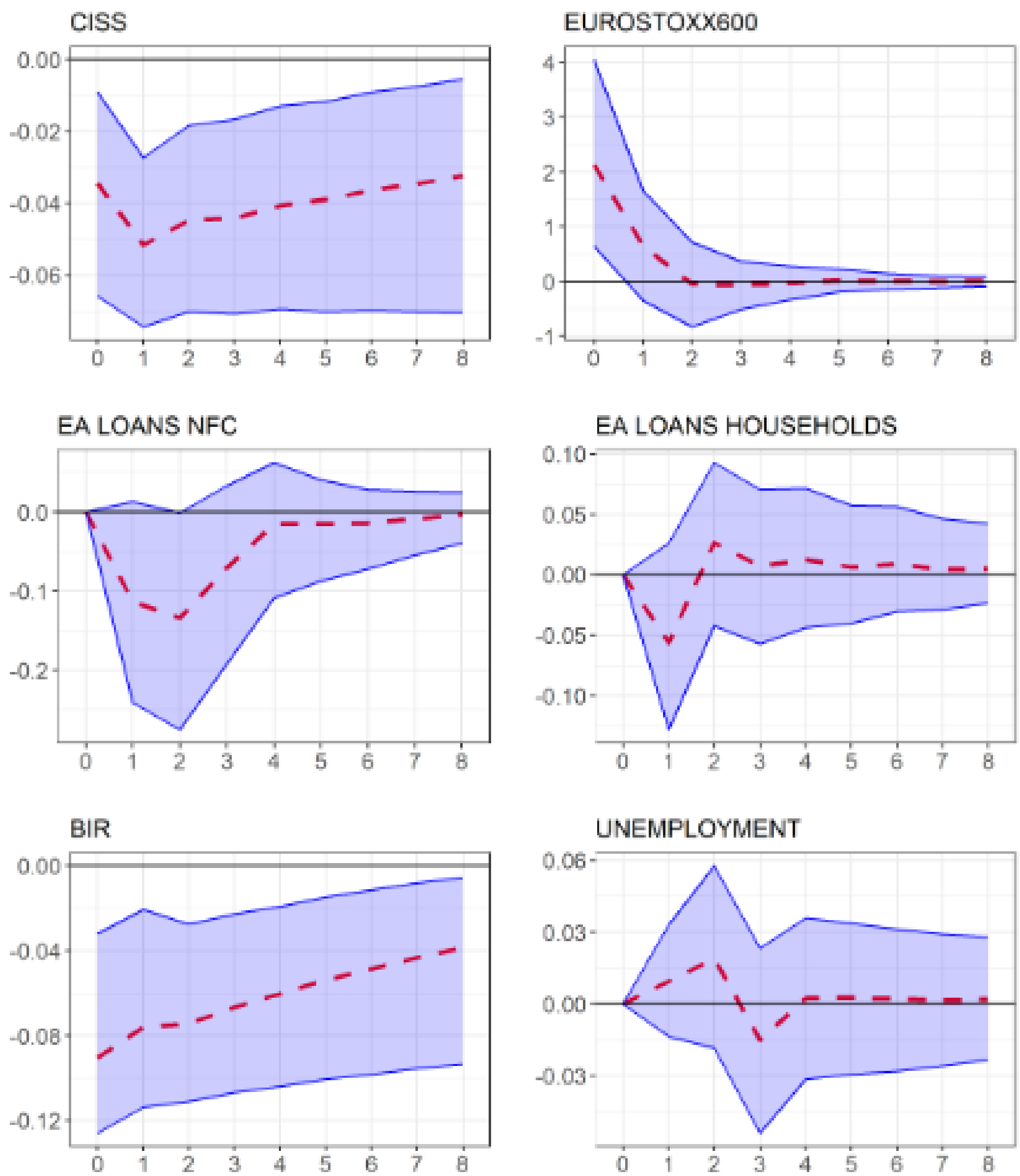


FIGURE 2: *Impulse response functions of a one standard deviation shock to the ECB's balance sheet and response of the* 5^{th} *variable of the extended model. The variables are the eurosystem balance sheet, the shadow rate, real GDP, inflation, and the* 5^{th} *variables are the CISS, the Eurostoxx 600,loans to non-financial corporations (EA LOANS NFC), loans to households, long-term bank interest rates to households and non-financial corporations (BIR), and unemployment. The long-term rate of bank new loans to households and non-financial corporation is derived from the model with 4 variables*

4.2 Individual Country Analysis

In this subsection, we estimate the previous baseline model (model 3 including the ECB balance sheet, long-term interest rates, real GDP, and HICP inflation) for 16 individual euro area countries[5]. Figure 6 and 7 report the impulse response functions for real GDP and HICP inflation to a 1 standard deviation shock to the ECB balance sheet for each individual euro area member in the analysis. The maximum, minimum, and cumulative impulse responses of a 1% positive shock to the ECB balance sheet are reported in table X and plots are shown in figure 3. Real GDP has a positive peak and cumulative impulse response for all countries, while the response of HICP inflation is positive for all countries except Greece and Portugal.

In order to better understand the sources of heterogeneity in the transmission of monetary policy, we seek to identify correlations between the maximum, minimum, and cumulative impulse responses and country-specific structural characteristics. We analyze the impulse responses of a range of economic and financial variables including real GDP, HICP inflation, long-term interest rates, CISS, unemployment, banks loans to households and non-financial corporations, and bank interest rates, and consider whether these responses are correlated with government debt-to-GDP ratios, tier 1 bank capital ratios, GDP per capita (PPP), and unemployment. The correlations and their plots are shown in table VI and figure 3. Debt-to-GDP, GDP per capita (PPP), and unemployment for each country is calculated as the average from 2009 to 2021. For tier 1 bank capital ratio, data from the ECB is only available from 2015 onwards, therefore we average the values from 2015 to 2021. These data come from Eurostat and the ECB. The full sources of the data are described in table VIII in annex.

Upon a first inspection, more vulnerable countries appear to have the larger magnitude in the impulse responses of real GDP and lower magnitude of HICP inflation. We consider more vulnerable countries as having larger debt-to-GDP and unemployment, and lower GDP per capita (PPP) and tier 1 bank capital ratios.

Some of our results differ than previous studies — particularly Boeckx et al. (2017) and Burriel and Galesi (2018) — in one important respect. While in the previously mentioned papers the researchers find a positive correlation between tier 1 bank capital ratios and peak real GDP

[5] We include 16 countries in our analysis. Countries included are Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Ireland, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia, and Spain. Latvia and Lithuania were not included because they only joined the euro area in 2014 and 2015 respectively. Estonia was not included due to some data unavailability

impulse responses, our results suggest the opposite, a negative correlation between tier 1 bank capital ratio and peak real GDP impulse responses. We obtain a correlation of peak IRF of real GDP and tier 1 bank capital of -0.45, while in the robustness we obtain a correlation close to zero. However, we should stress that the correlations with tier 1 bank capital are relatively small and therefore might not be fully conclusive. Nevertheless, the relationship is substantially different than prior research. The previous papers, the time period only go as far as 2015, and could not be fully representative of the full expansionary effects.

