"Real Sector and Banking System: Real and Feedback Effects. A Non-Linear VAR Approach"*

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Short Abstract

This paper studies the relationship between macro variables and banking sector. In particular, we are interested in quantitative and qualitative responses of the macro economic variables and the banking quality indicator to shocks generated in the macroeconomic system and in the banking sector.

In order to achieve this result, we estimate a non-linear VAR, based on four variables (output gap, interest rate, inflation rate and non-performing loans). Our study is based on country specific as well as pooled analyses. Impulse response functions are estimated using the local projections approach.

The results show evidence for real and feedback effects, the effect going from the macro variables to the banking sector and vice versa. Specifically, the two effects work via the output gap and interest rate while the inflation rate plays a marginal role in the shock transmission. The results are robust to the datasets used, to the shock identification procedures chosen and to the period taken into account.

Keywords: ***Financial Stability, Non-Linear VAR, Local Projections Methods.***

JEL: ***C32, E44, E47, G21, G32.***

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1-Introduction

The recent global financial crisis has stressed the importance of studying in a more careful way the interrelationships between real economy, banking sector and financial system. Specifically, it has showed that a shock generated in the financial market can have important consequences in the real economy and from there it can rebound to the financial sector stronger and more severe than before. The analysis between the real economy, banking sector and financial system has become even more important also in light of the fact that various governments are implementing policy measures in order to bailout, directly or indirectly, several financial institutions, to prevent failures of important players of the manufacturing sector, and to impart confidence to investors and shareholders. In order to understand the consequences of the financial shocks and of the economic policies, a thorough knowledge of the mechanisms linking the different pieces of the overall structure is needed. Specifically, it is the more and more important to understand how the variables react to a specific shock and how long it takes to the variables to recover from the shock.

Several theoretical and empirical studies have focused on the relationship between the macroeconomic sector and the banking system. On the one hand, theoretical studies focus both on the consequences of changes in the macroeconomic framework on the banking system (the real effect), and on the effects of changing the banking system conditions on the macroeconomic system (feedback effect). On the other hand, the majority of the empirical research focuses on the real effect. Only in recent years more attention has been given also to the empirical study of the feedback effect. In the majority of the cases, empirical analyses find evidence for real effect, but they fail in detecting the relationship going in the opposite direction. These results may be due to several reasons: non-linearities governing the relationship between the macroeconomic sector and the banking system could not have been taken into account; inappropriate methodologies for detecting these effects could have been employed.

In this paper, we estimate a non-linear Vector Autoregressive model (VAR) in order to examine the bilateral relationship between real sector and banking system. A VAR consists on a system of equations, where the explanatory variables are represented by a set of exogenous variables, and by the same dependent variables lagged by n-periods. Moreover, the results of the regressions are then used in order to study the response of the variables to specific shocks. This analysis is useful for understanding the magnitude of the effects of a shock and to predict the period needed by the variables to absorb the shock. In our case, in order to study the response of the variables to a specific shock we use the local projection approach. This is a method for estimating impulse response functions based on direct forecast, and it consists in repeated direct forecast estimations. The impulse response functions can be considered as the marginal effect of the dependent variable with respect to an innovation that occurred in a particular period. The marginal effect is computed re-estimating by OLS the forecasting model for each forecasted horizon.

Our study is based on country specific (using a dataset including the US and Switzerland) and on an unbalanced pooled dataset (enriching the initial dataset with data referring to other countries: Belgium, Finland, France, Ireland, Italy, Portugal, Spain, and the UK). The period taken into account is not homogenous across countries, even if all the quarterly observations are included in the period from 1983 to 2009. Four variables have been taken into account: the output gap, interest rate and inflation rate refer to the macro sector, while the non-performing loans over total loans is an indicator for measuring the quality of the banking sector.

In terms of results, our analysis shows findings that are robust to alternative shocks decompositions implemented and to different datasets (country specific and pooled data) used. More specifically, in all the cases analyzed there is evidence for real effect, working in the majority of the cases via output gap and interest rate. Moreover, we find evidence also for feedback effect. The results referring to the real effect confirm the prediction of theoretical contributions about flexible credit policies, while those concerning the feedback effect support the credit crunch behavior implemented by the banks when the banking system is hit by a negative shock. The inflation rate turns out to play a marginal role in the transmission of the shocks.

The rest of the paper is organized as follows: section 2 analyzes the related literature from a theoretical and empirical viewpoint. In section 3 and 4 we analyze the main features of the data set used in this study and the macroeconomic model estimated. Moreover, we also discuss the advantages of using the local projection approach for computing impulse responses. In section 5 we discuss the results obtained, while section 6 concludes.

2-Literature Review

2.1-Theoretical Literature

Several theoretical studies document the existence of channels linking the macroeconomic system and the financial sector. Specifically, it is possible to distinguish between nonmonetary and monetary channels.

