The ECB's Extraordinary Monetary Policies from 2011 to 2018: How important were these policies compared to the usual factors affecting banks' investment choices?

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Abstract

We examine the implications of all three major ECB unconventional policies, LTROs, asset purchase programs and negative ECB interest rate on deposit facility for bank investments among loans, government securities and cash deposited in central banks across euro area countries with a different level of financial distress. We address the question how important were all of these unconventional monetary policies for bank credit when compared to the usual bank-specific and macro factors affecting bank investment portfolios. Our results reveal that the ECB extraordinary monetary policy measures were crucial in improving lending output across the euro area countries as the usual bank-specific and macro factors affecting banks' investment portfolios were mainly associated with investments other than lending, in particular, government securities or cash in central banks. We find that changing the terms of LTROs into targeted lending operations, (T) LTROs, played a key role in imposing the desired investment behavior in crisis countries: lowering investments in government securities and increasing banks' lending. Last, we document that cash deposited in central banks appeared as an alternative investment to government securities, suggesting that banks were incentivized for investing in a more liquid assets instead of only focusing on sovereign debt.

The timely contribution and policy relevance of this paper are highlighted by the set of monetary policy measures put in place by the ECB to help the economy to absorb the shock of the COVID 19 crisis and to support access to credit for firms.

Keywords: euro area, monetary policy, banks, financial crisis
JEL Codes: E44, E52, G01, G21

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1. Introduction

ECB undertook a series of unconventional monetary policies in order to combat a severe economic scenario of a complete dry-up of the interbank market and a credit crunch during and after the euro area sovereign-debt crisis. The ECB strategy followed a diverse set of non-traditional liquidity interventions that altogether should have enabled borrowing opportunities for all banks under competitive funding conditions. The stated goals to be achieved included sustainable market liquidity and stimulation of bank credit to the economy.

The outcomes of such unconventional policy interventions are still being explored and the rationale behind their existence is somewhat unclear. While there are studies that show their positive effect on banks' lending, a large part of the literature finds that ECB liquidity provision induced European banks to purchase risky sovereign debt on their balance sheets. The evidence suggests that the increase in government bond holdings is further associated with a contraction in banks' lending. "Zombie lending" is another adverse lending behavior of the European banks related to the ineffectiveness of the ECB non-traditional liquidity operations.1

Fig.1 illustrates some stylized facts about bank assets that shaped the most banks' investment strategies over the soverign-debt post crisis period. Considering the ratio of gross loans to total assets, we observe that there was a downward trend in both non-crisis and crisis countries until 2011. From 2011, this ratio becomes to move upward for the non-crisis countries, but it keeps the same downward trend in the crisis countries. Then, in the period 2014-2017, we observe that the ratio follows an increasing trend in the case of both country groups. However, it starts to decline sharply at the beginning of 2017 in crisis countries. It is interesting that the holdings of government securities represent approximately 6% of total assets at the beginning of the sovereign debt crisis in 2009 and double by reaching approximately 11% - 13% of total assets in 2014. After 2014, we observe a sharp decline of this ratio for both country groups and at the end of our sample period in 2019, it falls below 8% in the case of both country groups. Another interesting observation follows from the comparison between the ratios of government securities and cash in central banks at the end of our sample period. We observe that the ratio of cash and balances in central banks reaches approximately to 8% of total assets on bank asset portfolios for both country groups, while the ratio of government securities falls below 8% in 2019.

Altogether, these stylized facts suggest structural change of investment assets on banks' balance sheet portfolios over the sovereign-debt post crisis period. Along with the inconclusive evidence in the literature, they raise the concern regarding the true effects of the diverse set of extraordinary monetary policies implemented by ECB in the post crisis period.

[1] Acharya et al. (2019) document zombie lending by European banks, a behavior suggesting they used funding provided by the ECB to extend new (subsidized) loans to economically failed existing borrowers with an aim to avoid loan defaults. Tracing the impact of the Outright Monetary Transactions (OMT) program announcement in 2012, they show that funding used by ECB is not allocated to the productive part of the economy.

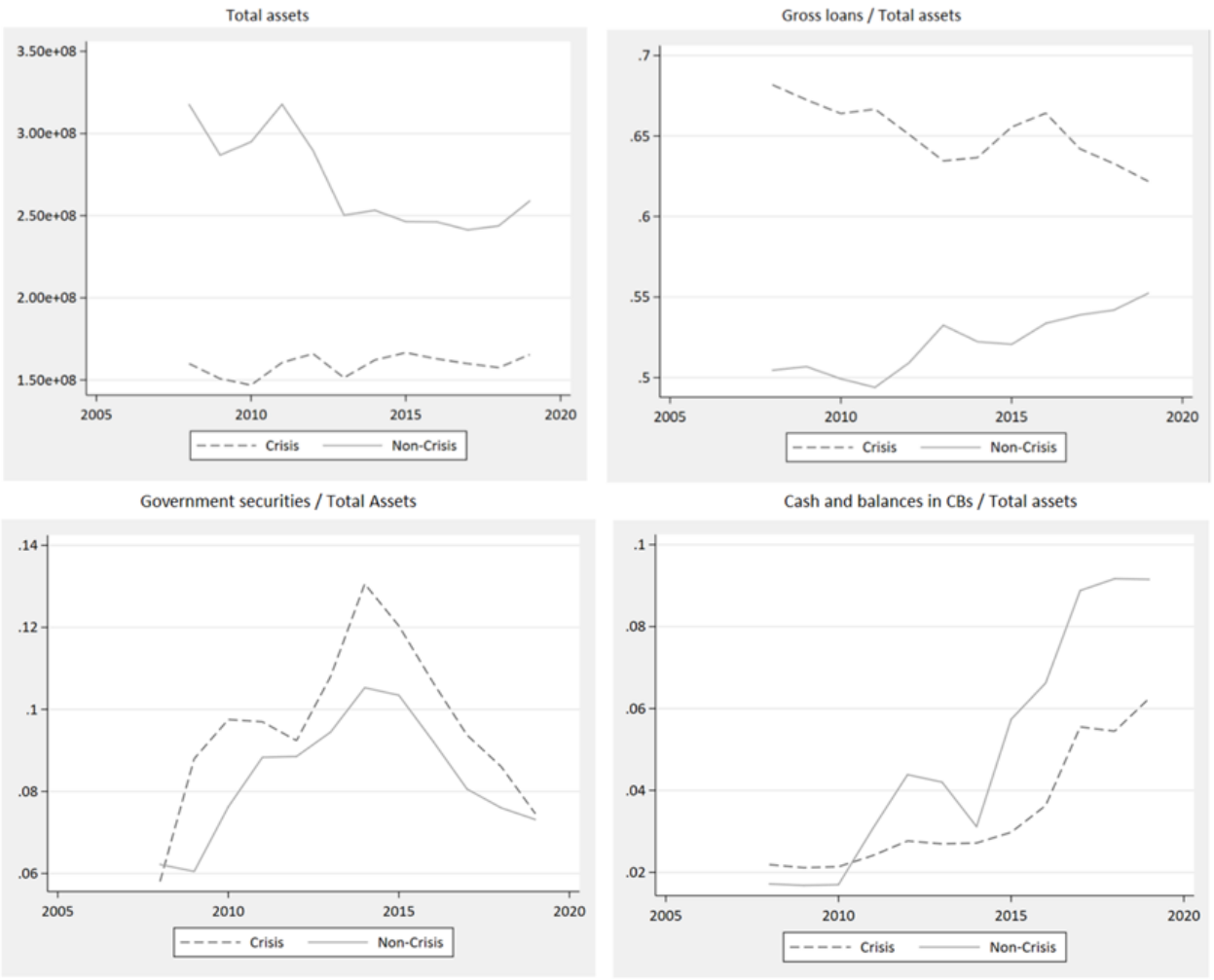

Figure 1: *Time series of total assets and the ratios of loans, government securities and cash and balances in central banks with respect to total assets of the bank*

Notes: The graphs show the evolution of the ratios over the period 2009 -2019. We show the ratios separately for non-crisis vs. crisis euro area countries

In our paper, we try to look from a different angle and shed light on the essential importance of the implementation of such diverse set of extraordinary monetary policy measures. We ask how much important were these unconventional monetary policies compared to the usual factors affecting bank investment decisions. For this purpose, we examine jointly the transmission of shocks to European Central Bank's (ECB's) extraordinary monetary policies, bank- specific and macroeconomic factors for banks´ choices among three leading investment assets: loans, government securities and cash and balances in central banks. The focus of our analysis is on differences in investments by banks incorporated in countries with different levels of financial distress[2]. To achieve this, we split banks into two samples according to the level of financial distress of the country in which they operate: crisis countries versus non-crisis countries.

[2] Considering that papers such as Steffen and Acharya (2015), Drechsler et al. (2016) and Altavilla et al.(2017) find that banks responses to lending and sovereign debt investments differ significantly in non-stressed and stressed countries of

Our findings clarify to what extent the diverse set of ECB's unconventional monetary policies are effective at limiting a credit crunch that was threatening the euro area's economy in the post sovereign debt crisis period. First, we find that the existence of the ECB extraordinary monetary policies is a crucial factor in motivating lending output across the euro area countries as the usual factors (macro and bank-specific factors) affecting banks' investment behavior were mainly associated with investments other than lending, in particular, government securities and cash in central banks. Next, the implementation of a diverse set, by nature and structure, ECB extraordinary monetary policies were of high relevance in imposing direction on banks' investment behavior as the level of a financial distress of a country differentiates the effects of extraordinary monetary policies.

We examine the sample period from 2009 through 2019 inclusive. Along with the stimulative extraordinary monetary policy operations over this period, there was a huge stress imposed on banks decision making by the attempt to control the liquidity risk in the euro-area banking system. It seems that banks were being pushed to focus on their liquid reserves, too. Therefore, in addition to loans and government securities, we also analyze banks' investments in cash and balances in central banks.

A large body of research finds that a set of macroeconomic conditions and bank-specific factors explains bank assets portfolios. For the purpose of our study, we take into account gdp and bank's capital and holdings in deposits from other banks as the most standard macroeconomic and bank-specific factors, respectively. The recent literature on European sovereign debt crisis suggests that banks' incentives for investments between loans and government securities are shaped in a large extent by the change in country's risk. This is why we include the country's risk in our analysis as an additional macroeconomic factor affecting bank assets portfolios and we measure it through the country's level in credit default swaps.

In our sample period, we have the ECB's extraordinary monetary policy operations as an additional factor that differs by structure from the standard ones, but still designed to impact bank assets portfolios. In this setting, we consider the European Central Bank's extraordinary monetary policy measures as a unique market feature of our crisis and post- crisis period. We classify the diverse set of ECB's Extraordinary Monetary Policies into three general categories: ECB lending operations known as Long-Term Refinancing Operations (LTROs), Asset Purchase Programs (APP) and interest rate on ECB's deposit facility. Within the LTROs we distinguish between the effects of the first round of LTROs and the 2nd round of targeted LTROs (TLTROs) that imposed different conditions on bank's lending, also known as "eligible lending".

We use the Panel Vector Autoregresion (PVAR) framework, because it allows us to exploit the serial correlation of the data and to explain banks' investment choices by the banks' other choices, a strategy likely to run into endogeneity problems. Panel vector autoregression models have been increasingly used in applied research and especially along with the

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the euro area. Additionally, De Santis and Surico (2013) suggest that the transmission of monetary policy over bank lending in the euro area is heterogeneous on many bases.

corresponding Stata estimation package of Love and Abrigo (2016)[3]. So far, researchers have been taking into account only a vector of endogenous variables in the main regression specification. In our knowledge, we are the first to consider exogenous variables within a panel VAR setting. In this matter, the paper adds to the literature a relatively novel empirical study that basis on a panel vector autoregression (pVAR) framework by including exogenous variables in the main regression specification.

Our first main result is that under this set of macroeconomic and bank-specific factors, and ECB extraordinary monetary policies only the LTROs and the ECB interest rate on deposit facility are associated with an increase in bank loans. Our results show that shocks in the macroeconomic factors such as the economic growth (*gdp)* or the relative level of country's risk (*cds*) or the standard bank-specific factors mainly motivated banks' investments in government securities or cash and balances in central banks, but not in loans. The only exception that our results show is the positive effect of banks' capital on loans for the sample of crisis countries. Second, our results show that implementing a diverse set of policy measures by nature and structure contributed in improving banks' willingness to lend in both samples of countries as the different ECB policy programs had different effects in non-crisis and crisis countries. For instance, we document a positive effect on lending in non-crisis countries only by the two rounds of LTROs. In crisis countries, we document that only the 2nd round of the LTROs affected positively bank lending along with the ECB's interest rate on deposit facility. Third, we document that changing the terms of LTROs into targeted lending operations, TLTROs, played a key role in imposing the desired investment behavior in crisis countries: lowering investments in government securities and increasing banks' lending. Fourth and finally, we document that cash and balances in central banks became an important investment decision affecting bank asset portfolios over our sample period. Our results suggest that banks gave priority to investments in cash deposited in central banks over investments in government securities when there are shocks in country's risk and targeted LTROs. This further implies a change in bank investment preferences toward liquid assets as an alternative to investments in government securities. Such change in investment preferences is important as it should potentially moderate banks' exposure to risky sovereign debt holdings and weaken sovereign stress transmission across euro area countries.

This paper fills a gap to the polarized findings between lending and government bond purchases in the literature that examines the effects of ECB unconventional monetary policies on bank credit. A series of papers use loans by individual banks to individual firms to assess the effects of the ECB's policies and programs on bank lending. Garcia-Posada and Marchetti (2016), Andrade et al. (2019), and Carpinelli and Crosignani (2021) conclude that ECB's 3-year LTROs implemented in December 2011 and February 2012 had a positive effect banks' supply of bank

3 An early article that examined panel VAR and that made Stata package available informally to other researchers was Love and Zicchino (2006). This panel VAR Stata program has been used in studies published in the American Economic Review (Head, Loyd-Ellis, and Sun, 2014), Journal of International Financial Markets, Institutions & Money (Love and Turk Ariss, 2014), Applied Economics (Mora and Logan, 2012), the Journal of Macroeconomics (Carpenter and Demiralp, 2012) etc.

credit to firms in respectively, Spain, France, and Italy. On the other hand, there are series of papers that suggest that ECB unconventional monetary policies contributed to a high extent in accumulation of sovereign debt on bank balance sheets portfolios. The empirical work of Acharya and Steffen (2015), Popov and Van Horen (2015), Drechsler et al. (2016), Altavilla et al. (2017), and Crosignani et al. (2020) suggests that European banks used ECB funding to purchase government bonds instead to increase lending. They show that such behavior is exacerbated in the case of low capitalized and stress countries banks.