In explaining their results, the previous papers argue that better capitalized banks increased monetary policy transmission power through the credit channel. Better capitalized banks are in a better position to generate new credit and hence it generated a positive impact on macroeconomic variables. Even though our results also suggest that the transmission of balance sheet expansions to loans to non-financial corporations is larger in countries with better capitalized banks (we obtain a positive correlation between tier 1 bank capital ratios and peak and cumulative impulse responses of loans to non-financial corporations) we obtain the opposite results for real GDP. Our results suggest that the credit channel did not overpower other channels of transmission and, therefore, less vulnerable countries did not have stronger responses of real GDP following a balance sheet shock than more vulnerable countries. The other channels of transmission, in this case, could be larger fiscal spending and fiscal sustainability given the easier and cheaper government access to financing following UMPs by more vulnerable euro area countries. Furthermore, the decrease in CISS and improved confidence can be a catalyst for increased consumption and investment.

Summarizing the findings from this section, and solely focusing on the stronger relationships found, high debt-to-GDP countries obtained larger peak impulse responses of real GDP and a lower trough of long-term sovereign rates, CISS, and bank interest rates. Countries with higher unemployment rates obtained larger peak impulse response of real GDP, and lower troughs of long-term sovereign rates, CISS, unemployment, and bank interest rates. During the sovereign debt crisis, UMP played a significant role in mitigating the pressures experienced by more vulnerable member states. As a result, it is expected that our findings would reveal that these countries experienced the greatest benefits from UMP.

We should underscore, however, that a high degree of caution should be employed when analyzing these correlations as this is a simple approach. Nevertheless, assuming the relationship of median impulse responses and their magnitudes are correct and accurate, these findings are noteworthy as they contrast with similar studies conducted previously.

Correlations Table				
Impulses	DTG	GPC	T1	Unemp
GDP Max	0.655	-0.452	-0.450	0.746
GDP Cumul	0.639	-0.461	-0.410	0.695
INF Max	-0.545	0.334	0.403	-0.302
INF Cumul	-0.590	0.341	0.300	-0.458
LTR Min	-0.748	0.329	0.252	-0.712
LTR Cumul	-0.792	0.288	0.268	-0.594
CISS Min	-0.837	0.574	0.488	-0.771
CISS Cumul	-0.801	0.582	0.290	-0.761
Unemp Min	-0.321	0.090	0.184	-0.491
Unemp Cumul	-0.468	0.296	0.304	-0.714
Loans H Max	-0.077	-0.044	0.062	-0.031
Loans H Cumul	-0.623	0.108	0.042	-0.516
Loans C Max	-0.319	0.175	0.409	-0.219
Loans C Cumul	-0.445	0.044	0.250	-0.475
BIR Min	-0.537	0.213	0.302	-0.661
BIR Cumul	-0.767	0.157	0.196	-0.430

TABLE *VI: Correlations of individual country estimations of peak and cumulative impulse response functions. DTG is debt to GDP, GPC is GDP per capita (PPP), T1 is the banking industry tier 1 ratio, Unemp Rate is the unemployment rate, BIR (short for bank interest rates) represents cost of borrowing for new long-term loans of non-financial corporations and households. The model used is the four variables with long-term interest rate (Model 3 from table IV). To obtain the impulse responses for the CISS, unemployment, loans to households, and loans to non-financial corporations, we extend our baseline model (model 3) to include 5 variables. The impulse responses of BIR are obtained with a 4 variable model with BIR as the interest rate component*

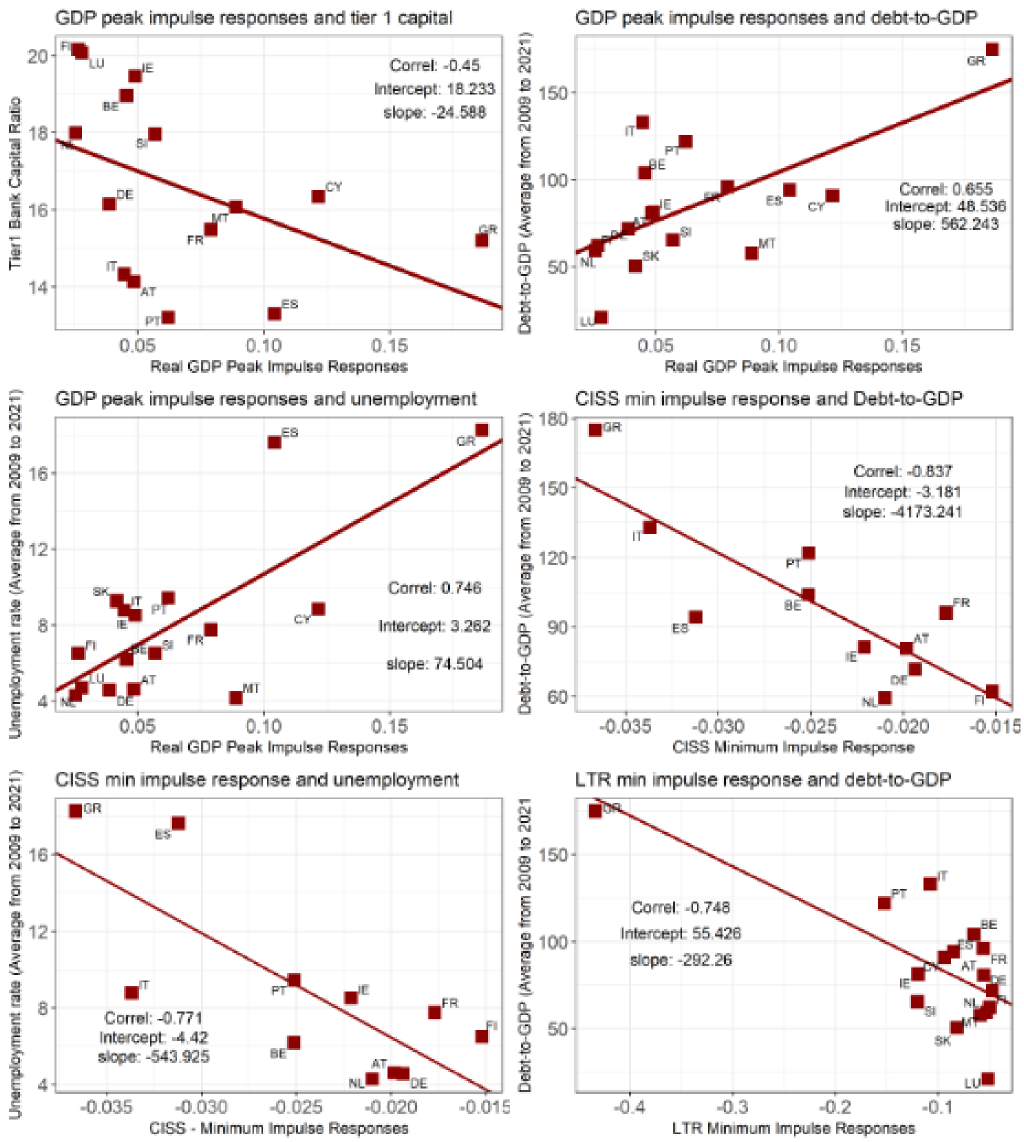


FIGURE 3: *Correlation plots. We show the most relevant correlation plots due to space limitations. All plots can be found at https://github.com/fgomespereira/Paper—Euro-Area-Expansionary-Balance-Sheet-Policies/tree/main/images*