Bernanke and Gertler (1989), show that a temporary real shock may generate persistent effects on the economic system. Specifically, in a context of not perfect substitutability between external and internal funds, it is shown that there exists a financial premium, defined as the difference between the costs of raising external versus internal funds. Financial premium is inversely proportional to the borrowers' financial position, i.e. net worth, liquidity cash flows. A negative shock affecting productivity worsens the financial position of potential borrowers, the financial premium increases leading to a decrease in the credit demand. Therefore, the economic downturn becomes more severe. The entire mechanism describe above is defined as "financial accelerator" and it is a mechanism that can be applied to any shock affecting borrowers' balance sheets and cash flows. A negative shock affecting economic productivity has also another effect working via credit supply. Specifically, the worsening of the borrowers' financial position leads to an increase in banks precautionary reserves reducing the capital available in the market. Moreover, credit supply can contract also if banks have thin capital buffers above the minimum capital requirement. If capital requirements are binding, then banks cannot expand lending without raising additional capital. In order to absorb a negative shock, a bank, characterized by thin capital buffers, prefers reducing lending rather than raising capital because the latter is more costly during recessions as noticed by Peek and Rosengren (1995). It turns out that a contraction in the credit supply may amplify and accelerate the economic downturn.

There are at least two additional channels than the classical "cost-of capital channel"[1] for describing the consequences of a monetary policy at the financial sector level. The first supplementary channel is the so called "balance-sheet channel". As pointed out by Bernanke and Gertler (1995), monetary policy not only affects the cost of the capital, but it has also an important impact on the value of the assets and of the cash flow of potential borrowers, that is their creditworthiness. Therefore, a tightening in monetary policy has an impact on the financial premium that borrowers have to pay in order to raise funds, amplifying the effects of the monetary policy. The other channel linking monetary policy and financial sector is represented by the so called "bank-lending channel" that affects directly the supply of intermediate credit. Specifically, a tightening in monetary policy shrinks banks' balance sheets and leads to a diversion of funds away from the banking system (disintermediation). As a consequence credit supply is reduced for bank-dependent borrowers, with important consequences at economic level.

Other theoretical studies focus on banking credit policy and moral hazard problems associated with particular economic conditions[2]. During an economic boom, banks decrease their lending standard. In this way, both high and low quality borrowers have more access to the credit. Therefore, the average quality of the borrowers decreases. Once the economic situation deteriorates, banks increase their requirements for current and future clients. The first consequence of this measure is a reduction of the amount of the credit available in the

[1] A tighter monetary policy affects borrowing, investment and consumption decisions via market interest rate.
[2] See for example Rajan (1994), Direr (2003), Ruckers (2004.

market. As a consequence the economic system experiences a credit crunch. Moreover, tighter borrowing requirement leads to an ambiguous impact on the quality of the borrowers. First, new borrowers are selected in a more rigorous way and as a consequence the average quality increases. Moreover, for current borrowers the new requirements could be more demanding as well, so that their loans could become non-performing, and the borrowers' average quality decreases. Finally, there is also the possibility of an adverse self-selection of the agents that stay in the market. Agents having alternatives ways for raising new funds may leave the market after an increase in the interest rate. As a consequence the market is characterized by a majority of low quality agents those loans are non-performing.

2.2-Empirical Literature

Parallel to the theoretical literature, there are also various empirical contributions with the aim of studying the impact of macro variables on banking indicators and vice versa. The empirical literature can be divided in three main groups.

The goal of the first-generation models (FGMs)[3], based on standard linear regressions, is to measure the marginal impact of macroeconomic variables on banking indicators and to analyze the banking behaviors (in terms of provisions against loan losses) with respect to the economic cycle. The main findings are that favorable economic conditions positively affect the quality of the banking system, while loan loss provisions show a countercyclical behavior.

The FGMs are easy to be implemented; however they have the important limitation that the dynamics linking the banking sector and the macro variables are totally ignored. Specifically, it is not possible to quantify the impact of a shock on a particular variable of interest and to measure the periods needed for absorbing the shock.

The second-generation models (SGMs)[4], based on Linear Vector Auto-Regressive approach (VAR), attempt to fill these gaps assessing the magnitude of the impact of the shock and the time needed to the system to recover from the shock.

Hoggarth et al. (2005) develop a hybrid linear VAR model in order to analyze the relationship between banking quality indicator and macroeconomic variables for UK. Specifically, they compute a linear-VAR, taking into account the following variables: the write-offs ratio as an indicator of the banking system fragility, and four macroeconomic variables such as the output gap, the nominal short-term interest rate, the annual RPIX inflation and the real exchange rate. At an aggregate level, they find that changes in output (relative to potential) negatively affect the write-offs ratio, although the opposite is not true. This implies

[3] Papers that can be included in the FGM's are those of Arpa et al. (2001), Pesola (2001), Bikker and Hu (2002), Salas and Saurina (2002), Pain (2003), Quagliariello (2004) Salas and Saurina (2005), Jiménez and Saurina (2005) among others.
[4] See for example Alves (2004), Pesaran et al. (2005), Gerlach and Peng (2005).

that there is evidence for real effect, but not for the feedback effect. Moreover, the bank write-offs ratio is positively affected by a shock coming from the nominal variables such as annual rate of retail price inflation and nominal interest rates.

Marcucci and Quagliariello (2007) also implement a linear-VAR model for Italy in order to capture and quantify the real and feedback effects, using the same specification of Hoggarth et al. (2005). The analysis is based on aggregated and sector level (corporate and households). Their findings are consistent with the previous results. In particular, macroeconomic variables are important in explaining the default rate -a positive GDP shock reduces the default rate-, while the inverse is not true: the banking system indicator does not help in explaining the macroeconomic variables.

