LISBON SCHOOL OF ECONOMICS AND MANAGEMENT

M. Sc. MONETARY AND FINANCIAL ECONOMICS

The Monetary Transmission Mechanism in the Euro Area: has it changed with the EMU? A VAR approach with fiscal policy and financial stress considerations

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May 2014

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Abstract

We study whether the adoption of the euro and a single monetary policy have brought about a change in the monetary transmission mechanism and in the interactions of monetary policy, fiscal policy and financial stress in the euro area. We find that the stylized facts of monetary transmission remain valid but the response of output and, mainly, the fiscal and financial stress variables to a monetary policy shock seem to be stronger in the post-EMU period. These changes may signal a higher degree of synchronization of the euro area countries' economies after the adoption of the euro. Regarding fiscal and financial stress shocks, the inclusion in the post-EMU period of the subprime and sovereign debt crises yields changes not only in the scale but also in the patterns of the responses of our model's main variables. Overall, we conclude that the subprime and sovereign debt crises have contributed markedly to the post-EMU impulse response functions and, if those periods of financial turbulence are excluded, the responses of the macro variables to monetary, fiscal and financial stress shocks in the post-EMU period are of a remarkably small magnitude.

JEL codes: E42, E44, E52, E58, E63

Keywords: monetary transmission mechanism, fiscal policy, financial stress, euro area, vector autoregressions

Contents

1. Introduction

In December 31st 1998 the conversion rates between 11 participating national currencies and the euro were fixed. In the following day, January 1st 1999 the euro became the official currency of 11 countries in Europe[1] and a single monetary policy was introduced under the authority of the European Central Bank (ECB).

Adopting the euro as a single currency was a culmination point of several decades of economic and financial integration between European countries and marked the third and final stage of the Economic and Monetary Union (EMU).[2]

However, since the beginning of the process leading to the establishment of a single currency in Europe there have been extensive discussions on whether a single monetary policy would be suitable for the countries that adhere to the euro, considering their differences in economic, financial and social structures.

For some time such fundamental discussions took place mostly amongst academic and political circles in Europe and also the USA. However, with the recent advent of the sovereign debt crisis in Europe after the 2008-2009 subprime crises, the discussion is ever more present in the common European citizen's everyday talk. Therefore, the referred culmination point may not be the final word on monetary integration in Europe and further developments are to be expected.

One of the fundamental aspects of the euro is the existence of a single monetary policy for the euro area conducted under the authority of the ECB. The monetary transmission mechanism (MTM) is the process through which monetary policy affects

[1] The eleven founding countries of the Euro were: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain. Since then other countries have adopted the euro: Greece joined in 2001, Slovenia in 2007, Cyprus and Malta in 2008, Slovakia in 2008, Estonia in 2011 and Latvia in 2014.
[2] For historical perspectives on the economic and monetary integration in Europe see, among others, Apel (1998) and Ungerer (1997).

real variables and prices in the economy and thus the understanding of this mechanism is pivotal in examining the single monetary policy under the ECB.

It is now 15 years since the adoption of the euro and 12 years since the entry in circulation of the euro coins and banknotes.[3] With the benefit of hindsight we will try to assess whether the adoption of a single monetary policy has brought about a change in the MTM of the euro area. Our perspective is euro area wide and we will use a quarterly data sample from 1987Q1 to 2011Q4 to study the transmission mechanism pre and post euro. The methodological approach will be a vector auto regression (VAR) model.

Furthermore, having in mind the impact of the subprime financial crisis and the sovereign-debt crisis in the euro area in the more recent years, we study at a macro-level the interactions between monetary policy, fiscal policy and stress in the financial sector for the area as a whole.

The rest of the paper is structured as follows: section 2 presents the related literature; section 3 reviews the econometric framework; section 4 presents the data, the variables and the empirical results and section 5 concludes.

2. Related literature

2.1. Monetary Transmission Mechanism related VARs

The process of establishing a single currency in Europe has, since its beginning, generated ample discussions among economists on whether a single monetary policy would be suitable for the countries that adhere to the euro and what could be the impacts of such a single policy. The economic literature on the MTM in Europe can be divided in two main approaches. One approach focuses on the MTM of the individual countries

[3] For the first three years the euro was only used for accounting purposes and did not have a physical existence. The euro coins and banknotes were introduced in 1 January 2002.

of the euro area, i.e., on a country by country basis. Other studies follow an area wide perspective, i.e., they study the transmission mechanism of the euro area as a whole. Both approaches have been used to analyze the transmission mechanism prior and after the stage three of the EMU.[4]

In 1999 the ECB launched a research initiative to study the transmission of monetary policy in the euro area. Angeloni et al. (2003a) have an overall compilation of several papers that were produced with this aim and in Angeloni et al. (2003b) a complete summary and discussion of the main findings is provided.

Following the ECB's initiative, around the turn of the century several authors focused their research on uncovering the stylized facts of the MTM in Europe and, in some cases, attempted to envisage the consequences for such mechanism of a single monetary policy. For instance, Mojon and Peersman (2003), following a country by country approach, find that the effects of monetary policy on GDP and prices were broadly similar in the individual countries of the euro area. This indicates that monetary policy transmission might be similar between those countries before the EMU. Guiso et al. (1999) focus on whether a common monetary policy for the euro area would have asymmetrical effects in the different countries and have a good literature overview on the topic. They report some significant differences across countries in several indicators that may matter for monetary transmission, even if no definitive conclusion seemed to be possible at the time. Peersman (2004) provides a comprehensive review of the pre-EMU literature on cross-country comparisons.

Smets and Peersman (2003), following an area wide approach, find that a temporary rise in the nominal and real short-term interest rate tended to be followed by a real

[4] Other branches of literature focus on different specific channels of the monetary transmission mechanism. These are out of the scope of this paper. For good reviews of the literature related to different transmission channels see, for instance, Boivin et al. (2010) and Weber et al. (2009).

appreciation of the exchange rate, a temporary fall in output and that prices seemed to be more sluggish and only started to fall significantly below zero several quarters after GDP. Reassuringly, these results were very similar to those obtained for the US economy using similar methodologies.

In recent years researchers have begun to assess monetary policy by the ECB, that is, the single monetary policy in the euro area after 1999. This has been possible because the common monetary policy in the euro area is now about 15 years old, therefore, using the latest available data, econometric studies based on time series are now starting to become more robust.

Weber et al. (2009) investigate if there has been a significant change in the overall MTM by estimating a standard VAR for the euro area and by endogenously searching for possible break dates. They report a significant break point around 1996 and some evidence for a second one around 1999 concluding that monetary transmission after 1998 is not very different from before 1996, but probably very different compared to the interim period of 1996 - 1999, indicative of a possible period of adjustment prior to the euro. Moreover, they find that the stylized facts of monetary policy transmission remain valid. Boivin, Giannoni and Mojon (2009) report important heterogeneity across countries[5] in the effect of monetary shocks before the launch of the euro and conclude that the creation of the euro has contributed to a greater homogeneity of the transmission mechanism across countries and an overall reduction in the effects of monetary shocks.

In the past couple of years various authors included in their analysis the subprime crisis period and, in some instances, the more recent sovereign debt crisis. However,

[5] The authors constructed a FAVAR using data from the six largest countries of the euro area.

these analyses are mostly focused on the effects of the unconventional monetary policy measures which have been taken since.[6]

Tables 1 and 2 present a brief systematic summary of the empirical literature on the MTM pre and post-EMU. We identify the period of the analysis, the sample, the methodology, the variables included in the empirical models and, finally, the main conclusions.

Regarding methodology, the seminal work of Sims (1980) was the precursor of the use of VAR models for the analysis of monetary policy and these models have been and still are a widely used framework to study the MTM. VAR models provide an empirical method of capturing the dynamic relations between economic variables (time series) without the need to impose rigid identification restrictions. This characteristic of the framework allows for more flexibility and less *a priori* theorization.

[6] See, in this respect, for instance, Peersman (2011), Giannone et al. (2011) and Giannone et al. (2012).

Table 1 – Related literature overview (pre-EMU sample)

	Authors	Data frequency / Period	Sample	Methodology	Variables	Main conclusions
Pre-EMU:	**Guiso, Kashyap, Pannetta, Terlizzese (1999)**	The study was centred on cross-country microeconomic data of June 1999.	UK, Germany, Italy, France, Spain, Netherlands, Belgium	n/a *- the authors conduct a mainly descriptive discussion based on microeconomic data from 7 selected countries.*	13 microeconomic variables, including: - employment protection indicator - capital output ratio - fraction of financing that is short term - exports outside EU-15 relative to GDP - firms' leverage - household indebtness - market capitalization relative to GDP - average bank size	The authors assess whether what appears to be large structural differences in the economic and financial structures of the various countries can lead to differences in the transmission mechanism. They find significant differences across countries in several indicators that may matter for monetary transmission, therefore assymetries may be in place for several years. However, no definitive conclusions can be made and several gaps remain to be filled, namely with relation to how countries would respond to the same temporal sequence of monetary policy shocks, holding fixed the exchange rate among them.
	Peersman, Smets (2003)	quarterly data 1980:Q1 - 1998:Q4 lags=3	Euro Area (area wide)	**VAR** *- variables in levels* *- shocks identification: Choleski [the authors test for alternative identification schemes: Sims e Zha (1998); Gali (1992)]* *- the authors conduct Chow tests for instability at the model after 1990:Q1.*	4 endogeneous variables: - real GDP - consumer prices - domestic nominal short-term interest rate - real effective exchange rate 3 exogenous variables: - world commodity price index - US real GDP - US nominal short-term interest rate	The authors show that the overall macroeconomic effects of a monetary policy shock in the euro area are very similar to those estimated for the US and are stable over time. They also examine how various real and financial variables (GDP components, monetary variables, asset prices, labour market variables) respond to an area-wide impulse.
	Mojon, Peersman (2003)	quarterly data 1980:Q1 - 1998:Q4 lags=2 or 3	Germany; Austria, Belgium and Netherlands; Finland, France, Greece, Ireland, Italy and Spain	**VAR** *- variables in levels* *- three identification schemes are used, depending on each country monetary integration with Germany (which is considered the nominal anchor of the ERM).*	4 endogeneous variablesl: - real GDP - consumer prices - domestic nominal short-term interest rate - real effective exchange rate 3 exogenous variables: - world commodity price index - US real GDP - US nominal short-term interest rate	The authors find that the hypotheses that the effects of monetary policy on GDP and on prices are broadly similar in the individual countries of the euro area cannot be rejected. In every country they find that an unexpected rise in the short-term interest rates leads to a decrease in GDP and a gradual decrease in prices, however there is some heterogeneity in the size of the effects.
	Ciccarelli, Rebucci (2006)	monthly data 1980:M1 - 1998:M12	Germany, France, Italy, Spain	**VAR** *(bayesian estimation)* *- two steps:* *1) measuring monetary policy through a time-varying SVAR;* *2) modeling the transmission mechanism through a time-varying VAR.*	**1) SVAR:** endogenous variables: - short term interest rates of the 4 countries exogeneous variables: - (inflation - target inflation) - (output - target output) - (nominal exchange rate - target nominal exchange rate) - Δ index of commodities price; - Δ M3; - US short term interest rate **2) VAR:** endogenous variables: - nominal exchange rate of ECU - germany interest rate - spread over Germany money market interest rate exogeneous variables: - commodity prices; - US output index	The authors study, for the pre-EMU period, the transmission mechanism of a common, homokedastic monetary policy shock, identified as an innovation to the reaction function of the Bundesbank, in Germany, France, Italy and Spain. They find that the long-run cumulative impact on output of a common, homoskedastic monetary policy shock has decreased in all countries after 1991. At the same time, cross-country differences in the effects of this shock have not decreased over time. The authors conclude that the transmission mechanism of European monetary policy is probably changing over time, albeit slowly and in all countries at the same time.