Other papers suggest that economic factors have a central role in explaining investments in sovereign debt by banks, particularly in times of stress. Angeloni and Wolff (2012) and Castro and Mencía (2014) study the link between sovereign yields and banks' sovereign debt holdings controlling for the macroeconomic situation in each country. Lamas and Mencía (2019) argue that Spanish banks increased their holdings of Spanish sovereign debt at the peak of the sovereign-debt crisis to hedge against European Monetary Union breakup by matching their assets and liabilities by nation. Gennaioli, Martin, and Rossi (2014, 2018) and Becker and Ivashina (2018) provide evidence that such increased bond holdings reduced private lending. Their main findings suggest that sovereign debt holdings negatively affect private capital formation.

Our work is also related to the literature that examines the impact of traditional monetary policy on the economy through the bank lending channel. In particular, our paper relates to the section of this literature that examines the effect of lower interest rates on bank behavior such as Maddaloni and Peydró (2011), Jiménez et al. (2014) and Dell'Ariccia et al. (2014).

Darracq-Paries and De Santis (2015) examine the effects of the ECB's 3-year LTROs on bank loan provision along with the macroeconomic indicators as real GDP and increased goods prices. On the basis on panel VAR estimations for the largest eleven euro area countries they show that the 3-year LTROs were effective in avoiding a major credit crunch during the European sovereign-debt crisis. In general, existing papers in the literature examine the effects of the first round of LTROs implemented in December 2011 and February 2012 on bank lending or banks' sovereign portfolio. Our paper is different in the attempt to examine the implications of both LTROs and targeted LTROs along with the asset purchase programs and ECB interest rate on deposit facility relatively to bank-specific and macroeconomic factors for the bank investment portfolios including loans, government securities and cash and balances in central banks.

The paper is divided into the following sections in addition to this introduction. Section two describes the ECB extraordinary monetary policy measures. Section three presents the data and the variables and section four elaborates on the panel VAR empirical methodology. Section five discusses the main empirical findings. The last section provides a summary of the paper and discusses broader implications of the findings.

2. ECB's Extraordinary Monetary Policies from 2011 to 2018

Hartmann and Smets (2018) summarize the ECB's monetary policy from 1999 to 2018 including the ECB's extraordinary polices and possible effects. We provide a tabular summary of the extraordinary policies undertaken by the ECB[4] in Table 1. These policies occurred as the ECB tried to ameliorate effects of the euro area sovereign debt crisis, which started in 2009 and lingered on into 2014 and 2015.

The policies divide naturally into five categories. The first category includes repurchase agreements over long periods, Long Term Refinancing Operations (LTROs). The second category includes asset purchases of covered bonds, for which there were three separate programs. Third, the ECB also has had asset purchase programs for corporate bonds, asset backed securities. The largest programs in terms of volume are purchases of euro area government bonds and related bonds. The fifth extraordinary policy is the negative interest rate on the ECB's deposit facility introduced in June 11, 2014.

Table 1: The ECB's Extraordinary Monetary Policy Measures in period 2009 to 2018

Program or policy	Year and month program began or ended									
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
LTROs										
LTRO 1 year	June ◄			► October						
LTRO 3 years			December ◄	► February						
TLTRO I 4 years						September ◄		► June		
TLTRO II 4 years								June ◄		► March
Purchases of covered bonds										
Covered bonds I	July ◄	► June								
Covered bonds II			November ◄	► October						
Covered bonds III						October ◄				► December
Purchases of Government Securities										
Government securities SMP		May ◄		► September						
Public Sector Purchase Program PSPP							March ◄			► December
Purchases of corporate bonds and asset backed securities										
Corporate bonds								June ◄		► December
Asset backed securities						November ◄				► December
Negative deposit facility rate										
Negative deposit facility rate						June ◄				

*We use the first and last months and years at which loans were provided to banks and the dates when the ECB was buying assets for the asset purchase programs. We provide the maturity date or initial term to maturity of assets for each of the Long Term Refinancing Operations (LTROs) and Targeted Long Term Refinancing Operations (TLTROs). We provide no such date for assets purchased because none of the assets acquired has gone to zero. We use the date June 2016 for expiration of TLTRO I since banks were allowed to pay off those loans and switch to the lower cost loans from TLTRO II if they were eligible. We leave the Outright Monetary Transactions (OMT) out of the table since purchases were zero. We draw a line between the first and last months when the beginning and ending months are not in consecutive years.

[4] Details are from ECB (2011).

2.1 ECB's Long-term Refinancing Operations (LTROs)

Long Term Refinancing Operations (LTROs) were a regular part of the ECB's monetary policy before the financial crisis. These loans typically had maturities of three months, although they were lengthened to a year in June 2009. Loans for these one-year maturities continued until October 2012. The first round of extraordinary LTROs, which the ECB calls simply LTRO, occurred in December 2011 and February 2012. These loans had terms of approximately three years. The interest rate was determined by the average main refinancing rate over the life the loan. Banks had the option to repay these loans after one year. These extraordinary LTROs were followed by Targeted Long Term Refinancing Operations (TLTROs).[5] These are quite different from the LTROs; they were targeted at increasing lending by banks to euro area non-financial firms and households excluding loans for purchases of houses. We call these "eligible lending" for convenience.[6] The first set of operations, TLTRO I, were conducted in eight operations from September 2014 to June 2016. (ECB 2014a, ECB 2014b). The allotment was related to banks' eligible lending in reference periods. Allotments after the initial periods were limited by additional eligible lending based on benchmarks. If eligible lending was less than the benchmark in April 2016, then all the borrowing had to be paid back in September 2016. The loans were limited to three times the eligible lending by banks. All loans matured in September 2018. The ECB gave banks the option to repay the loans in June 2016 when TLTRO II commenced. The interest rate was the rate on the ECB's main refinancing operations at the time of a loan plus ten basis points. A second round of TLTROs, TLTRO II, began in June 2016 with the last quarterly operation occurring in March 2017. The overall terms were similar to TLTRO I but the interest rate was more closely geared to the additional eligible lending by banks. The interest rate could be as low as the negative interest rate on the deposit facility. These loans had a maturity of four years but could be repaid after two years.

2.2 Other Extraordinary Monetary Policy Measures

The ECB also engaged in extraordinary purchases of assets including covered bonds, corporate bonds, sovereign debt and asset backed securities (ECB 2020b). In July 2009, the ECB announced the first of three Covered Bonds Purchase Programs. In CBPP I, the ECB purchased a nominal amount of 60 billion euros of covered bonds from July 2, 2009 to June 30, 2010. In CBPP II, the ECB purchased a nominal amount of 16.4 billion euros from November 2011 to the end of October 2012. Finally, CBPP III ran from October 20, 2014 to December 19, 2018. The assets acquired in CBPP I and CBPP II will be held to maturity and the ECB is reinvesting principal payments from securities bought under CBPP III. The ECB purchased government securities

[5] ECB (2020b) provides a summary of the TLTROs and links to related ECB documents.

[6] The ECB uses the term "eligible lending" to describe lending by banks to euro area non-financial firms and households excluding loans for purchases of houses.

under the Securities Market program from May 10, 2010 to September 6, 2012. In 2020, the securities still owned under the Securities Market Program in order of amount held were issued by Italy, Spain, Portugal, Greece and Ireland and had a book value of 47.9 billion euros. These purchases were sterilized and are being held to maturity. Outright Monetary Transactions were announced on the same date as the end of the Securities Market Program. Outright Monetary Transactions are conditional on a country being in an EU program, are unlimited in amount and the ECB is a creditor with the same standing as private holders of the securities. As of this writing, there have been no OMTs.[7] This does not mean the announcement had no effect. The ECB also purchased government securities under the Public Securities Purchase Programme (PSPP). This program ran from March 9, 2015 to December 19, 2018. Purchases included both nominal and inflation-indexed bonds. Besides national government bonds, the purchases included "bonds issued by recognized agencies, regional and local governments, international organizations and multilateral development banks located in the euro area."(ECB 2020b). The ECB purchased corporate bonds under the Corporate Sector Purchase Programme (CSPP) from June 8, 2016 to December 19, 2018. Principal payments were reinvested. The ECB also has purchased asset backed securities under the Asset Backed Securities Purchase Programme. These purchases occurred from November 21, 2014 to December 19, 2018. Principal payments were reinvested. On June 11, 2014, the ECB took the extraordinary action of lowering the interest rate on banks' deposits at the ECB to -10 basis points. It has remained negative ever since.

Figure 2 graphs the magnitudes and time length of the regular ECB LTRO operations and extraordinary LTRO operations, separately, and Figure 3 graphs the magnitudes and time length of the ECB asset purchase programs.

[7] Hartmann and Smets (2018) provide more details.

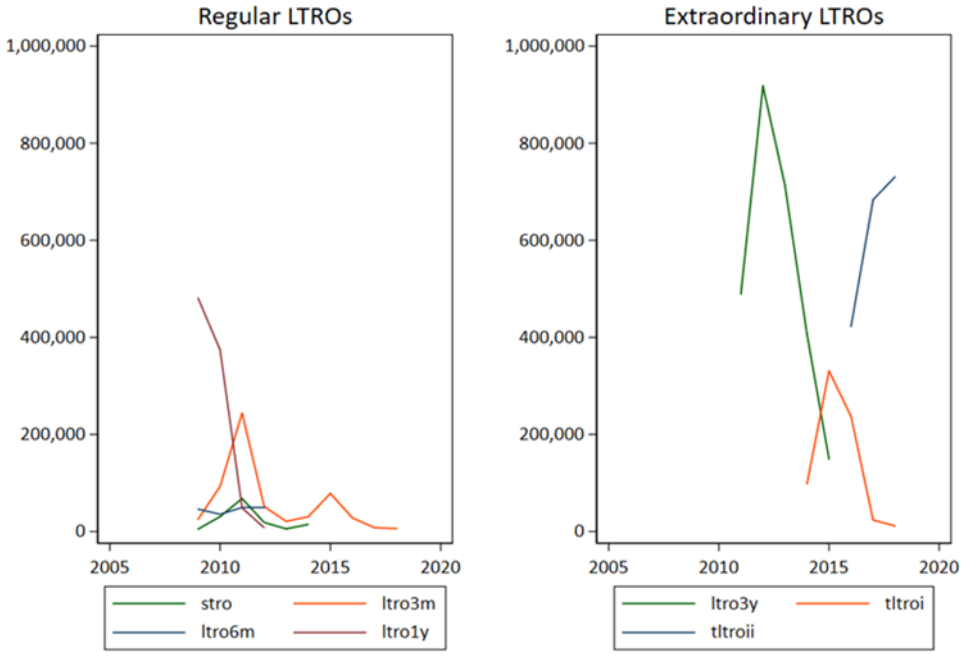

Figure 2: ECB's LTROs in period 2009 – 2018 (in mill. €)

Note: Left hand graph shows the magnitudes of the ECB's regular LTROs with a short term maturity of 3 months. Right hand graph shows the magnitudes of the ECB's extraordinary LTROs implemented from 2011 and on with 3-year and 4-year maturities

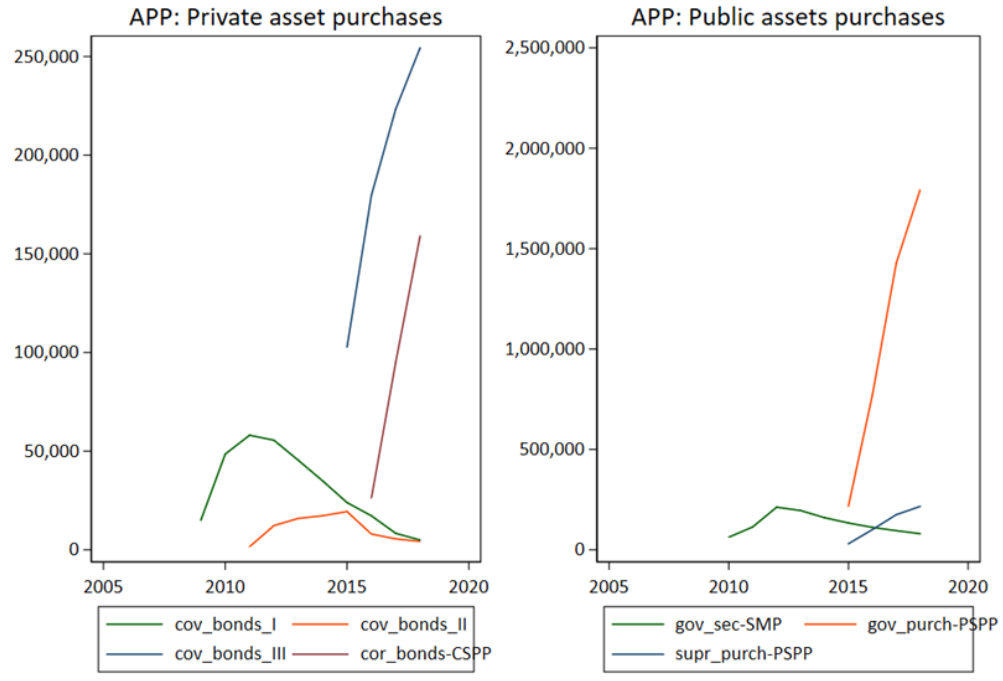

Figure 3: ECB's asset purchase programs (APP) in period 2009 – 2018 (in mill. €)

Note: Left hand graphs shows the magnitudes of the asset purchase programs that involved purchases of assets in the private sector. The right hand graph shows the magnitudes of the asset purchase programs that involved purchases of government bonds

3. Data and Variables

The data include banks in the 17 countries in the euro area for the sample period 2009-2019. The countries are Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia and Spain. These countries all used the euro as their national currency or had a fixed exchange rate relative to the euro for all of the period covered by our data.[8] We aim to provide empirical evidence on how did banks´ investment behavior differ in the euro-area countries on a different level of sovereign debt distress. To achieve this we follow Drechsler et al. (2016) and we construct two samples of banks according to the level of distressed-sovereign debt of the country in which the bank headquarter is. We construct the sample of crisis countries including those countries that were downgraded below AA after the onset of the sovereign debt crisis[9], Cyprus, Greece, Ireland, Italy, Malta, Portugal and Spain. The rest of the countries compose the sample of non-crisis countries as in Table 2.