Doverns et al. (2008) construct an annually based data set for German banks write-offs for the period between 1969 and 2005. They implement a VAR, taking into account four endogenous variables: real GDP growth, the inflation rate, the interest rate and the write-offs relative to outstanding loans. Moreover, they augment the specification including as well the US GDP growth treated as exogenous variable. The Cholesky decomposition and a method proposed by Uligh (2005) are the two different approaches implemented for the errors identification. Both methods lead to the same general results. The real and feedback effects work only via interest rate. A negative monetary shock generates an increase in the percentage of write-offs with respect to the outstanding loans, while an increase in the write-offs leads to a decrease in the interest rate by about .5%. GDP growth and inflation rate show results that are not statistically different from zero.

SGMs lead to a more precise analysis of the effects governing the relationship between the macro variables and the banking system. A common feature of the results based on linear VAR is that there is evidence for the real effect, working, above all, via interest rate. However, linear VAR models are not able to find evidence for the feedback effect: in the majority of the cases the feedback effect is statistically irrelevant.

One of the main limitations of the SGM is that potential non-linearities linking the real sector and the financial system are not taken into account. As explained above there are several theoretical arguments in favor of the existence of non linear links. The financial accelerator, the "balance-sheet channel" and the "banking-lending channel" show that the financial system can amplify non-linearly the consequences of a specific shock. As a consequence, it is required a model specification that takes into account these relationships that otherwise are totally missed[5]. Moreover, as it is has been shown in this paper, using a linear model specification when the true relationship among variables is non linear can lead important

[5] For non-linearities in time series see for example Christiano and Eichenbaum (1989), Stock and Watson (1994), Aksoy and Ledesma (2007). For non-linearities and non-linear VAR see for example Koop et al. (1996), Weise (1999), De Mello, Moccero and Mogliani (2009).

biases in term the inference. Specifically, the estimated coefficients are biased, affecting in this way, the impulse response functions, that are generated from the estimated coefficients. Finally, if the data generating process is non-linear a direct forecast method for computing impulse response functions is preferred, as documented by Jordà (2005).

In this paper we estimate a non-linear VAR model for assessing real and feedback effects linking the macroeconomic system and the banking sector. To achieve this result the impulse response functions have been estimated using the local projection approach. The non-linear specification may capture the non-linear relationship linking the two sectors documented before, while the local projection approach is a method for computing the impulse responses, based on direct forecast, which shows several advantages with respect to the iterated forecast methods traditionally used for this goal. In our knowledge, this is the first contribution of the third generation models, (TGMs), assessing the relationship between real sector and banking system using a non linear specification model. In a previous study, Drehmann et al. (2006) uses a similar setup with another goal: the aim of their research is to study the differences in impulse response functions referring to a linear and a cubic model specification. Moreover, their estimations are based on UK data and the dataset covers the period from 1992.Q4 to 2004Q3 for an overall of 48 observations. Drehmann et al. (2006) take into account four variables: GDP growth, inflation rate and interest rate, while a fourth variable, corporate liquidation rate, has been employed as a proxy for the corporate credit risk. Finally, they focus only on real effect. They show that linear and non-linear models lead to different results, especially when large shocks are considered. They find that a positive shock in the interest rate increases the probability of corporate default, while the default probability decreases when the economy experiences a positive shock in GDP growth.

Our analysis is similar in some aspects to Drehmann et al. (2006), but it contains important differences both from a methodological point of view and in terms of results. First, we focus on both real effect and feedback effects, while in their contribution the feedback effect is totally ignored.

Moreover, our study takes into account several countries while Drehmann et al. (2006) focus only on UK data. Specifically, we run two different analyses: on the one hand, we focus on country specific regressions, working with US and Swiss data; on the other hand, we work using a pooled data approach, enriching the initial dataset taking into account data referring to other countries: Belgium, Finland, France, Ireland, Italy, Portugal, Spain, and the UK. Furthermore, the period studied is larger in our analysis: it is not homogenous across countries, even if all the observations are included in the period from 1984 to 2009.

The third difference lies in the choice of the variables. The following variables have been taken into account in our study: the output gap, the nominal interest rate, the inflation rate and an indicator of the quality of the banking system: non-performing loans over total loans[6].

Another difference refers to the model specification: we estimate a VAR directly including also a measure of the banking system in the main specification, instead of using different specification for the macro variables and for the corporate liquidation rate as proposed by Drehmann et al. (2006).

3-The data set

Our study is based on country specific and pooled data analysis. The country specific analysis is refers on US and Swiss data, while the pooled data analysis includes data referring to several countries: Belgium, Finland, France, Ireland, Italy, Portugal, Spain, the UK as well as those of the US and Switzerland. The choice of working at country level and pooling the data across countries is due to the fact that the length period is not the same for all the countries included in the dataset. The largest period taken into account goes from 1983.q4 to 2009.q2, while the shortest series covers the period from 1989.q4 to 1994.q1. Specifically, in the majority of the cases the observations are less than 50. Only for the US and for Switzerland the number of observations is close to 100. This is the main reason way, our study goes in two different directions. On the one hand, we work using only the dataset referring to the US and to Switzerland. Based on this information we develop a non-linear VAR country specific. One the other hand, in order to check the robustness of the results obtained at country level, we merge the data set referring to the different countries. In this way, it is possible to estimate a non-linear pooled data VAR. Merging the information available for the different countries we are able to generate a dataset that counts a minimum of 513 and a maximum of 1030 observations depending on the variable.

