How stressed is the Monetary Transmission Mechanism? Financial Stress, Transmission and Financing Premium in the Euro Area

Geraldine Dany[1] and Jan-Christopher Scherer[2]

[1]Martin-Luther University Halle-Wittenberg and Halle Institute for Economic Research (IWH)
[2]Halle Economic Research Institute (IWH)

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Abstract

We develop financial stress indices for individual euro area countries and include these in a BVAR analysis of the monetary transmission mechanism. We identify a contractive monetary policy shock and an FSI shock and find that the premium in periphery countries increases substantially more than the premium in core countries for both shocks. When including the financial stress indices, we find that the responses of GDP and the premium are smaller.

JEL-Classification: E44, E51, C11, C38

Keywords: Financial stress, Monetary transmission mechanism, Euro area heterogeneity

1 Introduction

With the failure of the Lehman Brothers international interbank markets collapsed. Due to the exposures towards US asset backed securities or frozen liquidity and refinancing problems, euro area banks faced tremendous financial stress. Government interventions followed to rescue private banks and therewith transferred financial risk from the financial to the public sector, as public debt and fiscal expenditures rose. Consequently, the value of sovereign bonds decreased and introduced a feedback effect to banks over its collateral function. These problems were more severe in euro area periphery countries due to the capital flight home effect (Giannetti & Laeven 2012) at the very beginning of the financial crisis.

In the course of the recent financial crisis and the subsequent sovereign debt crisis the ECB has not only lowered the main refinancing rate until hitting the zero lower bound, but it has also put in motion a variety of unconventional policy measures. The measures aimed at calming down financial markets and stabilizing inflation rates as well as bringing real economic activity back on track. However, GDP growth, investment and overall consumer prices still remain at low levels throughout euro area countries. In the press conference on 25th of January 2015 the ECB announced a voluminous asset purchasing program of at least 1.1 trillion euro. This might be her last card to play. The ineffectiveness of expansionary monetary policy in the course of the double dip recession in the euro area raises the question whether the monetary transmission mechanism is impaired.

We study the effect of financial stress and distressed financial intermediaries to the monetary transmission mechanism for different euro area countries in the course of the recent crises.

A natural starting point for this study in macroeconomic literature is the financial accelerator model by Bernanke & Gertler (1995) as well as Bernanke, Gertler & Gilchrist (1999). They suggest possible asymmetries in the transmission mechanism over the business cycle. They account for the presence of financial frictions by introducing an agency problem between borrowers and lenders that lead to a wedge between internal financing cost and external financing cost, named external financing premium. The external financing premium is affected by monetary policy and magnifies the conventional interest rate channel in times of economic downturn. In particular, expansionary monetary policy can lower the external financing premium as it increases the net worth and collateral of creditors. This is even more effective in recessions when credit constrains are binding. This mechanism refers to the credit channel of monetary transmission, which can be divided into two sub-channels: The balance sheet channel of households and firms and the bank-based channel. Within the latter banks play a special role in overcoming an information asymmetry between lenders and borrowers in credit markets. Apart from the bank lending channel[1], the bank capital channel emphasizes the state of the intermediaries balance sheet which in turn has important implications for credit markets. Asset price decreases or equivalently a decline in credit quality may lead to a deterioration of the banks' balance sheet and leverage ratio. This may lead to a reduction in banks' capital, when external financing for the bank is costly, the bank needs to deleverage which implies a decline in lending. Bank-lending-dependent firms face a credit shortage which will introduce cut backs of spending and a fall in aggregate demand. Evidence on asset prices influence and procyclical leveraging has been shown by Adrian & Shin (2010). Expansionary monetary policy can enhance credit supply by raising asset prices improving banks leverage ratio or by increasing banks profit via lower short run interest rates.

From the rough description of the bank capital channel it is not surprising that this channel has gained popularity since the start of global financial crisis. Capturing key elements of the financial crisis on the on hand, the bank capital channel on the other hand suggest that monetary policy should be more effective in driving down loan interest rates, improving banks balance sheet positions and pushing up credit and investment. However this picture is not supported when looking at euro area data. In the last decade real corporate investment figures of the euro area depict a sharp increase prior to the financial crisis, going from 344

[1] Within the framework of the bank lending channel expansionary monetary policy increases bank reserves and deposits, bank loans rise and therewith credit supply, enhancing consumption.

billion Euro in 2005Q1 to 406 billion Euro in 2008Q1, and then gradually returning to initial levels with a slight downwards trend at the end of the sample. As it can be seen in figure 1, asymmetric real corporate investment developments across euro area countries are underlying this aggregate movement, where periphery countries clearly experience an ongoing decline in real corporate investment since the start of the financial crisis. In contrast, core countries' corporate investment stagnates at levels comparable to the first half of the 2000s.

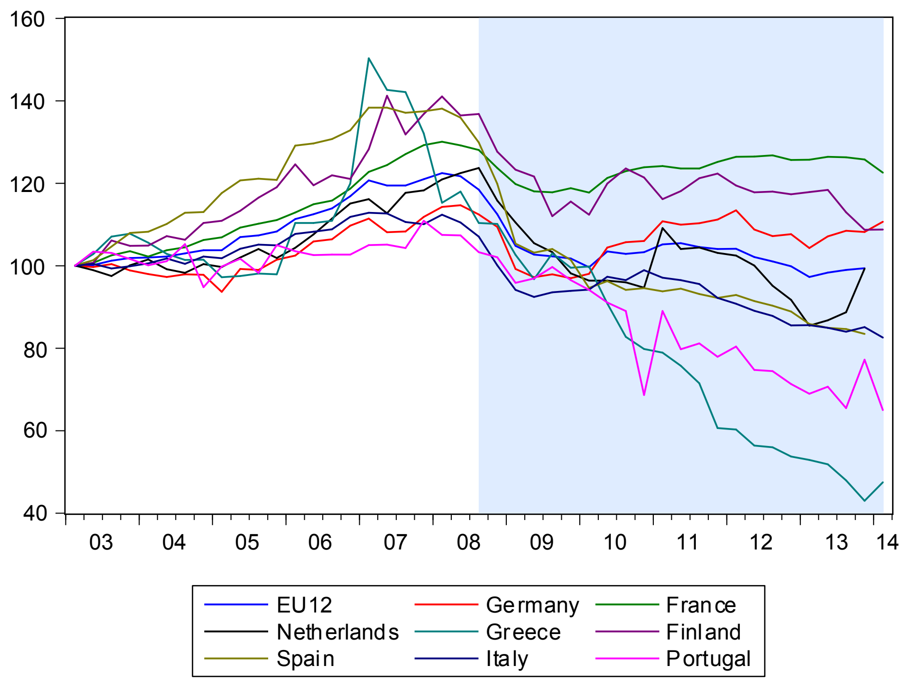

Figure 1: Real corporate investment

What can explain this divergence? Corporate credit growth fell down and until now has not recovered despite continuously expansionary monetary policy stance of the ECB realized by conventional as well as unconventional monetary policy measures. Over the last years the ECB has conducted several unconventional monetary policy programs[2] to restore the credit channel and in particular the bank lending channel (ECB press conference 02/10/2014) and lift up annual growth of loans to non-financial corporations.

[2]For example the asset-backed securities purchase program (ABSPP) and the covered bond purchase programme (CBPP3).

The functioning of the transmission mechanism, however, is also influenced by the degree of financial stress prevailing in the respective system. As the macroeconomic asymmetries throughout the euro area have increased during the crisis, it is plausible to conjecture that different levels of stress in the countries have an impact on the risk premia, despite the single monetary policy conducted by the ECB for all member countries. Note that this financial stress captures systemic risk in the financial sector as a whole. In times of restrictive monetary policy, high levels of financial stress and the accelerator mechanism will interact and aggravate tight lending conditions. In times of an expansive monetary policy and high systemic stress as observed in the recent crises, however, both mechanisms might work in opposite direction, as the accelerator mechanism would amplify the stimulus while high stress levels may restrain the effects of the impulse. Thus, the interest rates at which firms can take on new loans vary across countries. Figure 2 depicts credit rates for non-financial corporations[3] for our set of countries.

We observe two distinct subsamples: Before the crisis the differences between countries was relatively small and decreasing. After the crisis, however, the diversion increased substantially in the run-up to the debt crisis and reached a peak at the end of 2011. The increase was especially pronounced for Greece and Portugal, but the rates also rose in Spain and Italy. These four countries constitute the group of our "periphery countries". The remaining four "core countries" show distinct lower refining conditions for firms. And although the spread between all countries decreased somewhat from 2012 onward, it still remains considerably higher than before the crisis.

In this paper we study whether systemic financial stress influences the monetary transmission mechanism in the euro area and explains diverging loan rate development across euro area countries. Furthermore, we examine to what extend a capital quality shock on euro

[3] up to one year, up to one million Euro.

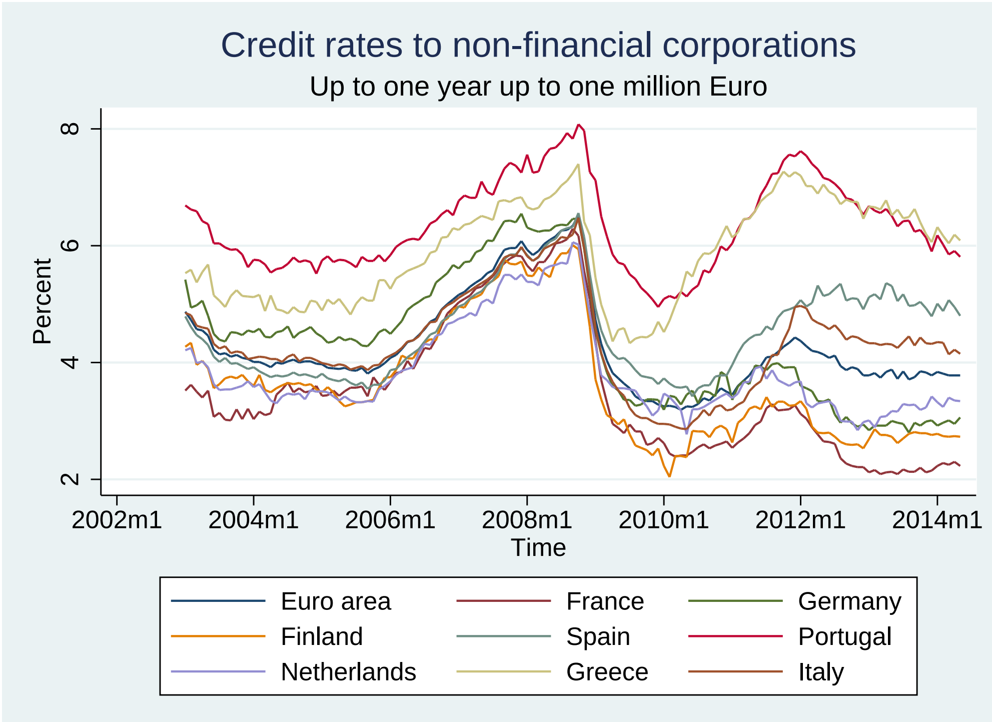

Figure 2: Credit rates for non-financial corporations

areas banks' balance sheets together with increased overall financial stress works contrary towards the financial acceleration mechanism underlying the credit channel. For the analysis we employ the following strategy: We estimate a structural BVAR using sign restrictions for eight euro area countries and the aggregate. The sign restrictions we impose are validated by the model of Gertler, Kiyotaki et al. (2010). To this end, we recalibrate their model to the fit euro area data and vary the critical parameters to confirm the robustness of the implied sign restrictions.

The remainder of this paper is organized as follows. Section 2 presents the data used in our VAR analysis. Afterwards we describe our approach to incorporate financial stress and the resulting stress indices. Section 4 then contains the VAR analysis. We first present the theoretical foundations for our model setup and then give the empirical implementation and results. Finally, section 5 concludes.

2 Data

We use monthly data from 2003M1 to 2014M1. The set of variables we employ comprises for each country and the euro area as a whole the four variables detrended real GDP (interpolated to monthly frequency using built-in Eviews routines), our generated financial stress indices (FSI), the shadow rate of Wu & Xia (2014) for the ECB and a variable we call premium, which is the difference between credit rates to non-financial corporations (up to one million Euro, up to one year maturity) and a reference rate. We also examined different maturities, however, the dynamics are very similar and the spreads are standardized for the factor analysis anyway. The variables are depicted in table 4. While the construction of the FSI will be explained in detail in the next section, the remaining variable calling for further explanation is the shadow rate.

The shadow rate of Wu & Xia (2014) is a measure of the overall monetary policy stance, which not only takes into account the standard main refinancing rate of the ECB, but also unconventional monetary policy measures such as asset purchases and forward guidance conducted by the central bank. In a situation where the normal refinancing rate is close to the zero lower bound (ZLB) and the central bank conducts unconventional monetary policy to provide further monetary stimulus, the shadow rate thus allows to quantify the effect of these unconventional measures[4].