Table 2 – Related literature overview (including post-EMU sample)

	Authors	Data frequency / Period	Sample	Methodology	Variables	Main conclusions
Post-EMU:	**Weber, Gerke, Worms (2009)**	quarterly data 1980:Q1 - 2006:Q4 lags=2	Euro Area (area wide)	**VAR** *- variables in levels* *- shocks identification: Choleski; sign restriction [Uhlig (2005)];* *- breakpoint tests: Chow tests; Ploberger, Kramer, Kontrus fluctuation test.*	4 endogeneous variables: - real GDP - GDP deflator - indicator of real housing wealth - domestic nominal interest rate (3M) (inclusion of long term interest rate and money does not improve model) 2 exogenous variables: - non-oil commodity price index - US short term interest rate	The authors approach is to identify break dates in the Monetary Transmission Mechanism (MTM) of the Euro Area, independent of specific causes and then checking whether MTM as a whole has changed. The authors find two break points, one in 1996, another in 1999. The MTM in 1980-1996 is similar to the one in 1999 - 2006. There seems to have been an atypical interim period in 1996 - 1999. The comparisons on MTM are made first by visually comparing the Impulse Response Functions and then by estimating an extended VAR with period dummy and conducting tests for the coefficients of the dummys.
	Boivin, Giannoni, Mojon (2009)	quarterly data 1980:Q1 - 2007:Q3 lags=3	Euro Area (area wide) + 6 individual countries (biggest countries)	**FAVAR** *- the authors transform the series - they use y-o-y growth rates of all time series, except interest rates, unemployment and capacity utilization which are in levels.*	33 economic variables for each country and the euro area, including: - two interest rates, M1 and M3; - effective exchange rates; - index of stock prices - GDP, deflator, PPI, CPI - unemployment rate - hourly earnings, capacity utilization, retail sales and: - interest rates for USA, Japan and UK; - EUR/USD exchange rate; - index of commodity prices and the price of oil.	The authors find important heterogeneity across countries in the effect of monetary shocks before the launch of the euro. The creation of the euro has contributed to: 1) a greater homegeneity of the transmission mechanism accross countries; 2) an overall reduction in the effects of monetary shocks.
after subprime:	**Cecioni, Neri (2011)**	monthly data: Pre-EMU: 1994:M1 - 1998:M12 Post-EMU: 1999:M1 - 2007:M7 and 1999:M1 - 2009: M9 (*post EMU sub-samples to test for subprime effects*) lags=4 quarterly data (*to assess robustness of results*): 1989:Q1 - 2009:Q2 lags=3	Euro Area (area wide)	**SVAR** and **DGSE** (bayesian estimation) *- variables in levels* *- shocks identification: recursive (Choleski); Sims e Zha (1999); sign restrictions [Uhlig (2005)].*	SVAR: 6 endogeneous variables: (monthly) - industrial production - HICP - EONIA; - M2 - commodities prices - nominal effective exchange rate 6 endogeneous variables: (quarterly) - real GDP - GDP deflator - 1 month interest rate; - M2 - commodities prices - nominal effective exchange rate	The autors do not search for structural breaks in the data, they assume that such a break may have ocurred in 1999:M1 with the creation of the EMU. They find: - SVAR: The effects of a monetary policy shock on output and prices have not significantly changed over time. Also there are no significant differences before and after the burst of the subprime turmoil. The authors claim that this cannot be the final word on the evolution of the MTM as changes in the conduct of monetary policy and the structure of the economy may have offset each other giving rise to similar responses of output and inflation to monetary policy shocks between the two periods. - DGSE: monetary policy has become more effective in stabilizing the economy as the result of a decrease in the degree of nominal rigidities and a shift in monetary policy towards inflation stabilization.
	Peersman (2011)	monthly data 1999:M1 - 2009:M2 lags=4	Euro Area (area wide)	**SVAR** (bayesian estimation) *- variables in levels* *- shocks identification: zero and sign restrictions* *- breakpoint tests to test for stability: Quandt-Andrews, CUSUM, Chow.*	6 endogeneous variables: - industrial production - HICP - volume of bank credit - monetary base - level of interest rate on credit - level of the monetary policy rate	Macroeconomic effects of unconventional monetary policies (characterized by increasing the size of balance sheet or the monetary base) are similar to the effects obtained through innovations of interest rates. However, the transmission mechanism is different in terms of timings, interest rate spreads and credit multipliers.
	Giannone, Lenza, Phil, Reichlin (2011)	monthly data . 1991:M1 - 2008:M8 *(pre-subprime crisis to estimate model and study stilized facts)* . 1999:M1 - 2010:M3 *(based on the previous time sample, the authors estimate previsions for this second sub-sample)* lags=13	Euro Area (area wide)	**VAR** (bayesian estimation) *- variables in levels.*	39 variables, including: - macroeconomic, financial, monetary and credit variables plus a set of variables from the US to capture international linkages. (*for more detail please see table 1, pp. 6 of Giannone, Lenza, Reichlin (2012)*)	During the financial crisis 2007-2010 the ECB not only cut interest rates significantly but also introduced a package of non-standard monetary policy measures, intended to complement standard interest rate decisions, and not substitute them, with the aim to insure the effectiveness of the monetary transmission mechanism. The authors conclude that non-standard monetary policy measures introduced by the ECB following Lehman's demise were successful in insulating, at least in part, the liquidity and credit conditions facing households and firms from the breakdown of financial intermediation seen in the interbank money market in late 2008, thus the stylised facts of the monetary transmission mechanism were observed.

2.2. Fiscal policy, monetary policy and financial instability

The effects of monetary policy on macroeconomic aggregates have been broadly studied mainly using VAR frameworks or the New Keynesian DSGE models and some stylized facts have been identified as we mentioned previously. Particularly for the euro area, researchers have then turned their focus to the impact of the EMU on those stylized facts, and, more recently, on the functioning of the different transmission channels during the subprime and the sovereign debt crisis and the effects of the unconventional monetary policy response to the crises.

Conversely, when it comes to the effects of fiscal policy on macroeconomic aggregates there are no stylized facts, i.e., there are no facts which are broadly agreed upon. The difficulties start on the basics: how to distinguish between a change in revenues and expenditures caused by the automatic stabilizers and a deliberate fiscal policy change. Afonso et al. (2011) have a comprehensive review on the fiscal policy' VAR related literature and they point out the different results that often arise when different identification schemes are used and also in cross-country samples.

For instance, Afonso et al. (2011) use a Threshold VAR to study the effects of fiscal policy in high financial stress regimes and low financial stress regimes. They find that the response of economic growth to fiscal shocks are generally positive in both financial stress regimes and that financial stress has a negative effect on output growth and it increases the government debt-to-GDP ratio. Their country sample[7] also point that the initial conditions, such as, the existence of financial stress, the diverse levels of government indebtedness and the implicit monetary policy, are relevant to determine the nonlinearities that were found regarding the effects of a fiscal shock on economic activity.

[7] They estimate a TVAR for the US, UK, Germany and Italy.

The interactions between financial system stress and monetary policy are also relevant. Stress in the banking sector, stock markets and exchange rate markets may play important roles in the transmission of monetary policy shocks.[8] For example, Baxa et al. (2013) conclude that central banks when faced with high financial stress often alter the course of monetary policy mainly by decreasing the interest rates and that the size of the response varies overtime as well as across countries.[9] They also report some cross-country heterogeneity regarding the effects of specific types of financial stress.

3. Econometric framework

To analyze the effects of a monetary policy shock in the euro area we use a VAR model with the following representation:

$$[1] \qquad Z_t = A(L)Z_{t-1} + \mu_{t,}$$

where Z_t is the vector of endogenous variables and u_t is the vector of serially uncorrelated disturbances that have a zero mean and a time invariant covariance matrix. *A(L)* denotes a polynomial matrix in the lag operator. We also include a constant in the model.

The vector of endogenous variables in our benchmark model consists of six euro area variables: real GDP growth (y_t), inflation (p_t), annual change in the debt-to-GDP ratio (f_t), long-term nominal interest rate (l_t), short-term nominal interest rate (i_t) and a financial stress indicator (s_t):

$$[2] \qquad Z_t' = [y_t \quad p_t \quad f_t \quad l_t \quad i_t \quad s_t].$$

[8] In the case of the exchange rate, they may be more relevant for open economies than for a big and relatively closed economy as the euro area.

[9] Their sample includes the US, UK, Australia, Canada and Sweden.

The inclusion of a debt sustainability indicator (proxied by the debt-to-GDP ratio) and a measure of financial stress, although not common in the monetary policy VAR related literature, will hopefully allow us to incorporate in the dynamics of our model two variables that historically, and possibly more markedly in (recent) times of economic and financial distress, may influence the monetary transmission mechanism.[10]

We identify the monetary policy shocks by assuming a recursive (Choleski) structure. The variables are ordered as in [2] which reflect some assumptions about the links between the economic variables. Specifically, we assume that the monetary policy shocks (i.e., the changes in short-term nominal interest rate – i_t) do not have a contemporaneous impact on output, prices, debt-to-GDP ratio and long term interest rates but may affect contemporaneously the financial stress indicator. On the other hand, the policy interest rate does not respond to contemporaneous changes in the financial stress indicator. The ordering of the fiscal variable before output follows Afonso et al. (2011) and is justified by the need to identify the effects of the automatic stabilizers in the economy. The financial stress indicator is ordered last which implies it reacts contemporaneously to all variables in the system.