All the series are quarterly based and they have been seasonally adjusted. Four variables have been included in the dataset. Three of them refer to the real economy, while the last variable is an indicator of the quality of the banking sector. Specifically, in order to describe the macroeconomic system we focus on output gap (GAP), nominal interest rate (INTE) and inflation rate (INFL). The output gap has been generated considering the percentage difference between the cycle and the trend component of the Gross Domestic Product, using a HP-filter. The consumer price index for all items has been used in order to describe price dynamics. Percent quarterly changes have been taken into account. Interbank interest rate

[6] This is the variable chosen for all the countries but for Switzerland, where instead an indicator proposed by Hanschel and Monnin (2004) has been used. This choice is due to the fact that for Switzerland data referring to non-performing loans were not available.

has been used as the interest rate variable. In the literature several indicators of the quality of the banking system has been used. Hoggarth et al. (2005) use write-offs. This is the same choice made by Dovern et. al. (2008), even if they also employ another measure: return on equity. Marcucci and Quagliariello (2006) utilize bank borrowers' default rate while Drehman et. al. (2005) use the corporate liquidation rate. In this paper, following Gambera (2000), we use the non-performing loans as an indicator of the quality of the banking system[7]. A loan is automatically defined as non-performing if it is in default since at least three months. This is not the case for the write-offs. In this case, in fact, it is under the discretion of the banks whether to define a loan as write-off. Therefore, it can be that write-offs are under-reported during recessions and over-reported during expansionary periods to mitigate effects on banks' equity. This is the main reason why we prefer using non-performing loans instead of write-offs as a measure of the quality of the banking sector. Table 3 of the Appendix includes a precise definition of all the variables characterizing the dataset.

In table 2 of the Appendix, we report the correlation between the variables for the US, Switzerland and for the pooled data case, where the initial dataset has been augmented taking into account also other countries. A first result is the negative correlation between the output gap and the non-performing loans for the US case (-.23): larger values for the output gap are associated with a smaller fraction of non-performing loans. A correlation with a positive sign drives the relationship between the two variables for the Swiss case (.34). This puzzling result can be due to the fact that for Switzerland, because of a lack of data, a different variable for describing the banking quality have been used. Analyzing the correlation between inflation rate and non-performing loans, for the Swiss and the US cases we find that it is positive and equal to .24 and .16 respectively. This means that higher values of inflation are associated to larger level of non-performing loans. Finally, Switzerland and the US show similar results with respect to the correlation between interest rate and non-performing loans, showing values around .33. This means that a higher interest rate is associated with a larger fraction of non-performing loans. Focusing on panel correlations on the one hand, the results show a negative correlation between the non-performing loans and the output gap and non-performing loans and inflation rate. On the other hand, there exists a positive correlation between the non-performing loans and the interest rate. In all the cases, the correlations are on the order of 5% at most.

[7] Because a lack of data for Switzerland an indicator taking into account the information coming from several variables referring to the banking sector has replaced the non-performing loans.

4-The macroeconomic model

The non-linear VAR model in its matrix form takes in the following form:

$$y_t = \alpha^0 + B_1^1 y_{t-1} + Q_1^1 y_{t-1}^2 + \varepsilon_t^0$$

Specifically, following previous studies in the same topic[8] our model consists of four variables: the output gap, the inflation rate, the interest rate and the banking indicator, that are defined by y_t^g, π_t, r_t and b_t respectively. Moreover, $y_t \equiv \left[y_t^g, \pi_t, r_t, b_t\right]^T$, $y_{t-1} \equiv \left[y_{t-1}^g, \pi_{t-1}, r_{t-1}, b_{t-1}\right]^T$, $y_{t-1}^2 \equiv Diag[y_{t-1} y_{t-1}^T]$, and finally, B_1^1 and Q_1^1 are the matrixes of the coefficients referring to the linear and the quadratic part of the specification. The system of equations characterizing our model can be interpreted as an IS curve, the supply curve, a modified Taylor rule and an extra equation linking the real variables and the banking indicator[9].

In the specification of the model only one period lagged explanatory variables have been taken into account. This choice is justified by the outcome of the selection order criteria, reported in table 4 of the Appendix, and by the fact that our series are not sufficiently long. For Switzerland both the Hannan-Quinn Information Criteria (HBIC) and the Schwarz Bayesian Information Criteria (SBIC) find that the optimal length is one. Moreover, this result is also robust to different length periods. For the US the results are more puzzling: taking into account also the observations after 2007.q2 the criteria suggest for an optimal lag different from one. However, if the sample period is shrunk, dropping the most recent observations, then the SBIC shows that the optimal length is equal to one lag. Even if there is not agreement about the optimal one period lag length, we prefer to specify the model using only one lag, in order to make the country specific results more comparable. Moreover, this choice can be justified also by the fact that adding a relevant number of explanatory variables, the degrees of freedom decrease. This is not a problem per se, but it becomes an issue if the sample is not sufficiently large, as in this case. The choice of specifying the model including just one period lagged explanatory variables, is also consistent with previous contributions. Finally, the local projections approach prevents for possible problems related to misspecifications issues[10].