To draw further insights from the results, we estimate a simple OLS regression model to explain macroeconomic responses given macroeconomic vulnerability structural characteristics. We use as independent variables the country macroeconomic variables used for the correlation analysis. Our model is as follows

$$Y_c = \beta_0 + \beta_1(DTG) + \beta_2(GPC) + \beta_3(UNE) + \beta_4(T1) + \varepsilon_c \qquad (2)$$

where Y_c will equal the peak responses of real GDP, and minimum impulse response of long-term interest rate and CISS obtained from the BVAR specification calculated previously[6]. DTG is government debt-to-GDP, GPC is GDP per capita (PPP), $T1$ is banks tier 1 bank capital ratio, UNE is the unemployment rate.

The results are reported in table VII. Unemployment is statistically significant in explaining real GDP peak impulse responses. Debt-to-GDP is statistically significant in explaining minimum impulse responses of long-term interest rates and CISS.

	GDP Peak	GDP Peak	LTR Min	LTR Min	CISS Min	CISS Min
(Intercept)	0.0069	0.0305	0.1207	0.3331	−0.0011	−0.0055
	(0.0391)	(0.0890)	(0.0806)	(0.1759)	(0.0118)	(0.0137)
DTG	0.0003	0.0001	−0.0014*	−0.0018*	−0.0001*	−0.0001
	(0.0003)	(0.0004)	(0.0006)	(0.0008)	(0.0001)	(0.0001)
GPC	−0.0000	−0.0000	−0.0000	−0.0000	−0.0000	−0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
UNE	0.0055*	0.0063*	−0.0088	−0.0085	−0.0006	−0.0006
	(0.0024)	(0.0027)	(0.0050)	(0.0054)	(0.0004)	(0.0004)
T1		0.0000		−0.0112		0.0005
		(0.0046)		(0.0091)		(0.0006)
R^2	0.6085	0.6339	0.6551	0.7091	0.7881	0.8044
Adj. R^2	0.5107	0.4874	0.5689	0.5928	0.6973	0.6739
Num. obs.	16	15	16	15	11	11

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

TABLE *VII: Statistical analysis - Countries included in the GDP Peak regression are Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Ireland, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia, Spain. Slovakia is removed when we include Tier 1 Capital. CISS regression includes 11 countries: Austria, Belgium, Finland, France, Germany, Greece, Ireleand, Italy, Netherlands, Portugal, and Spain.*

[6] For robustness, instead of the peak impulse response functions we also used the cumulative impulse responses up to 8 periods (2 years) after the initial shock and obtained similar results

4.3 Vulnerable vs Non-Vulnerable Analysis

Given the results obtained for the individual country analysis, we attempt at making a distinction between vulnerable and non-vulnerable countries by aggregating variables for these two groups. We categorize vulnerable countries as Greece, Italy, Portugal and Spain. These were the countries most impacted by the European sovereign crisis. We categorize as non-vulnerable all the remaining countries: Austria, Belgium, Finland, France, Germany, Ireland, Netherlands, Cyprus, Luxembourg, Malta, Slovakia, and Slovenia. We estimate the same structural model described in the previous sections, but now we take the arithmetic mean of the transformed variables (growth rates) for each time period for the vulnerable and the non-vulnerable group. The real GDP and inflation impulse responses are estimated from model 3 described in table IV. CISS and unemployment is estimated with model 3 extended to 5 variables (we include CISS and unemployment to model 3 as the 5^{th} variable).

Figure 4 reports the impulse responses of the vulnerable vs. non-vulnerable groups. The results obtained are consistent with the individual country analysis, the vulnerable countries had larger peak and cumulative impulse response of real GDP growth, and lower minimum responses of HICP, CISS, and unemployment after a positive innovation to the ECB balance sheet.

Even though, in the short run, balance sheet expansion policies seem to provide relief and positive outcomes for the period analyzed, — particularly in the more vulnerable countries — it is important to underscore that these policies do not solve potential structural problems such as the high debt-to-GDP and fiscal policy disparity of the member states. One could argue that UMP policies could be the wrong incentive for countries to start reducing their debt-to-GDP levels and conduct prudent and sustainable fiscal policy. Supporting this argument, figure 5 shows the average debt-to-GDP levels of vulnerable and non-vulnerable countries. The difference of debt-to-GDP levels of vulnerable countries continues to increase relative to non-vulnerable countries.