The lag length of the endogenous variables, Z_t, is an important aspect of the estimation procedure because if the lag length is too small the model may be wrongly specified and if it is too long degrees of freedom are being lost. The usual lag length selection criteria are presented on appendix A.3. The tests results indicate one lag for the Schwarz information criteria (SC) and two lags for Akaike (AIC) and Hannan-Quinn (HQ) information criteria. The Akaike criteria may overestimate the lags but the SC and HQ are consistent for small samples (Lutkepohl (2005)). We opt for one lag mainly because the limited number of observations in the pre and post-EMU sub-

[10] In this respect see, for instance, our literature reviews on Afonso et al. (2011) and Baxa et al. (2013).

samples could impair the estimation of a six variable VAR if more lags were considered.

4. Empirical analysis

4.1 The data and variables

We estimate the VAR model using quarterly data from 1987Q1 to 2011Q4. The source for the euro area wide macroeconomic time-series was the 12th update of the Area-Wide Model (AWM) database[11], except the government debt for the euro area which was retrieved from the Quarterly Fiscal database for the euro area.[12] The financial stress index that we use for the euro area is the Composite Indicator of Systemic Stress (CISS) proposed by Halló et al. (2012)[13], and the data was made available by the ECB. The time sample is limited due to data availability, specifically, the CISS time series only starts in 1987 and the data from the latest available update of the AWM database stops in 2011Q4.

For real GDP and the GDP deflator, we use the annual growth rates of the logs. For the debt-to-GDP ratio we use the annual change in the ratio. These transformations allow us to sidestep the known non-stationarity characteristics of the original levels variables. Real GDP, GDP deflator and debt-to-GDP ratio are seasonally adjusted. The

[11] For a description of the model and dataset see Fagan et al. (2001) and the respective statistical annex.
[12] For a description of the database please see Paredes et al. (2009). We use the Euro Area general government debt, and then calculate the debt-to-GDP ratio using the GDP provided in the AWM database. The resulting series has a very good match with the Eurostat debt-to-GDP ratio series for the euro area, available only with data after 2000Q1.
[13] The CISS is an indicator of contemporaneous stress in the financial system proposed by Halló et al. (2012). Its main goal is to "*measure the (...) current level of frictions, stresses and strains (or the absence of these) in the financial system and to condense that state of financial instability into a single statistic*" (idem). It is a composite indicator focused on the systemic dimension of financial stress, and comprises the five most important segments of an economy's financial system: bank and non-bank financial intermediaries, money markets, securities (equities and bonds) markets and foreign exchange markets. For more details on the construction of the CISS please refer to Halló et al. (ibidem).

monetary policy instrument is a three month nominal interest rate, as in Fagan et al. (2001). For CISS we computed the quarterly averages of weekly values.[14]

4.2 Overview of macroeconomic, monetary, fiscal and financial developments[15]

The average year-on-year growth rate of real GDP for the euro in our sample was 1,9%. During these 25 years there were two very marked recessions, the first one in 1993 and the second and deeper recession in 2008 - 2009. Also, smaller growth rates were observed in 2002 - 2003 and after the second quarter of 2011.

Regarding the annual change in the GDP deflator (our proxy for inflation) and the long and short term interest rates, there has been a change in the levels of these variables, in the sense that during the 90s there was a decrease in the values from the considerable high levels observed in the end of the 1980s to more or less stabilized lower levels from 1998 onwards.

The debt-to-GDP ratio for the euro area has increase at a steady pace from just below 60% in 1987 to around 75% in 1996. From 1996 to 2008 the ratio has declined somewhat, having attained a level of 67% in that year. After 2008, and related notably to the governments answer to the subprime crisis and also the need to capitalize the banking sector, there was a very sharp increase in the debt-to-GDP ratio, which in the end of 2010 had already climbed to 86% of GDP. During 2011, the ratio continued its increase, albeit at a slower pace, having closed the year at 88%.

Finally, concerning the Composite Indicator of Systemic Stress - our financial stress variable – we can observe a prolonged period of very high stress in the euro area from 2007Q3 until the end of our sample in 2011Q4 (with slight improvements in 2010Q3 and 2010Q4). The very high financial stress in this period is, on the one hand, due to the

[14] In Appendix A.1 we present in a systematic manner all the data and sources.
[15] In Appendix A.2 we present the graphical representation of the time series of our variables.

subprime crisis, whose first signs appeared during 2007 - namely with the decision by BNP Paribas in the 9th of August 2007 to stop the redemptions of three funds by BNP Paribas due to the subprime problems - and was compounded by the failure of Lehman Brothers in the 15th of September 2008, resulting in the highest historical levels of the CISS in 2008Q4 and 2009Q1. On the other hand, from the end of 2009 onwards, the high levels of financial stress are mainly justified by the sovereign debt crises in Europe that followed the subprime crises. The first signs appeared on the yields of the Greece sovereign bonds whose rise led to the financial assistance program to Greece by the IMF, the European Commission and the ECB (the "Troika") in May 2010. Afterwards, there was also the financial assistance program to Ireland in November 2010 and another to Portugal in May 2011. Apart from the very high periods of stress after 2007, the rest of our sample has some other episodes of increased financial stress, albeit at comparatively lower level, including the European Exchange Rate Mechanism crisis in 1992, the Russian crisis in 1998-1999 and a period of increased stress in 2001 following the events of the 9th of September.

4.3 Empirical results

We are interested in investigating whether there have been changes in the MTM associated with the adoption of the Euro and in the interactions between monetary and fiscal policy. To that end we consider two balanced sub-samples. The first sub-sample refers to the years prior to the adoption of the euro and goes from 1987Q1 to 1998Q4. The second sub-sample includes post-euro adoption years – 1999Q1 to 2011Q4. The aim is to inspect the respective impulse response functions (IRFs) and detect any differences that may exist between them.[16]

Furthermore, we also explore the relevance of additional sub-samples, namely, a subprime and a sovereign debt crisis sub-sample. To do so we exclude from the post-EMU sub-sample the final years - which correspond to the periods of these two crises.

Our VAR model includes two macroeconomic policy variables – the interest rate and the debt-to-GDP ratio – and a financial stress variable. Therefore, it can be used to study the interactions of fiscal and monetary policy, on the one hand, and of these two macro variables with financial stress, on the other hand. It is possible to study these interactions in our framework basically by analyzing the impact of monetary shocks on the fiscal variable and the impact of fiscal shocks on the interest rate and also the impact of financial stress in both variables (as well as in all the other non-policy related variables in our VAR).

4.3.1 The effects of interest rates shocks

The complete set of responses of the variables to the (negative) monetary shock, for all sub-samples, is shown in appendix A.4. The solid line depicts the median response estimate and the dashed lines the two-standard error confidence intervals. For all sub-samples considered, the one-standard deviation monetary policy shock is estimated to be around 30 basis points, which is in line with the estimate obtained by Peersman and Smets (2003).

[16] We implicitly assume that the adoption of the euro in 1999Q1 may be a cause for a structural break in the monetary transmission mechanism. Another approach would be to test the data for the existence of such a break, as done by Weber et al. (2009), but our short time-sample limits the robustness of econometric testing for structural breaks.

Comparing the pre-EMU and post-EMU sub-samples, we can observe a stronger response of the main macro-economic variables to a negative interest rate shock (i.e., a temporary increase in the short-term interest rate) in the post-EMU sub-sample. In particular, the output growth reacts more negatively in the first 8 to 10 quarters, and then the recuperation of output growth is done at a faster pace. Although there are differences in the amplitude of the output growth response, the time frames in which those responses develop don't seem to differ significantly between the two sub-samples - while in the pre-EMU sub-sample the output growth turns positive after around 14 quarters, in the post-EMU sub-sample such recovery occurs after 12 quarters.

As regards inflation, there seems to be a somewhat bigger price-puzzle[17] in the post-EMU sub-sample than in the pre-EMU sub-sample. The negative response of inflation to an increase in the interest rate seems to be of a similar scale, although in the pre-EMU period the response is somewhat more prolonged in time.

Concerning the response of the fiscal variable, we observe a much higher increase in the debt-to-GDP ratio after a negative interest rate shock in the post-EMU sub-sample than in the pre-EMU sub-sample. In fact, the increase in the annual change of the debt-to-GDP ratio in the second sub-sample more than doubles that of the first sub-sample. The same pattern holds for the financial stress response – a negative monetary policy shock has a much higher impact on the financial stress variable in the post-EMU sub-sample than in the pre-EMU sub-sample.

Overall, the changes in the responses of our VAR variables in the post-EMU sub-sample are more significant for the fiscal and financial stress variables than for output

[17] A price-puzzle is a price increase following an interest rate tightening, which is a widespread feature on VAR literature.

growth and inflation. These changes may be a consequence of a higher degree of synchronization of the euro area countries' economies after the adoption of the euro.

However, if we exclude from the post-EMU sub-sample the quarters after the beginning of the subprime crises, i.e., if our post-EMU sub-sample stops at 2007Q2, the IRFs are of a much smaller magnitude[18] and, also, there is a very considerable price-puzzle. As Peersman (2011) concluded, the policy response to the recession after the subprime crises seems to have improved the identification of conventional monetary policy shocks. In our paper we can further corroborate that this may have been the case because our sub-sample that excludes the sovereign debt crisis yields results that are much similar to the full sample results, therefore, it was the subprime crises' period, and not the sovereign debt crises' period that contributed to improving the identification of conventional monetary policy shocks.

4.3.2 The effects of fiscal shocks

The complete set of responses of the variables to the positive fiscal shock, for all sub-samples, is shown in appendix A.5. If we compare the period of 1987Q1 – 1998Q4 to the period of 1999Q1 – 2011Q4, the changes in the IRFs of our variables to a fiscal shock are substantial, not only in magnitude but also in the directions of the responses. For instance, the response of output growth to a positive fiscal shock in the second sub-sample is negative in the first few quarters, whilst such an answer is positive in the pre-EMU sub-sample.