We have data on 105 banks that have their headquarters in countries in the euro area. We required that a bank have three years of consecutive data available.[10] Banks´ financial information is from BankFocus based on the banks´ consolidated statements which are reported according the International Financial Reporting Standards (IFRS). The paper uses General Accepted Accounting Principles (GAAP) for bank financials over the study period if IFRS financials are not available. Due to the existence of unit roots in our data and the need to use lag values as instrumental variables in our methodology, we lose significant amount of data. Finally, we run the regressions on a dataset of 75 banks and 447 bank-year observations in total. Table 2 provides the list of countries in non-crisis and crisis samples with the total bank-year observations and number of banks per country. Germany, Italy and Spain have more than 10 banks per country, and the prevalence of the German banks is obvious in our dataset.[11]

Table 3 summarizes all the variables used in the paper. We use all of the bank-level variables in ratio terms and we scale them by total assets except for tangible equity over tangible assets. Tangible equity relative to tangible assets, *taneq*, is our proxy for bank capitalization measured as total equity minus intangible assets relative to total assets minus intangible assets.

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[8] The countries in the European Union which joined the euro area after the euro's inception and the year of adoption are Cyprus 2008, Estonia 2011, Greece 2001, Latvia 2014, Lithuania 2015, Malta 2008, Slovakia 2009, and Slovenia 2007 (ECB 2020a).

[9] Drechsler et al. (2016) consider May 2010 to be the start of the sovereign debt crisis in the European Union

[10] Some banks disappear between 2011 and 2019, some new ones appear and some banks do not have all of the variables used in this study available for some periods.

[11] Such a prevalence of German banks might overweight the rest countries on cross-country basis and prevent smaller countries from influencing the coefficients.

Table 2: Sample coverage across countries

Non-crisis countries	Number of observations	Percent of total observations	Number of banks
Austria	734	7.48%	9
Belgium	789	8.04%	8
Estonia	170	1.73%	2
Finland	135	1.38%	2
France	947	9.66%	9
Germany	1587	16.18%	18
Luxembourg	375	3.82%	4
Netherlands	661	6.74%	6
Slovakia	119	1.21%	1
Slovenia	303	3.09%	3
Group total		59.12%	62
Crisis countries			
Cyprus	239	2.44%	3
Greece	519	5.29%	4
Ireland	613	6.25%	6
Italy	936	9.54%	12
Malta	203	2.07%	2
Portugal	433	4.41%	4
Spain	1067	10.88%	12
Group total		40.88%	43
Sample total			105

Table 3: Description and summary of variables

Abbreviation	Description
Bank-level variables	
grossls	Gross loans/Total assets
govsec	Government securities/Total assets
cashbalCB	Cash and balances in central banks/ Total assets
depbks	Deposits from banks / Total assets
taneq	Tangible common equity/ Tangible assets = (Total equity - Intangible assets) / (Total assets - Intangible assets)
Macro variables	
gdp	Country GDP growth rate
cds	The government credit default swap level for country *j* in year *t* relative to the median credit default swap level in year *t* for the eurozone countries
ECB policy variables	
ltro1	The first round ECB extraordinary Long Term Refinancing Operations that took place from 2011 - 2014
ltro2_tar	The second round ECB extraordinary Long Term Refinancing Operations that took place from 2015 - 2018
apptot	ECB extraordinary asset purchase programs: total of private and public asset purchases that occured over the period 2009 - 2018
ecb_intrate	ECB interest rate on deposit facility

Table 4 reports the summary statistics of bank-level variables and Table 5 reports the differences in means analysis of bank-level variables in non-crisis vs. crisis countries. There is significant difference in means in all of the bank assets categories between banks that operate in crisis vs. non-crisis countries except for holdings in deposits from other banks (*depbks*)

Table 4: Summary statistics - Bank variables

	All (105 Banks)				
	Obs	Mean	Std.Dev.	Min	Max
grossls	1,094	0.57	0.20	1.43E-06	0.99
govsec	757	0.09	0.07	2.15E-05	0.36
cashbalCB	1,095	0.05	0.06	3.79E-05	0.52
depbks	1,088	0.16	0.14	3.84E-05	0.94
taneq	1,097	0.07	0.07	-0.05	0.88
total assets	1,097	2.24E+08	3.82E+08	415,368.00	2.20E+09

	Non-crisis countries (62 Banks)				
	Obs	Mean	Std.Dev.	Min	Max
grossls	649	0.52	0.21	2.76E-03	0.95
govsec	467	0.09	0.07	3.00E-05	0.36
cashbalCB	648	0.05	0.07	3.79E-05	0.52
depbks	642	0.16	0.15	3.84E-05	0.94
taneq	649	0.06	0.07	-0.004	0.88
total assets	649	2.68E+08	4.42E+08	415,368.00	2.20E+09

	Crisis Countries (43 Banks)				
	Obs	Mean	Std.Dev.	Min	Max
grossls	445	0.65	0.16	1.43E-06	0.99
govsec	290	0.10	0.06	2.15E-05	0.27
cashbalCB	447	0.04	0.05	1.12E-04	0.34
depbks	446	0.15	0.12	0.01	0.83
taneq	448	0.07	0.08	-0.05	0.76
total assets	448	1.60E+08	2.59E+08	697,434.00	1.52E+09

Table 5: Diff-in-means analysis of non-crisis vs. crisis countries

		Crisis countries					**Non-crisis countries**					**t-test**	
Variables	obs	mean	median	sd	min	max	mean	median	sd	min	max	ttestcrisis	pvaluecrisis
grossls	1096	0.65	0.67	0.16	0.00	1.22	0.52	0.55	0.21	2.76E-03	0.95	-10.88	0.00
govsec	757	0.10	0.09	0.06	0.00	0.27	0.09	0.07	0.07	3.00E-05	0.36	-2.36	0.02
cashbalCB	1096	0.04	0.02	0.05	0.00	0.34	0.05	0.02	0.07	0.00E+00	0.52	4.26	0.00
depbks	1088	0.15	0.13	0.12	0.01	0.83	0.16	0.11	0.15	3.84E-05	0.94	0.69	0.49
taneq	1097	0.07	0.06	0.08	-0.05	0.76	0.06	0.05	0.07	-4.10E-03	0.88	-2.03	0.04
totassets	1097	2.E+08	6.E+07	3.E+08	7.E+05	2.E+09	3.E+08	7.E+07	4.E+08	4.E+05	2.E+09	4.66	0.00

The source of the GDP data is from the World Bank's Economic Development Indicators. The unit data on credit default swap is in levels and is from Thompson Reuters. The credit default swap exposure by country is measured as the ratio of government's credit default swap for country *j* in year t relative to the median credit default swap for the Eurozone countries in year t. Hence, it is a relative measure. We report the summary statistics and the pairwise correlations of the macroeconomic variables over the years in Appendix 1.

The data on extraordinary monetary policy variables are from the ECB. Our data on ECB policy programs is restricted only to the annual quantities provided for the entire euro area. This is why we construct annual observations for the first round Long Term Refinancing Operations (*ltror1*), the second round of Long Term Refinancing Operations – targeted LTROs (*ltror2_tar*) and asset purchase programs (*apptot*) by considering the corresponding annual quantity as a fraction of the total quantity provided by ECB for the particular program over our sample period 2009-2019.

$$ltror1_t = \frac{sum(ltro3y_t)}{total(ltro)} \qquad ltror2\_tar_t = \frac{sum(tltroi_t + tltroii_t)}{total(ltro)} \qquad apptot_t = \frac{sum(app_t)}{total(app)}$$

The first round of LTROs are alive from 2011-2015, hence we have five annual observations measured in quantities for ltror1. The targeted LTROs are alive from 2015-2018, which gives us four annual observations for ltror2_tar. We have nine annual observations for the asset purchase programs for the period 2010 – 2018.

4. Empirical methodology

We use a panel data VAR methodology in order to analyze jointly the transmission of macroeconomic shocks, bank specific factors and ECB policy shocks to the bank investment choices while allowing for unobserved bank heterogeneity. We specify a first-order panel VAR model as follows:

$$y_{i,j,t} = \mu_i + \Theta(L)y_{i,j,t-1} + \delta c_{j,t} + \gamma cb_t + \varepsilon_{i,j,t} \qquad (1)$$

where $y_{i,j,t}$ is a vector of five bank-level endogenous variables $\{taneq_{i,j,t}, depbks_{i,j,t}, grossls_{i,j,t}, govsec_{i,j,t}, cashbalCB_{i,j,t}\}$ and $\Theta(L)$ is the lag operator of the endogenous covariates. In this model, we measure the response of leading bank investment assets that we expect to be sensitive to the set of macroeconomic, bank-specific and monetary policy shocks over our sample period and those are gross loans (*grossls)*, government securities (*govsec)* and cash and balances in central banks (*cashbalCB*). Along with the extraordinary monetary policy operations, there was an adoption on a set of other restriction measures with a lot of emphasis on the regulation of liquidity risk. There was a significant pressure imposed on banks´ decision making by the policy makers´ attempt to control the liquidity risk in the euro-area banking system. Consequently, the holdings of cash and balances in central banks had become an important investment decision affecting bank asset portfolios along with the gross loans and governments securities over our sample period. Therefore, gross loans, government securities and cash and balances in central banks represent bank investment choices in our model by bank *i*, in country *j,* in year *t,* all measured relative to bank's assets. The other bank variables considered in the endogenous VAR setting are deposits from other banks relative to total assets (*depbks*) and tangible equity relative to tangible assets ($taneq$) . They enter in our regression model to capture bank-specific factors corresponding to interbank market exposure and bank capital, respectively. Only lagged values of bank variables are included on the right-hand side of regressions, which lessens endogeneity problems.

The control variables $c_{j,t}$ are the real GDP growth rate in country *j* which houses bank *i*'s headquarters and the relative level of country's credit default risk , both measured at year *t*. cb_t captures the ECB extraordinary policy variables in our model: the first round of LTROs (*ltror1*), the targeted LTROs (*ltror2_tar*), the ECB asset purchase programs (*apptot)* and ECB negative interest rate on deposit facility (*ecb_intrate*) all measured at year *t*.

We allow for individual heterogeneity in the levels of bank variables by introducing fixed effects, denoted by μ_i in the model. The advantage of the panel VAR methodology is that it combines the traditional VAR approach that accounts for the endogeneity among the variables, with the panel-data approach, which accounts for the individual bank specificity by introducing fixed effects. Therefore, it allows us to isolate the response of bank investment choices to shocks of macroeconomic variables, bank-specific factors or ECB policy variables through the orthogonalization of the impulse-response functions. Orthogonalized impulse-response functions describe the reaction of one variable to the innovations in another variable in the model, while

keeping all other innovations constant. We use the Cholesky decomposition of variance-covariance matrix of residuals to identify orthogonal shocks in our variables of interest. The procedure requires adopting an economic reasoning to sort out the contemporaneous links among the variables.

Our model combines a set of bank-level variables, macro-level variables and policy variables. The literature such as Bernanke and Blinder (1992), Carpenter and Demirlap (2012) and Love and Ariss (2014), combines only macro-level variables with the bank-level variables in a VAR endogenous setting. Their ordering assumes that the macroeconomic variables affect bank-level variables contemporaneously, but the macro variables are not affected by the bank-level variables within the same period. This is consistent with the economic and VAR literature, where macroeconomic variables should be ordered first as they have immediate impact on bank variables, while the feedback from bank-level variables on macroeconomic variables could be considered only with a lag. Our model has two main distinctions from the related literature. The first one is that we account for the effect of multiple ECB extraordinary monetary policy operations, we consider them as unique by their structure and purpose, and consequently, we include corresponding policy variables at a macro level. The other distinction is that we account the macro-level variables and the policy variables as purely exogenous variables in the panel VAR model. The VAR setting of endogenous variables is composed only of the bank-level variables, that is the vector $y_{i,j,t}$ in Eq.1, while we account for the macro-level variables and the ECB policy variables out of the vector $y_{i,j,t}$. By such structuring, we assume that macro-level variables and the policy variables would affect bank-level variables only contemporaneously. Therefore, by not combining them with the bank-level variables in a VAR endogenous setting, we assume that macro shocks are more likely to be transmitted to individual banks rather than vice versa.

The Cholesky decomposition employs the following ordering in the vector of endogenous variables, $y_{i,j,t}$, in Eq.1. We assume that a bank's capitalization is affected by the bank's investment choice variables (*grossls*, *govsec* or *cashbalCB*) and interbank market exposure (proxied by *depbks*) only with a lag. We assume that the effect of bank´s capitalization on *depbks* are contemporaneous because banks with less capitalized are perceived as riskier and other banks would reduce their deposits in these banks. Finally, we assume that gross loans (or any other variable from the list of bank investment choices) affect bank-specific factors, *taneq* and *depbks* with a lag and they are simultaneously affected by all other variables. The reasoning behind this assumption is that gross loans are part of the banks' assets portfolios, which by construction depend on funding sources as bank capitalization and deposits from other banks. Hence, in our specification gross loans (or government securities or cash and balances in CB) are the most endogenous variables in the system, capturing all available information. Furthermore, it is reasonable for us to order cash and balances in central banks and government securities holdings after gross loans in the endogenous setting, since they are more prone to

change in the current period in response to adjustments in banks´ lending and capitalization, than vice versa.[12]

We estimate our panel VAR model in Stata program developed earlier by Love and Zicchino (2006) and recently improved by Love and Abrigo (2016). Allowing for bank individual fixed effects in the presence of dependent lags in the panel VAR causes the coefficients to be biased if a standard mean-differencing procedure is employed to eliminate fixed effects. Therefore, we use forward mean-differencing, also referred to as "Helmert procedure." The procedure follows Arellano and Bover (1995), which allows untransformed lagged regressors to be used as instruments because the variables are forward mean differenced, and by this, the coefficients can be estimated by a system of Generalized Method of Moments (GMM). We employ Monte Carlo simulations to calculate standard errors of the impulse-response functions and to generate a 95 percentile confidence intervals.