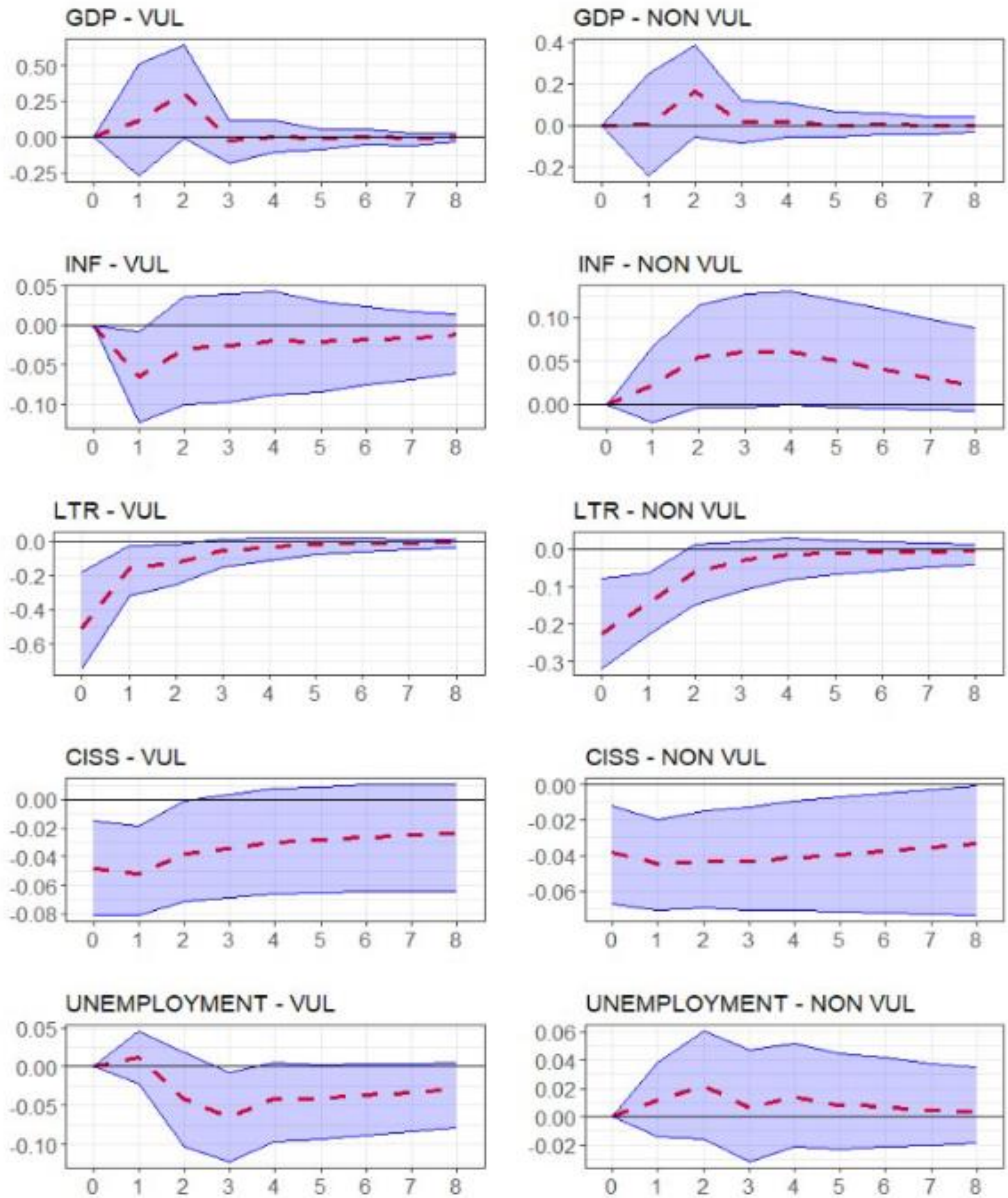


FIGURE 4: *Vulnerable and non-vulnerable impulse response functions. We consider vulnerable countries Greece, Italy, Portugal, and Spain and non-vulnerable the remaining countries in the analysis: Austria, Belgium, Cyprus, Finland, France, Germany, Ireland, Luxembourg, Malta, Netherlands, Slovakia, and Slovenia.*

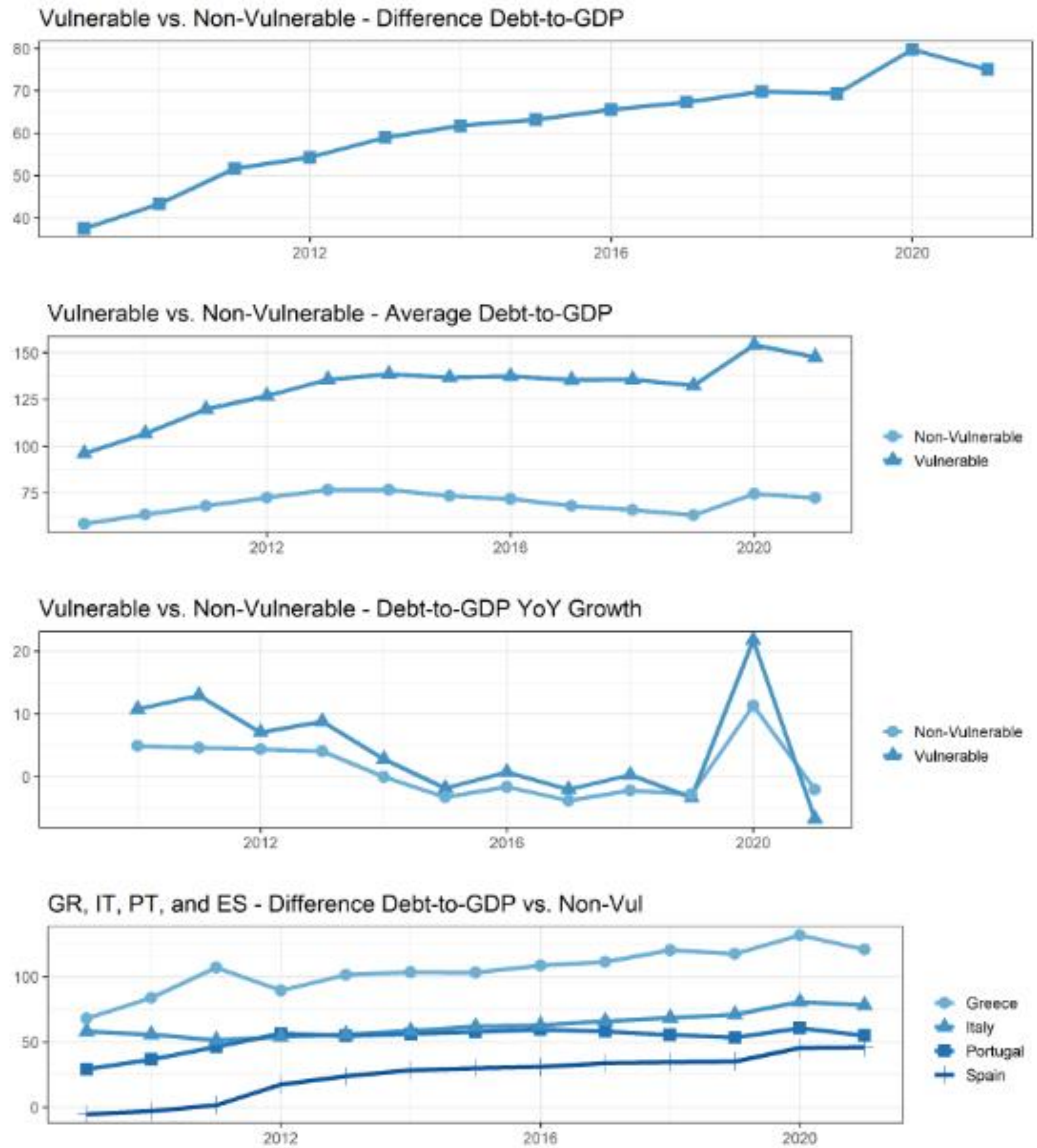


FIGURE 5: *Difference between the average debt-to-gdp of vulnerable and non-vulnerable countries. We classified as vulnerable countries Greece, Italy, Portugal, and Spain. The average is done with equal weights. Source: ECB SDW and authors' calculations*

5 Conclusion

In this paper, we rely on a Bayesian structural VAR to understand how the ECB's balance sheet expansionary policies (BSEPs) impacted macroeconomic variables in the euro area. Our primary finding is that more vulnerable member states had larger magnitude in desirable impulse responses after a ECB's BSEP shock than non-vulnerable member states. We show this in two ways. First, we estimate models for 16 euro area countries and compute the maximum, minimum and cumulative impulse responses of several macroeconomic variables following a positive innovation to the ECB's balance sheet for each country. Euro area countries with higher debt-to-GDP ratios and unemployment had on average larger peak impulse response of real GDP, and lower minimum impulse responses in long-term interest rates (derived from sovereign bond yields), CISS, bank interest rates, and unemployment.