[18] Boivin et al. (2009) also find an overall reduction in the effects of monetary shocks after 1999 using a sample that does not include the subprime crises (their sample stops in 2007Q3). They conclude that "their model predicts that by removing an exchange-rate risk through the monetary union, and by having a central bank more decisively focused on inflation and output stabilization, the impact of monetary disturbances on measures of economic activity has been reduced, as observed in the data".

These changes may be related to the governments' answer to the subprime recession – after the subprime crises there was a steep increase in governments' debt-to-GDP ratio and this increase was accompanied by a deep recession. This idea is supported by the following: if we look at the estimates of the one-standard deviation fiscal policy shock, we conclude that such a shock was estimated at around 0.3 percentage points (p.p.) in the pre-EMU period, but its estimate rose to more than 0.5 p.p. in the post-EMU sub-sample. However, if we exclude the subprime period (and the sovereign debt crises period) – i.e., if we consider the 1999Q1-2007Q2 sub-sample – the estimate of a one-standard deviation fiscal policy shock comes down to just over 0.2 p.p.. The lower than average real GDP growth and higher than average annual increase in debt-to-GDP ratio that characterizes the sovereign debt crises may also be importantly related to the change in direction of the output growth response to a fiscal shock.

In the pre-EMU sub-sample the long-term interest rate responds with a steady increase to a positive fiscal shock, while the short-term interest rate responds with a slight decrease in the first few quarters followed by a prolonged increase. In the pos-EMU sub-sample both the short-term and long-term interest rate responses are negative in the first few quarters and turn to slightly positive ground after about 15 quarters, albeit the scale of the fall and posterior rise of the short term interest rate is comparatively higher. Therefore, a positive fiscal shock seems to be followed by a steepening of the yield curve in the short run for both sub-samples.

4.3.3 The effects of financial stress shocks

The complete set of responses of the variables to the financial stress shock, for all sub-samples, is shown in appendix A.6. As expected the shocks are considerably higher in the post-EMU sub-sample if we include the subprime and the sovereign debt crisis period. In the full post-EMU sub-sample, the one-standard deviation financial stress shock is estimated at around 45 points, whilst for the pre-EMU and post-EMU except subprime sub-samples the estimates are similar, at around 30 points.

Concerning the IRFs to a financial stress shock, by construction, there is no contemporaneous impact on the variables of our model. Comparing the pre-EMU sub-sample with the 1999Q1 – 2007Q2 responses, there seem to be slight decreases in the magnitude of the responses of the macroeconomic variables in our model to a financial stress shock but the pattern of such responses remain the same – small temporary increases in the output growth and small temporary decrease in inflation followed by an also temporary increase.

On the contrary, if we include in the post-EMU sub-sample the period of the subprime crises (i.e., if we consider the period 1999Q1-2009Q4), there has been a clear change in the magnitude and pattern of responses, with the output growth responding in a strong and negative fashion to the shock and the debt-to-GDP responding with a strong increase in its annual change. Furthermore, including the sovereign debt crises period (i.e., considering the whole post-EMU period – 1999Q1 to 2011Q4) increases the negative response of output growth to the financial stress shock. Lastly, there is a positive response of the long term interest rate to a financial stress shock in any of the post-EMU sub-samples, which did not exist in the pre-EMU sub-sample.

4.4. Robustness check: an alternative pre-EMU sub-sample

Weber et al. (2009) found that there may have been a significant break point in the monetary mechanism period in the euro area around 1996 and some evidence for a second one around 1999, suggestive of an interim period from 1996Q2 to 1998Q4 of adjustment prior to the euro. Following that conclusion we estimate a VAR from

1981Q1 to 1996Q1 and the respective IRFs and then compare with the post-EMU sub-samples.

The bulk of our conclusions remain valid. However there is an interesting insight regarding the response of output growth to a fiscal shock. As it turns out, the alternative pre-EMU sub-sample yields a decrease in the output growth following a fiscal shock (albeit a small and temporary decrease), while the original pre-EMU sub-sample yielded a considerable positive and lasting response of real GDP growth to a fiscal shock. Still, the conclusion holds - the characteristics of the subprime and sovereign debt crises were the main drivers behind the changes in the responses of the macro variables to a fiscal shock.

5. Conclusions

The adoption of the euro and of a single monetary policy might have contributed to changing the monetary transmission mechanism and the interactions of monetary policy, fiscal policy and financial stress in the euro area.

Our results indicate that the stylized facts of monetary transmission remain valid but the response of output and, mainly, of the fiscal and financial stress variables to an increase in the short term interest rate seems to be stronger in the post-EMU period. These changes may be a consequence of a higher degree of synchronization of the euro area countries' economies after the adoption of the euro. However, if we exclude from the post-EMU period the subprime crises the sizes of the responses are quite smaller. Our results support Peersman (2011) conclusion that the policy response to the subprime recession seems to have improved the identification of conventional monetary policy shocks.

Regarding fiscal and financial stress shocks, the inclusion in our post-EMU sub-sample of the subprime and sovereign debt crises yields changes in the scale but also in the patterns of the responses of the main variables of our model. For instance, there is a very strong increase in the debt-to GDP ratio following a financial stress shock in the post-EMU period, while such a response was a negative in the pre-EMU period. Again, one important feature is the small magnitude of the IRFs of the post-EMU period when we exclude the subprime and sovereign debt crises.

Overall, we find that the subprime and the sovereign debt crises period have contributed markedly to the post-EMU impulse response functions and, if we exclude that period of financial turbulence from the post-EMU sample, the responses of our VAR variables to monetary, fiscal and financial stress shocks are of a remarkably small magnitude.

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Appendix

A. 1 - Data description and sources

Variables in the VAR model:

y_t GDP, annual growth rate of the log of the real GDP (Y) used: $y_t = log(Y_t) - log(Y_{t-4})$.

p_t Price level (P), annual growth rate of logs used: $p_t = log(Pt) - log(Pt_{-4})$.

l_t Long term interest rate.

i_t Short-term interest rate.

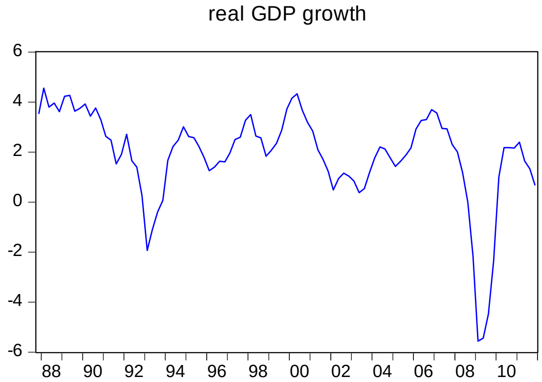
f_t Annual change in the debt to GDP ratio: $ft = F_t - F_{t-4}$.

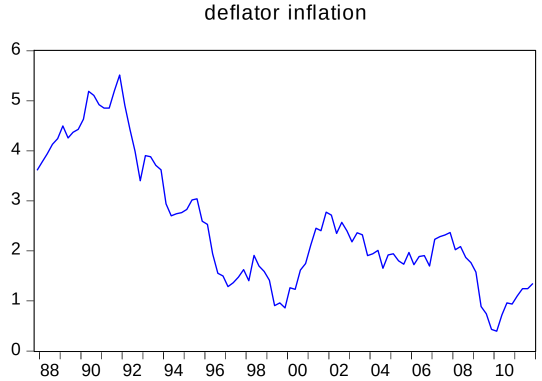
s_t Financial stress index (CISS), quarterly averages of weekly values.

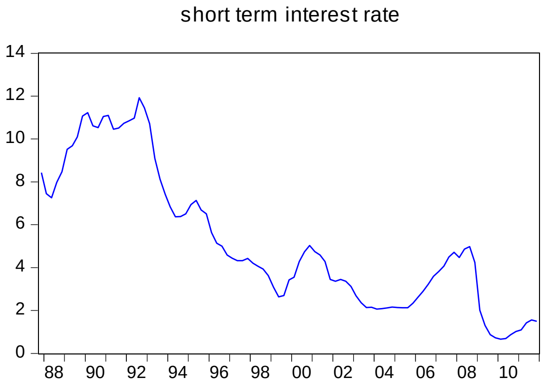
Sources:

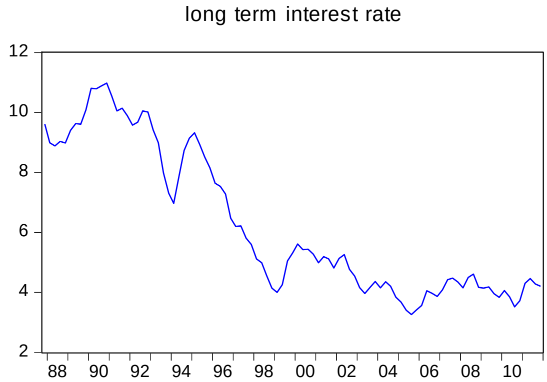
	Variables	Data Sources	Periodicidade	Time sample availabitlity	Seasonally adjusted?	Series ID
Euro Zone						
Y_t	GDP (real)	Area Wide Model Database - *12th update*	quarterly	1980Q1-2011Q4	*Yes*	YER
P_t	GDP deflator	Area Wide Model Database - *12th update*	quarterly	1980Q1-2011Q4	*Yes*	YED
l_t	Long term interest rate (nominal)	Area Wide Model Database - *12th update*	quarterly	1980Q1-2011Q4		LTN
i_t	Short term interest rate (nominal)	Area Wide Model Database - *12th update*	quarterly	1980Q1-2011Q4		STN
F_t	Debt/GDP	Quarterly Fiscal Database - ECB	quarterly	1980Q4-2012Q4	*Yes*	MAL
S_t	Composite Indicator of Systemic Stress	ECB	weekly	1987-2013		CISS

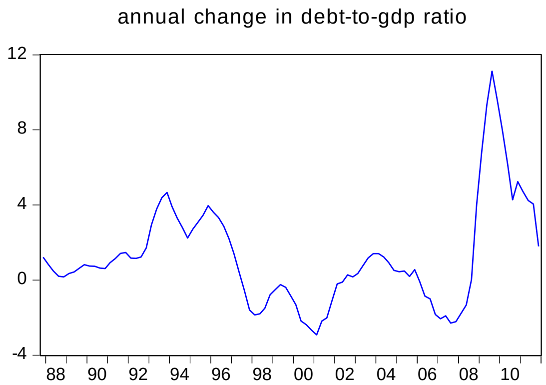
A. 2 – Data on the variables used in the VAR