The results of the Augmented Dickey Fuller test, reported in table 5 of the Appendix, show evidence that the majority of the series are stationary even if there are some exceptions. In

[8] A similar specification has been used by Hoggart et al. (2005), Marcucci and Quagliariello (2008) among others.
[9] For more details see Batini-Haldane (1999), Blacke and Westaway (1996), Hoggarth et al. (2005)
[10] See for instance Marcellino et al. (2006) for further details about this topic.

general, the results of the tests for detecting unit root are not able to clearly asses the stationary properties of the series. This is particularly true in the case of small samples. The unit root problem can be solved by taking the n differences of the series concerned until when it becomes stationary. However, this method leads to an important loss of information. Moreover, working with series at the difference, we lose the economic meaning of the analysis. These are the main reasons why we prefer to follow the approach implemented in previous contributions, and to work with the series at the level. The unit root issue is mitigated by using local projections for computing the impulse response functions. In the pooled data approach we adopt the same specification used for the country specific analysis and we estimate the model using fixed and random effects.

The main difference of our model with respect to the second generation models is that we add a quadratic term capturing possible non-linearities linking macroeconomic system and banking sector. The quadratic specification employed in this paper, and already used by Drehmann et al. (2006), may be considered the natural extension of the previous family of models. Implementing a more flexible specification, we reassess the relevance of the real and feedback effects.

The existence of non-linearities linking the relationship between the macroeconomic system and the banking system has been documented in several theoretical contributions. Bernanke and Gertler (1989), show that a temporary real shock may affect the borrowers' balance sheets and cash flows, so that the original shock has a persistent and accelerated effect on the economic system. A temporary shock on the real sector has consequences also on the credit supply: the worsening of the borrowers' financial position leads to an increase in banks precautionary reserves reducing the capital available in the market, and generating therefore a persistent effect of the temporary shock. Moreover, Peek and Rosengren (1995) show that, during recessions, banks with thin capital buffers, in order to meet the capital requirement standards, prefer reducing lending rather than raising capital, because the latter is more costly. Rajan (1995), Direr (2003) and Ruckers (2004) show that, in a context of moral hazard problems, credit supply is affected by economic conditions. In particular, they show that the banking system may amplify the booming and busting phases of the economic cycle, using a flexible credit policy. Finally, also an inflation rate out of control may have persistent effects on the economic system: an instable inflation rate can be interpreted as a signal of a relaxation of monetary policies and therefore perceived as a source of uncertainty. An increase in the perception of uncertainty may affect negatively the investment decisions, bearing on the production process and furthermore on the borrowers' balance sheets and cash flows.

A part from previous arguments there exist also technical reasons justifying the choice of including in the model specification a quadratic term. Specifically, estimating a linear model when the relationship among the variables of interest is non-linear may lead to biased results. Moreover, if the Data Generating Process (DGP) is non-linear, as pointed out by Jorda (2005), using an iterated approach for computing the impulse response functions may lead to inconsistent results.

4.1-Monte Carlo simulation

In order to measure the possible bias in the impulse response functions due to the estimation of a linear model when the Data Generating Process (DGP) is non-linear we run a Monte Carlo simulation. We simulate a bivariate vector autoregressive model assuming that the two variables, x and z are characterized by a non-linear relationship. Specifically, the non linear relationship is described by the following expression.

$$Y_t = \delta + B_1 Y_{t-1} + B_2 Y_{t-1}^2 + \eta_t$$

where $Y_t \equiv [x_t, z_t]^T$, and $Y_{t-1}^2 \equiv Diag[Y_{t-1} Y_{t-1}^T]$, and finally, B_1 and B_2 are the matrixes of the coefficients referring to the linear and the quadratic part of the specification. In particular, it is possible to define four main cases: B_1 and B_2 positive definite (case I), B_1 negative definite and B_2 positive definite (case II), B_1 positive definite and B_2 negative definite (case III) and finally B_1 and B_2 negative definite (case IV) [11].

Two different specifications, linear and non-linear, of the VAR model have been taken into account and then the correspondent impulse response functions have been estimated, considering small shocks and big shocks. The impulse responses have been generated using the local projection approach. Moreover, we also compute an average measure of the bias defined as distance between the linear and the non-linear impulse response functions.
We run the simulations considering 100 and 1000 observations respectively, and we repeat the simulation 10000 times. As shown by the graphs reported in the appendix, the impulse response functions referring to the linear and non-linear model specifications show different shapes. The differences are more important when the number of observations is small and the size of the shock is large.

4.2-Identification

A crucial issue in the VAR models is represented by the identification procedure. The impulse response functions are computed from the reduced form of the VAR. Moreover, the errors terms of the reduced form have no economic interpretation while this is the case of the

[11] The four cases lead to similar results so that we report only the graphs corresponding to case I.

errors terms referring to the unrestricted model. Defining a particular structure for describing the contemporaneous relationship of the variables included in the VAR is crucial for understanding the relationship between the error terms in the unrestricted and reduced forms. In other words, the identification procedure is needed in order to relate the shocks of the unrestricted with those of the reduced form.
Let us define the unrestricted model specification in the following way

$$B_0 y_t = \alpha + B_1 y_{t-1} + Q_1 y_{t-1}^2 + u_t$$

where $y_t \equiv \left[y_t^g, \pi_t, r_t, b_t\right]^T$, $y_{t-1} \equiv \left[y_{t-1}^g, \pi_{t-1}, r_{t-1}, b_{t-1}\right]^T$, $y_{t-1}^2 \equiv Diag[y_{t-1} y_{t-1}^T]$ while B_0, B_1 and Q_1 refers to the contemporaneous, linear and quadratic impacts of the explanatory variables. The previous system can be also expressed in a reduced form:

$$y_t = \alpha^0 + B_1^1 y_{t-1} + Q_1^1 y_{t-1}^2 + \varepsilon_t^0$$

where the relationship between the two specifications is given by the following equalities:

$$\alpha = B_0 \alpha^0 \quad B_1 = B_0 B_1^1 \quad Q_1 = B_0 Q_1^1 \quad u_t = B_0 \varepsilon_t^0$$

ε_t^0 is the vector of the reduced form shocks, while u_t is the vector that refers to the shock of the unrestricted model and it has an economic meaning. In our case, the size of the shock is constructed taking into account the standard deviations of the variables of interest.