Figure 3 shows both the ECB main refinancing rate and the shadow rate in comparison. We see that the shadow rate is almost identical to the main refinancing rate before the crisis. After the fall 2008 the dynamics of both series still match, however, the lower values of the shadow rate reveal a monetary policy of the ECB that was substantially more expansive than captured by the main refinancing rate alone. The explanation for the observed differences are the unconventional measures the ECB conducted after 2008, including long-term refinancing options for banks offered in the course of the financial crisis and the asset purchase programs mentioned in the introduction.

[4]For technical details we refer the reader to the paper of Wu & Xia (2014)

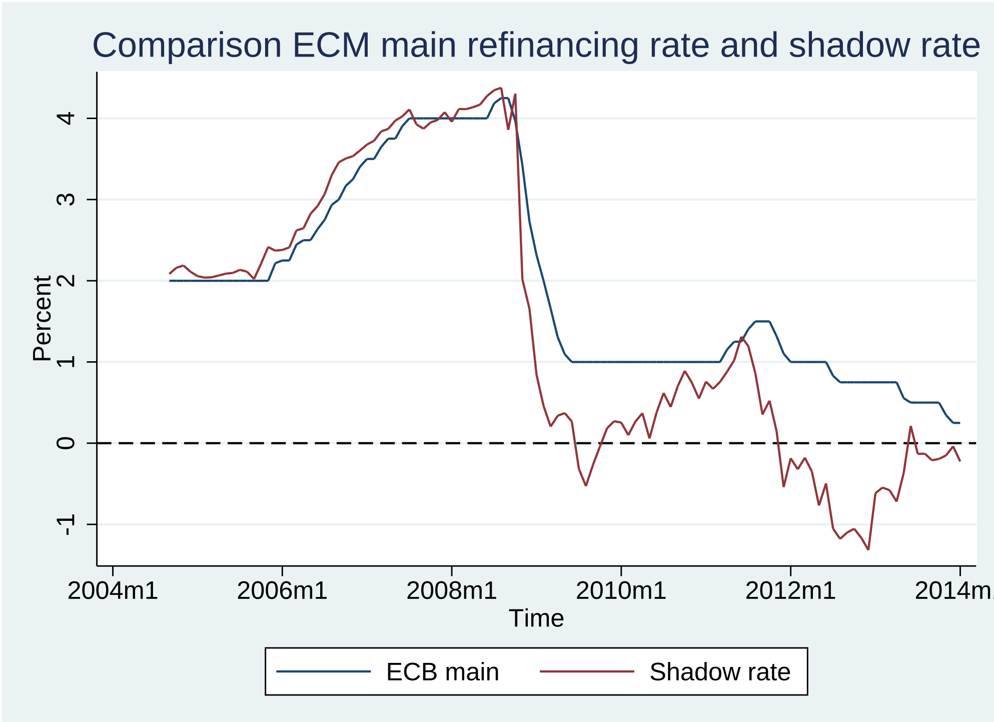

Figure 3: ECB main refinancing rate and shadow rate

3 Financial stress

Starting as a credit default crisis straining bank balance sheets, the Great Recession starting 2007 developed into the most severe economic downturn of the last decades. One important aspect accelerating the progression from a crisis in the financial sector to one with dramatic effects on the real economy in the EMU was the collapse of the interbank market caused by increasing mistrust of corporate banks to provide short-term financing to (perceived) troubled banks. Because of this financial stress, the structure and the very nature of the monetary transmission mechanism (MTM) have changed.

As a consequence, any analysis that seeks to analyze the MTM should account for systemic financial stress. Since it helps explaining the effects of MTM in the post-crisis world, financial stress contains important additional information which should be included in standard models to (still) get meaningful results for the time after the crisis. The crucial question then emerges as how systemic financial stress can be quantified and condensed in a sufficiently compact way. This task, however, proves to be a complicated one, because financial stress is an abstract term describing a complex and multilayer issue. A specific difficulty arises from the multiplicity of aspects that may contribute to the concept: Several channels, different markets and various variables have to be taken into account. In this paper we utilize a factor model to capture the different influences and distil an index of financial stress.

3.1 Factor analysis

The idea behind factor analysis is that a vector of latent factors f drives the comovement of a large number of underlying (time series) variables n. These factors are weighted, orthogonal main directions of variation in the data, employing the covariance matrix of the variables. Since f « n, this approach allows to condense the information of many variables in a sparse number of factors. How many factors are actually needed to explain a sufficient amount of variation in the underlying variables crucially depends on the comovement of these variables. The higher the comovement and therefore the correlation in the data, the more variation can be explained with less factors.

It is our goal to encompass the different facets of financial stress while at the same time remaining a parsimonious specification. To capture the different ingredients of financial stress (explain why interest rate spreads do the job), we consider the following measures for each country and the euro area:

1. spread between 3m-Euribor rate and Eonia –> liquidity risk, interbank market
2. spread between 12m-Euribor rate and Eonia –> liquidity risk, interbank market
3. spread between 3m-Euribor (unsecured) and 3m-repo-rate (secured) –> default risk, interbank market
4. spread between 12m-Euribor (unsecured) and 12m-repo-rate (secured) –> default risk, interbank market

5. spread between credit rates for non-financial corporations and yield on twelve month government t-bills –> financial premium

6. volatility of banking sector stock markets index

7. marginal leverage ratio of banks

As standard for factor analysis, the generated spreads and variables are first standardized (include reason for this - comparability of weights in the pca). Estimation of the factors then is carried out by principal components analysis (pca).

In our baseline specification, we use the spread between 12m-Euribor rate and Eonia, the spread between 12m-Euribor and 12m-repo-rate and the spread between the yield on twelve month government t-bills and the reference rate computed from AAA government bond yields. Financial stress in a country derives from two sources - country-specific and euro area-wide determinants. By only selecting one spread for both the liquidity and the default risk (which are based on euro area wide data) in combination with two country-specific determinants, we avoid putting too much weight on the non-idiosyncratic components of financial stress.

To check for robustness, we also estimated several variations in the composition of spreads and variables. These variations include estimation based on the spread between the Eonia rate and the overnight repo rate and the spread between 3m-Euribor rate and Eonia for the euro area wide components, all four euro area wide components and additionally including the marginal leverage ratio of Burke (2014) as a country-specific determinant. In addition, we vary the number of retained factors. However, all variations leave the constructed FSI essentially unchanged and thus we revert to the baseline specification.

We retain the first two factors for each country[5], which, in sum, explain between 92.39% (Netherlands) and 94.08% (Germany) of total variation in the data for the individual coun-

[5]Standard criteria would suggest keeping those factors with eigenvalues larger than one. However, since for most countries there is not a clear cutoff after the first factor such that the second factor still explains a reasonable amount of total variation in the data and we are not confined to only one factor, we set the threshold to 0.5. This results for all countries in two factors.

tries. (include table with explained variation of the factors in the appendix). For the euro area as a whole we explain 93.47%.

Following the methodology inHollo, Kremer & Lo Duca (2012), the two retained factors are then summed up, weighted by their respective share of explained variation. This weighted sum is our index of systemic stress for the respective country.

3.2 Analysis of the generated FSI

The resulting indices are depicted in graph 4

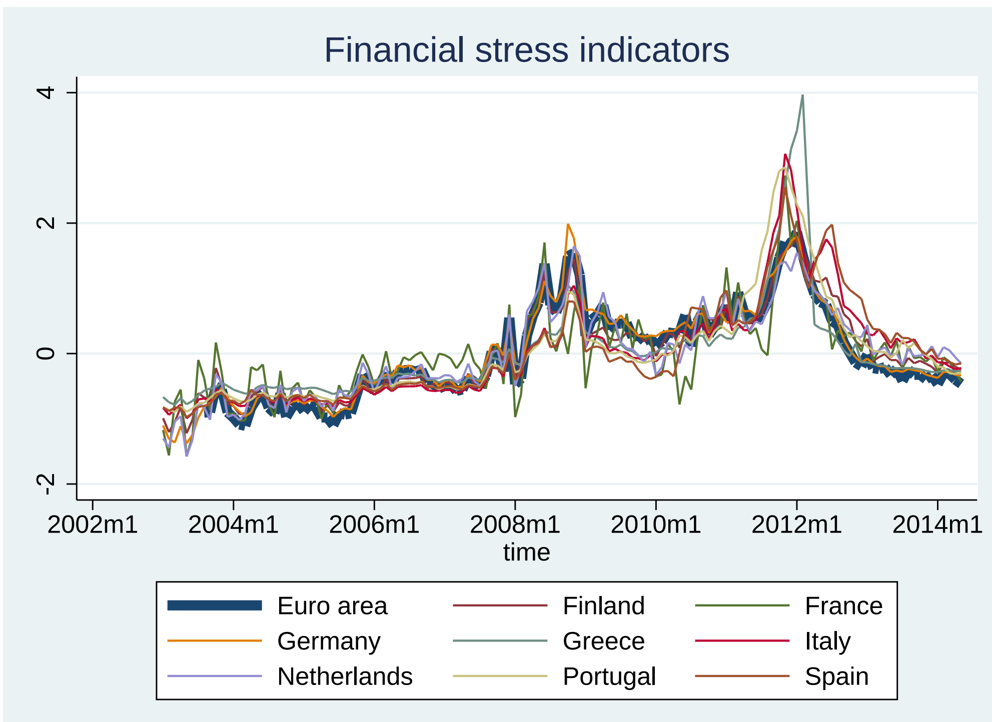

Figure 4: Overview FSI

Several features emerge. First, the stress indicators exhibit very similar patterns over time. After the first three years of relatively low stress the indices start rising in the end of 2005, culminating in the first of two major peaks in the end of 2008. The stress level then declines somewhat but without reaching the pre-crisis levels again. The second and larger peak occurs between November 2011 and January 2012, when the European debt crisis intensified.

Second, though the similarity described above, distinctions arise between the two peaks of financial stress. Whereas the financial crisis in 2008 triggered high stress levels especially in the core countries Germany, Finland and the Netherlands, the debt crisis 2011/2012 brought with it high levels of financial stress especially in the periphery countries. This is also apparent when examining the absolut values of the the indices. The three largest country maxima pertain to Greece (3.97), Italy (3.06) and Portugal (2.85), while the three lowest maxima retain to the Netherlands (1.64), Finland (1.77) and Germany (1.99).

After the second peak the stress indices decline again, to lower levels than in the mid-peak period between fall of 2008 and end of 2011, but without reaching the low levels seen before the outbreak of the financial crisis. Overall, we are able to capture the broad macroeconomic developments in the euro area quite well with our generated FSIs, even when relying on only three underlying and easy calculable spreads and variables. This argument is strengthened further when comparing our estimate for the euro area to the Composite Indicator of Systemic Stress (CISS) of Angelopoulou, Balfoussia & Gibson (2014), which utilizes a more complex method and more variables to obtain the index. As graph 5 shows, the dynamics of both measures are reasonably comparable. The correlation between both measures is 0.77. While both stress indices identify the same peaks of systemic stress, both differ in assigned values. Our FSI shows higher levels of stress in during the debt crisis 2011/2012 whereas it is the other way round for the first peak in 2008.

4 VAR analysis

In this section we present our analysis and discuss the results. Our approach is based on two building blocks.

The first of these blocks consists of the monetary DSGE model of Gertler & Karadi (2011) (henceforth GK), which we take as theoretical foundation for our sign restrictions. To this end, after a short recap of the main characteristics of the model, we calibrate it to the

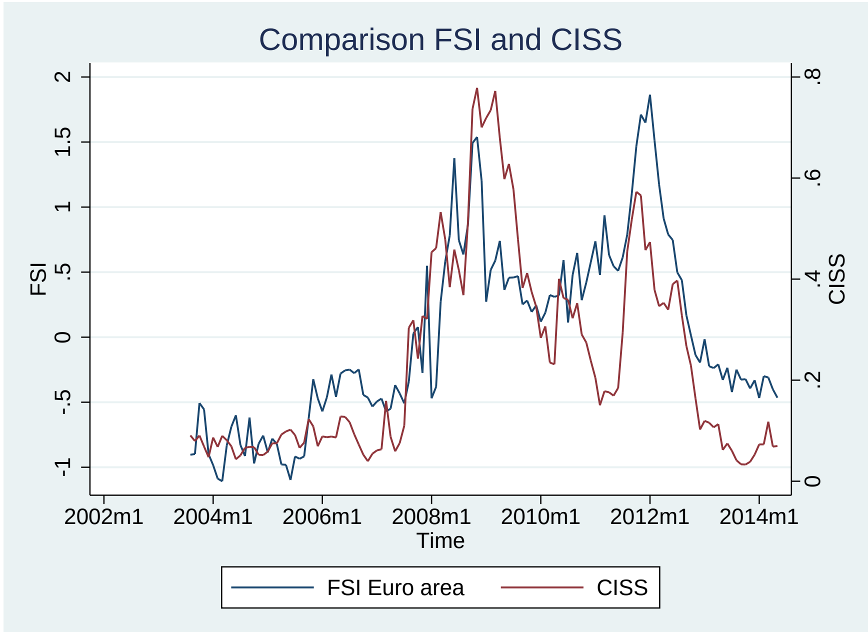

Figure 5: Comparison FSI and CISS

euro area, following the instructions in Smets & Wouters (2003). Besides relatively standard DSGE model parameters, the central mechanism of financial intermediation in the GK model involves three main parameters. To validate our sign restrictions setup, we then examine the robustness of the implied impulse responses within GK by varying these parameters over reasonable ranges of the parameter space.