We attempt to address issues of non-stationarity in our series by conducting two different unit root tests: Fisher Augmented Dickey-Fuller test (ADF) and Fisher Phillips-Perron test (PP). These tests have been developed for testing the presence of unit roots in unbalanced panel data, while PP test is also robust to serial correlation. The null hypothesis is that all series are non-stationary and the alternative hypothesis is that at least one of the series in the panel is stationary. Table 6 presents the results of the ADF and PP unit root tests for the variables in levels and transformed variables in first differences. We do not reject the null hypothesis of the ADF nor PP unit root test for all variables in levels except *depbks.* However, for the variables presentation in first differences we reject the null hypothesis for all five bank level variables in both tests at 1% significance level. The GMM estimator used in PVAR suffers from weak instrument problems when variables being modeled are near unit root. In other words, the moment conditions become irrelevant when the variables have unit roots. Thus, using bank variables in levels yields inconclusive results as most of the panels in our data are nonstationary. In order to mitigate this issue, we specify the reduced-form panel VAR model using first difference approach for bank variables. Therefore, we estimate our first order panel VAR as in Eq.(2), where Δ is the difference operator:

$$\Delta y_{i,j,t} = \mu_i + \Theta(L)\Delta y_{i,j,t-1} + \delta c_{j,t} + \gamma cb_t + \varepsilon_{i,j,t} \qquad (2)$$

[12] Mora and Logan (2012) apply the same reasoning for ordering bank assets in a panel VAR setting

Table 6: Fisher panel unit root tests

Variable	ADF	p-value	Phillips-Perron	p-value
grossls				
Level	-1.1032	0.1350	-2.2582**	0.0120
Difference	-9.5086***	0.0000	-18.2985***	0.0000
govsec				
Level	0.3069	0.6205	-3.9258***	0.0000
Difference	-6.9720***	0.0000	-14.5778***	0.0000
cashbalCB				
Level	2.9629	0.9985	2.4932	0.9937
Difference	-7.1285***	0.0000	-16.4875***	0.0000
depbks				
Level	-4.6900***	0.0000	-5.8727***	0.0000
Difference	-12.1961***	0.0000	-20.2445***	0.0000
taneq				
Level	2.3975	0.9917	-1.4922	0.0678
Difference	-4.7551***	0.0000	-17.567***	0.0000

Crisis countries

Variable	ADF	p-value	Phillips-Perron	p-value
grossls				
Level	0.4865	0.6867	-1.9500	0.0256
Difference	-2.7922**	0.0026	-12.5963***	0.0000
govsec				
Level	-2.465***	0.0069	-1.1532	0.1244
Difference	-2.9664***	0.0015	-9.7597***	0.0000
cashbalCB				
Level	3.4499	0.9997	0.3504	0.637
Difference	-5.0206***	0.0000	-13.3301***	0.0000
depbks				
Level	-6.8944***	0.0000	-3.9359***	0.0000
Difference	-9.8620***	0.0000	-9.4619***	0.0000
taneq				
Level	-0.5465	0.2924	-0.494	0.3106
Difference	-8.5392***	0.0000	-13.1277***	0.0000

ADF is Fisher Augmented Dickey-Fuller test of unit roots
PP is Fisher Phillips-Perron test of unit roots
* Significance at 10%
** Significance at 5%
*** Significance at 1%

5. Discussion of results

Our particular variables of interest are bank investment choice variables: loans (*grossls)*, government securities (*govsec)*, and cash deposits in central banks (*cashbalCB)* . The key focus is to study how different are their responses to shocks in bank financing variables, bank capitalization *(taneq)* and deposits from other banks (*depbks),* and macro factors in comparison to shocks in ECB policy variables and whether they are different across countries of the euro area with different levels of financial distress or credit default risk.

For this purpose, we rerun our baseline panel VAR model given by Eq.(2) separately on each sample: non-crisis and crisis countries. We examine general bank dynamic relationships as well as the contemporaneous relationships with macro and ECB policy variables on the basis on coefficients estimates of the reduced-form models and impulse-response functions for both samples. However, the estimates of the reduced – form model as well as the simple impulse-response functions have no causal interpretation due to the correlation of residuals. In order to provide a causal interpretation of the results, we focus on the orthogonalized impulse-response functions. We present them in a set of graphs including the 5% error bands generated by Monte Carlo simulation.

We report the coefficients estimates of the reduced-form for non-crisis and crisis countries in Tables 4 and 5 in Appendix 2. In Appendix 3 we report the results and the complete analysis when we rerun our baseline panel VAR model of Eq. (2) on the sample of the entire euro area. We show that the results of the entire euro-area sample are different from those of the sample of non-crisis or crisis countries. It presents an additional empirical evidence that the relative financial distress of a country is an important factor to be considered in the process of designing and implementing different monetary policy measures.

We now turn to discuss our main results of interests on the basis on orthogonalized IRFs. In this section, we present the set of orthogonalized impulse response functions of our main interests, while the complete sets of IRFs for the samples of non-crisis and crisis countries are given in Appendix 2.2. Figure 4, 5, 6 and 7 present the orthogonalized impulse-response functions of bank level variables, macro and ECB policy variables, respectively, for the sample of non-crisis countries. Figure 8, 9, 10 and 11 present corresponding orthogonalized impulse-response functions for the sample of crisis countries. First, we examine and discuss the set of IRFs for non-crisis countries and then we continue to discuss the set of IRFs for crisis countries.

5.1 Non-crisis euro area countries

In Figure 4, we present the responses of our main variable of interests, *grossls*, *govsec* and *cashbalCB* to shocks in bank-specific factors, bank deposits (*depbks)* and bank capital *(taneq).* We observe similar investment pattern with respect to shocks in bank deposits and bank capital. A positive shock to bank deposits or bank capital results in an increase in government securities and a drop in cash in central banks. Actually, we observe that a positive shock in bank capital imposes changes on all other bank investment variables and only *govsec* show positive response to it. These results show the tendency of banks in non-crisis countries to use their financing sources primarily for investments in government securities, instead for investments in loans or cash in central banks over our sample period.

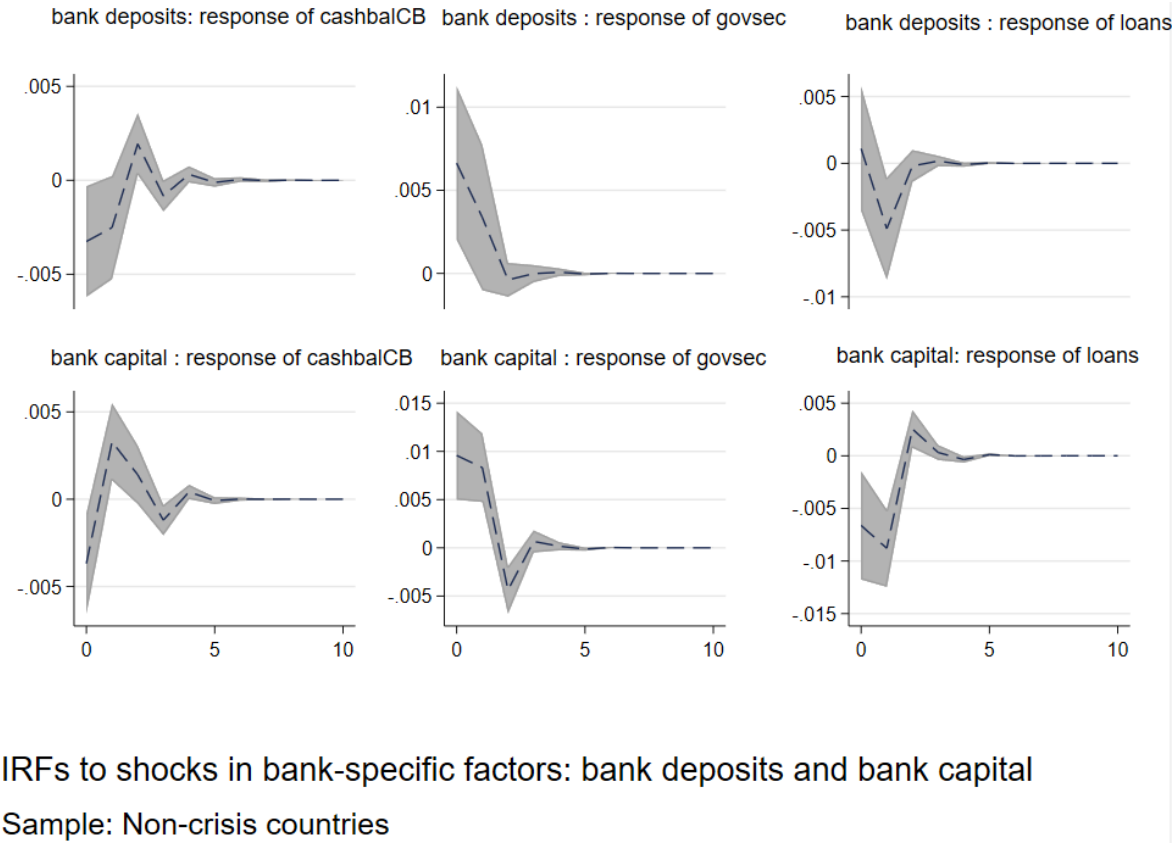

Figure 4: Orthogonalized IRFs of bank variables for non-crisis countries
Note: Errors are 5% on each side generated by Monte-Carlo with 200 reps

In Figure 5, we present the responses of our bank investment choice variables to shocks in macro variables: *cds* (relative level of riskiness of the country *j)* and *gdp* (economic growth). A positive shock to *gdp* causes a drop in cash in central banks, but there is no evidence for an increase in any other investment variable. A positive shock in a country *cds* level causes a positive and negative change in government securities and loans, respectively. A positive response of government securities (*govsec)* as a result of a positive shock in the level of country riskiness (*cds)* could reflect that banks see opportunities for higher returns from investments in

sovereigns due to relatively higher country risk. Furthermore, banks decreased lending investments at the expense of higher investments in government securities when there is a positive change in the level of credit default risk of a country.

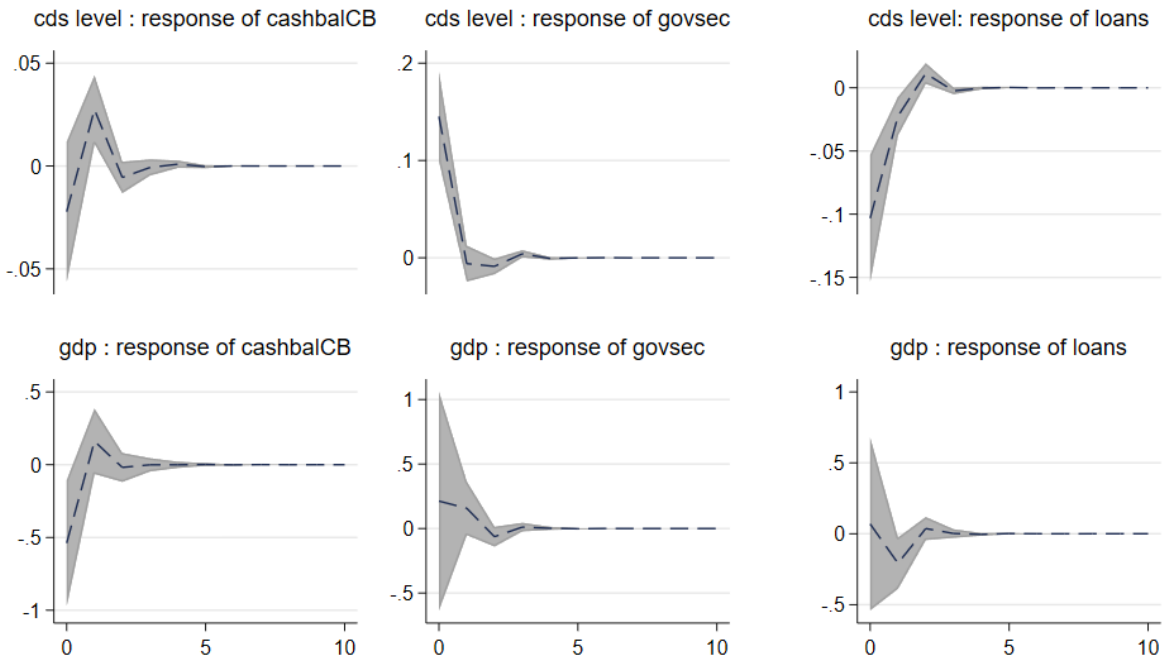

Figure 5: Orthogonalized IRFs of bank variables in response to macro variables for non-crisis countries
Note: Errors are 5% on each side generated by Monte-Carlo with 200 reps

Figure 6 presents the responses of bank investment variables to shocks in LTROs, *ltror1* and *ltror2_tar*. Considering the first round of LTRO (*ltror1*) and the targeted LTRO lending operations (*ltror2_tar*), we observe that a positive shock to either of them does not cause a change in banks' investment behavior with respect to government securities and loans. A positive shock to both LTROs variables results in an increase in the ratio of loans and a decline in the ratio of government securities in the sample of non-crisis countries. The results also reveal that targeted LTROs stimulated an increase in the ratio of cash in central banks in comparison to the first round LTROs, for which there is no evidence if they had any effect on cash in central banks.

In Figure 7, we observe that, a positive shock in asset purchases facilities (*apptot*) results in opposite effects: it causes an increase in government securities (*govsec)* and a drop in loans (*grossls)*. We do not find evidence about any effect of the ECB deposit facility rate on bank investment variables.

Regarding the effects of ECB policy programs in non-crisis countries, we can conclude that LTROs stimulated investments in lending (*grossls)* and cash in central banks, while asset purchase programs (*apptot*) stimulated investments in government securities (*govsec)*. The results estimated on the sample of non-crisis countries reveal that all standard factors documented in the literature as important for banks investment decisions motivated banks to invest in government securities over our sample period (the exception is the economic growth (*gdp*)). From the set of ECB policy variables, we observe that asset purchase programs also motivated banks to increase government securities. In other words, of all factors we examine in this study only the LTROs are associated with an increase in loans. Therefore, our results show that LTROs played significant role in stimulating banks' lending in non-crisis countries and preventing side effects on credit output and financial stability.