In order to identify the shocks we have to impose at least $(n^2 - n)/2$ restrictions. Looking in details the matrix B_0 we have

$$B_0 = \begin{bmatrix} 1 & -b_{y^g 2} & -b_{y^g 3} & -b_{y^g 4} \\ -b_{\pi 1} & 1 & -b_{\pi 3} & -b_{\pi 4} \\ -b_{r1} & -b_{r2} & 1 & -b_{r4} \\ -b_{b1} & -b_{b2} & -b_{b3} & 1 \end{bmatrix}$$

The identification strategy implemented in this paper is base on the Cholesky factorization.

Following other contributions on the same topic[12], we adopt the following variables order: bank fragility indicator, output gap, inflation rate and interest rate. This order implies that the bank fragility indicator reacts, at the impact, only to its shock, but it does not react to shocks coming from any other variables. Output gap reacts contemporaneously only to shocks generated by the banking variable or that can be ascribe to its own innovation. This order is justified by some evidence found by Pain (2003) and Quagliariello (2009). Finally, the interest rate and the inflation rate lie at the bottom of the list implying that they do not react at the impact to stress or output gap shocks. The rest of the parameters of the matrix B_0 are computed by estimating the structural form of the model, once the restrictions have been imposed. The main disadvantage of the Cholesky decomposition is that the impulse response functions can be affected by the endogenous order ascribed to the variables. In order to check the robustness of the result we also compute the impulse response functions imposing other variable orders. In particular, we inverted the order of the variables, so that at the impact the interest rate reacts to its shock only, while the banks quality indicator reacts to any shock. The results based on the two variables orders, reported in the appendix, are similar in the majority of the cases[13]. The main conclusion of this analysis is that the variables order does not affect the results achieved.

Another drawback of the Cholesky decomposition is that some restrictions are imposed ex-ante. In order to check the robustness of the results we follow an alternative approach that imposes the restrictions needed for the identification only ex-post. In particular, we estimate the model in its unrestricted form. From this estimation, the restrictions coming from the regressions results are imposed. In this way, it is possible to use all the information coming from the data. This method is more flexible than the Cholesky decompositions because the restrictions are imposed ex-post instead that ex-ante. Two main drawbacks refer to this alternative approach. First, the model is over-identified, and consequently the standard errors may be imprecise; second the restriction may depend on the specification of the model, so that if the model is mis-specified, this can affect the restrictions imposed. In any case, for our scope these drawbacks are less relevant.

Comparing the impulse response functions based on the different identification approaches, we can conclude that the results are similar in the three cases –Cholesky using two different orders and the alternative approach.

[12] See for instance Hoggarth and Pain (2002) for UK, Hoggarth et al. (2005), Goodhart and Hofmann (2001), Marcucci and Quagliariello (2006), Drehmann et al. (2006).

[13] Results for Switzerland and those referring to the fixed and random effects estimations lead to similar results. For the US case, there is just one impulse response function that shows a different pattern.

4.3-Impulse Response Functions

The traditional approach for computing impulse response is based on a moving average (MA) representation of the VAR model. This approach is characterized by important drawbacks. First, it can result in a waste of degrees of freedom because in order to compute true impulse responses a large lag length may be required. This requirement can become a problem if the sample size is too small[14]. Second, there is a problem of non-uniqueness of the MA representation of the VAR model specification, and then a multiplicity of the impulse responses. Lippi and Reichlin (1993) show that for a given estimated VAR a variety of MA representations lead to plausible results from an economic viewpoint[15]. Third, if there are problems of unit roots then the impulse response functions are no more consistent when long horizons are taken into account and the model is estimated at level[16]. Moreover, as we work with a non-linear VAR, another important problem can arise. Specifically, as pointed out by Jordà (2005)[17] the linear VAR can be considered as a first-order Taylor approximation of the unknown Data Generating Process (DGP). The non-linear VAR can be interpreted as a more flexible approximation of the DGP. Therefore, it is no more straightforward using the traditional approach for computing impulse response functions that can lead to misspecification errors. Moreover, this is true when the one period model is mis-specified.

Jordà proposes to use the local projections, instead of the traditional approach, for computing the impulse response functions. It is an approach based on direct forecasts instead of iterated forecasts. Jordà proves that if the true and unknown DGP is linear, then the local projections approach leads to impulse response functions that are consistent but not efficient. Furthermore, if the DGP is non-linear then the local projections approach leads to the best approximation at each horizon in time. Several studies compare the performance of the direct and iterated forecasts. The former exceeds the latter in several cases: when the negative component of the MA specification is large; when the sample data is too small and it displays unit root and structural breaks; when the lag order is low and a short horizon is taken into account. In the lights of these facts, in this paper, following among others Drehmann et at. (2005) and Haug and Smith (2007), we compute the impulse response functions using a local projections approach.