In the second building block we then utilize the findings of this procedure to estimate a Bayesian SVAR identified via sign restrictions in the style of Uhlig (2005). Data for individual countries in the euro area allows us to examine differences across countries.

4.1 The Gertler-Karadi model

GK develop a quantitative monetary DSGE model similar to the ones of Christiano, Eichenbaum & Evans (2005) and Smets & Wouters (2007) incorporating a financial accelerator mechanism as in Bernanke et al. (1999). In contrast to the latter, however, GK explicitly model financial frictions through an agency problem between households and financial intermediaries. Households lend funds to competitive financial intermediaries for a gross return R_{t+1}. The financial intermediaries in turn use the deposits to lend to non-financial firms, receiving the stochastic return R_{kt+1}. The central quantity in their model is the difference between the cost of refinancing for the intermediaries and their stochastic return, $R_{kt+1} - R_{t+1}$, called the risk-adjusted premium. To allow for financial frictions, they introduce an agency problem between financial intermediaries and households: In every period the financial intermediaries have the possibility to sideline a fraction λ of available funds. The households in turn may recover the remaining share $1 - \lambda$ by forcing the intermediary into bankruptcy, but λ is lost. As a consequence, the households will only be willing to lend to the financial intermediaries as long as the incentive constraint is fulfilled according to which the losses from cheating have to be always at least as large as the possible gains (see equation 9 in KG). This constraint "limits the intermediaries leverage ratio to the point where the banker's incentive to cheat is exactly balanced by the cost. In this respect the agency problem leads to an endogenous capital constraint on the intermediary's ability to acquire assets." (KG, p.10). With frictionless financial markets, the premium will be zero. With the agency problem described above, however, the premium may be positive.

This forms the basis for the accelerator mechanism in the model which works as follows. A decline in investment (due to, for example, a negative technology or contractive monetary policy shock) reduces the prices of assets the intermediaries hold (i.e. the loans to the non-financial firms) which in turn degrades their balance sheets. Due to the limitation in obtaining funding from households, the premium the intermediaries demand increases, pushing up refinancing costs for the non-financial firms and thereby further reducing investment. The accelerator mechanism enhances the effects of a monetary policy shock, compared to a conventional DSGE model in the fashion of Smets & Wouters (2007) without financial frictions. With this framework GK capture a key element of the recent financial crisis, namely the deterioration in banks' assets and therefore balance sheet which was triggered by negative capital quality shocks due to bad and failing loans.

4.2 Derivation of shock identifying restrictons

Because the GK model is calibrated for the US, we recalibrate it to attain consistent sign restrictions for the euro area. The intermediary sector in the GK Model introduces two novel parameters, the leverage ratio of banks and the risk premium of lending to firms. Both values have not been validated in the literature so far and GK call their choices "suggestive". To check whether the restrictions implied by the model are robust, we vary the two critical parameters over a reasonable range.

For the euro area calibration we take the estimates from Smets & Wouters (2003) which are reported in table 3. Main differences between the calibration in GK and our euro area model are the parameters for the Calvo pricing and the price indexation which are 0.909 and 0.429, respectively, for the euro area and 0.779 and 0.241, respectively, in GK. For the consumption habit parameter we choose 0.551 (0.815 in GK). With respect to the parameters underlying the monetary policy rule GK adopt the original Taylor rule parameters for inflation (1.5) and output gap (0.5), as well as an interest rate smoothing coefficient of 0.8. In contrast, these parameters are estimated by SW to be 1.668, 0.144 and 0.928, respectively.

We first simulate a baseline model with financial frictions and the frictionless DSGE variant of GK with the described euro area calibration, but with the calibration for the financial parameters taken from GK, that is we set the parameters for the leverage ratio equal to 4 and the premium to 0.10. The resulting impulse responses for a monetary policy and a capital quality shock are depicted in graph 6 and graph 7.

In both figures the solid blue line shows the model with the accelerator mechanism present (GK) while the dotted red line depicts the model without this financial friction (SW). In the case of the restrictive monetary policy shock we see a stronger negative response of GDP with the accelerator mechanism present. The reason is the rise in the premium (not present in the model without accelerator mechanism) which reinforces the initial restrictive monetary impulse: Investment goes down, the assets of the financial intermediaries drop in value and as a consequence the latter increase the premium, further increasing refinancing

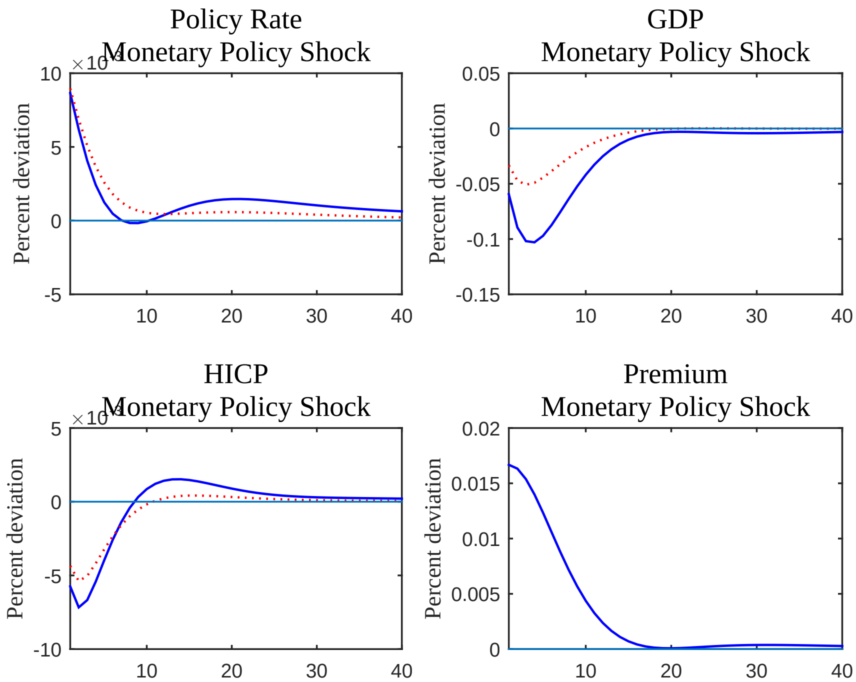

Figure 6: Gertler-Karadi monetary policy shock

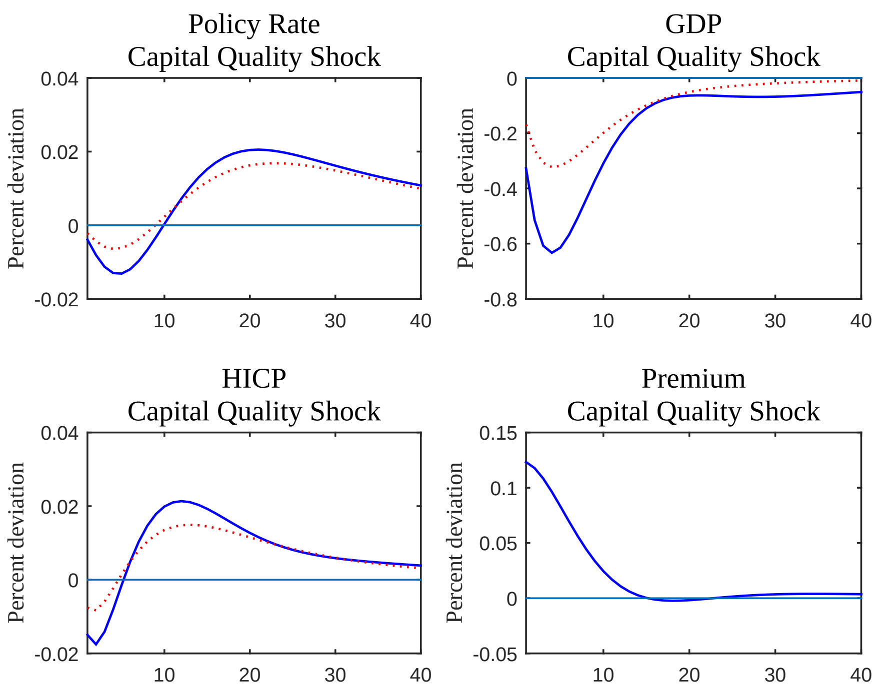

Figure 7: Gertler-Karadi capital quality shock

Table 1: Interval of confirmed signs

Parameter	**Interval**
Leverage ratio	1.9 – 31
Spread	0.01 – 0.87

costs of firms and thus investment. The stronger decrease in GDP in turn causes the policy rate to return to the initial state faster, although the differences are quite small. By the same reasoning does HICP initially decline stronger when the accelerator mechanism is active. Turning to the capital quality shock, a decrease in the intermediaries' assets implies an increase in asset sales due to the leverage ratio constraints they are facing. Therewith the premium rises and output declines. The financial frictions in the intermediary sector introduce a slowdown of GDP recovery as opposed to the frictionless DSGE model, despite expansionary monetary policy. The dynamics are compatible with the results in GK. The size of the output response is also comparable with those shown by GK peaking at -6 percent decline for the model with the accelerator mechanism. However, the response of inflation and the policy rate is substantially smaller in magnitude. To test the robustness of the impulse responses to the variation of the leverage ratio ϕ and the premium $R_k - R$ we vary the respective parameters over the intervals ϕ =[0-35] and $R_k - R$ =[0-1) in 1 and 0.01 steps, respectively. Table 1 reports the interval over which the signs of the impulse response functions are confirmed.

These intervals include the entire range of the corresponding values across euro area countries which are reported in tables 5 and 6 in the appendix. Thus, we can use the GK model as a basis for the sign restrictions in our empirical analysis.

These intervals include the entire range of the corresponding values across euro area countries which are reported in tables 5 and 6 in the appendix. We obtain the identifying sign restrictions from the impulse responses of the GK model in particular from a monetary policy and a capital quality shock, depicted in table 2. In particular we impose a positive reaction of the premium for 1 to 4 months for both a monetary policy shock and a capital quality shock. However, the policy rate is restricted to be positive for 1 to 4 months for the policy shock but negative for 1 to 4 months for the capital quality shock. In the estimations we additionally introduce our financial stress indicator, which we will loosely sign restrict to be positive for one month for both shocks. As we are interested on the effects of these two shocks on the real economic activity, we leave GDP unrestricted.

Table 2: Sign restrictions

Shock	**FSI**	**Premium**	**shadow rate**	**GDP**
restrictive monetary policy	+	+	+	?
for periods	(1)	(1-4)	(1-4)	
negative FSI	+	+	-	?
for periods	(1)	(1-4)	(1-4)	

4.3 Empirical approach

We estimate a Bayesian VAR for every country in our sample, with and without the FSI, and identify a monetary policy and a capital quality shock enhanced with systemic risk. For the identification of our structural VAR we proceed as follows.
Let $y_t = [GDP_t \; fsi_t \; premium_t \; shadowrate_t]'$ denote the vector of variables. A VAR model of order p in these variables is then given by

$$y_t = v + A_1 y_{t-1} + \cdots + A_p y_{t-p} + u_t \tag{1}$$

which can be rewritten as

$$y_t = u_t + \Phi_1 u_{t-1} + \Phi_2 u_{t-2} + \ldots \tag{2}$$

by the Wold theorem. Since the u are reduced form shocks, their variance-covariance matrix, denoted Σ_u will in general not be the identity matrix and therefore the effect of a shock to one variable can not be examined in isolation and the structural relationship between shock and effect cannot be determined. The structural shocks ϵ are linear combinations of the reduced form shocks u, so $A\epsilon_t = u_t$. Using this relationship in 2 yields

$$y_t = A\epsilon + \Theta_1\epsilon_{t-1} + \Theta_2\epsilon_{t-2} + \dots, \tag{3}$$

with $\Theta_i = \Phi_i A$ for $i = 1, 2, \dots \infty$. The matrix A is given by a decomposition of Σ_u in the way that $\Sigma_u = AA'$. Accordingly, the matrix A is not unique and one has to introduce additional information in form of restrictions into the model. We do this by imposing sign restrictions on how variables in the model react to different shocks. To this end, the matrix A is decomposed into an eigenvector matrix (P), the square roots of the eigenvalues (D) and the product of rotation matrices. Adopting the methodology of Canova & De Nicolo (2002) and Peersman & Smets (2003) we make use of rotation matrices for orthogonolizing the distinct structural shocks. The product of rotation matrices is defined to be $P = \sum_{m,n} Q_{m,n}(\theta)$ with

$$Q_{m,n} = \begin{pmatrix} 1 & \cdots & 0 & \cdots & 0 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & \cdots & \cos(\theta) & \cdots & -\sin(\theta) & \cdots & 0 \\ \vdots & \vdots & \vdots & 1 & \vdots & \vdots & \vdots \\ 0 & \cdots & \sin(\theta) & \cdots & \cos(\theta) & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & \cdots & 0 & \cdots & 0 & \cdots & 1 \end{pmatrix} \tag{4}$$

Depending on the number of variables included there is a finite number of rotation matrices with $\theta = \theta_1, \theta_2, \dots, \theta_i$ that reflect the angle by with rows m and n rotate. We use a Bayesian estimation approach with priors and posteriors are set to be Normal-Whishard. To determine a finite number of admissible draws from the posterior we jointly draw the posterior for the alphas from the unrestricted Normal-Wishard posterior and at the same time a draw from a uniform distribution for the rotation matrices. We then calculate the impulse responses and only keep those sets that full fill the restrictions for both shocks, giving zero weight to the prior. We report the median responses with 84th and 16th percentile probability bands.