In a second exercise, we average the model variables for vulnerable (Greece, Italy, Portugal, and Spain) and non-vulnerable countries (Austria, Belgium, Cyprus, Finland, France, Germany, Ireland, Luxembourg, Malta, Netherlands, Slovakia, Slovenia) and estimate two additional models. By juxtaposing the impulse responses from these two models, the same conclusion is reached — more vulnerable countries had larger magnitudes in desirable impulse responses. Specifically, non-vulnerable countries had larger magnitude in the response of real GDP, and lower magnitudes in the responses of inflation, CISS, long-term interest rates, and unemployment.

These results are compelling because, first, they are akin to theoretical considerations of monetary policy models and of conventional monetary policy empirical results. Second, these results contrast with previous findings from similar studies where non-vulnerable countries had larger desirable impulse responses than vulnerable countries, specifically larger peak impulse responses of real GDP following a shock to the ECB balance sheet.

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Annex

Data Used

Variable	Source	Data source code	Trans.
Real GDP	Eurostat	namq_10_gdp (na_item: B1GQ, unit: CLV10_MEUR, s_adj: SCA)	2
Inflation (HICP)	ECB SDW	ICP.M.CC*.N.000000.4.INX	2
Long-term interest rate	ECB SDW	IRS.M.CC*.L.L40.CI.0000.EUR.N.Z	1
Eurosystem Balance Sheet	ECB SDW	BSI.M.U2.N.C.T00.A.1.Z5.0000.Z01.E	2
Household Loans	ECB SDW	BSI.M.CC*.N.A.A20.A.1.U6.2250.Z01.E	2
Non-fin corporations loans	ECB SDW	BSI.M.CC*.N.A.A20.A.1.U6.2240.Z01.E	2
Loans	ECB SDW	BSI.M.CC*.N.A.A20.A.1.U6.2240.Z01.E + BSI.M.CC*.N.A.A20.A.1.U6.2250.Z01.E	2
Banks long term interest rates	ECB SDW	MIR.M.CC*.B.A2J.KM.R.A.2230.EUR.N	1
CISS	ECB SDW	CISS.M.CC*.Z0Z.4F.EC.SOV_CI.IDX	1
Unemployment	Eurostat	lfsq_urgan (age: Y15-74, citizen: TOTAL, sex: T)	1
EONIA	ECB SDW	EON.D.EONIA$_{T}O.RATE$	1
MLF	ECB SDW	FM.D.U2.EUR.4F.KR.DFR.LEV	1
Debt-to-GDP	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 Capital (PPP)	Eurostat	nama_10_pc(na_item: B1GQ, unit: CP_PPS_EU27_2020_HAB	N/A
T1 Capital Ratio	ECB SDW	SUP.Q.CC*.W0._Z.I4002._T._Z._Z. - _Z._Z.PCT.C	N/A

TABLE VIII: *This table summarizes the data used in the models*
**CC - Country Code (AT, BE, CY, FI, FR, DE, GR, IE, IT, LU, MT, NL, PR, SK, SI, ES)*
Treatment: 1 - differences; 2 - log differences
Monthly data is transformed to quarterly by taking the values at the end of the month for each respective quarter

Lag Selection Analysis for the 6 Models

Model 1: ECB-BS, GDP, HICP				
Lag	AIC	HQ	SC	FPE
1	3.939356	4.118057	4.416393*	51.45343
2	3.757099*	4.069826*	4.591914	43.1312*
3	3.987032	4.433784	5.179624	55.04674
4	4.240755	4.821533	5.791125	72.8347
Model 2: ECB-BS, SIR, GDP, HICP				
Lag	AIC	HQ	SC	FPE
1	3.037142	3.334976*	3.832203*	20.917597
2	3.033779	3.569882	4.46489	21.2047
3	2.769608*	3.543979	4.836768	16.993963*
4	2.880989	3.893627	5.584198	20.652216
Model 3: ECB-BS, LTIR, GDP, HICP				
Lag	AIC	HQ	SC	FPE
1	1.799593*	2.097427*	2.594654*	6.068076*
2	1.816748	2.352851	3.247859	6.278883
3	2.109385	2.883756	4.176545	8.781394
4	2.392028	3.404666	5.095237	12.66525
Model 4: ECB-BS, BIR, GDP, HICP				
Lag	AIC	HQ	SC	FPE
1	-0.4803	-0.18246	0.314765*	0.620737
2	-0.77131*	-0.23521*	0.659796	0.471955*
3	-0.61883	0.155539	1.448328	0.573738
4	-0.29199	0.720651	2.411222	0.86489
Model 5: ECB-BS, MLF, EONIA-MLF, GDP, HICP				
Lag	AIC	HQ	SC	FPE
1	-4.843862434	-4.401906437*	-3.674361802*	0.007928509
2	-5.048618489*	-4.238365827	-2.904533997	0.006689692*
3	-4.746013877	-3.567464552	-1.627345526	0.009915944
4	-4.74126778	-3.19442179	-0.64801557	0.01197517
Model 6: ECB-BS, MLF, EONIA-MLF, CISS, GDP, HICP				
Lag	AIC	HQ	SC	FPE
1	-11.2096	-10.59086*	-9.572298*	1.37148E-05
2	-11.43969*	-10.29061	-8.39899	1.16928E-05*
3	-10.99031	-9.310876	-6.546206	2.21887E-05
4	-11.40192	-9.192137	-5.554414	2.20516E-05

*indicates lag order selection by criterion
ECB-BS - ECB Balance Sheet; SIR - Shadow Interest Rate
MLF - ECB's Marginal Lending Facility