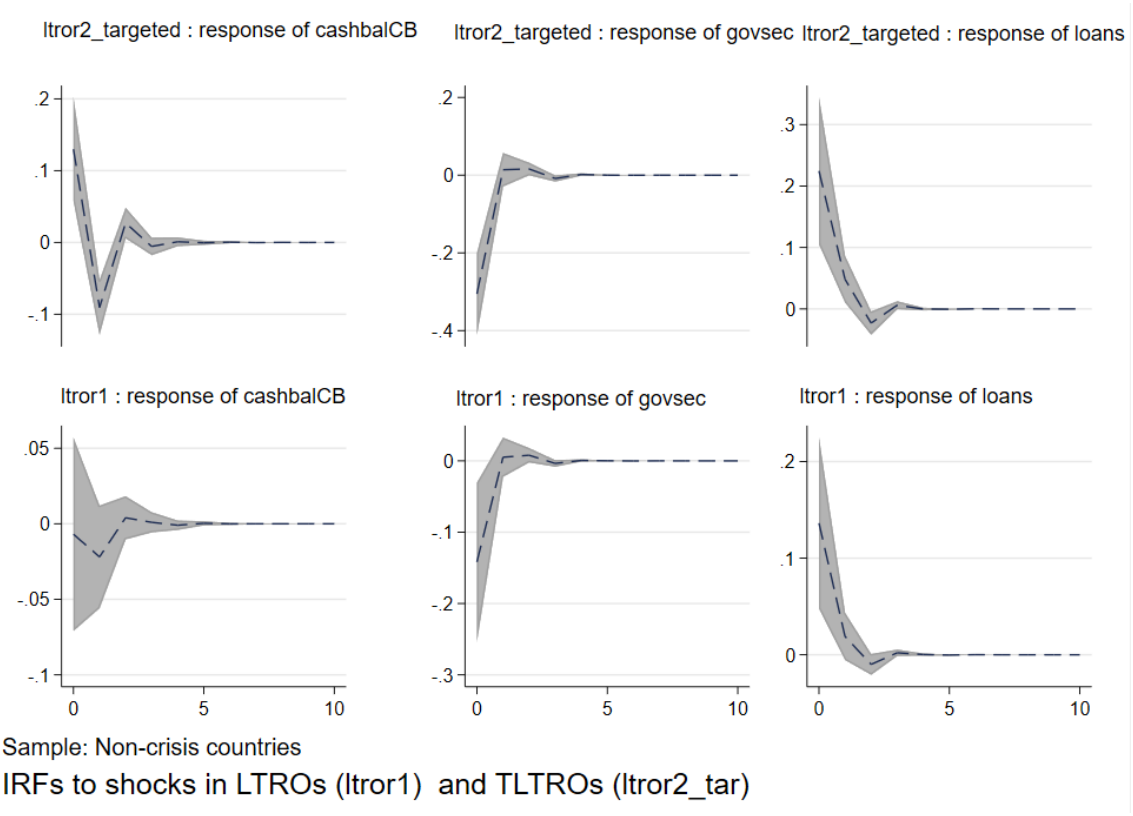

Figure 6: Orthogonalized IRFs in response to LTROs for non-crisis countries
Note: Errors are 5% on each side generated by Monte-Carlo with 200 reps

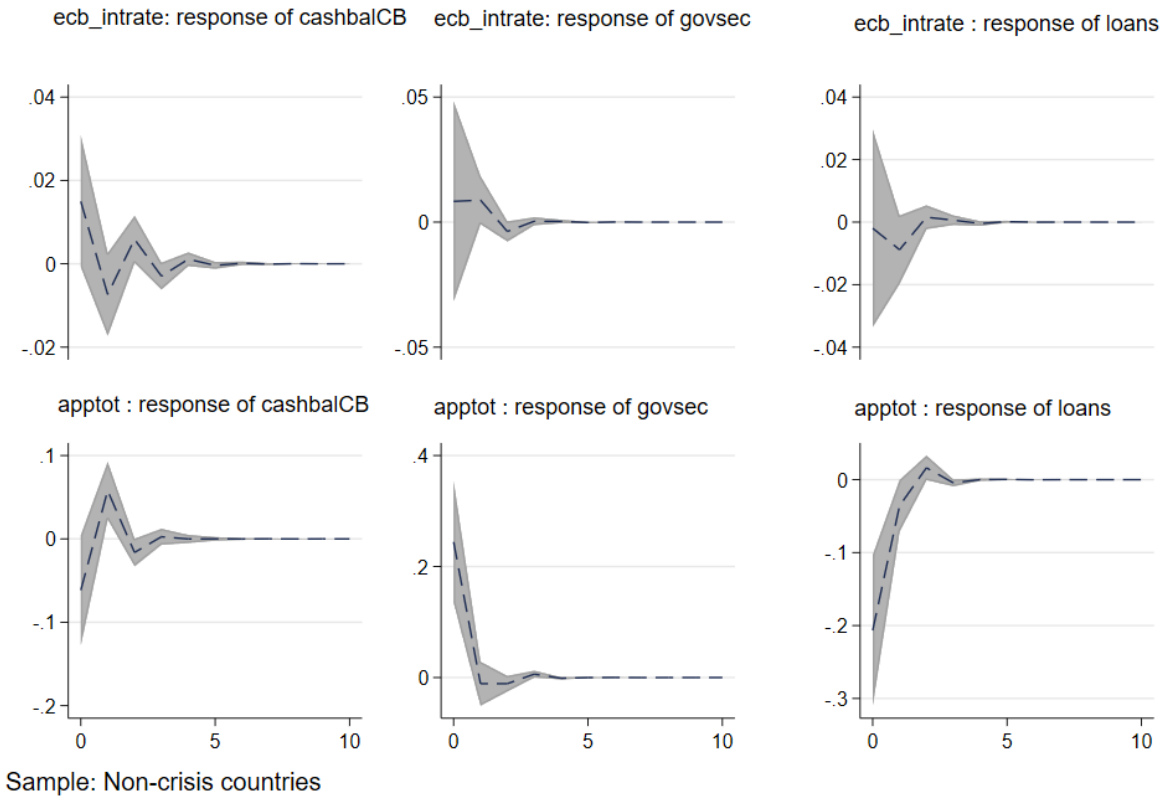

Figure 7: Orthogonalized IRFs in response to APP and ECB interest rate - non-crisis countries
Note: Errors are 5% on each side generated by Monte-Carlo with 200 reps

5.2 Crisis euro area countries

Orthogonalized IRFs of bank level variables for the sample of crisis countries are given in Figure 8. We do not find evidence for any significant responses of our investment choice variables to shocks in bank deposits. These findings suggest that shocks to wholesale deposits do not change banks' investment choices in crisis countries. Moreover, it seems that banks did not consider funding with wholesale deposits in the presence of the various extraordinary monetary policies. A positive shock in bank capital (*taneq)* results in an increase only in loans (*grossls)*, but we do not find evidence if has an effect on *govsec* or *cashbalCB*s as it is the case with non-crisis countries.

Figure 9 presents the responses to shocks in macro variables, economic growth (*gdp*) and the relative level of riskiness of the country (*cds).* We observe that a positive shock in the economic growth is associated with an increase in government securities, while a positive shock in the relative level of riskiness of the country is associated with an increase in cash in central banks. In comparison to non-crisis countries, we observe that banks show tendency toward investments in government securities under favorable economic growth conditions. While the positive response of cash in central banks due to a positive shock in cds is likely explained by the low risk weight of that type of assets under the conditions of higher country risk.

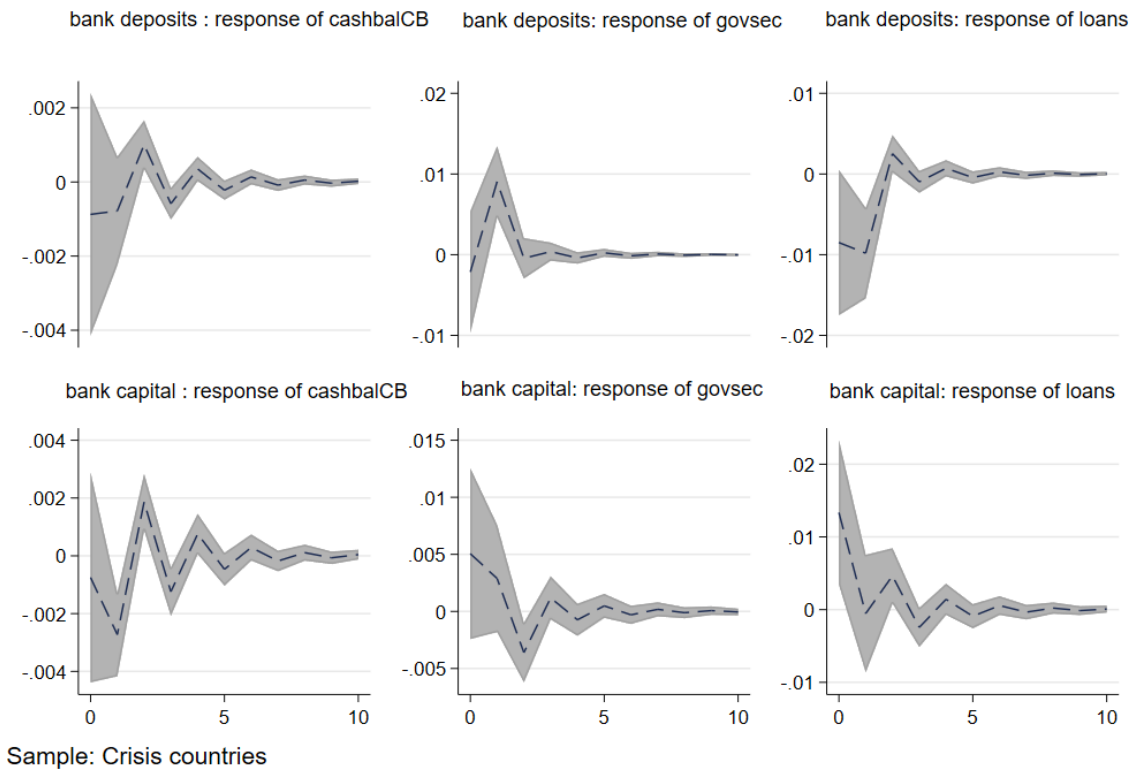

Figure 8: Orthogonalized IRFs in response to bank factors – crisis countries
Note: Errors are 5% on each side generated by Monte Carlo with 200 reps

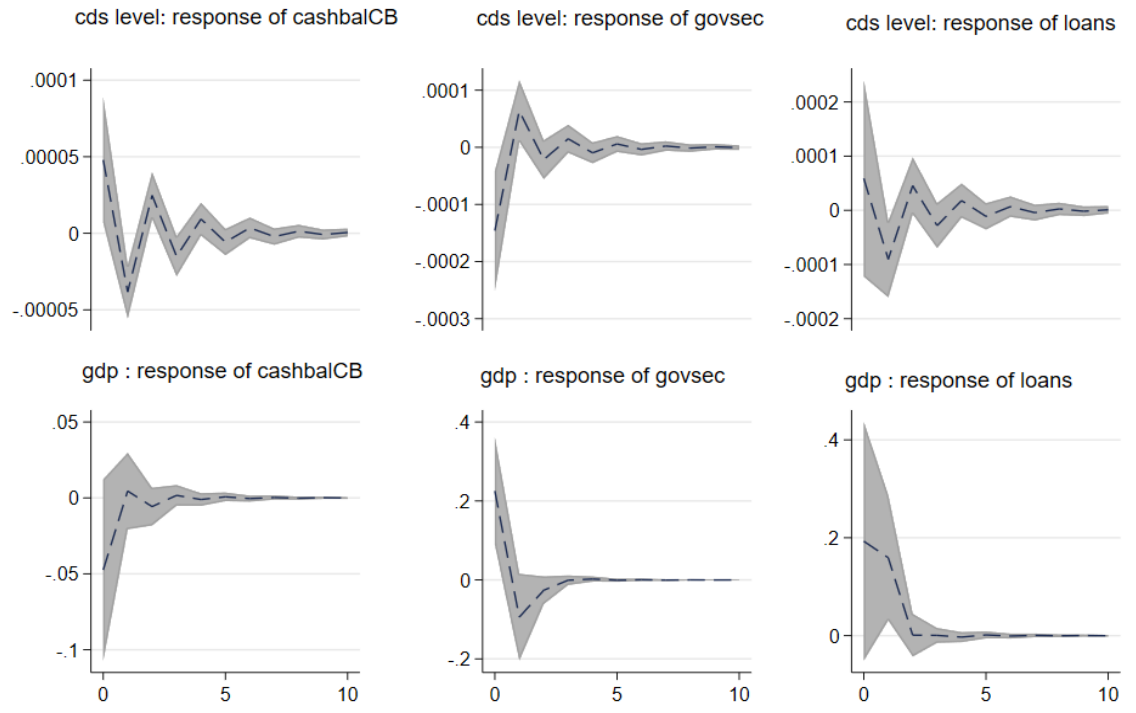

Figure 9: Orthogonalized IRFs in response to macro factors – crisis countries
Note: Errors are 5% on each side generated by Monte-Carlo with 200 reps

Figure 10 show the responses of our bank investment variables to shocks in the first round and the second round of LTROs. We observe that changing the terms of borrowing to targeted LTROs makes a difference in the investment behavior of banks in crisis countries. While we do not find evidence if a positive shock in the first round of LTROs is associated with a change in loans, we observe that a positive shock in targeted LTROs causes a positive response in bank's lending. Similarly, a positive shock in the first round of LTROs is associated with a positive response in government securities, however, a positive shock in targeted LTROs causes a drop in government securities. These results suggest that in the case of crisis countries, the change in the terms of borrowing for banks were crucial in improving lending output.

Regarding the rest two ECB policy measures, in Figure 11, we observe that a positive shock in asset purchase programs is associates with an increase in government securities. In comparison to the sample of non-crisis countries, the ECB interest rate on deposit facility is associated with an increase in loans in the sample of crisis countries.

The set of results estimated on the sample of crisis countries support the findings in the sample of non-crisis countries about the high importance of the various ECB extraordinary monetary policy measures for affecting the direction of bank investment behavior. In the case of crisis countries, we observe that the macro factors increase the ratios of government securities and cash in central banks and only the bank's capital is associated with an increase in the ratio of loans. Under these circumstances, the increase of loans due to positive shocks in the targeted LTROs and ECB interest rate on deposit facility is a huge contribution to improving overall lending output. Moreover, these findings suggest that implementing various policy measures that differ by nature and structure was a necessary approach in order to capture the differences across countries in the euro area on a different level of a financial distress.

We observe that while the results show that changing the terms of borrowing under LTROs do not have effect on banks' investment behavior in non-crisis countries, it represents a crucial change for banks' investment behavior in crisis countries. In addition, we do not find evidence about any effect of the ECB interest rate on deposit facility on loans in non-crisis countries, but ECB interest rate on deposit facility is positively associated with loans in crisis countries.