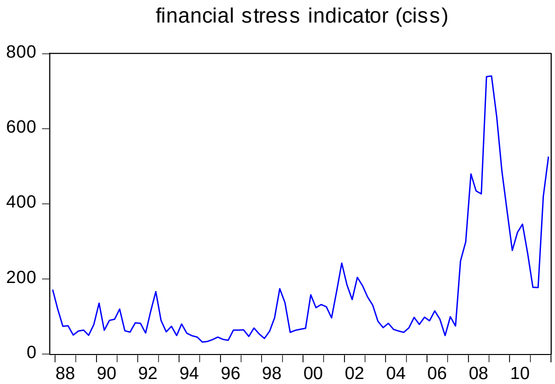




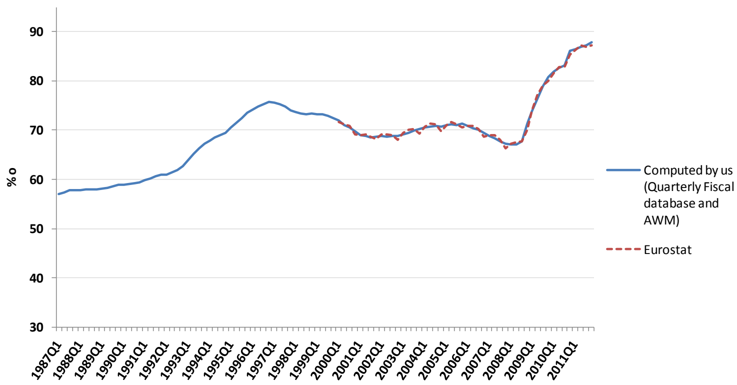








Debt-to-GDP ratio (in levels – original series)



A. 3 – Lag selection criteria

VAR Lag Order Selection Criteria
Endogenous variables: Y P F L I S
Exogenous variables: C
Sample: 1987Q1 - 2011Q4
Included observations: 96

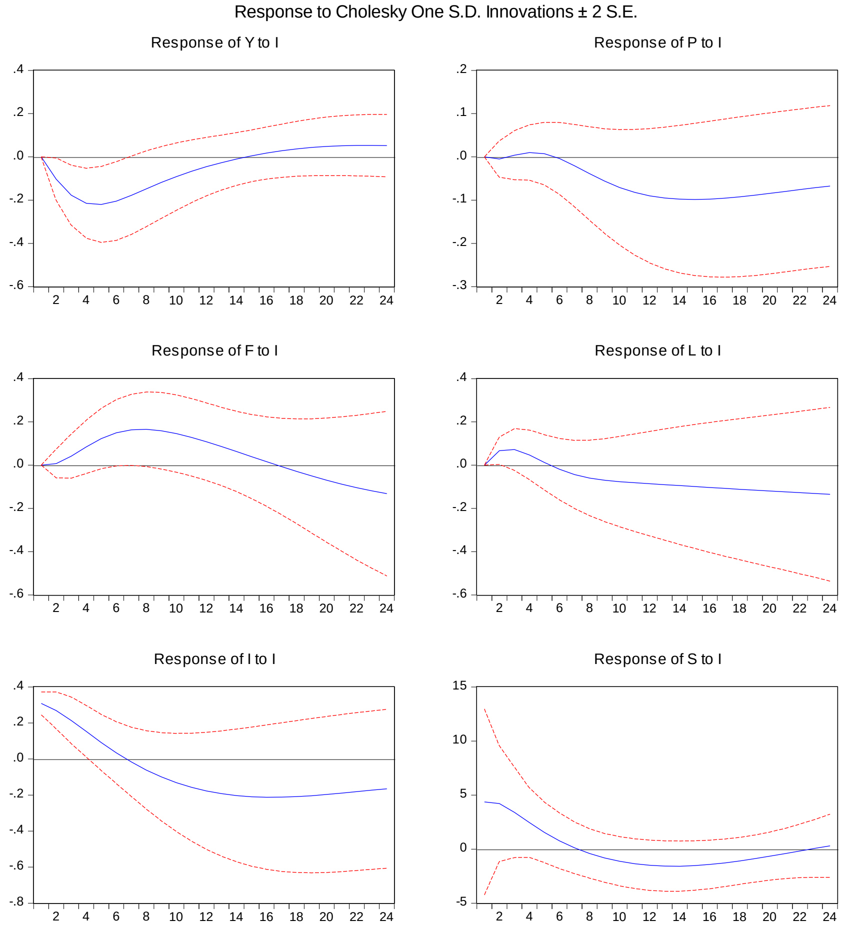
Lag	AIC	SC	HQ
0	28.94277	29.10304	29.00755
1	16.42683	**17.54874***	16.88033
2	**15.76005***	17.84359	**16.60225***
3	15.85670	18.90186	17.08760
4	15.99905	20.00584	17.61866

* indicates lag order selected by the criterion

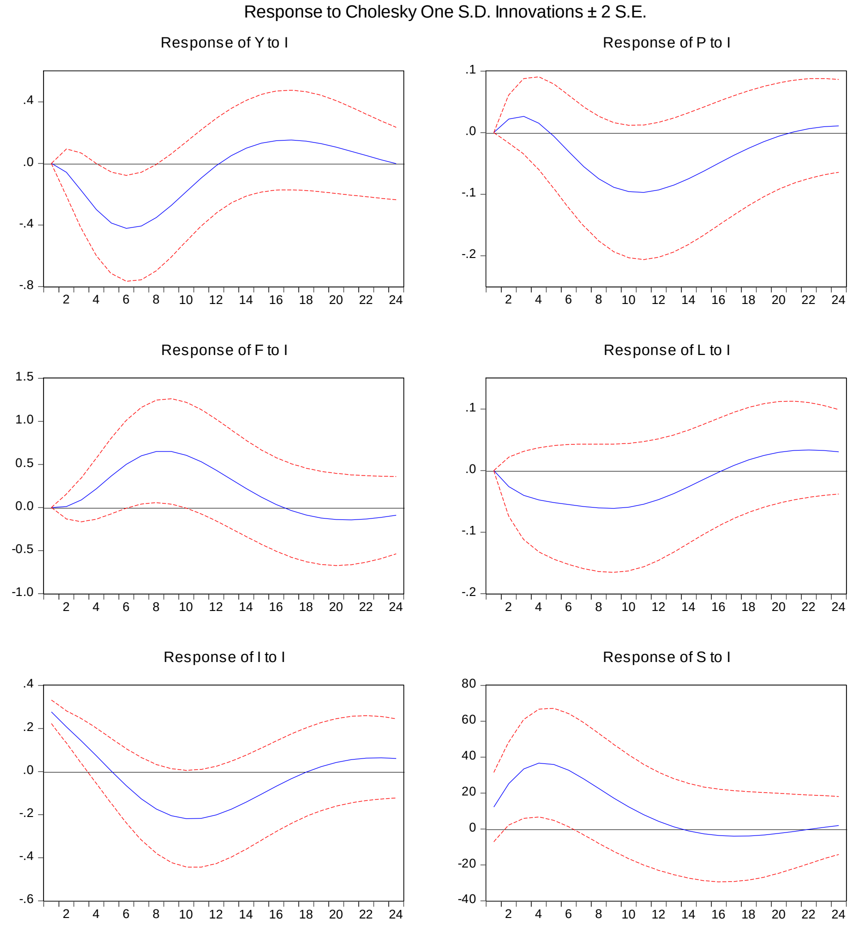
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