TABLE *IX: Lag Selection Analysis*

GDP Responses to a 1SD shock to the eurosystem balance sheet

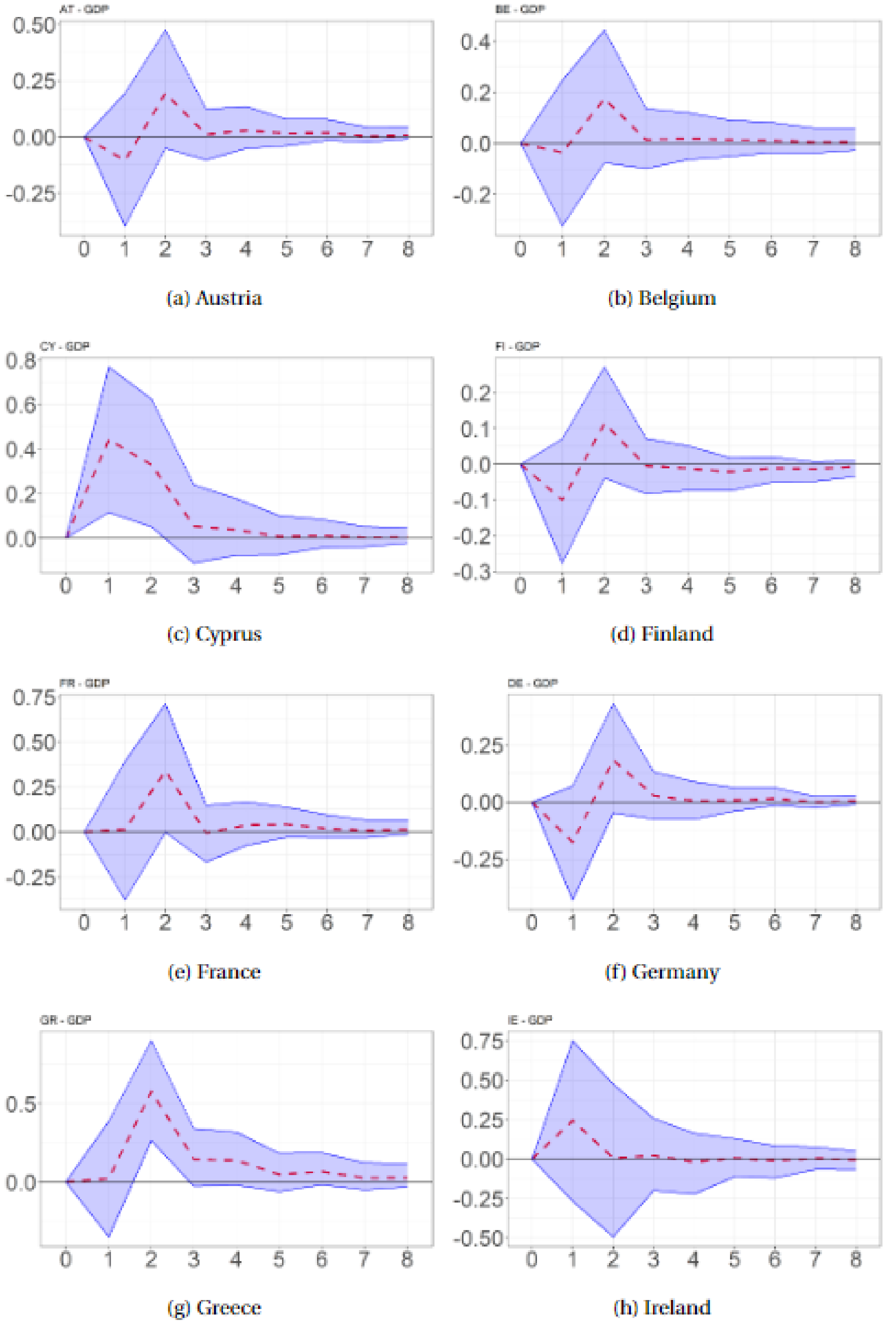

FIGURE 6: *Response of real GDP quarterly growth to a one standard deviation exogenous shock to the eurosystem balance sheet*

GDP Responses to a 1SD shock to the eurosystem balance sheet (cont.)

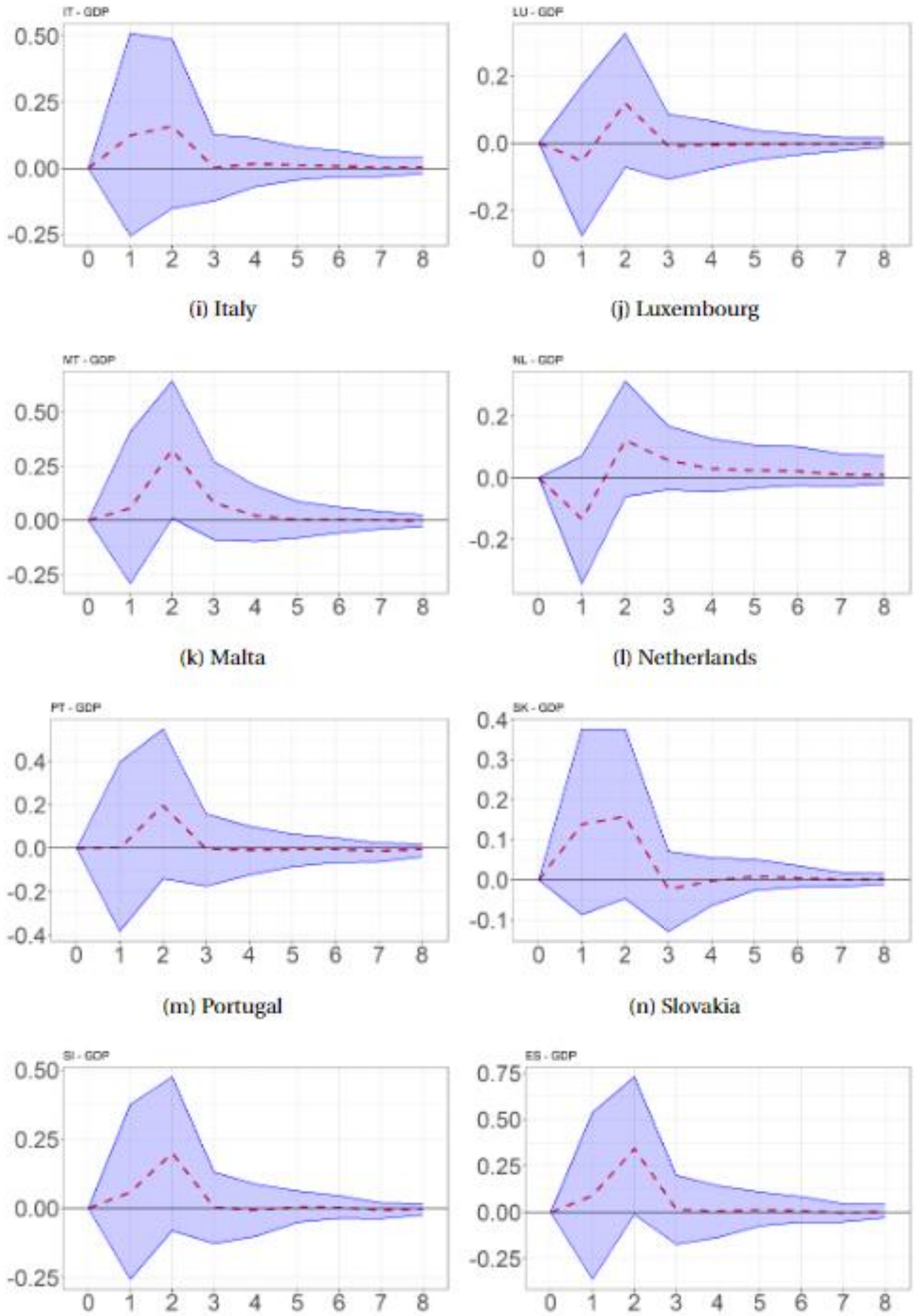

FIGURE 6: *(continued) Response of real GDP quarterly growth to a one standard deviation exogenous shock to the eurosystem balance sheet*