This method consists in estimating, by OLS, a model for each point in time of the period length we are interested in. Based on the regression results the corresponding impulse response value is computed.

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[14] For instance Kapetanios, Pagan and Scott (2007) show that it is difficult to recover information from a shock using a low lag order, and that a higher lag order is needed in order to extract full information.

[15] Specifically, they show that adding reasonable dynamics to the basic model of Blanchard and Quah (1989) it is possible to find results where the role of demand is not as important as in the original contribution.

[16] For more details about this problem, see for instance Phillips (1998) and Pesavento and Rossi (2006).

[17] Also Koop, Pesaran and Potter (1996) deal with impulse response functions in a context of non-linear models.

Let us assume that we have a system of n equations in n dependent variables. Moreover, two groups of explanatory variables characterize the reduced form of the model. On the one hand, we include the lagged components; on the other hand, we also take into account their quadratic elements. Furthermore, the length of the horizon is S, so that we have s periods, corresponding to s models to be estimated. In our specific case, the length horizon of interest is twelve periods, S=12, that is three years, while the macroeconomic model is characterized by four variables, n=4.

The model, in its reduced form, is defined by the following specification:

$$y_{t+s} = \alpha^s + B_1^{s+1} y_{t-1} + Q_1^{s+1} y_{t-1}^2 + \varepsilon_{t+s}^s \text{ with } s=1,2...,S \qquad \textbf{[1]}$$

where $y_{t+s} \equiv \left[y_{t+s}^g, \pi_{t+s}, r_{t+s}, b_{t+s}\right]^T$, $y_{t-1} \equiv \left[y_{t-1}^g, \pi_{t-1}, r_{t-1}, b_{t-1}\right]^T$, and $y_{t-1}^2 \equiv Diag[y_{t-1} y_{t-1}^T]$. For each *s*, we compute the impulse response generated by the innovation vector d_i at *s=0*. In particular for each *s*, the dependent variable is updated by one period, while the explanatory variables are always the same.

The impulse response can be considered as the marginal effect of the dependent variable for *s=1,2...,S* with respect to an innovation that occurred at *s=0*:

$$IR(t,s,d_i) = \frac{\partial y_{t+s}}{\partial \upsilon_t} = E\left(y_{t+s} \middle| \varepsilon_t = d_i; Y_t\right) - E\left(y_{t+s} \middle| \varepsilon_t = 0; Y_t\right) \text{ with } s=1,2...,S \qquad \textbf{[2]}$$

where $E(\cdot|\cdot)$ is the conditional expectation, y_{t+s} is the *nx1* vector of the dependent variables at period $t+s$, $Y_t \equiv \left[y_{t-1}, y_{t-1}^2\right]^T$ is the set of the explanatory variables, ε_t is the *nx1* vector of innovations expressed in the reduced form. Finally, d_i is the column *i* of the *nxn* matrix *D* that contains all the shocks.

Combining eq.[1] and eq.[2] leads to

$$IR(t,s,d_i) = \hat{B}_1^s \tilde{d}_i + \hat{Q}_1^s \left(2\bar{y}\tilde{d}_i + \tilde{d}_i^2\right) \text{ for } s=1,2...,S \qquad \textbf{[3]}$$

where $\tilde{d}_i$ is the vector of the innovations and $\bar{y}$ is the vector of the explanatory variables computed at their average values, once they have been pre-multiplied by the inverse of matrix capturing the instantaneous relationship between the variables when s=0, crucial for the errors identification. The estimation of the impulse response functions consists on two steps. The first step refers to the estimation of the contemporaneous effects matrix from the unrestricted model when $s = 0$. In the second step, eq.[1] is used in order to compute the impulse response functions as reported in eq.[3], at each point of the horizon of interest. The system in eq.[1] can be estimated using normal OLS. At each point in time of the horizon of interest, if the estimated parameters are different from zero, it is possible to compute the values of the impulse response functions. Moreover, for s=0 the impulse response values are obtained imposing $B_1 = I$ and $Q_1 = 0_n$. Finally, from the eq.[3] it is possible to construct a confidence interval for the impulse response functions, working with the variance/covariance matrix of the estimated coefficients for each s.

5-Results of the estimations

In order to establish some link between our study and previous contributions on this topic we start by analyzing the results referring to the linear specification before studying the non-linear model outcomes. Moreover, we focus on the results of the country specific analysis based on US and Swiss datasets, and on the outcome referring to the across countries analysis.

5.1-Linear specification results

The results for the US referring to the linear specification, reported in table 6a of the Appendix, show that the non-performing loans are playing a crucial role on the other variables specifications. In particular, a deterioration of the banks quality leads to a decreasing both of the output gap and of the interest rate. The impact of the banks quality on the inflation rate is positive but statistically not significant. Focusing on the contribution of the output gap, interest rate and inflation rate in explaining the variability of the quality in the banking sector, in none of the cases the coefficients are statistically significant.