A. 4 – Effects of interest rates shocks

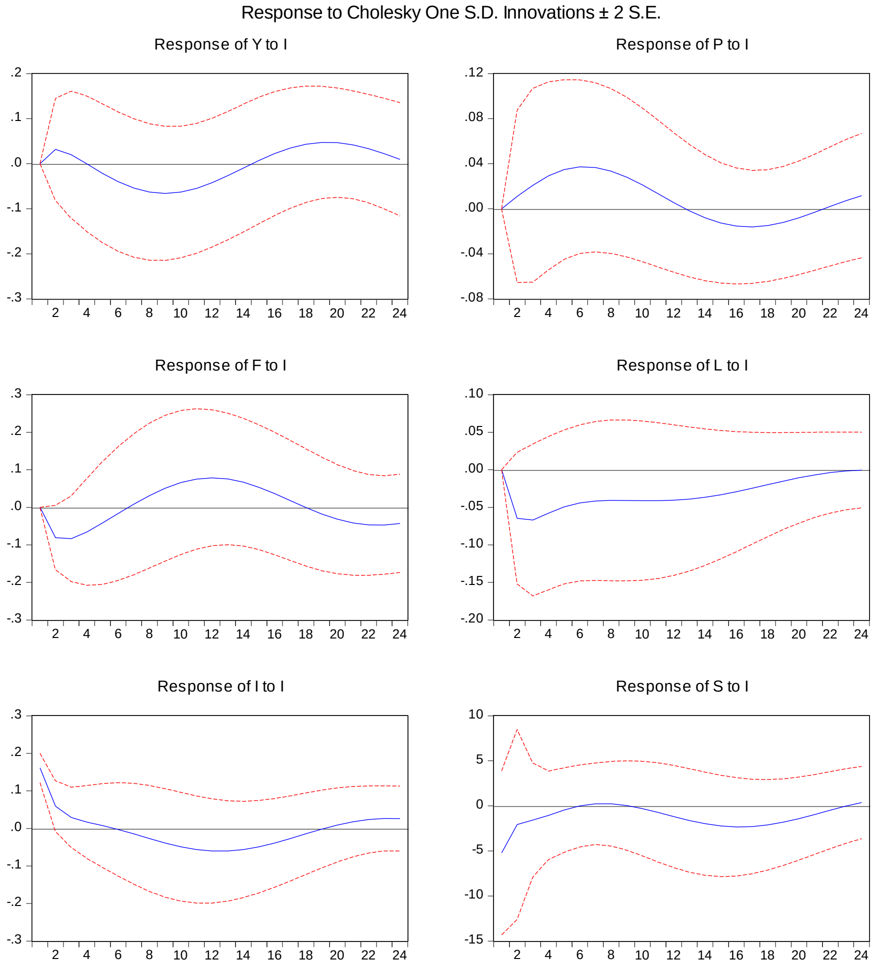
Pre-EMU sub-sample: 1987Q1 – 1998Q4



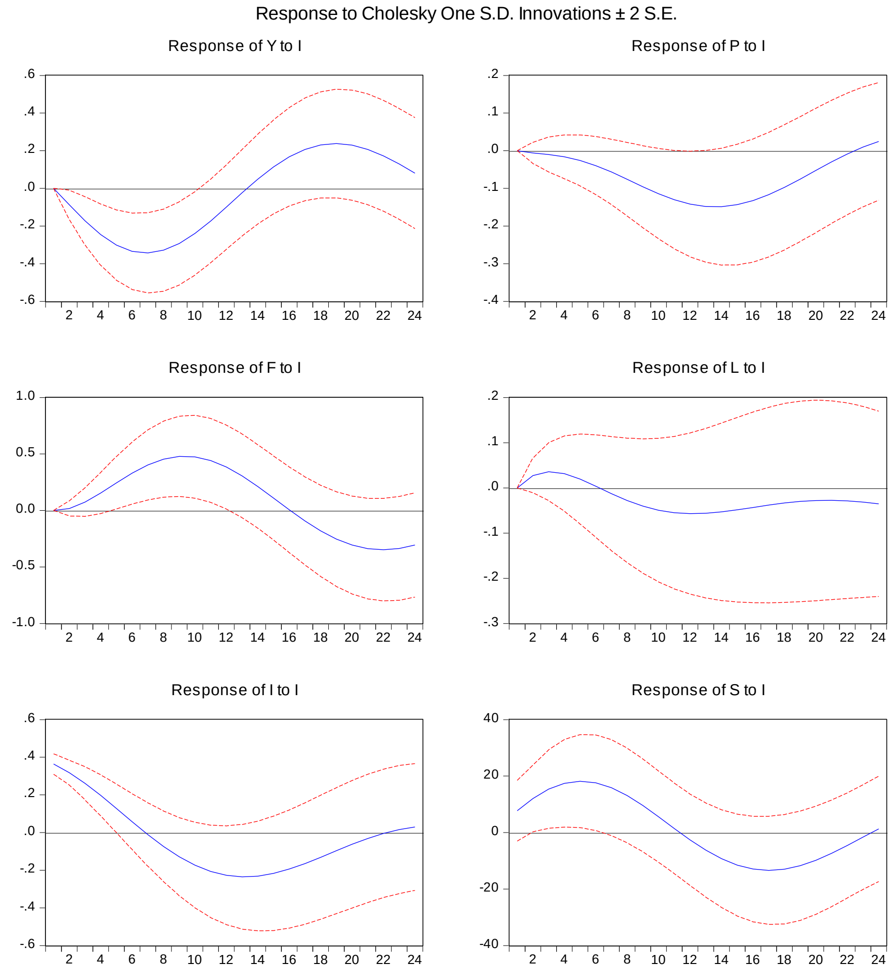
Post-EMU sub-sample: 1999Q1 – 2011Q4



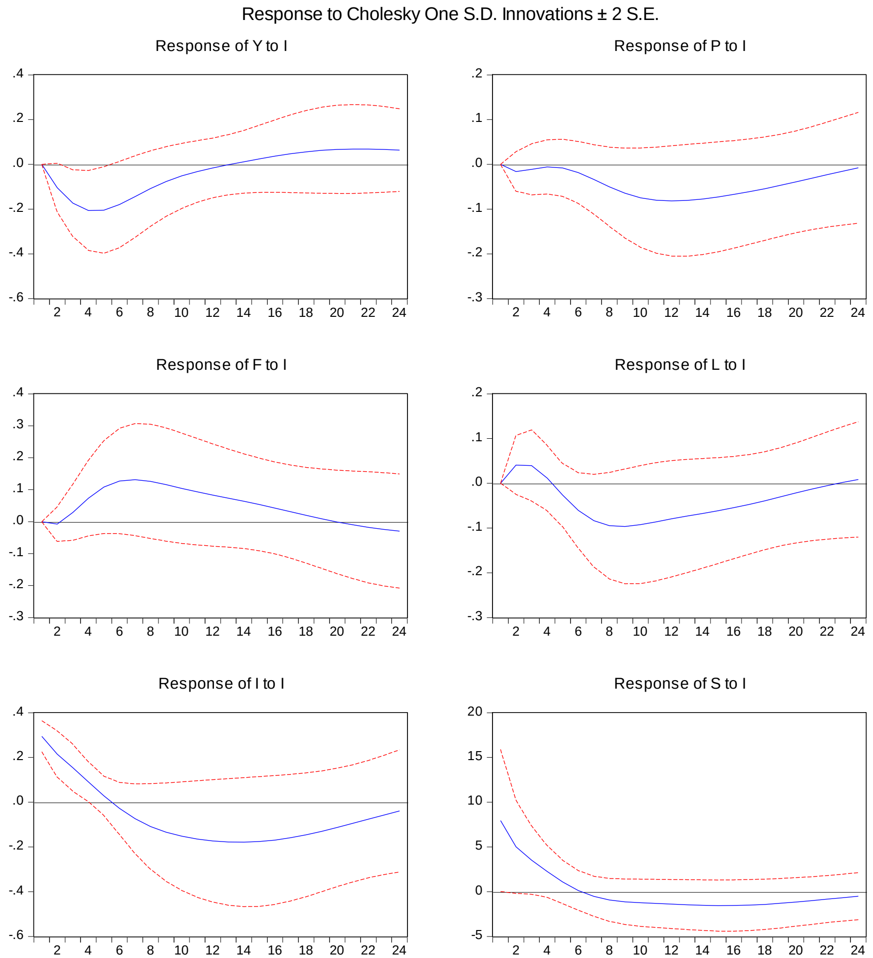
Post-EMU, pre-subprime crisis sub-sample: 1999Q1 – 2007Q2