INF response to a 1 SD shock to the eurosystem balance sheet

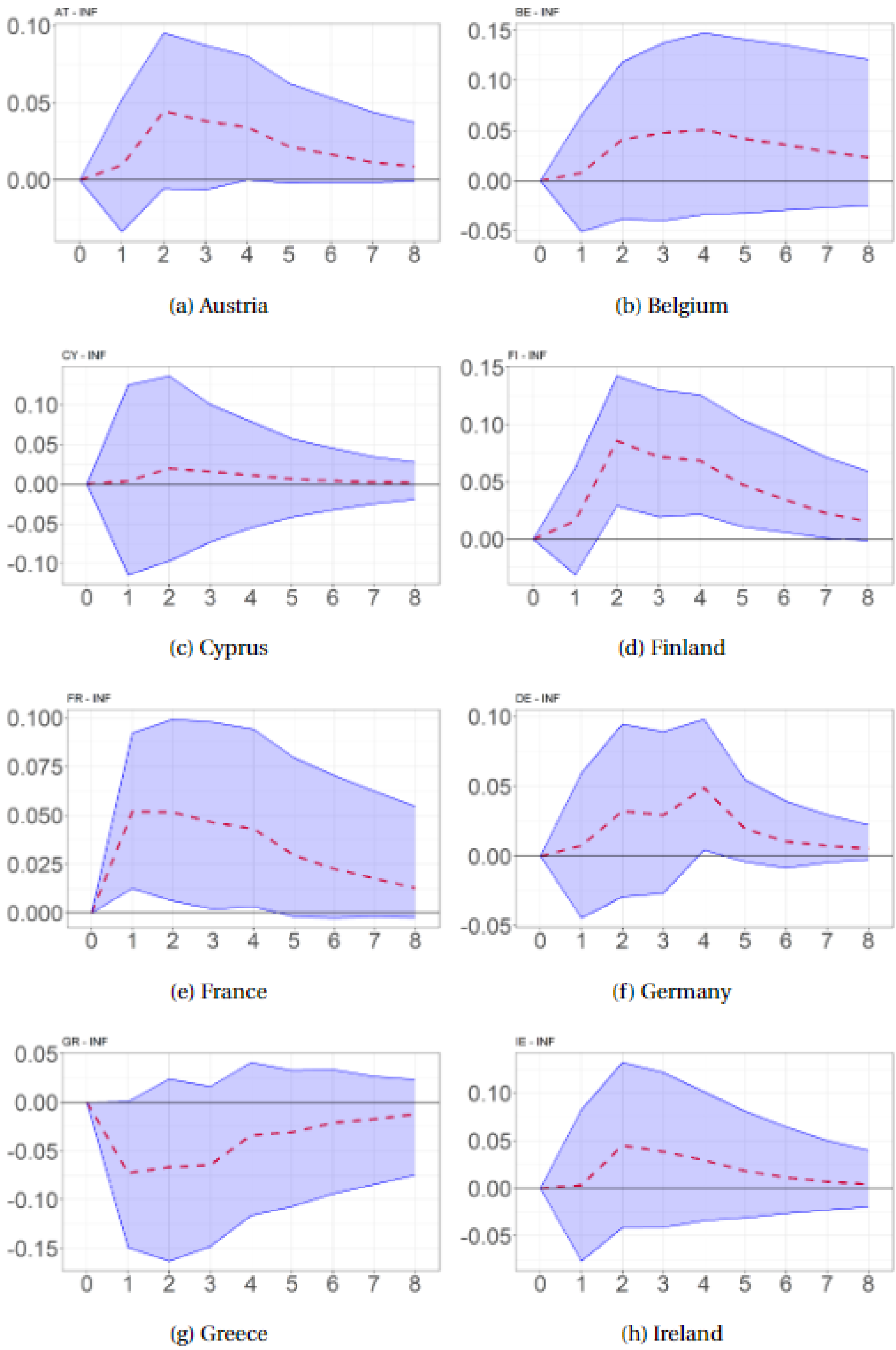

FIGURE 7: *Response of inflation growth to a one standard deviation exogenous shock to the eurosystem balance sheet*

INF response to a 1 SD shock to the eurosystem balance sheet (cont.)