4.4 Results

We firstly turn to the country specific results, comparing the reaction of variables with and without the the FSI included. The subsequent figures always depict the impulse response function of GDP, the premium and the policy rate to a restrictive monetary policy shock of one standard deviation of the the shadow rate.

Figures 8, 9 and 10 present the results for Germany. Without the FSI GDP reacts negatively for 10 months with a peak effect of -0.5 percentage points. Including the FSI amplifies the effect of a monetary policy shock on GDP. GDP now reacts negatively for 40 months and the minimum is now -1.3 percentage deviation. However, the responses of the premium is significantly negative for 50 months. As opposed to the response of the premium in the model with FSI that is insignificantly negative. The insignificance of the premium might signal less pronounced financial frictions in the intermediary sector for Germany. The responses of the FSI shock for Germany lend further credit to this explanation as the GDP does not react significantly to a negative FSI shock likewise the response of the premium. The responses for Finland are shown in figures 11, 12 and 13. GDP reacts significantly negative to a monetary policy shock without FSI for 15 months with a minimum of -0.8. This reaction is strengthen when including the FSI, as the minimum then is displayed as -1. Again the premium is insignificantly different from zero when including the FSI. Like in the case for Germany the FSI shock triggers only modest reactions in GDP and the premium. The monetary policy shocks and FSI shocks for France are depict in figures 14, 15 and 16. Concerning the monetary policy shock without the FSI they show a strongly and significantly negative reaction of GDP (-1.3) for 20 months. This response tuns insignificant by the inclusion of the FSI also the FSI shock dies not depict significant effects on GDP and only a slight positive response for the premium.

For the Netherlands the results are contained in figures 17, 18 and 19 and show very strong negative response of GDP, -1.9 without the FSI. The premium reacts positive to the with a peak effect of 0.4 for 10 months. Including the FSI reduces the responses: GDP now reacts with -0.4 and the premium turns insignificant. The FSI shock fo the Netherlands shows strong positive response for the premium and a long-lasting negative response for GDP of -1.5, picking up real economic effects of an increasing overall financial risk.

Figures 20, 21 and 22 show the results for Spain. Without the FSI GDP reacts prolonged (negative for 44 months) and extremely strong (-9), and the response of the premium is positive, but barely significant. With the FSI included the response of GDP is still long lasting and very high, but with a peak of -7 somewhat lower than without the FSI. The premium does not change much, but becomes significantly positive for 36 month. Examining the FSI shock we see that the responses are similar to the monetary policy shock without FSI, indicating that high financial stress enhanced the downturn in Spain.

Turning to Greece, we see in figures 23, 24 and 25 that without the FSI GDP reacts more negatively and the premium more positively to a monetary policy shock than when the FSI is included. Financial stress therefore dampens the accelerator mechanism. The FSI shock also points in this direction, as the response of monetary policy is significantly negative for 30 months and large in absolute values.

The same weakening of the accelerator mechanism can in part also be observed for Italy (figures 26, 27 and 28): Though GDP reacts relatively similar to a monetary policy shock with and without the FSI, in the latter case the premium reacts significantly positive to the contractive policy, whereas the response is insignificant when the FSI is included. Given that the response of the policy rate to a FSI shock is significantly negative for more than 20 months, this suggests that high levels of stress disturbed the transmission mechanism.

Finally, the results for Portugal are depicted in figures 29, 30 and 31. They show the same pattern as the one observed for Greece. Financial stress impaired the monetary transmission mechanism.

Turning to country comparison, figures 32, 33 and 34 show an overview of the response of all countries to a monetary policy shock without and with the FSI, respectively. The dotted blue lines always depict periphery countries (Greece, Italy, Spain, Portugal) while the dashed red lines represent core countries (Netherlands, Germany, France, Finland). The responses of GDP to a policy shock are very similar between both country groups, however, the response of the premium is substantially higher for the periphery countries. The same holds for the effects of the FSI shock. In response, the premium reacts stronger in periphery countries compared to core countries.

5 Conclusion

In this paper we analyze the effects of financial stress on the monetary transmission mechanism in different euro area countries. To this end, we compute country-specific financial stress indices and include them in a Bayesian structural VAR. The indices are generate employing a factor model and various interest rate (spreads) which are supposed to capture different facets of financial stress. In the end it turns out that a very parsimonious specification with only three easy computable variables are sufficient to capture the main episodes of financial stress in the euro area. The Bayesian structural VAR is identified by imposing sign restrictions on the impulse response functions of the variables in the model. Specifically, we recalibrate the model of monetary DSGE model with accelerator mechanism of Gertler et al. (2010) to match the data in the euro area and perform simulation exercises to determine the robustness of the implied sign restrictions. We find that the premium in periphery countries increases substantially more than the premium in core countries for both a contractive monetary policy shock and an FSI shock. While high systemic stress should enhance the accelerator mechanism in the model if restrictive monetary policy is conducted, we expect the stress to work against the accelerator mechanism in times of expansive monetary policy as observed over the last years in the euro area. When including the financial stress indices, we find that the response of GDP and the premium is smaller.

6 Appendix

6.1 Tables

Table 3: Calibration

Parameter	Value	Description
β	0.99	Discount rate
σ	1	Intertemporal elasticity of substitution
h	0.552	Habit formation parameter
χ_0	3.4	Starting value for the labor utility weight
φ	0.265	Inverse Frisch elasticity of labor supply
ζ	7.2	Elasticity of marginal depreciation wrt the utilization rate
λ_0	0.3815	Starting value for the fraction of divertible funds
ω_0	0.002	Starting value of proportional starting up funds
θ	0.9716	Survival probability of bankers
α	0.30	Capital share
δ	0.025	Depreciation rate
$\frac{G}{Y}$	0.2	Government expenditures over GDP
η_I	1.728	Elasticity of investment adjustment cost
Retail firms		
ϵ	4.167	Elasticity of substitution between goods
γ	0.909	Calvo parameter
γ_P	0.429	Price indexation parameter
Monetary policy		
ρ_i	0.9	Interest smoothing parameter
κ_π	1.668	Inflation coefficient
κ_y	-0.133/4	Output gap coefficient
Shocks		
σ_ξ	0.10	Size of capital quality shock
ρ_ξ	0.1	Persistence of capital quality shock
σ_{Ne}	0.01	Size of the wealth shock
σ_i	0.01	Size of the monetary policy shock

Table 4: Variables used

Variable	Description	Source
GDP	real gross domestic product, seasonally and work day adjusted	Eurostat
FSI	financial stress indicator	own computations
reference rate	AAA government bonds constant maturity one year	Data stream
premium	interest rate spread between NFC loan rate and AAA reference rate	ECB and Data stream
shadow rate	measure of monetary policy stance incorporating unconventional monetary policy	Wu & Xia (2014)

Table 5: Statistics parameter variation – Leverage ratio

Statistic	Euro area	Germany	Finland	Spain	France	Greece	Italy	Netherlands	Portugal
Overall									
Mean	16.6007	21.2817	15.8910	12.0290	16.4405	11.4176	12.7347	22.2312	11.7605
Max	18.6254	24.2903	27.1637	15.9982	19.1195	22.4706	14.8400	26.9527	13.8887
Min	12.4726	16.6235	9.6189	7.1666	14.5392	5.4098	9.4883	18.6964	7.6289
pre-crisis									
Mean	17.7044	22.5418	12.4598	12.8665	15.7994	11.7290	13.9762	22.4100	11.6555
Max	18.2991	24.2903	17.2368	15.0803	17.9384	13.1594	14.8400	26.4182	12.6485
Min	16.9210	20.8627	9.6189	11.8473	14.5392	9.9295	12.6350	19.5227	10.3380
after									
Mean	15.4970	20.0016	19.3221	11.1915	17.0815	11.1063	11.4932	22.0524	11.8655
Max	18.6254	21.9157	27.1637	15.9982	19.1195	22.4706	13.9580	26.9527	13.8887
Min	12.4726	16.6235	13.4189	7.1666	15.4724	5.4098	9.4883	18.6964	7.6289

Table 6: Statistics parameter variation – Spread

Statistic	Euro area	Germany	Finland	Spain	France	Greece	Italy	Netherlands	Portugal
Overall									
Mean	2.5260	2.5265	1.8668	2.8257	1.7134	4.1672	2.5930	2.0857	4.5807
Max	4.2165	3.5291	3.1865	5.5239	2.9740	7.0615	4.8165	3.5265	7.4665
Min	1.0819	1.6331	0.7719	0.8352	0.5767	2.0083	1.0251	0.5783	2.4383
pre-crisis									
Mean	1.6134	2.0939	1.2328	1.4156	1.0699	2.6914	1.6475	1.1325	3.3523
Max	2.3431	2.7806	1.8419	2.2431	1.5934	3.3333	2.4031	1.7631	4.3631
Min	1.0819	1.6331	0.7719	0.8352	0.5767	2.0851	1.0251	0.6219	2.5251
after									
Mean	3.0736	2.7860	2.2471	3.6718	2.0995	5.0527	3.1604	2.6576	5.3177
Max	4.2165	3.5291	3.1865	5.5239	2.9740	7.0615	4.8165	3.5265	7.4665
Min	1.1483	1.6483	0.9683	0.9783	1.0483	2.0083	1.0683	0.5783	2.4383