Post-EMU, pre-sovereign debt crisis sub-sample: 1999Q1 – 2009Q4

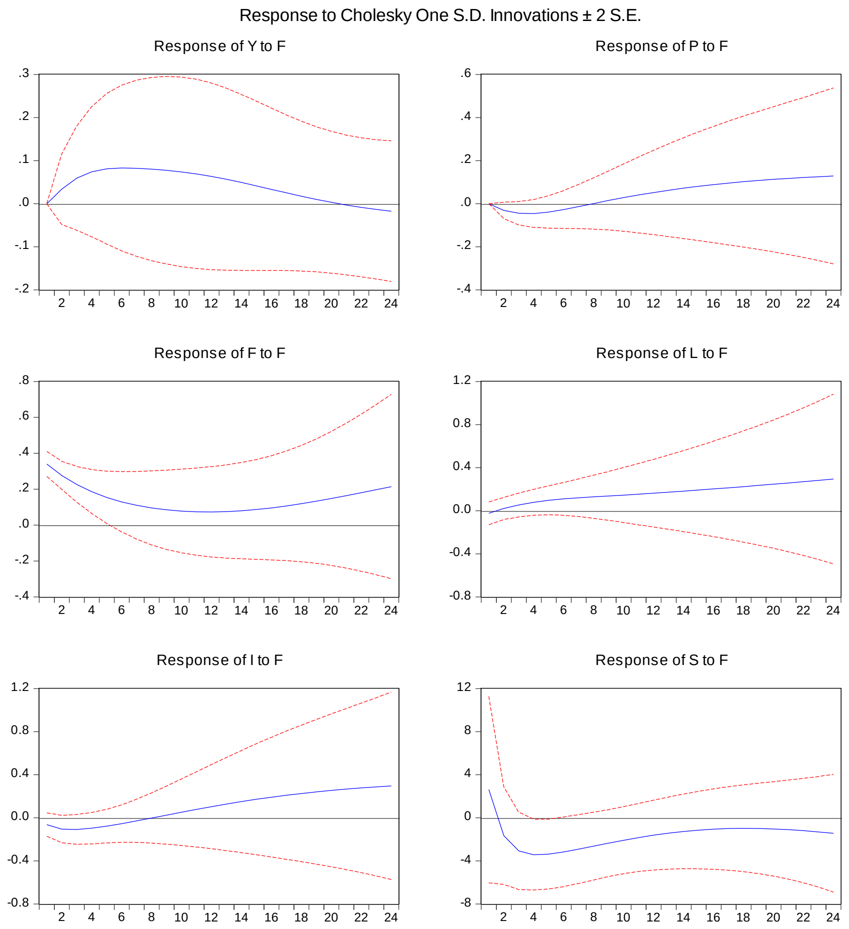


Alternative pre-EMU sub-sample: 1987Q1 – 1996Q1

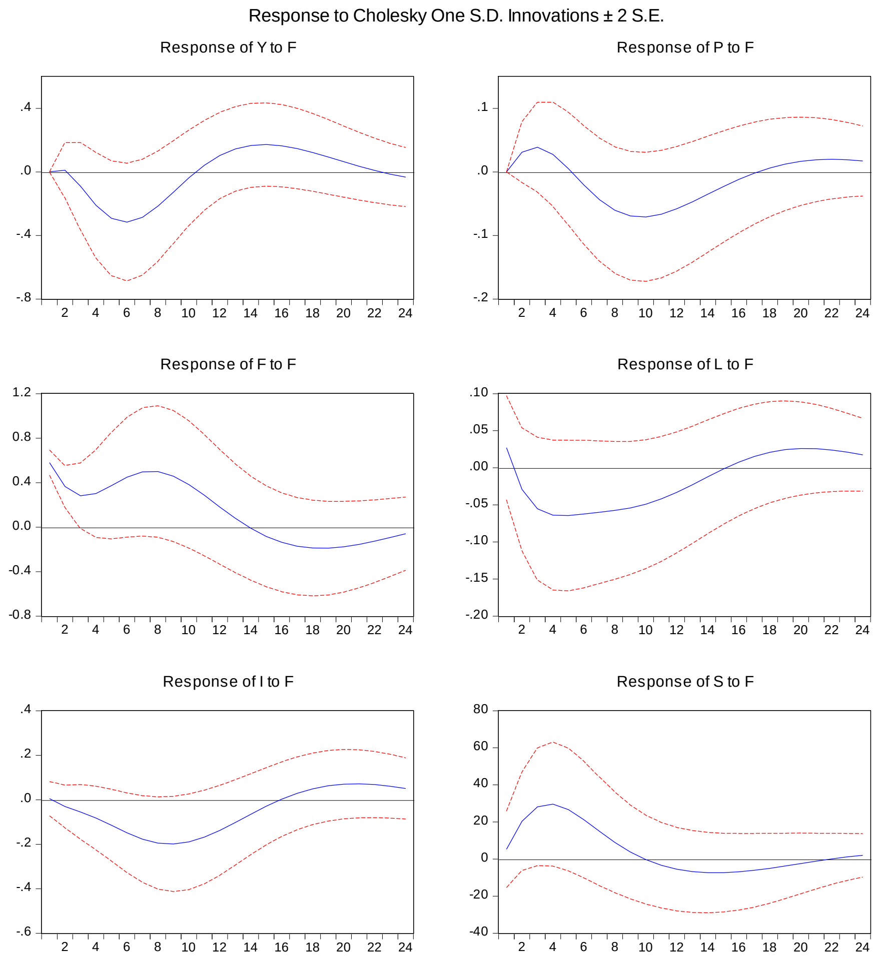


A. 5 – Effects of fiscal shocks

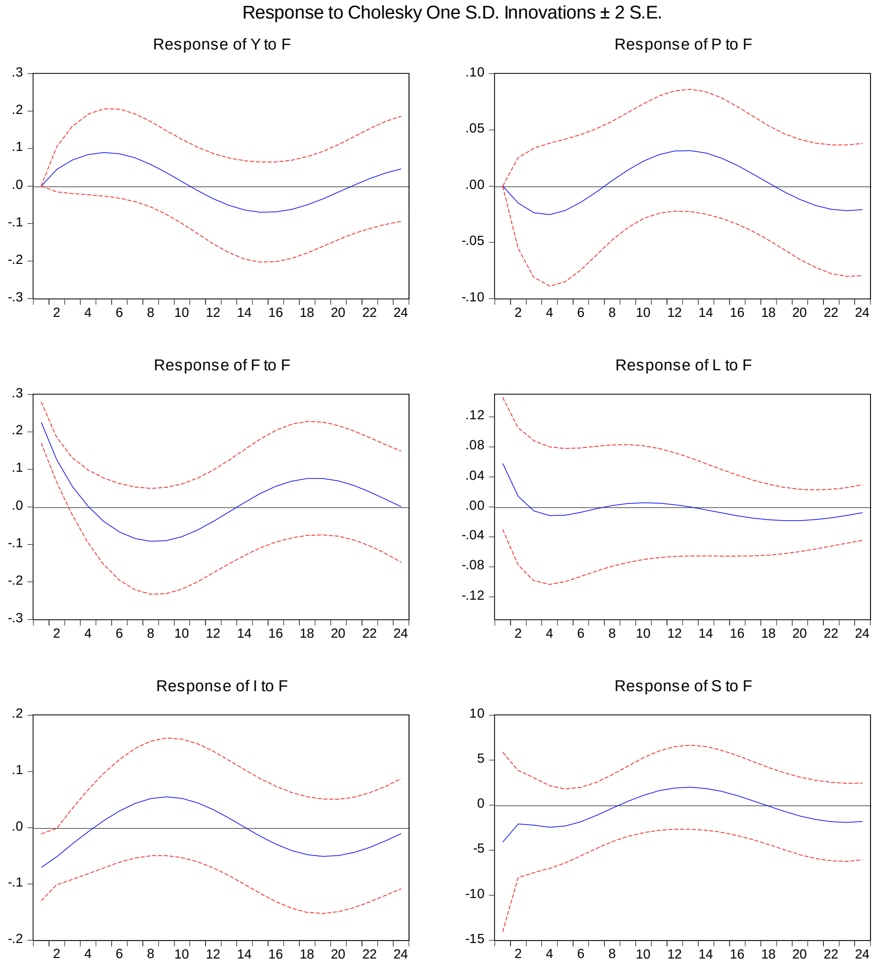
Pre-EMU sub-sample: 1987Q1 – 1998Q4



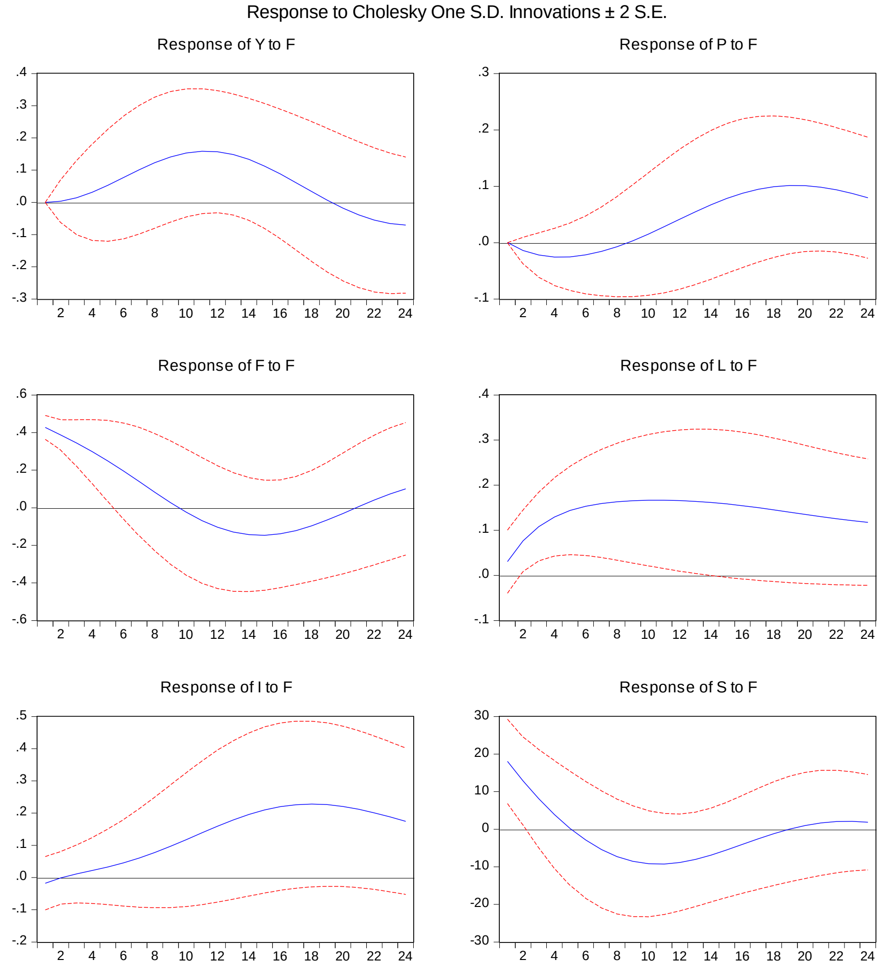
Post-EMU sub-sample: 1999Q1 – 2011Q4



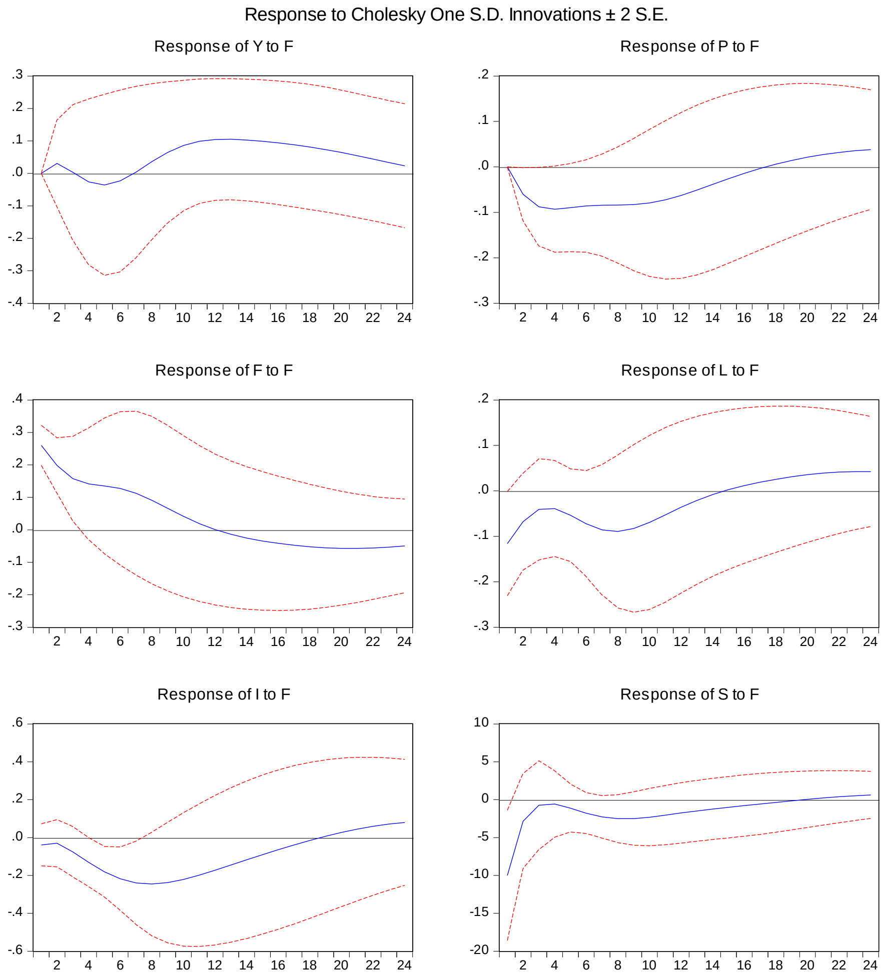
Post-EMU, pre-subprime crisis sub-sample: 1999Q1 – 2007Q2