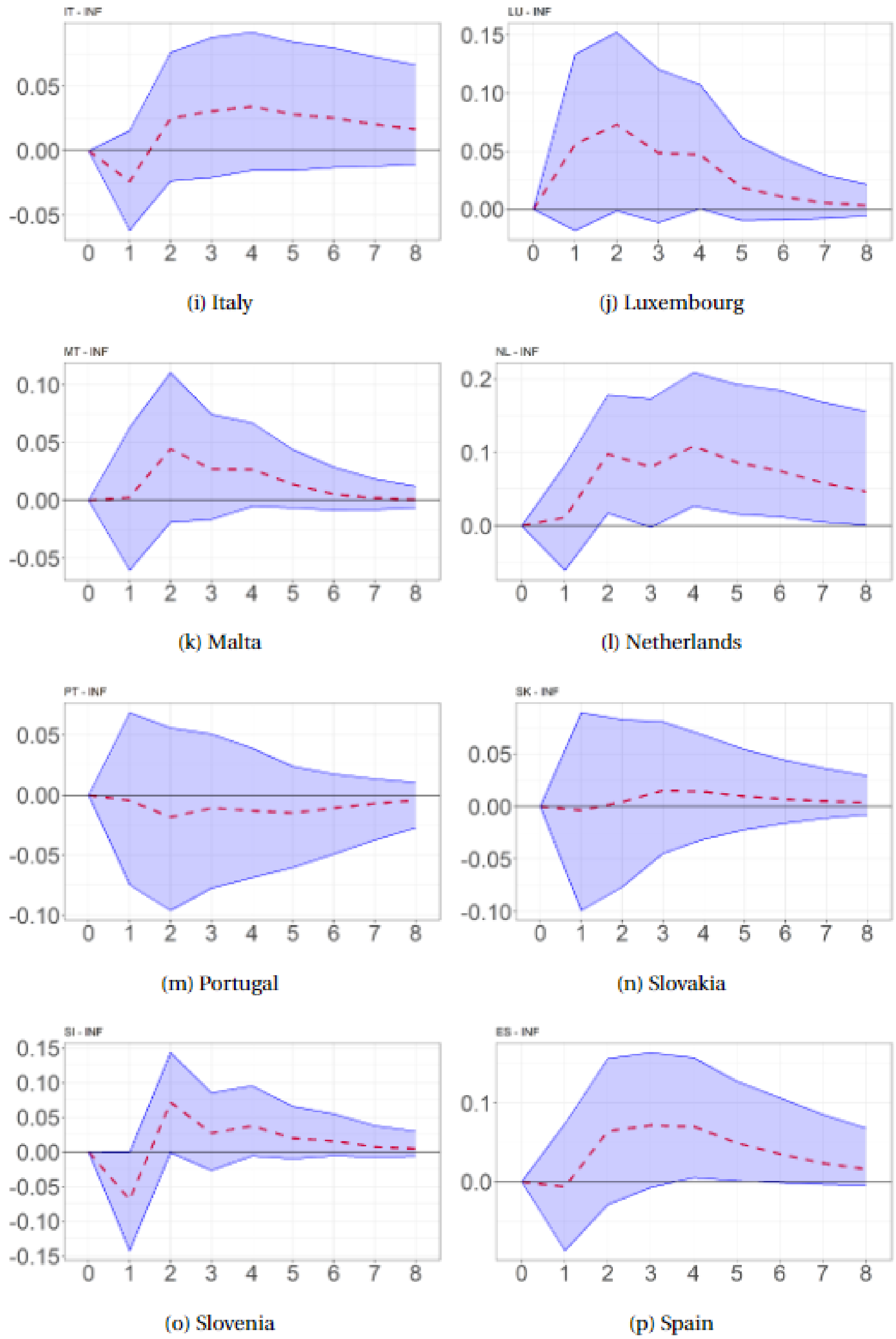

FIGURE 7: *(continued) Response of inflation growth to a one standard deviation exogenous shock to the eurosystem balance sheet*

Maximum, Minimum, and Cumulative IRF Individual Countries

	GDP Max	INF Max	LTR Min	CISS Min	BIR Min	UNE Min
AT	0.0484	0.0112	-0.0557	-0.0198	-0.0470	-0.0018
BE	0.0455	0.0129	-0.0654	-0.0251	-0.0245	-0.0042
CY	0.1216	0.0055	-0.0941		-0.1250	-0.0384
DE	0.0387	0.0101	-0.0476	-0.0194	-0.0264	
ES	0.1042	0.0219	-0.0852	-0.0312	-0.0896	-0.0123
FI	0.0263	0.0190	-0.0501	-0.0152	-0.0656	-0.0010
FR	0.0790	0.0130	-0.0562	-0.0177	-0.0203	0.0000
GR	0.1865	0.0000	-0.4336	-0.0366	-0.1819	-0.0232
IE	0.0489	0.0098	-0.1198	-0.0221	-0.0613	-0.0073
IT	0.0446	0.0101	-0.1080	-0.0337	-0.0626	-0.0068
LU	0.0278	0.0165	-0.0518		-0.0862	-0.0139
MT	0.0889	0.0126	-0.0593		-0.0384	0.0000
NL	0.0253	0.0241	-0.0533	-0.0210	-0.0227	-0.0021
PT	0.0620	0.0000	-0.1524	-0.0251	-0.1550	-0.0142
SI	0.0568	0.0200	-0.1205		-0.0841	-0.0030
SK	0.0416	0.0043	-0.0820		-0.0520	-0.0105

TABLE *X: Maximum and minimum IRF response after a 1% increase in the eurosystem's balance sheet. GDP, INF and LTR were obtained from a model with 4 variables: ECB balance sheet, long-term interest rate, real GDP, and HICP inflation (model 3 from table IV). CISS and UNE were obtained by including a* 5^{th} *variable to the previous model.*

	GDP	INF	LTR	CISS	BIR	UNE
AT	0.0467	0.0474	-0.0936	-0.1245	-0.0603	0.0232
BE	0.0521	0.0692	-0.1719	-0.1545	-0.1319	-0.0039
CY	0.2506	0.0192	-0.1661		-0.0815	-0.1372
DE	0.0093	0.0322	-0.0575	-0.1046	-0.0798	
ES	0.1415	0.0985	-0.0807	-0.1681	-0.0595	-0.0671
FI	-0.0117	0.0790	-0.0852	-0.1201	-0.0597	0.0115
FR	0.1116	0.0699	-0.0927	-0.1188	-0.1258	0.0240
GR	0.3465	-0.1054	-0.5494	-0.2204	-0.2409	-0.1264
IE	0.0431	0.0343	-0.2184	-0.1287	-0.0785	-0.0044
IT	0.0944	0.0469	-0.1455	-0.1687	-0.1825	-0.0036
LU	0.0102	0.0595	-0.0764		-0.1045	-0.0115
MT	0.1329	0.0342	-0.0833		-0.0510	0.0202
NL	0.0307	0.1260	-0.0866	-0.1529	-0.0968	0.0056
PT	0.0516	-0.0234	-0.3848	-0.1460	-0.1343	-0.0459
SI	0.0708	0.0325	-0.1133		-0.1254	0.0220
SK	0.0777	0.0168	-0.0668		-0.0565	-0.0525

TABLE *XI: Cumulative IRF response after a 1% increase in the eurosystem's balance sheet after 8 quarters*

Robustness – Correlations for Period 2009:Q1 to 2019:Q4

Robustness - Correlations Table 2009:Q1 - 2019:Q4				
Impulses	DTG	GPC	T1	Unemp
GDP Max	0.573	-0.202	-0.048	0.538
GDP Cumul	0.612	-0.280	-0.152	0.465
INF Max	-0.703	0.265	0.521	-0.424
INF Cumul	-0.793	0.363	0.318	-0.611
LTR Min	-0.729	0.335	0.130	-0.714
LTR Cumul	-0.752	0.295	0.166	-0.625
CISS Min	-0.873	0.633	0.390	-0.815
CISS Cumul	-0.588	0.576	0.259	-0.648
Unemp Min	-0.302	-0.242	-0.09	-0.344
Unemp Cumul	-0.589	0.148	0.121	-0.578
Loans H Max	-0.064	-0.123	-0.077	0.030
Loans H Cumul	-0.601	0.070	-0.060	-0.465
Loans C Max	-0.148	0.093	0.484	-0.015
Loans C Cumul	-0.547	0.132	0.300	-0.489
BIR Min	-0.453	0.167	0.180	-0.621
BIR Cumul	-0.617	0.095	0.129	-0.385

TABLE XII: *Robustness - Correlations of individual country estimations of max, min, and cumulative impulse response functions for the period 2009:Q1 to 2019:Q4. DTG is debt to GDP, GPC is GDP per capita (PPP), T1 is the banking industry tier 1 ratio, Unemp Rate is the unemployment rate, BIR (short for bank interest rates) represents cost of borrowing for new long-term loans of non-financial corporations and households. The model used is the four variables with long-term interest rate (Model 3 from table IV). To obtain the impulse responses for the CISS, unemployment, loans to households, and loans to non-financial corporations, we extend our baseline model (model 3) to include 5 variables. The impulse responses of BIR are obtained with a 4 variable model with BIR as the interest rate component*