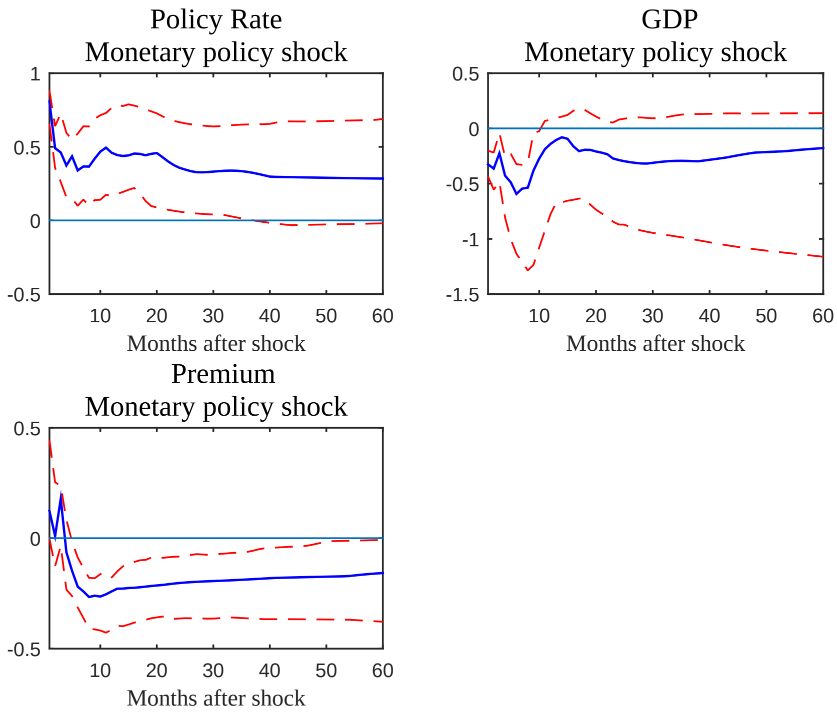

Figure 8: Germany without FSI policy shock

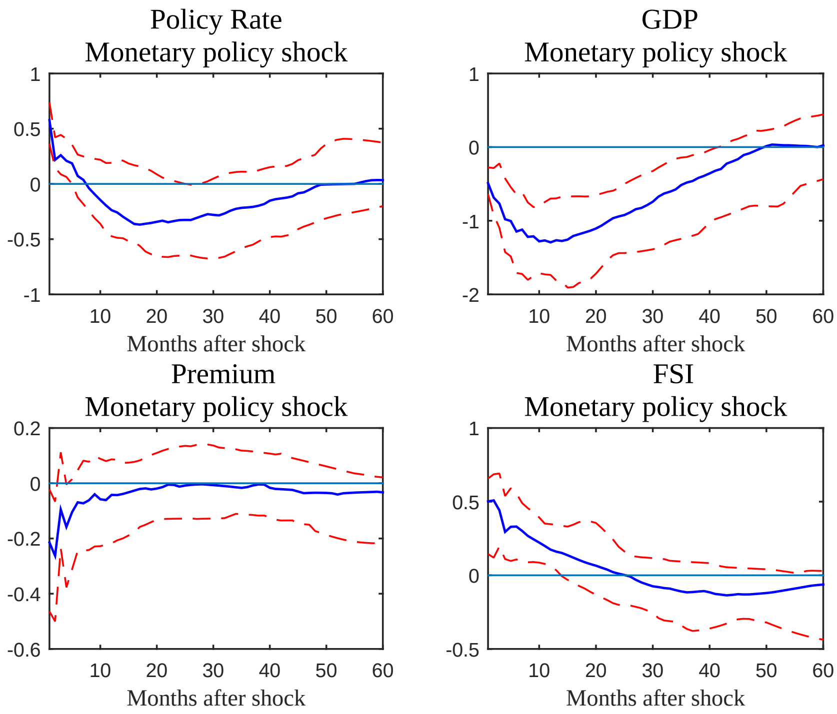

Figure 9: Germany with FSI policy shock

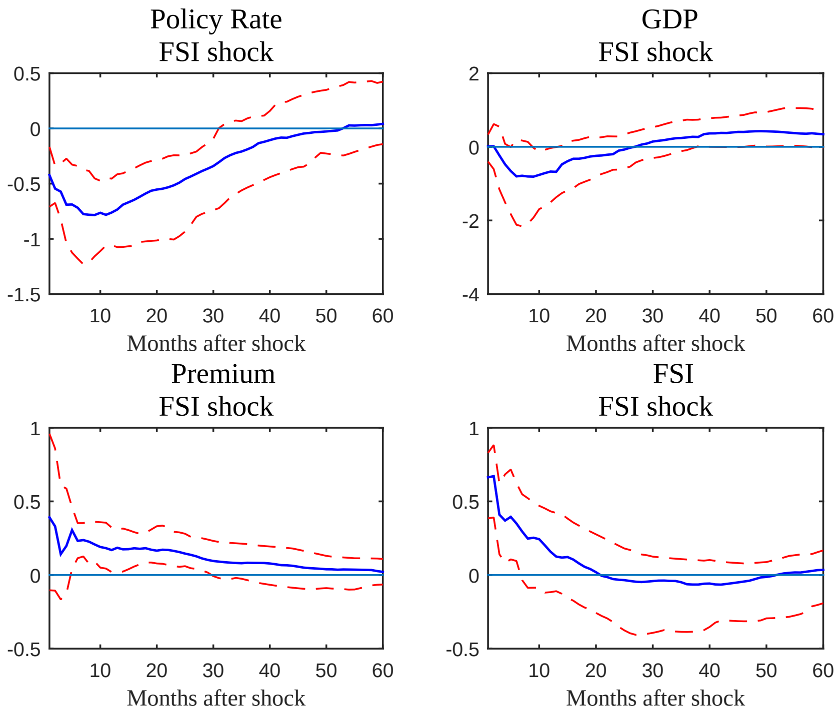

Figure 10: Germany FSI shock

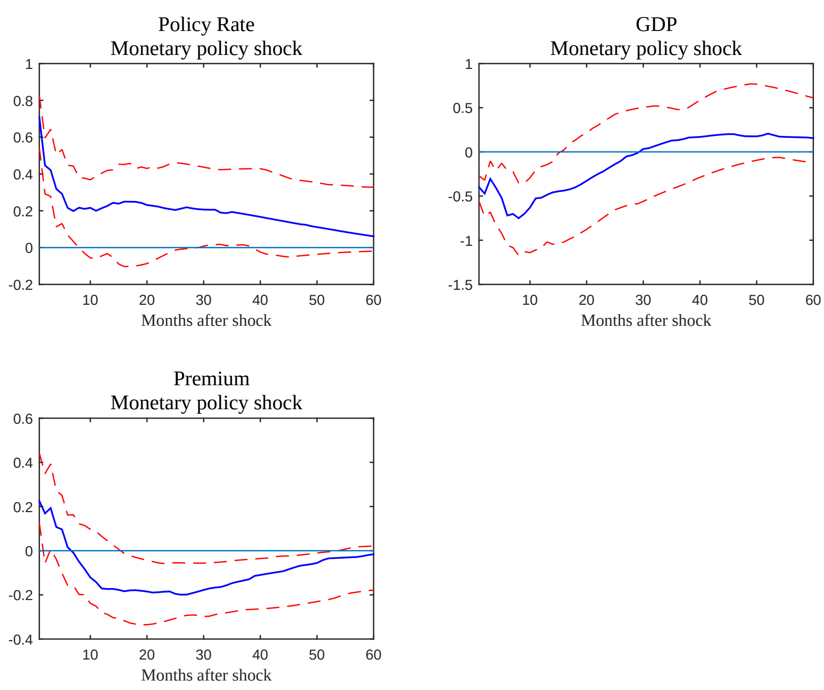

Figure 11: Finland without FSI policy shock

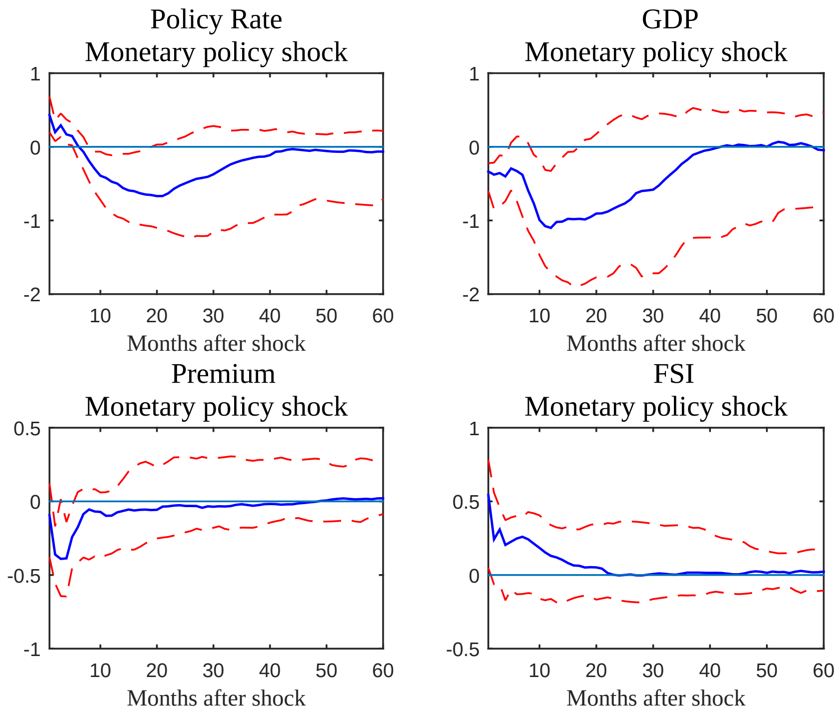

Figure 12: Finland with FSI policy shock

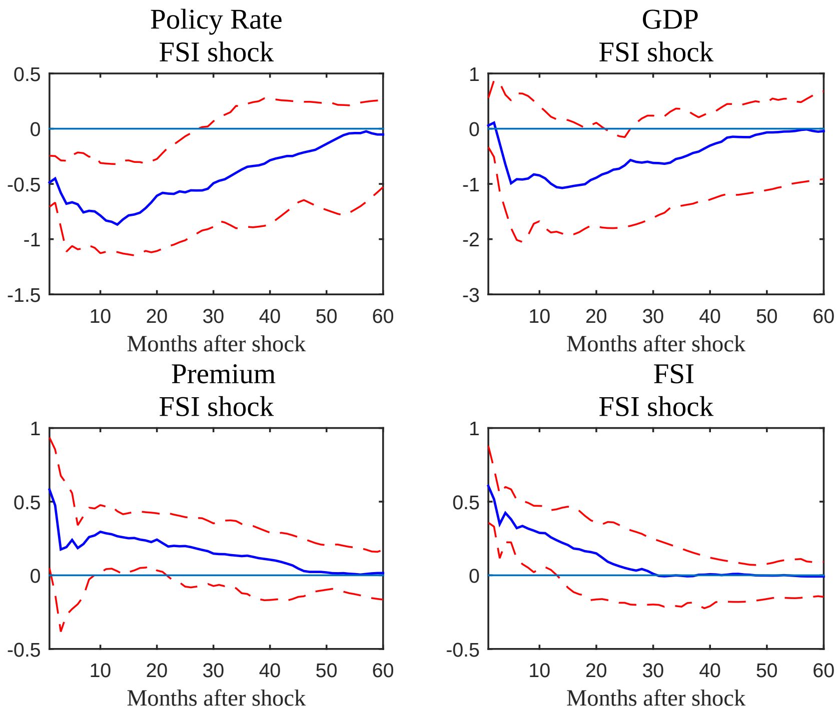

Figure 13: Finland FSI shock

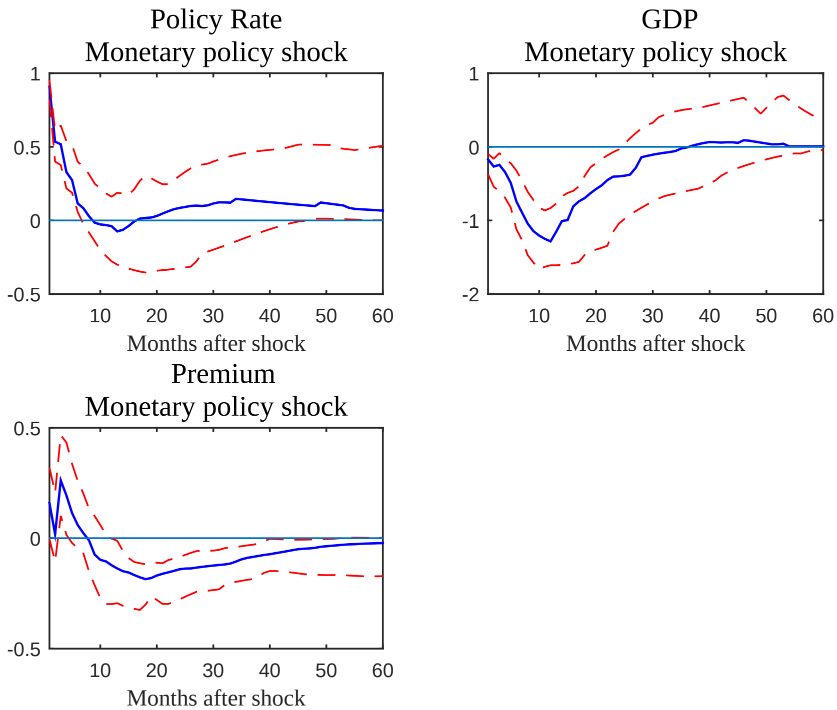

Figure 14: France without FSI policy shock

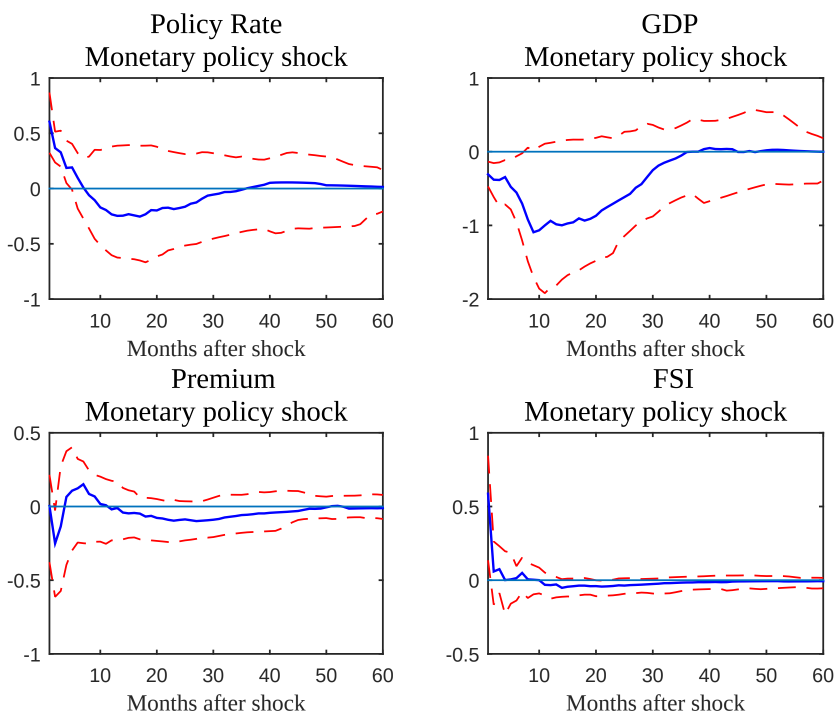

Figure 15: France with FSI policy shock

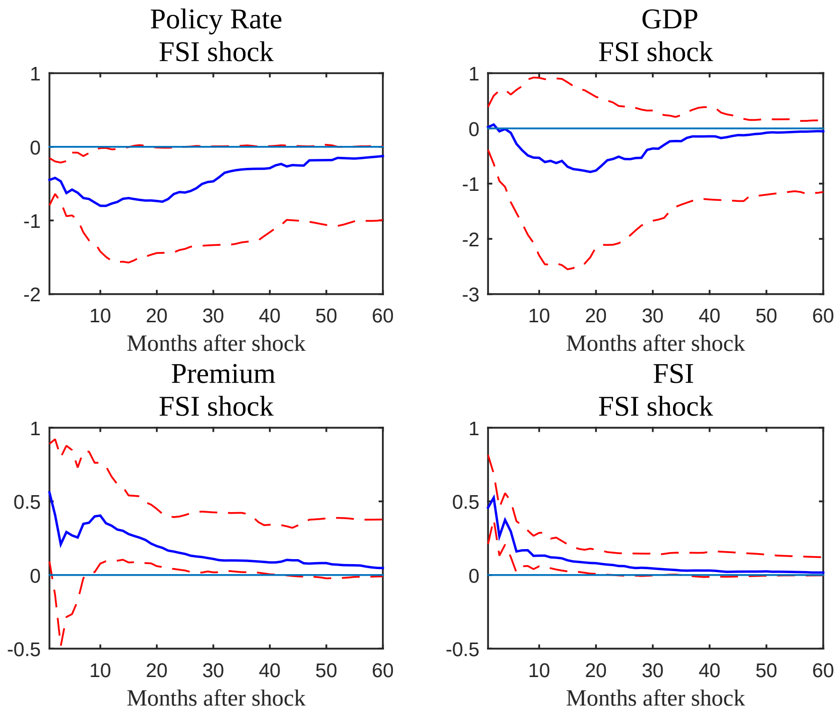

Figure 16: France FSI shock

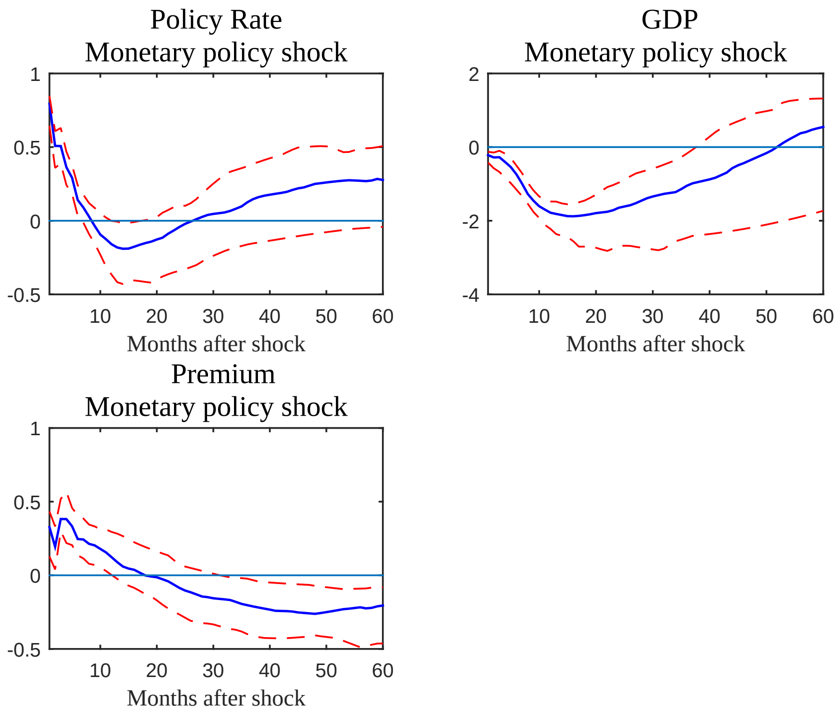

Figure 17: Netherlands without FSI policy shock

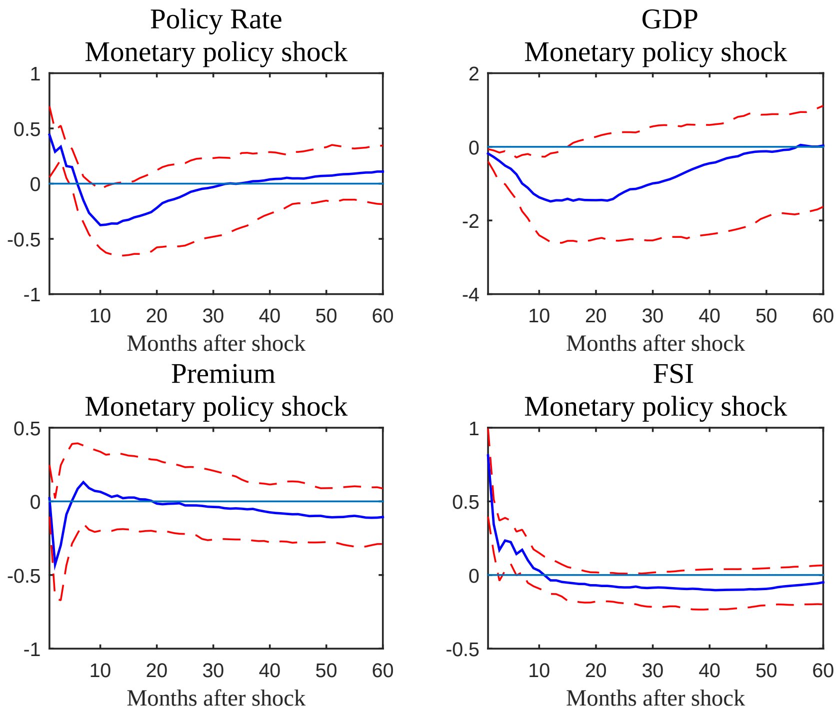

Figure 18: Netherlands with FSI policy shock

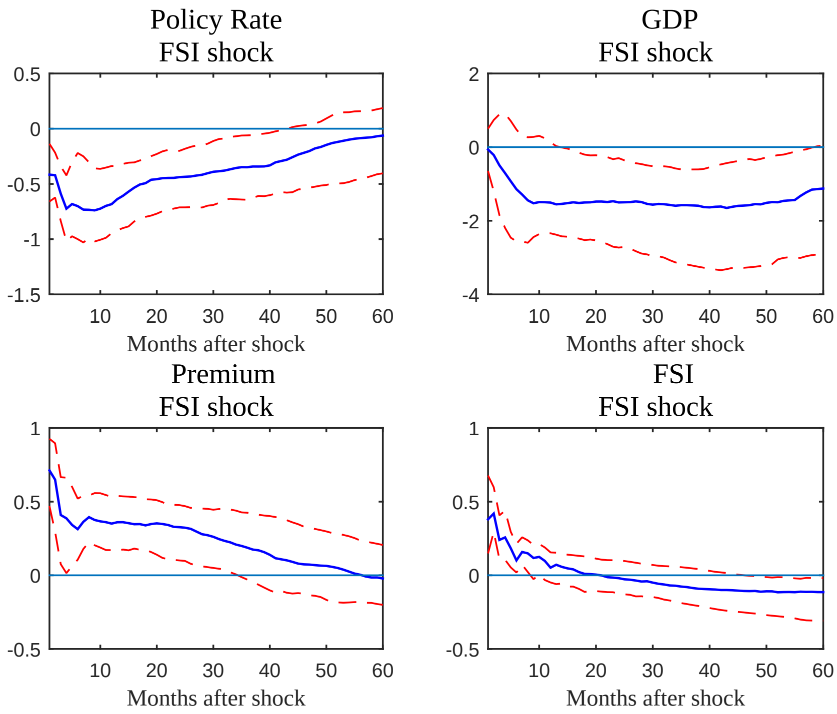

Figure 19: Netherlands FSI shock

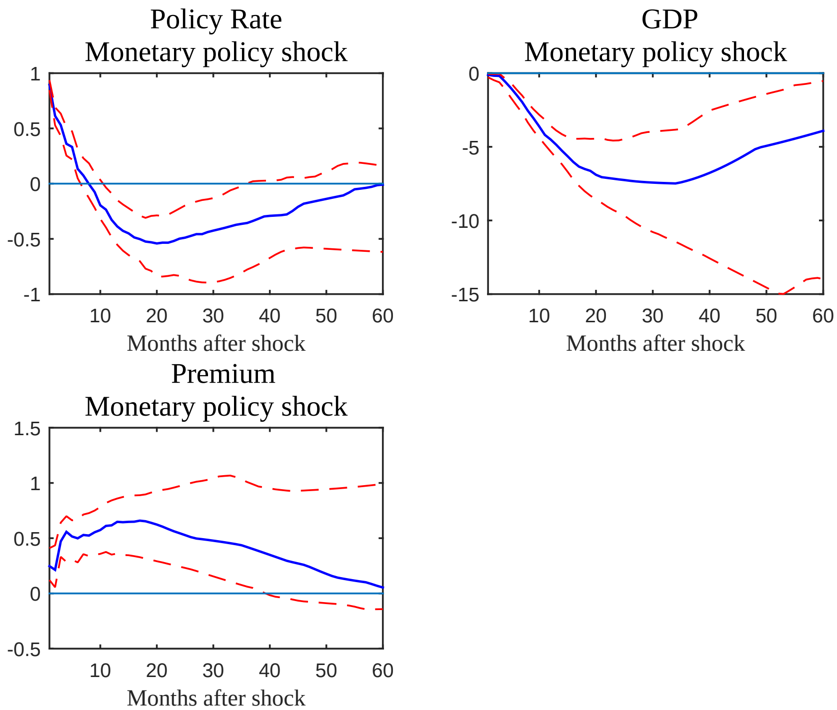

Figure 20: Spain without FSI policy shock

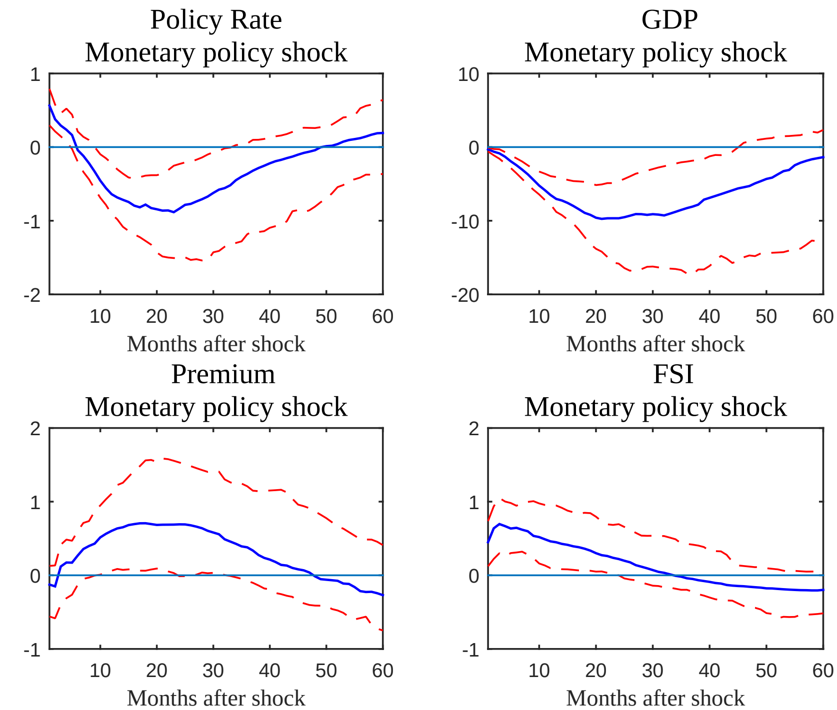

Figure 21: Spain with FSI policy shock

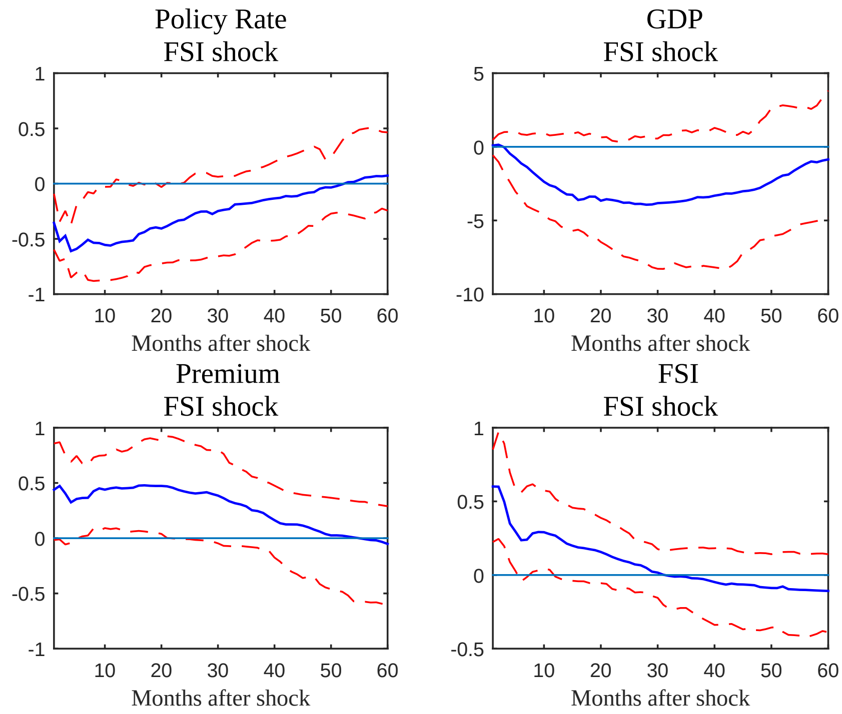