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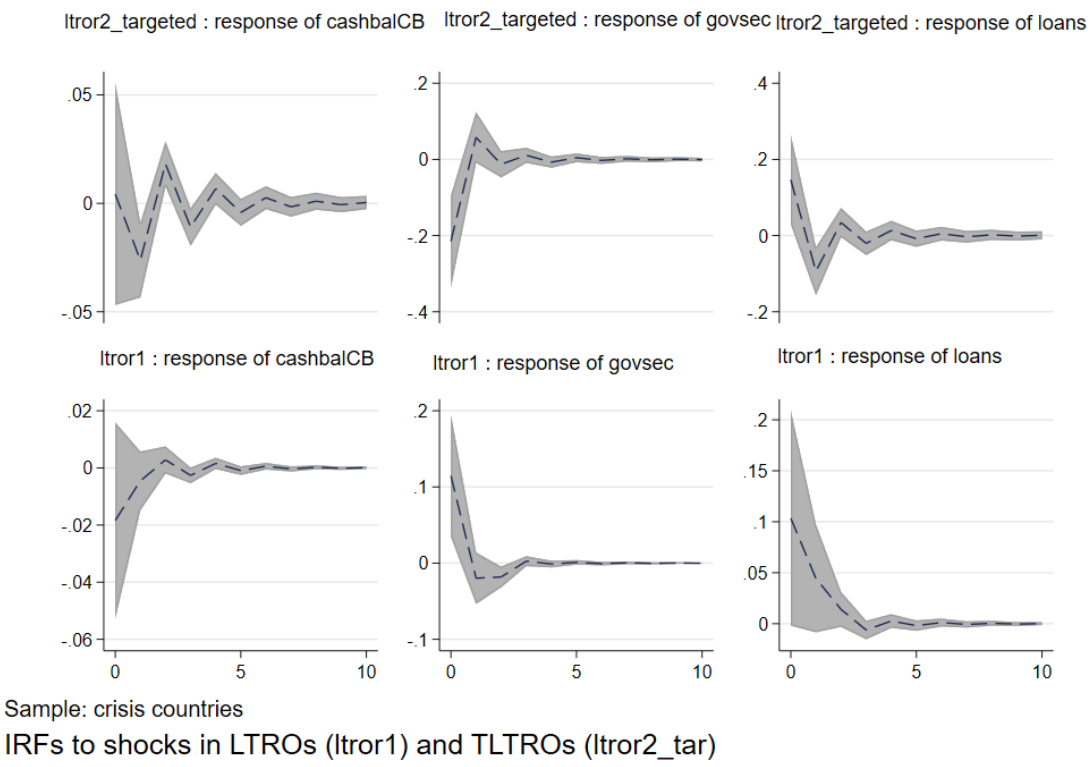

Figure 10: Orthogonalized IRFs to shocks in LTROs – crisis countries
Note: Errors are 5% on each side generated by Monte-Carlo with 200 reps

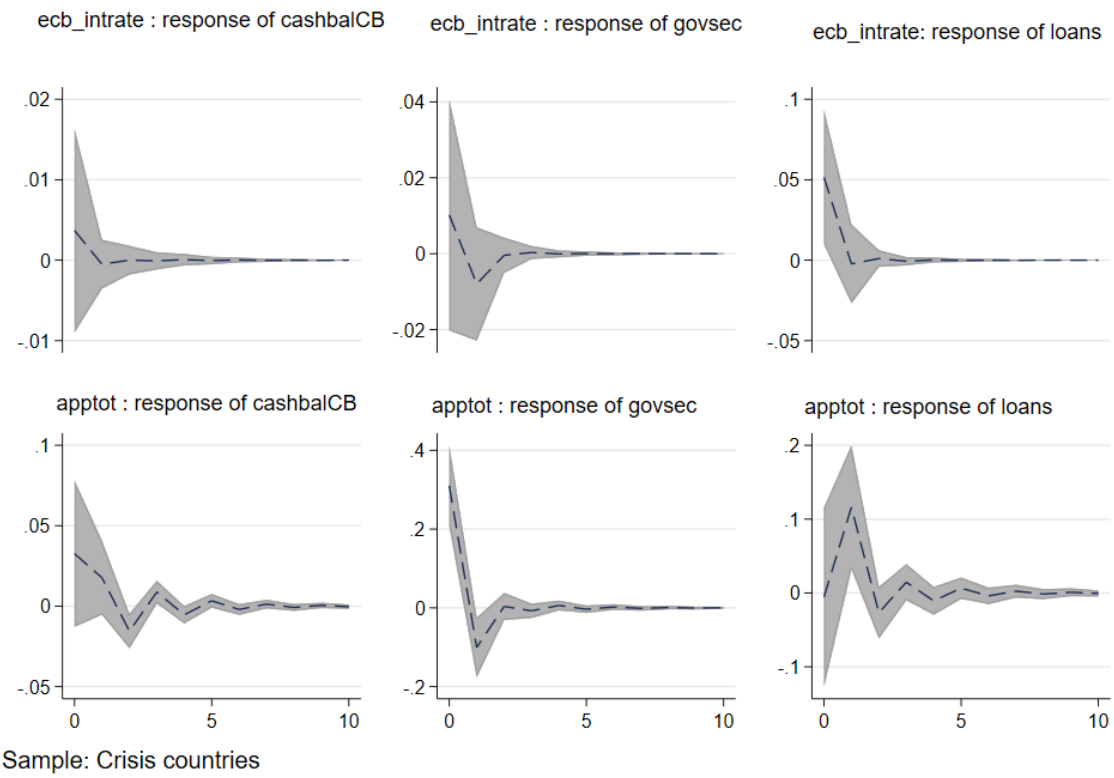

Figure 11: Orthogonalized IRFs to shocks in Asset Purchase Programs and ECB interest rate on deposit facility
Note: Errors are 5% on each side generated by Monte-Carlo with 200 reps

6. Conclusion

ECB implemented quite a diverse set of unconventional monetary policies during and after the Euuropean sovereign debt crisis with a major goal of stimulating bank credit to the economy, but the findings are limited to particular programs and the true effects are still inconclusive. We examine the implications of all three major ECB unconventional policies, LTROs, asset purchase programs and negative ECB interest rate on deposit facility for bank investments among loans, government securities and cash deposited in central banks across euro area countries on a different level of financial distress. We address the question how important were all of these unconventional monetary policies when compared to the usual bank-specific and macro factors affecting bank investment portfolios.

We consider the presence of the ECB extraordinary monetary policy measures as a unique feature of our post- crisis period and examine its implications for bank investment behavior. On the basis of panel vector autoregressive framework, we demonstrate empirically four categorical findings. First, the presence of the ECB extraordinary monetary policy measures were crucial in improving lending output across the euro area countries as the standard factors affecting banks' investment behavior were associated with investments other than lending, in particular, government securities or cash in central banks. Next, the implementation of various ECB extraordinary monetary policy measures by nature and structure were of high relevance in imposing direction on banks' investment behavior in both samples, as the relative level of a financial distress of a country differentiates banks' incentives for investments between risky sovereign debt holdings and loans. For instance, the asset purchase programs stimulated investments in government securities in both country groups, but through LTROs banks' lending was affected positively across the two country groups. In addition, while only both LTROs affect positively loans in non-crisis countries, targeted LTROs and the ECB interest rate supported bank lending in the crisis countries where the lending output to the economy was much more critical. Third, we find that changing the terms for banks' borrowing from the ECB lending facilities from LTROs to targeted LTROs made a significant difference in banks' investment behavior in crisis countries. Our results show that under the targeted LTROs, banks in crisis countries started to increase investments in loans and to decrease government securities on their balance sheets, which is consistent with the stylized facts given in Figure 1. These results suggests that ECB lending operations managed to turn around banks' incentives for investing between loans and government securities in crisis countries, which represented a major issue in the onset of the European sovereign debt crisis. Finally, we document that cash deposited in central banks became an important investment opportunity for banks under this set of bank-specific factors, macroeconomic variables and non-traditional policy tools. We consider this finding of high relevance because it implies that banks were incentivized for investing in a more liquid assets instead for investing in risky sovereign debt holdings as it was the case during the first round of LTROs. Cash in central banks appeared as an alternative to government securities and this is a

contribution toward lowering banks' sovereign risk exposures and the transmission of sovereign stress across euro area.

Considering the interactions between bank investment variables and ECB policy variables, we find that the level of financial distress of a country is an important factor to be considered when designing and implementing monetary policies. The finding suggest that the existence of LTROs was significant for banks' lending in the case of both samples after the implementation of the targeted LTROs. Furthermore, while LTROs played important role in stimulating loan investments in both samples, we find that the ECB interest rate was also of great importance in fostering loan investments in banks that operate in crisis countries.

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Appendix 1: Additional descriptive statistics

Table 1: Sample coverage across countries for bank-year observations per variable

Non-crisis countries	*grossls*	*govsec*	*cashbalCB*	*depbks*	*taneq*	*total assets*
Austria	81	59	83	83	83	83
Belgium	86	76	86	86	86	86
Estonia	19	12	19	12	19	19
Finland	16	16	16	16	16	16
France	100	80	100	100	100	100
Germany	188	85	188	188	188	188
Luxembourg	43	37	43	43	43	43
Netherlands	67	55	67	67	67	67
Slovakia	12	12	12	12	12	12
Slovenia	35	35	35	35	35	35
Group total	649	467	648	642	649	649
Crisis countries						
Cyprus	25	21	25	25	25	25
Greece	48	46	48	48	48	48
Ireland	64	51	64	63	64	64
Italy	130	26	130	130	130	130
Malta	23	23	23	23	23	23
Portugal	41	35	41	41	41	41
Spain	116	88	116	116	117	117
Group total	445	290	447	446	448	448
Sample total	1094	757	1095	1088	1097	1097

Table 2: Summary statistics of the macroeconomic variables over time

		GDP growth rate					Credit default swap level				
Year	No. obs	mean	median	min	max	st.dev	mean	median	min	max	sd.dev
2009	16	-0.05	-0.04	-0.14	-0.02	0.03	1.10	1.01	0.39	3.34	0.73
2010	16	0.02	0.02	-0.05	0.06	0.02	1.50	1.03	0.33	5.93	1.37
2011	16	0.01	0.02	-0.09	0.07	0.03	2.19	1.09	0.33	13.37	3.18
2012	16	-0.01	-0.004	-0.07	0.03	0.03	8.31	1.28	0.33	111.24	27.47
2013	16	-0.002	0.000	-0.07	0.05	0.03	14.92	1.22	0.35	214.47	53.24
2014	16	0.02	0.01	-0.02	0.09	0.03	17.44	1.02	0.44	258.55	64.30
2015	16	0.04	0.02	-0.004	0.25	0.06	2.48	1.05	0.40	18.41	4.37
2016	16	0.03	0.02	-0.002	0.07	0.02	1.95	1.05	0.43	10.18	2.40
2017	16	0.03	0.03	0.02	0.08	0.02	1.69	1.04	0.40	7.69	1.82
2018	16	0.03	0.03	0.01	0.08	0.02	1.40	1.10	0.27	5.60	1.40
2019	16	0.02	0.02	0.003	0.06	0.02	1.38	1.06	0.28	4.95	1.31

* Credit default swap for Luxembourg is 0 over the entire sample period 2009-2019

* It is excluded from the summary statitics as an outlier

Table 3: Pairwise correlation between GDP and Credit Default Swap level across time

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
-0.50	-0.62	-0.84	-0.88	-0.63	-0.33	-0.14	-0.17	-0.25	-0.06	0.11	0.17

Table 4: List of Banks

	Bank	Bank's Headquarter	Country
1	Investar (Holding of Argenta Bank- en Verzekeringsgroep)	ANTWERPEN	BELGIUM
2	OP Financial Group	HELSINKI	FINLAND
3	BNP Paribas S.A.	PARIS	FRANCE
4	Societe Generale S.A.	PARIS	FRANCE
5	ABN AMRO Bank N.V.	AMSTERDAM	NETHERLANDS
6	Groupe Credit Agricole	MONTROUGE	FRANCE
7	CaixaBank, S.A.	VALENCIA	SPAIN
8	BFA, Tenedora de Acciones, S.A.U.	MADRID- CASTILLE-LA MANCHE	SPAIN
9	THE BANK OF NEW YORK MELLON S.A./N.V.	BRUSSELS	BELGIUM
10	Liberbank S.A.	MADRID	SPAIN
11	RCI Banque	NOISY LE GRAND CEDEX	FRANCE
12	BPI France (Banque Publique d'Investissement)	MAISONS ALFORT	FRANCE
13	Deutsche Pfandbriefbank AG	Unterschleißheim	GERMANY
14	Bayerische Landesbank	MÜNCHEN	GERMANY
15	Commerzbank AG	FRANKFURT AM MAIN 1	GERMANY
16	Deutsche Bank AG	FRANKFURT AM MAIN	GERMANY
17	Aareal Bank AG	WIESBADEN	GERMANY
18	DekaBank Deutsche Girozentrale	Frankfurt am Main	GERMANY
19	HASPA Finanzholding	HAMBURG 11	GERMANY
20	Landesbank Hessen-Thueringen Girozentrale	Frankfurt am Main	GERMANY
21	Norddeutsche Landesbank Girozentrale	HANNOVER	GERMANY
22	Caja de Ahorros y M.P. de Zaragoza	ZARAGOZA	SPAIN
23	ABANCA Corporacion Bancaria, S.A.	LA CORUNA (A CORUNA)	SPAIN
24	Volkswagen Bank GmbH	BRAUNSCHWEIG	GERMANY
25	Landesbank Berlin Holding AG	Berlin	GERMANY
26	Kutxabank, S.A.	BILBAO	SPAIN
27	Volkswagen Financial Services AG	BRAUNSCHWEIG	GERMANY
28	Unione di Banche Italiane S.p.A.	BERGAMO	ITALY
29	Hypo Real Estate Holding GmbH	MUENCHEN	GERMANY
30	DZ Bank AG Deutsche Zentral-Genossenschaftsbank	FRANKFURT AM MAIN	GERMANY
31	Municipality Finance PLC	HELSINKI	FINLAND
32	OESTERREICHISCHE VOLKSBANK AG (Volksbank Gruppe)	VIENNA	AUSTRIA
33	DEPFA BANK plc	DUBLIN 1	IRELAND
34	HSH Nordbank AG	HAMBURG	GERMANY
35	Allied Irish Banks, plc	DUBLIN 2	IRELAND
36	Bank of Ireland	DUBLIN 4	IRELAND
37	Credit Institution Ulster Bank Ireland Designated Activity Company	DUBLIN 2	IRELAND
38	Credit Institution Iccrea Banca S.p.A. - Istituto Centrale del Credito Coo	ROME	ITALY
39	Banca Monte dei Paschi di Siena SpA	SIENA	ITALY
40	Banca Carige S.p.A. - Cassa di Risparmio di Genova e Imperia	GENOVA	ITALY
41	Credit Institution Banque Internationale à Luxembourg S.A.	LUXEMBOURG	LUXEMBOURG
42	Banque et Caisse d'Epargne de l'Etat	LUXEMBOURG	LUXEMBOURG
43	BNG Bank N.V.	THE HAGUE	NETHERLANDS
44	ING Groep N.V.	AMSTERDAM	NETHERLANDS
45	Cooperatieve Rabobank U.A.	UTRECHT	NETHERLANDS
46	Credit Institution de Volksbank N.V.	'S-HERTOGENBOSCH	NETHERLANDS
47	ING Bank N.V.	AMSTERDAM	NETHERLANDS
48	Caixa Geral de Depositos, S.A.	LISBON CODEX	PORTUGAL
49	Banco Comercial Portugues, S.A.	PORTO	PORTUGAL
50	Banco Bilbao Vizcaya Argentaria, S.A.	BILBAO	SPAIN