Post-EMU, pre-sovereign debt crisis sub-sample: 1999Q1 – 2009Q4

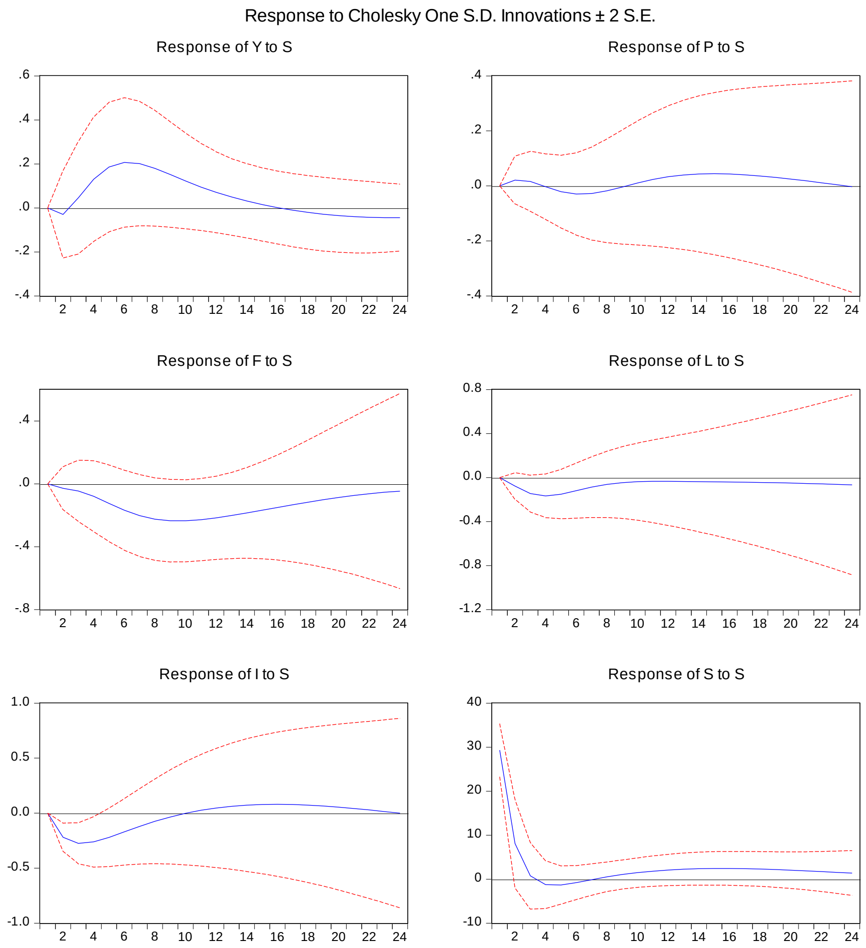


Alternative pre-EMU sub-sample: 1987Q1 – 1996Q1

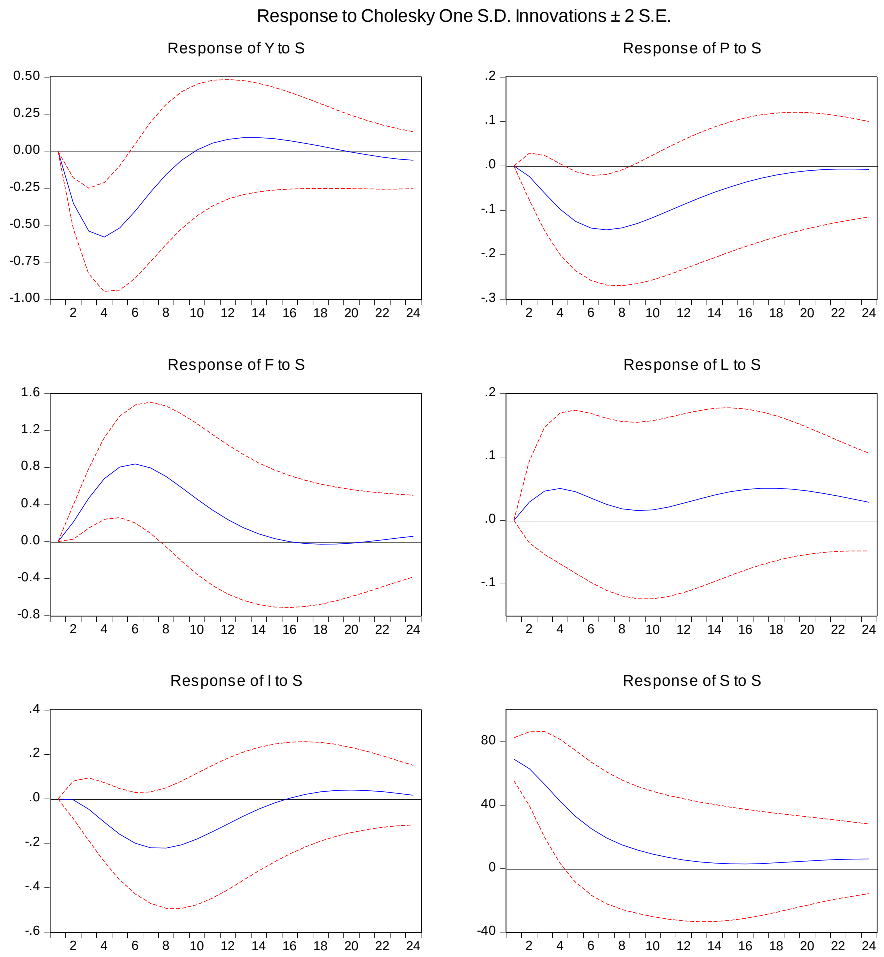


A. 6 – Effects of financial stress shocks

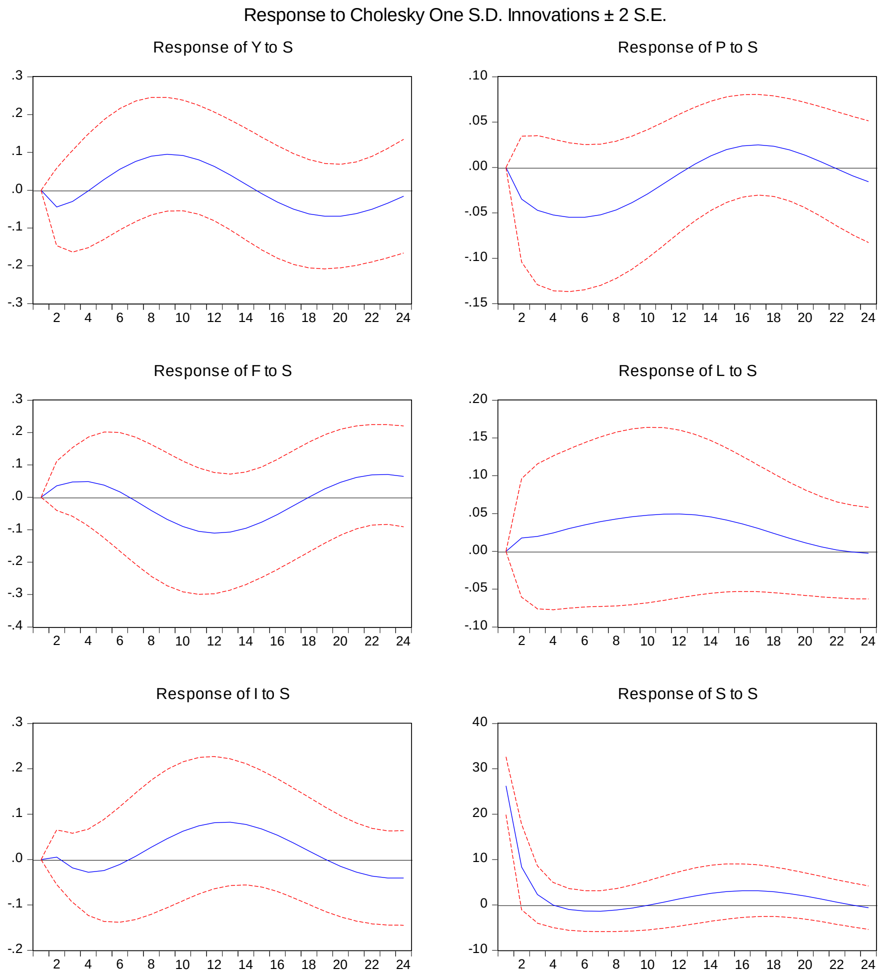
Pre-EMU sub-sample: 1987Q1 – 1998Q4



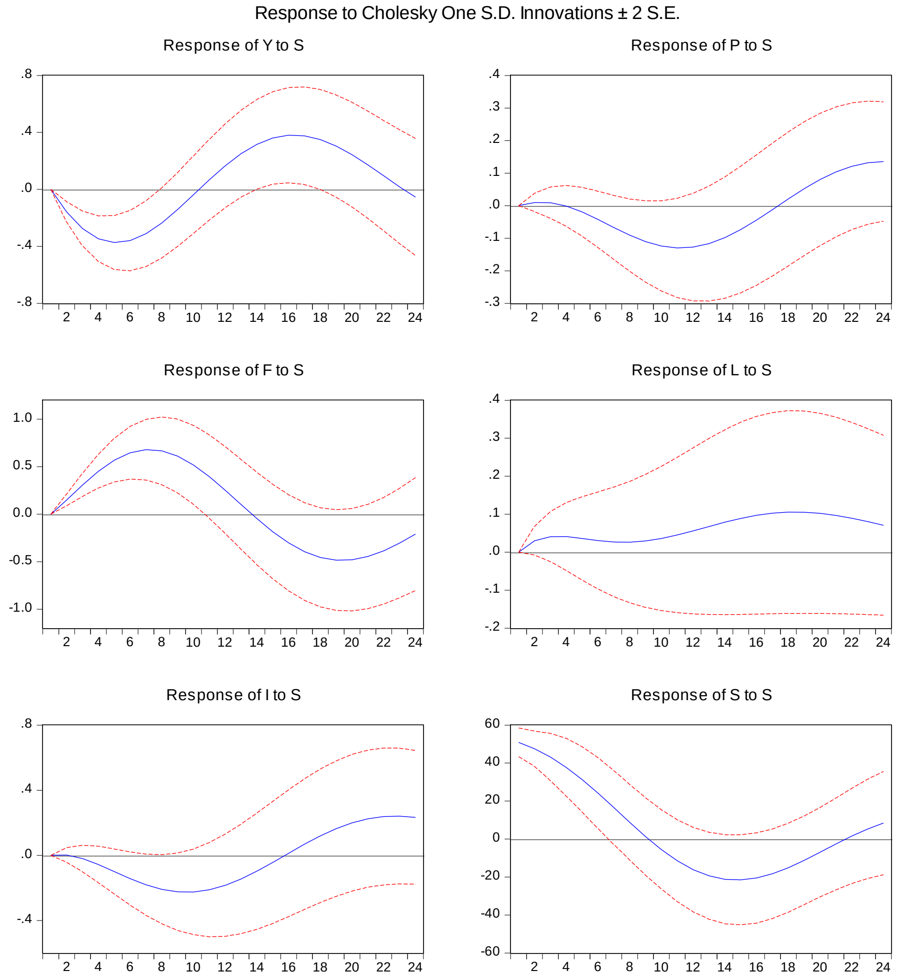
Post-EMU sub-sample: 1999Q1 – 2011Q4



Post-EMU, pre-subprime crisis sub-sample: 1999Q1 – 2007Q2



Post-EMU, pre-sovereign debt crisis sub-sample: 1999Q1 – 2009Q4



Alternative pre-EMU sub-sample: 1987Q1 – 1996Q1