Figure 22: Spain FSI shock

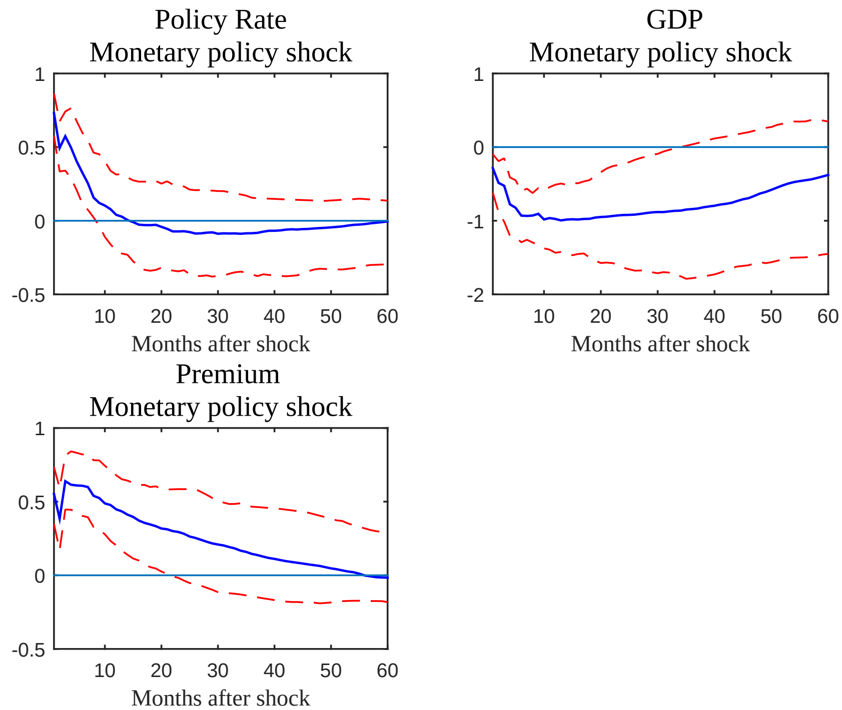

Figure 23: Greece without FSI policy shock

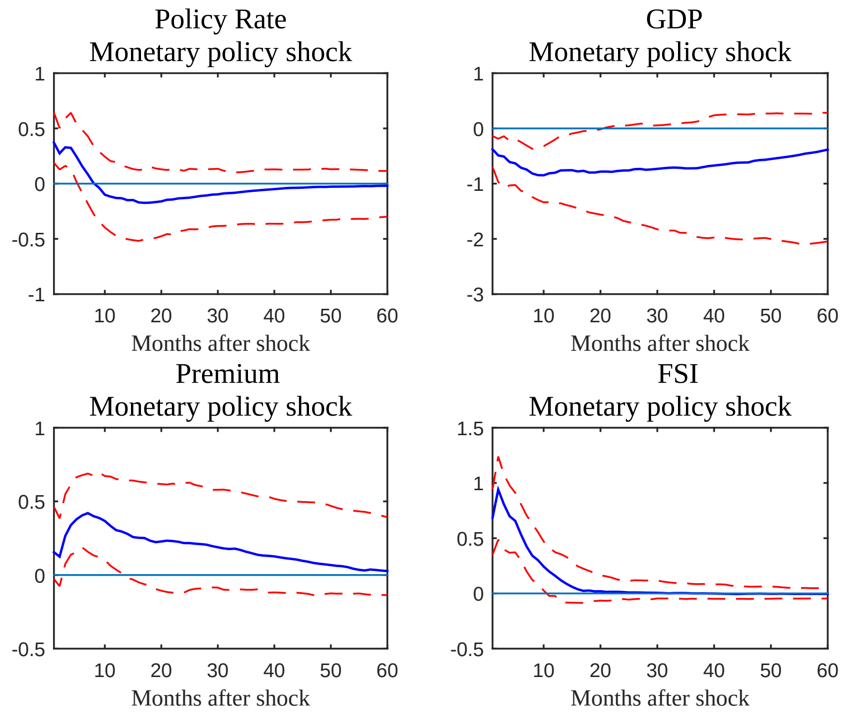

Figure 24: Greece with FSI policy shock

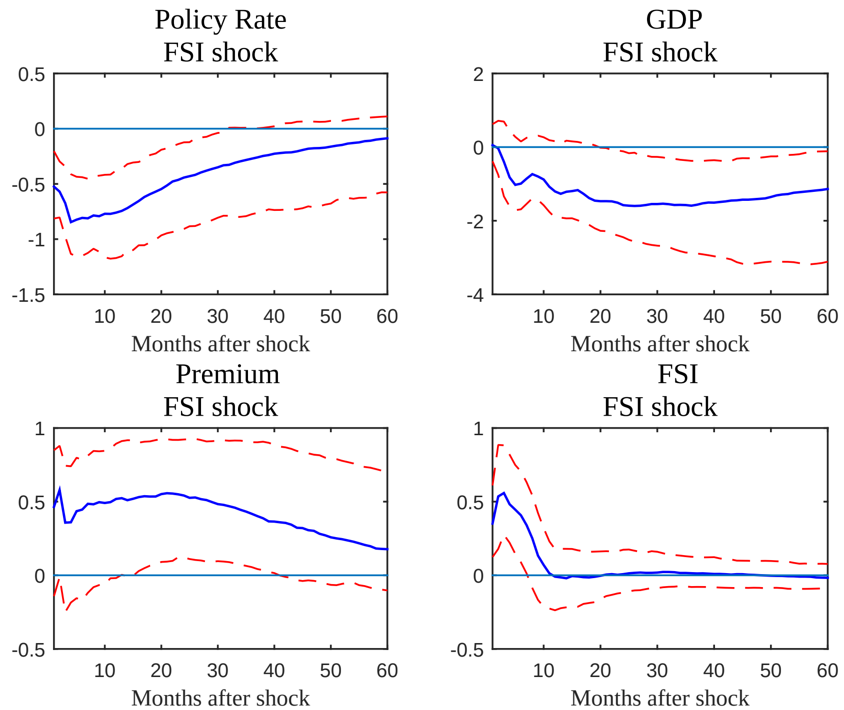

Figure 25: Greece FSI shock

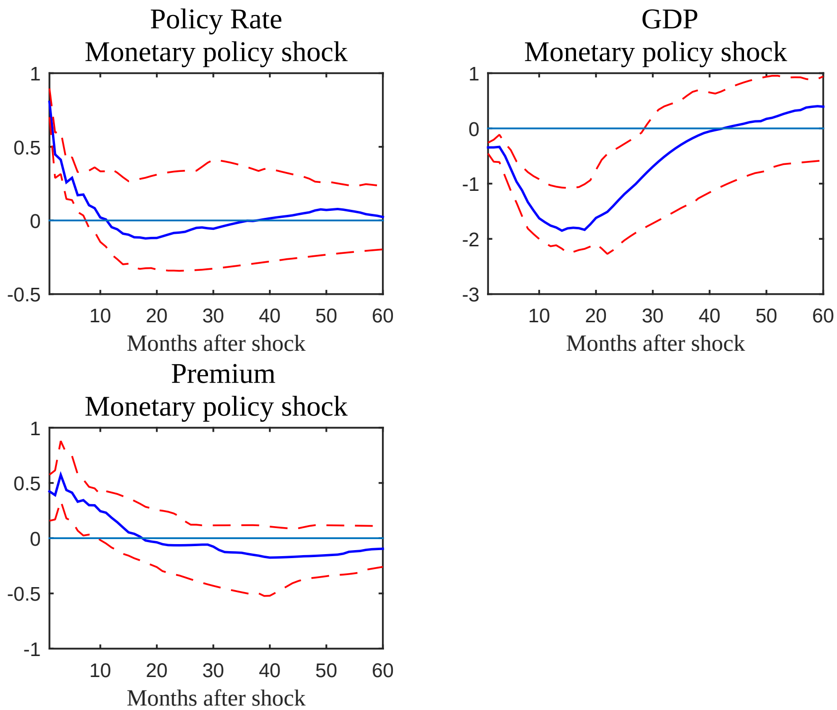

Figure 26: Italy without FSI policy shock

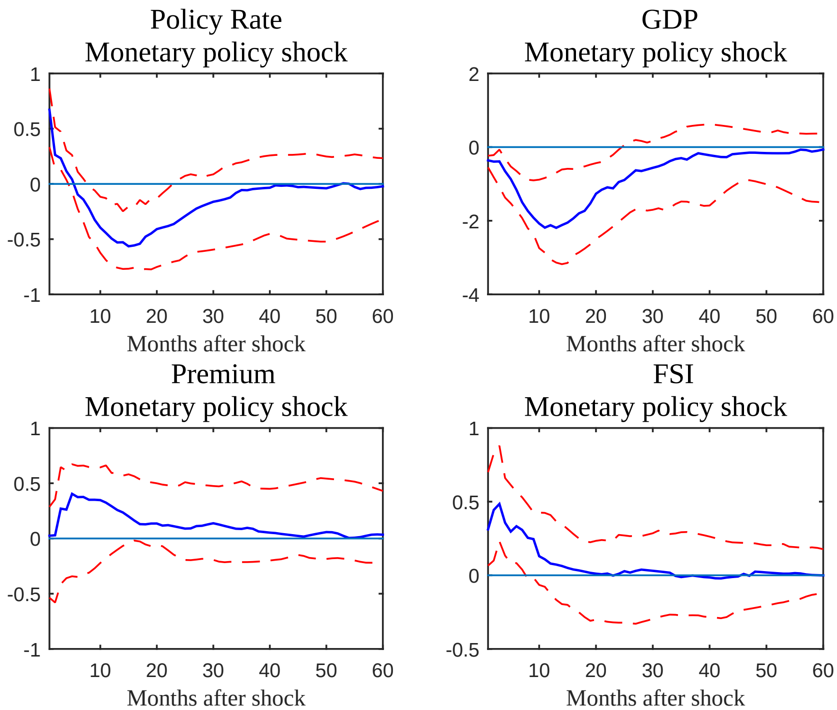

Figure 27: Italy with FSI policy shock

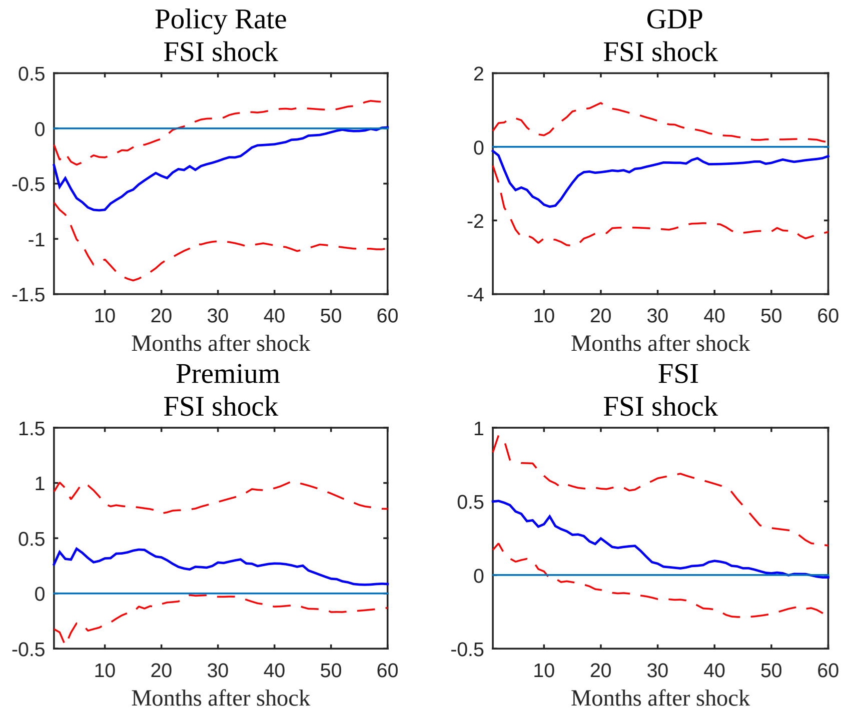

Figure 28: Italy FSI shock

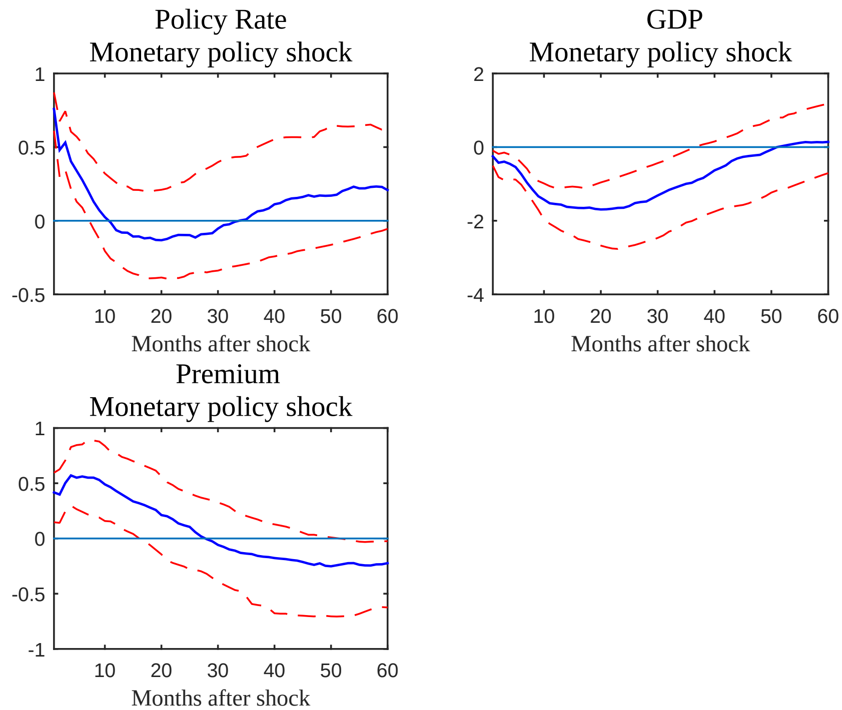

Figure 29: Portugal without FSI policy shock

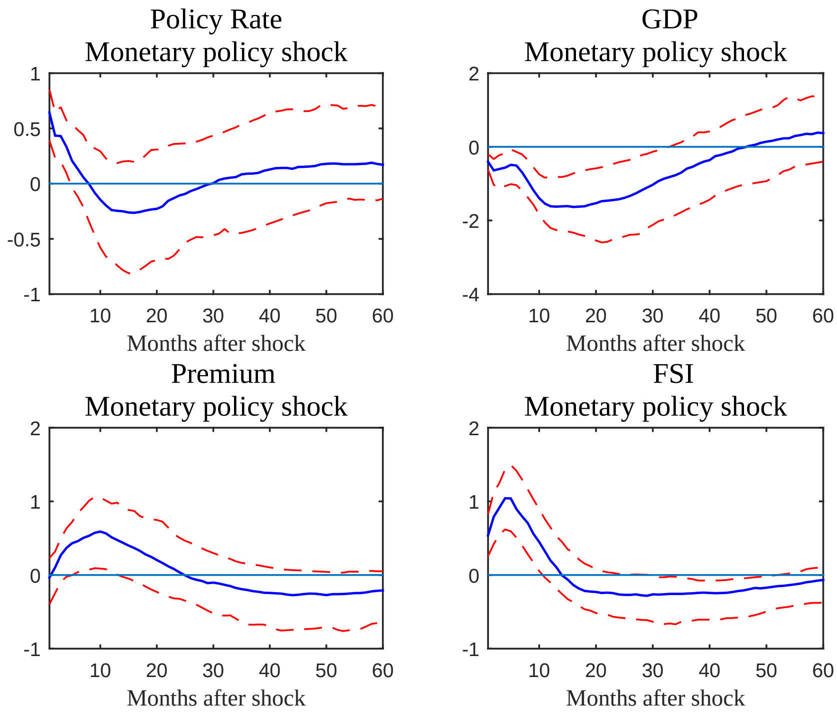

Figure 30: Portugal with FSI policy shock

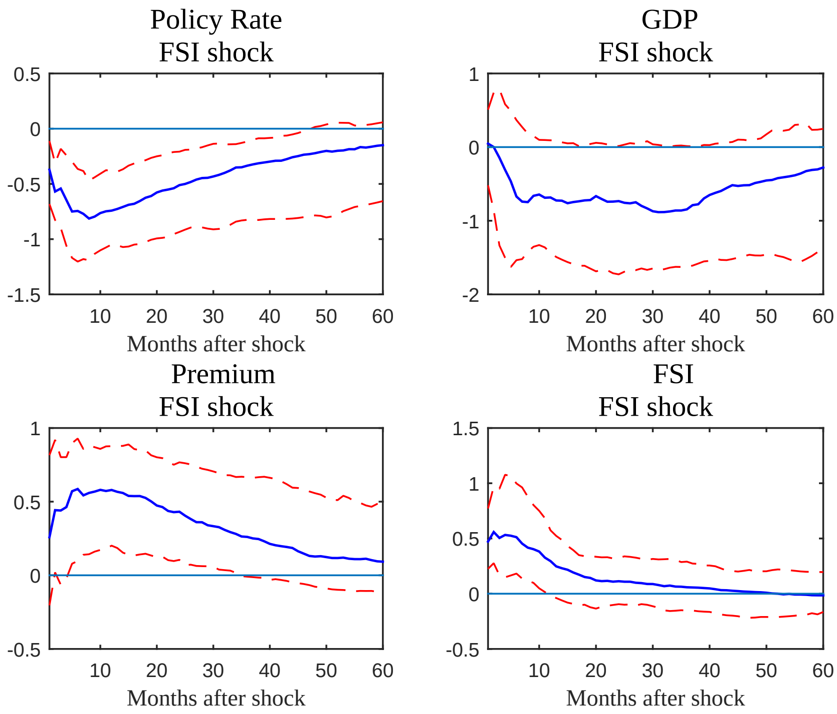

Figure 31: Portugal FSI shock

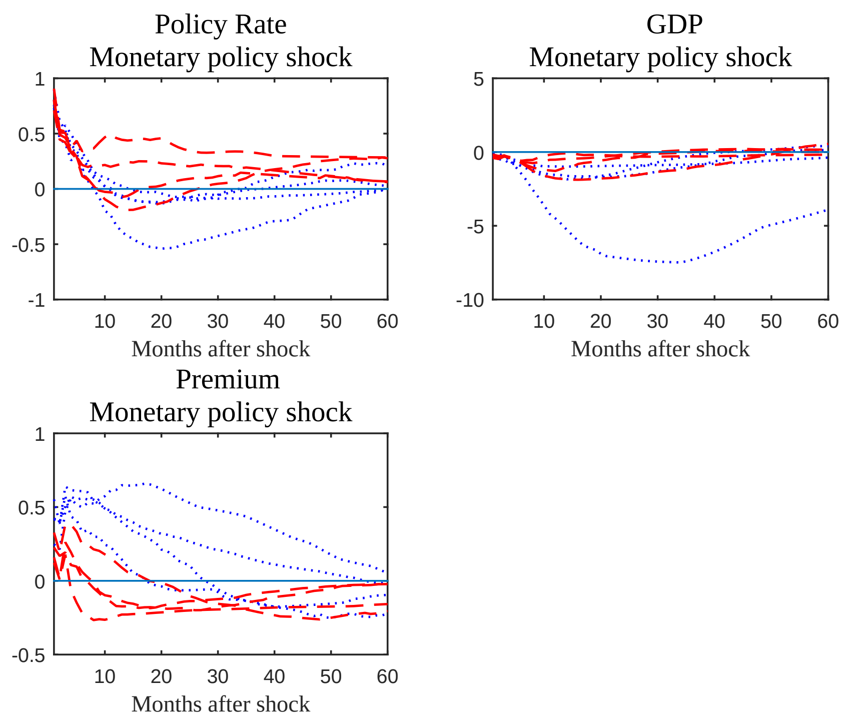

Figure 32: Comparison countries wihtout FSI policy shock

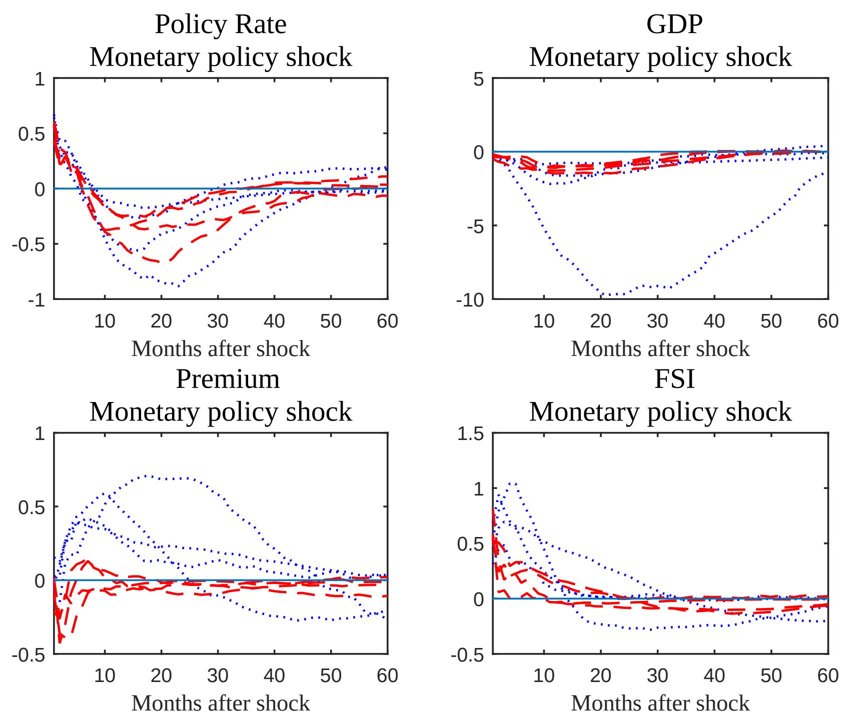

Figure 33: Comparison countries with FSI policy shock

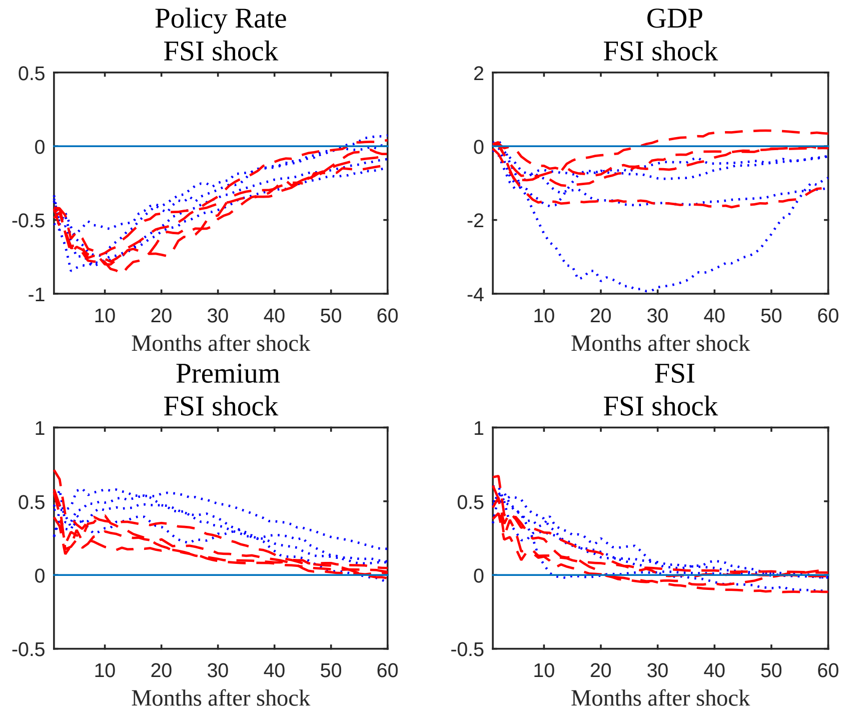

Figure 34: Comparison countries FSI shock

6.2 Figures

References

Adrian, T. & Shin, H. S. (2010). Liquidity and leverage, *Journal of financial intermediation* **19**(3): 418–437.