51	Bankinter	MADRID -CASTILE-LA MANCHA	SPAIN
52	Banco de Sabadell S.A.	ALICANTE	SPAIN
53	Groupe BPCE	PARIS	FRANCE
54	Bank of Valletta plc	VALLETTA	MALTA
55	La Banque Postale	PARIS CEDEX 06	FRANCE
56	RBC Investor Services Bank S.A.	ESCH-SUR-ALZETTE	LUXEMBOURG
57	Sberbank Europe AG	VIENNA	AUSTRIA
58	Bank of Cyprus Public Company Ltd	NICOSIA	CYPRUS
59	Nova Kreditna Banka Maribor d.d.	MARIBOR	SLOVENIA
60	Nova Ljubljanska banka d. d.	LJUBLJANA	SLOVENIA
61	Cyprus Popular Bank Public Co Ltd	NICOSIA	CYPRUS
62	Hellenic Bank Public Company Ltd	NICOSIA	CYPRUS
63	Raiffeisenlandesbank Oberosterreich AG	LINZ	AUSTRIA
64	Credit Institution Tatra banka, a.s	BRATISLAVA	SLOVAKIA
65	Raiffeisen Bank International AG	VIENNA	AUSTRIA
66	Alpha Bank AE	ATHENS	GREECE
67	Banca Piccolo Credito Valtellinese	SONDRIO	ITALY
68	AXA Bank Belgium	BRUSSELS	BELGIUM
69	BPER Banca S.p.A.	MODENA	ITALY
70	National Bank of Greece S.A.	ATHENS	GREECE
71	Credit Institution Banque Degroof Petercam SA	BRUSSELS	BELGIUM
72	BAWAG P.S.K.	VIENNA	AUSTRIA
73	Landwirtschaftliche Rentenbank	FRANKFURT	GERMANY
74	Raiffeisenlandesbank Niederoesterreich-Wien AG	VIENNA	AUSTRIA
75	Piraeus Bank S.A.	ATHENS	GREECE
76	Investeringsmaatschappij Argenta (Argenta Bank)	ANTWERPEN	BELGIUM
77	Banque PSA Finance	PARIS	FRANCE
78	Credit Institution Swedbank AS	TALLINN	ESTONIA
79	Mediobanca Spa	MILAN	ITALY
80	Dexia NV*	BRUSSELS	BELGIUM
81	Banco BPI S.A.	PORTO	PORTUGAL
82	Credito Emiliano S.p.A.	REGGIO-EMILIA	ITALY
83	Banca Popolare di Sondrio	SONDRIO	ITALY
84	Erste Group Bank AG	VIENNA	AUSTRIA
85	Intesa Sanpaolo S.p.A.	TORINO	ITALY
86	UniCredit S.p.A.	MILANO	ITALY
87	Banco Santander S.A.	SANTANDER-CANTABRIA	SPAIN
88	Landesbank Baden-Wuerttemberg	STUTTGART	GERMANY
89	SID Bank Inc Ljubljana	LJUBLJANA	SLOVENIA
90	KBC Group NV	BRUSSELS	BELGIUM
91	Belfius Bank SA/NV	BRUSSELS	BELGIUM
92	Eurobank Ergasias S.A.	ATHENS	GREECE
93	Criteria Caixa, S.A.U.	PALMA DE MALLORCA	SPAIN
94	Unicaja Banco S.A.	MALAGA-MURCIA	SPAIN
95	Societe de Financement Local (SFIL)	ISSY LES MOULINEAUX	FRANCE
96	Novo Banco, S.A.	LISBOA	PORTUGAL
97	AS LHV Group	TALLINN	ESTONIA
98	Financial Holding Raiffeisenbankengruppe OÖ Verbund eGen	LINZ	AUSTRIA
99	Permanent TSB Group Holdings P.L.C	DUBLIN 2	IRELAND
100	Erwerbsgesellschaft der S-Finanzgruppe mbH & Co KG	NEUHARDENBERG	GERMANY
101	Precision Capital S.A.	LUXEMBOURG	LUXEMBOURG
102	MeDirect Group Limited (MBD Group)	VALLETTA	MALTA
103	Credit Institution Banco BPM S.p.A	MILANO	ITALY
104	BAWAG Group AG	WIEN	AUSTRIA
105	Bank of Ireland Group Public Limited Company	DUBLIN	IRELAND

Appendix 2: Lag-order selection criteria, granger causality analysis and reduced-form coefficients estimates

In this section, we examine lag-order selection criteria and granger causality analysis to justify the structure of our baseline panel VAR model represented by Eq. (2) for each sample. Considering the lag-order selection criteria, we fit a first-order panel VAR for each sample using the first four lags of endogenous variables as instruments. Table 1 presents results from the first-,second-, and third-order panel VAR models using the first four lags of the endogenous variables as instruments for the sample of non-crisis countries and first and second-order panel VAR models with same instruments criteria for the sample of crisis countries.[13] We observe that on the basis on the three model-selection criteria by Andrews and Lu (2001), the first-order panel VAR is the preferred one for both samples because it has the smallest MBIC, AIC, and MQIC and it does not reject Hansen's J statistics for over identification restriction. By taking into account the first-order panel VAR using the first four lags of endogenous variables as instruments, our final sample of non-crisis countries is composed of 49 banks and 295 bank-year observations, while the final sample of crisis countries is composed of 26 banks and 152 bank-year observations.

Table 1: lag-order selection criteria

Non-crisis countries

lag	CD	J	J pvalue	MBIC	MAIC	MQIC
1	.984377	75.85562	.4506524	-321.1422	-74.14438	-174.1108
2	.9874124	46.31534	.6220162	-218.3499	-53.68466	-120.3289
3	.87959	28.94856	.2660722	-103.3841	-21.05144	-54.37358

Crisis countries

lag	CD	J	J pvalue	MBIC	MAIC	MQIC
1	-1.928816	75.52371	.4613243	-284.1606	-74.47629	-159.6371
2	.7817486	35.15877	.7270457	-161.4686	-46.84123	-93.39579

We then test for Granger causality and we present the Wald tests results in tables 2 and 3 for non-crisis and crisis countries, respectively. It is common in both samples, that the coefficients of all lags of all endogenous variables appearing on the equations of each bank dependent variable *taneq*, *depbks*, *grossls*, *govsec* and *cahsbalCBs*, jointly are different from zero. The null hypothesis that the coefficients of all lags of all endogenous variables does not Granger

[13] Due to smaller number of observations, we are able to test only first- and second- order panel VAR model on the sample of crisis countries

cause jointly each of the dependent variables is rejected at 1% confidence level. These results suggest that lag values of bank variables we examine in this model have endogenous relationship.

Table 2: Granger causality tests – Non-crisis countries

panel VAR-Granger causality Wald test
Ho: Excluded variable does not Granger-cause Equation variable
Ha: Excluded variable Granger-causes Equation variable

Equation \ Excluded	chi2	df	Prob > chi2
dtaneq			
ddepbks	0.061	1	0.805
dgrossls	4.353	1	0.037
dgovsec	16.808	1	0.000
dcashbalCB	0.159	1	0.690
ALL	21.787	4	0.000
ddepbks			
dtaneq	25.870	1	0.000
dgrossls	0.014	1	0.906
dgovsec	0.618	1	0.432
dcashbalCB	1.739	1	0.187
ALL	27.946	4	0.000
dgrossls			
dtaneq	20.837	1	0.000
ddepbks	4.385	1	0.036
dgovsec	3.666	1	0.056
dcashbalCB	3.502	1	0.061
ALL	35.263	4	0.000
dgovsec			
dtaneq	39.445	1	0.000
ddepbks	4.643	1	0.031
dgrossls	4.780	1	0.029
dcashbalCB	1.646	1	0.200
ALL	55.753	4	0.000
dcashbalCB			
dtaneq	0.774	1	0.379
ddepbks	11.085	1	0.001
dgrossls	25.310	1	0.000
dgovsec	0.358	1	0.549
ALL	39.269	4	0.000

Table 3: Granger causality tests – Crisis countries

```
panel VAR-Granger causality Wald test
  Ho: Excluded variable does not Granger-cause Equation variable
  Ha: Excluded variable Granger-causes Equation variable
```

Equation \ Excluded	chi2	df	Prob > chi2
dtaneq			
ddepbks	2.987	1	0.084
dgrossls	5.993	1	0.014
dgovsec	23.074	1	0.000
dcashbalCB	5.757	1	0.016
ALL	36.696	4	0.000
ddepbks			
dtaneq	0.642	1	0.423
dgrossls	1.870	1	0.172
dgovsec	21.375	1	0.000
dcashbalCB	4.442	1	0.035
ALL	29.080	4	0.000
dgrossls			
dtaneq	3.301	1	0.069
ddepbks	7.596	1	0.006
dgovsec	6.216	1	0.013
dcashbalCB	4.578	1	0.032
ALL	29.816	4	0.000
dgovsec			
dtaneq	19.678	1	0.000
ddepbks	10.298	1	0.001
dgrossls	32.165	1	0.000
dcashbalCB	4.687	1	0.030
ALL	60.386	4	0.000
dcashbalCB			
dtaneq	25.186	1	0.000
ddepbks	1.913	1	0.167
dgrossls	1.240	1	0.265
dgovsec	2.174	1	0.140
ALL	28.472	4	0.000

Appendix 2.1 Coefficients estimates of the reduced-form of Eq. (2)

Table 4: Coefficients estimates of the reduced-form of non-crisis countries:

VARIABLES	(1) dtaneq	(2) ddepbks	(3) dgrossls	(4) dgovsec	(5) dcashbalCB
L.dtaneq	-0.154**	-0.680***	-0.666***	0.791***	-0.0482
	(0.0675)	(0.134)	(0.146)	(0.126)	(0.0548)
L.ddepbks	-0.00313	0.0363	-0.111**	0.121**	-0.0965***
	(0.0127)	(0.0488)	(0.0528)	(0.0561)	(0.0290)
L.dgrossls	-0.0283**	-0.00357	-0.0128	-0.0721**	-0.220***
	(0.0136)	(0.0304)	(0.0492)	(0.0330)	(0.0437)
L.dgovsec	-0.0827***	0.0213	-0.0805*	-0.184***	-0.0206
	(0.0202)	(0.0271)	(0.0420)	(0.0470)	(0.0345)
L.dcashbalCB	-0.00666	-0.0495	0.103*	-0.0857	-0.419***
	(0.0167)	(0.0375)	(0.0553)	(0.0668)	(0.0659)
gdp	0.134*	0.405	0.0690	0.213	-0.538**
	(0.0780)	(0.251)	(0.319)	(0.421)	(0.229)
cds_euro_sc	0.0131*	0.00918	-0.103***	0.145***	-0.0222
	(0.00795)	(0.0187)	(0.0242)	(0.0224)	(0.0180)
ltror1	-0.0122	-0.0174	0.136***	-0.142***	-0.00690
	(0.0137)	(0.0364)	(0.0424)	(0.0534)	(0.0312)
ltror2_tar	-0.00863	-0.0675	0.225***	-0.305***	0.130***
	(0.0147)	(0.0424)	(0.0557)	(0.0556)	(0.0396)
apptot	0.00466	0.0842**	-0.207***	0.244***	-0.0615*
	(0.0131)	(0.0376)	(0.0531)	(0.0514)	(0.0369)
ECB_YR	0.0134**	0.00704	-0.00195	0.00830	0.0150*
	(0.00565)	(0.0153)	(0.0151)	(0.0194)	(0.00836)
Observations	295	295	295	295	295
Instruments	1/4	1/4	1/4	1/4	1/4
FE elim	fod	fod	fod	fod	fod
CD	0.81	0.81	0.81	0.81	0.81
J	68.45	68.45	68.45	68.45	68.45
pval	0.69	0.69	0.69	0.69	0.69
Model	FD	FD	FD	FD	FD
Panels	49	49	49	49	49

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Coefficients estimates of the reduced-form of the crisis countries

VARIABLES	(1) dtaneq	(2) ddepbks	(3) dgrossls	(4) dgovsec	(5) dcashbalCB
L.dtaneq	-0.533***	0.125	-0.310*	0.387***	-0.134***
	(0.0898)	(0.156)	(0.171)	(0.0872)	(0.0266)
L.ddepbks	-0.0404*	-0.133**	-0.121***	0.0943***	-0.0131
	(0.0234)	(0.0536)	(0.0439)	(0.0294)	(0.00949)
L.dgrossls	-0.0514**	-0.0790	0.124	-0.214***	-0.0172
	(0.0210)	(0.0578)	(0.0791)	(0.0377)	(0.0155)
L.dgovsec	0.110***	-0.392***	0.174**	-0.100	0.0328
	(0.0229)	(0.0848)	(0.0697)	(0.0712)	(0.0222)
L.dcashbalCB	-0.176**	0.380**	-0.436**	-0.209**	-0.108**
	(0.0735)	(0.180)	(0.204)	(0.0963)	(0.0476)
gdp	0.129***	-0.953***	0.193*	0.225***	-0.0474
	(0.0422)	(0.252)	(0.111)	(0.0687)	(0.0296)
cds_euro_sc	0.000218***	-0.000134	5.89e-05	-0.000146***	4.79e-05**
	(3.37e-05)	(8.18e-05)	(9.23e-05)	(5.28e-05)	(2.00e-05)
ltror1	0.0889***	-0.258***	0.103*	0.115***	-0.0184
	(0.0171)	(0.0727)	(0.0550)	(0.0400)	(0.0174)
ltror2_tar	0.0830***	0.387***	0.146**	-0.215***	0.00426
	(0.0268)	(0.0944)	(0.0620)	(0.0593)	(0.0258)
apptot	-0.0258	-0.571***	-0.00537	0.310***	0.0326
	(0.0235)	(0.0911)	(0.0574)	(0.0544)	(0.0225)
ECB_YR	-0.0142	0.110***	0.0515**	0.0102	0.00369
	(0.00874)	(0.0352)	(0.0204)	(0.0138)	(0.00614)
Observations	152	152	152	152	152
Instruments	1/4	1/4	1/4	1/4	1/4
FE elim	fod	fod	fod	fod	fod
CD	0.56	0.56	0.56	0.56	0.56
J	95.18	95.18	95.18	95.18	95.18
pval	0.06	0.06	0.06	0.06	0.06
Model	FD	FD	FD	FD	FD
Panels	26	26	26	26	26

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix 2.2: The complete set of orthogonalized impulse-response functions

Sample of non-crisis countries:

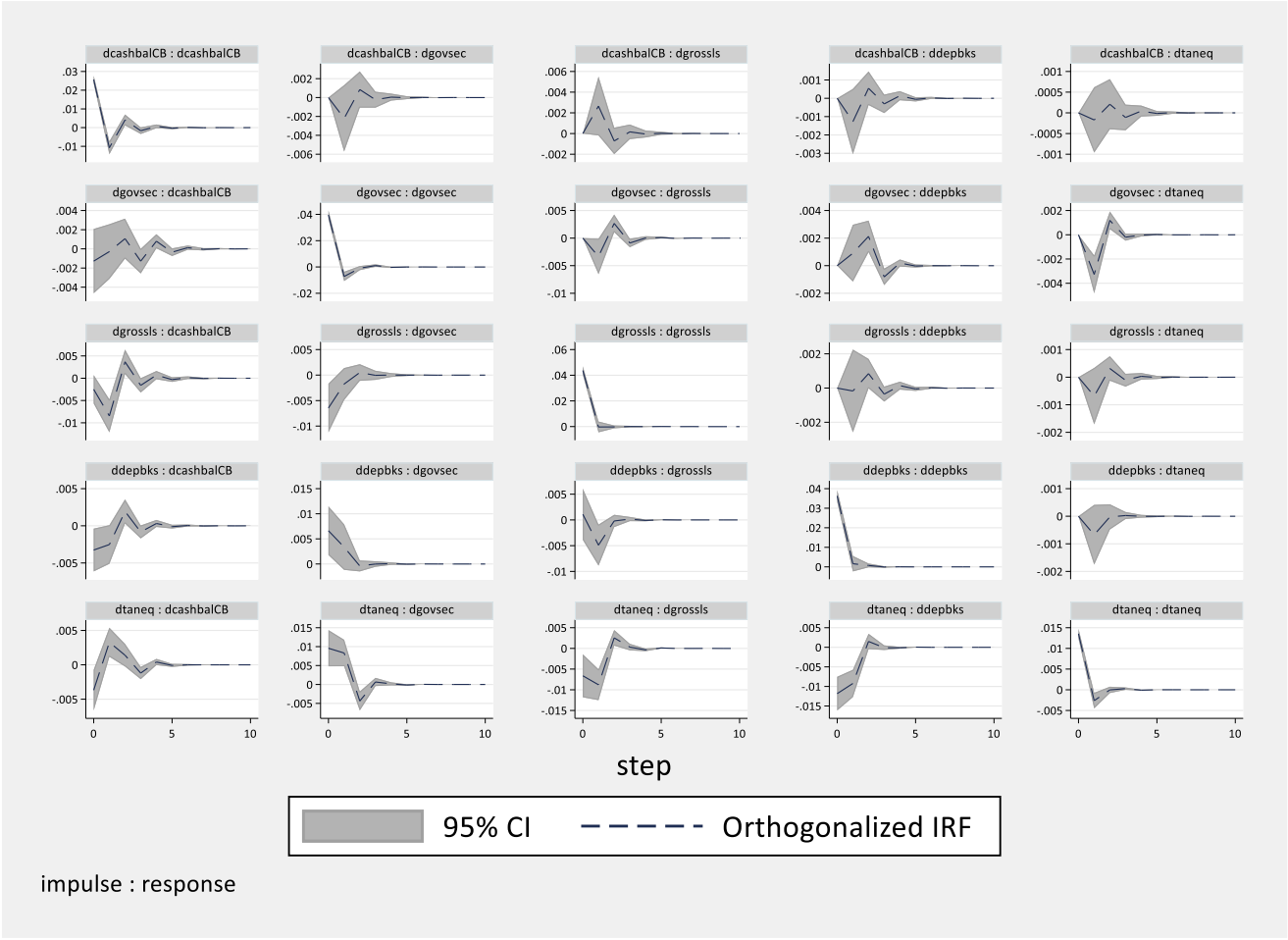

Figure 1: Bank level variables – non-crisis countries

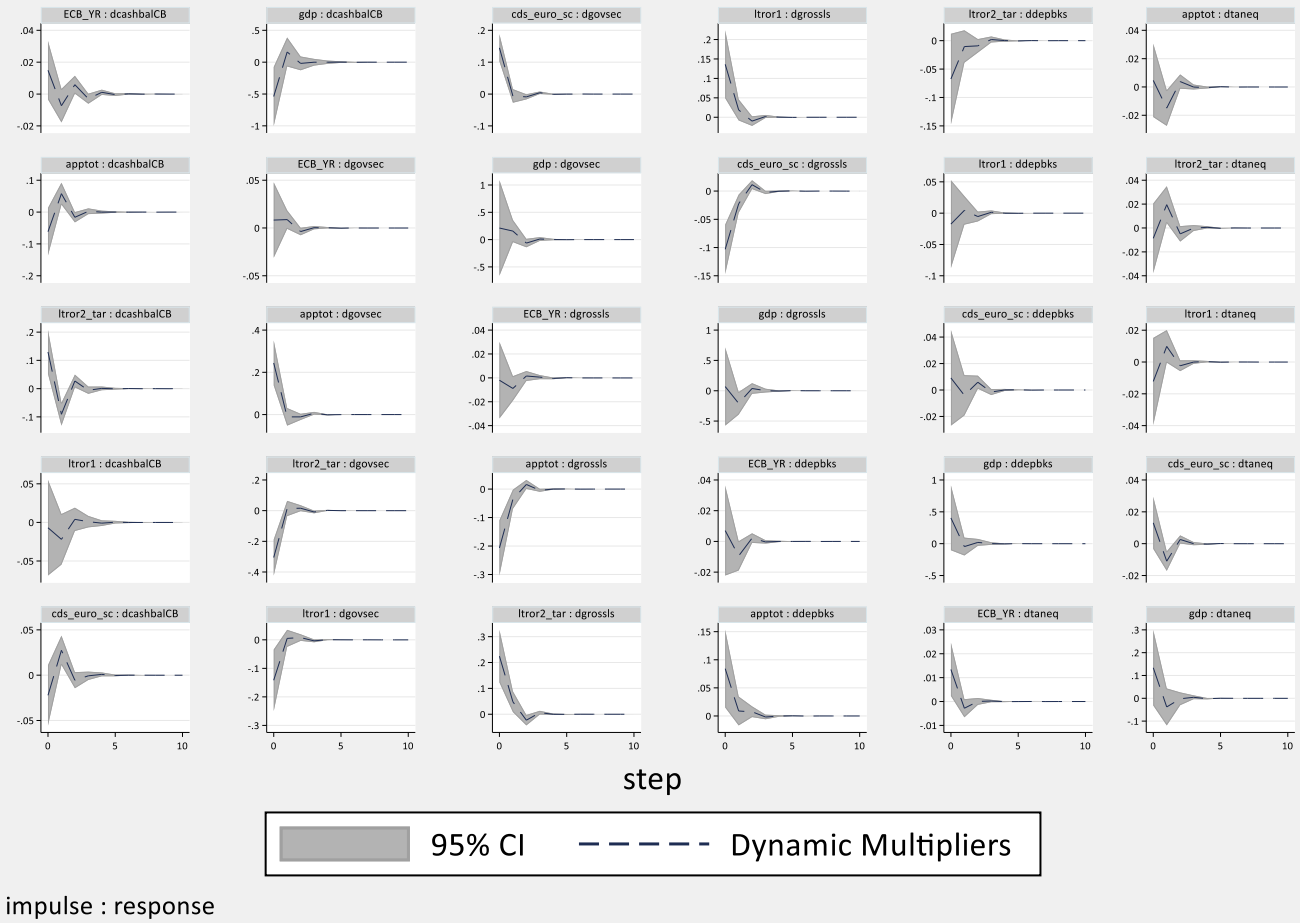

Figure 2: Responses of bank variables to shocks in macro and ECB policy variables – non-crisis countries

Sample of crisis countries:

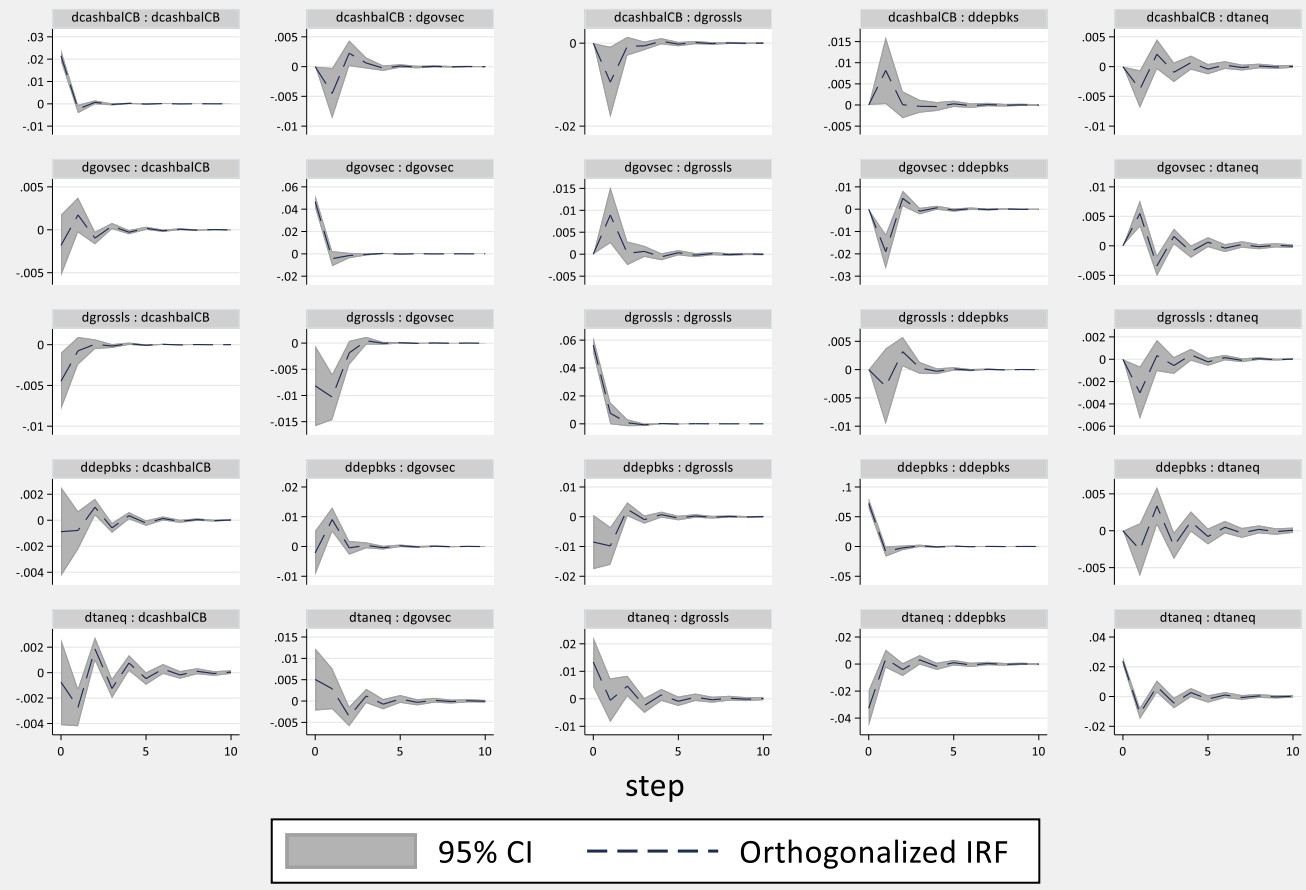

Figure 3: Bank level variable – crisis countries

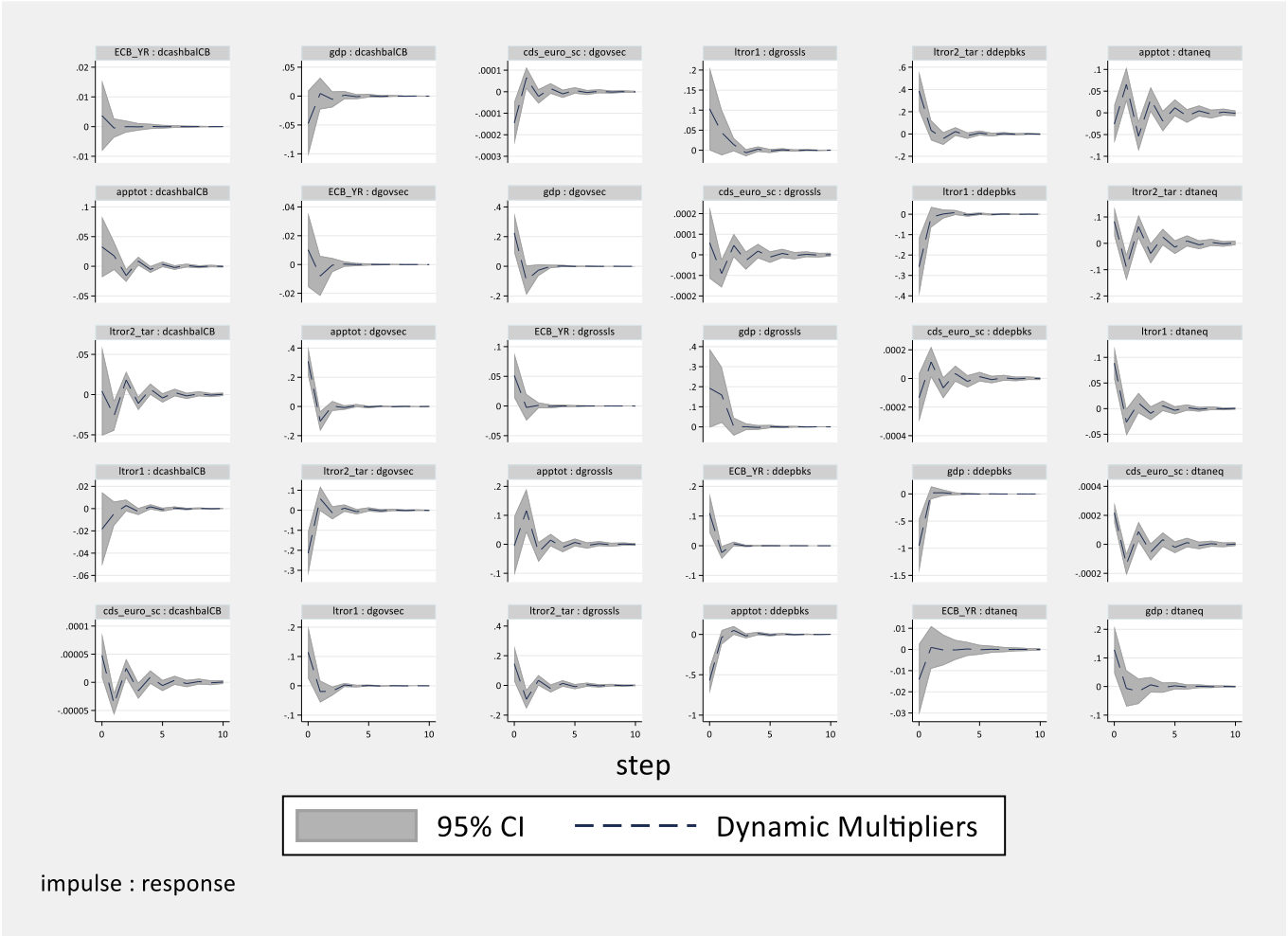

Figure 4: Responses of bank variables to shocks in macro and ECB policy variables – crisis countries