Angelopoulou, E., Balfoussia, H. & Gibson, H. D. (2014). Building a financial conditions index for the euro area and selected euro area countries: what does it tell us about the crisis?, *Economic Modelling* **38**: 392–403.

Bernanke, B. S. & Gertler, M. (1995). Inside the black box: The credit channel of monetary policy transmission, *The Journal of Economic Perspectives* **9**(4): 27–48.

Bernanke, B. S., Gertler, M. & Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework, *Handbook of macroeconomics* **1**: 1341–1393.

Burke, J. V. (2014). Assessing leverage in the financial sector through flow data.

Canova, F. & De Nicolo, G. (2002). Monetary disturbances matter for business fluctuations in the g-7, *Journal of Monetary Economics* **49**(6): 1131–1159.

Christiano, L. J., Eichenbaum, M. & Evans, C. L. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy, *Journal of political Economy* **113**(1): 1–45.

Gertler, M. & Karadi, P. (2011). A model of unconventional monetary policy, *Journal of monetary Economics* **58**(1): 17–34.

Gertler, M., Kiyotaki, N. et al. (2010). Financial intermediation and credit policy in business cycle analysis, *Handbook of monetary economics* **3**(3): 547–599.

Giannetti, M. & Laeven, L. (2012). The flight home effect: Evidence from the syndicated loan market during financial crises, *Journal of Financial Economics* **104**(1): 23–43.

Hollo, D., Kremer, M. & Lo Duca, M. (2012). Ciss-a composite indicator of systemic stress in the financial system.

Peersman, G. & Smets, F. (2003). The monetary transmission mechanism in the euro area: evidence from var analysis, *Monetary policy transmission in the Euro area* pp. 36–55.

Smets, F. & Wouters, R. (2003). An estimated dynamic stochastic general equilibrium model of the euro area, *Journal of the European economic association* **1**(5): 1123–1175.

Smets, F. & Wouters, R. (2007). Shocks and frictions in us business cycles: a bayesian dsge approach, *The American Economic Review* **97**(3): 586–607.

Uhlig, H. (2005). What are the effects of monetary policy on output? results from an agnostic identification procedure, *Journal of Monetary Economics* **52**(2): 381–419.

Wu, J. C. & Xia, F. D. (2014). Measuring the macroeconomic impact of monetary policy at the zero lower bound, *NBER Working Paper* (w20117).