Looking on the results referring to Switzerland, reported in table 7a of the Appendix, it is clear the role played by the banks quality indicator: it affects negatively both the output gap and the interest rate. In both cases the results are statistically significant at 1% and at 5% respectively. The results referring to the impact of the banking indicator on the inflation rate is statistical not different from zero. Analyzing the marginal effect of the macroeconomic variables on the banks quality indicator, the results are statistically significant, at 5% only for the output gap, while the estimated coefficients for the interest rate and the inflation rate are statistically not significant. An increase in the output gap leads to a positive marginal effect on banking index, which implies that the stress in the banking sector is larger than on average.

The results of the pooled data regressions, reported in tables 8a and 9a of the Appendix, confirm previous findings. On the one hand, looking at the fixed effect results, the lag value of the banking indicator has a negative impact on the output gap. This result is statistically significant at 5%. The outcomes referring to interest rate and inflation rate specifications are statistically not different from zero. Moreover, analyzing the marginal contribution of the macroeconomic variables on the banking indicator we find that only the interest rate has an impact on the banks quality measure. The marginal impact of the interest rate is positive and statistically significant at 5%. On the other hand, regarding at the results referring to the random effect estimations the banks quality indicator is never statistically significant in the specifications for the macroeconomic variables. However, output gap and interest rate have a marginal impact on the banking indicator that is positive and statistically significant at 5% and 10% respectively.

Comparing our results with those of Hoggarth et al. (2005), based on a UK dataset, the common result refers to the role played by the output gap in explaining the banks quality measure. Moreover, the results referring the role of the interest rate and inflation rate diverge. In our case, interest rate has an impact on the banking indicator that is statistically different form zero, while the inflation rate shows results never statistically significant. In Hoggarth et al. (2005) contribution the reverse holds. Moreover, in their study, they do not find a statistically significant impact of the banks quality variable on the macroeconomic variables, while in our case there is evidence for this kind of relationship. This difference could be due to the fact of the shorter dataset used by Hoggarth et al. (2005).

5.2-Quadratic specification results

In order to analyze the results referring to the quadratic specification, reported in table 10 of the Appendix, a general clarification is needed. For the quadratic specification, $y_t = \alpha + \beta_1 x_t + \beta_2 x_t^2 + \eta_t$, the marginal effect of the explanatory variable, x_t, on the dependent variable, y_t, is given by the following expression: $\frac{\partial y_t}{\partial x_t} = \hat{\beta}_1 + 2\hat{\beta}_2 \bar{x}$. Looking at the results for the US, the main finding is that the marginal effect of the each macroeconomic variable on the banks quality measure is statistically not different from zero. However, analyzing the marginal impact of the banks quality indicator on the other three variables, we can conclude that it affects both output gap and interest rate. Its contribution is negative and statistically significant different from zero at 1% and at 5% respectively. Finally the marginal effect of the banking indicator on the inflation rate leads to results that are not statistically different form zero. For the US case the result of the linear and the quadratic specifications are consistent.

Analyzing the results referring to Switzerland, also in this case, we can find some regularity between the linear and the quadratic specifications. Specifically, the marginal impact of the output gap on the banks quality indicator is positive. This result is statistically significant at 1%. Moreover, interest rate and inflation rate show results that are statistically not significant. Analyzing the marginal impact of the banking quality indicator on the other variables the results show evidence for a negative and statistically significant result, at 1%, on the output gap, while the marginal impact on the other two macroeconomic variables of the banking quality indicator is statistically not significant.

Comparing the results referring to the US and to Switzerland three results arise. First, the results referring to the marginal impact of the output gap on the banking indicator are different in sign and in magnitude. In the Swiss case the marginal impact is positive around .20, higher output gap leads to a worsening in quality of the banking indicator; while in the US case the marginal effect is equal -.008. Second, in both cases the banking indicator has a similar effect, in terms of sign and magnitude on the output gap. The effect is negative, statistically significant at 1% and equal to .20. The third result refers, on the one hand, on the inconsistent results about the interest rate, (statistically significant for the US case only); on the other hand, they concern the not significant outcomes, from a statistic viewpoint, associated to the inflation rate.

The results referring to the pooled data approach partially confirm the country specific analysis outcome. First, both output gap and interest rate have a marginal impact on the banking quality measure that is negative and statistically significant. These results are achieved both in the fixed effect and the random effect estimations. Consistent results are also those referring to the inflation rate. In none of the cases, the results are statistical significant. Looking at the impact of the macroeconomic variables on the banks quality indicator the results are puzzling. In the fixed effect estimation the output gap has no influence, while the interest rate has a impact that is positive and statistical significant at 5%; the random effect results show evidence for a positive and statistical significant impact, at 1%, of the output gap while the result referring the interest rate is not significant.

5.3-Results of the impulse response functions

Looking at the graphs of the impulse response functions, we can conclude that in general there is evidence for real and feedback effects. These results are robust: country specific and pooled data analyses lead to similar results. The same is true for the findings obtained using different assumptions about the endogenous order ascribed to the variables in the error specification procedures.

5.3.1-Real effect

Analyzing the real effect, some common features arise over the results obtained. First, the real effect works via output gap and interest rate channels. Moreover, results related to the inflation rate are statistically not significant. The patterns characterizing the impulse response functions of the banks quality indicator after a positive shock in the output gap and in the interest rate are robust to the different cases analyzed. At the impact, the response of the banking indicator to a positive output gap shock is negative. This implies that the quality of the banking system improves. Thereafter, the fraction of non-performing loans increases showing an inverted U-shaped curve, before converging again to the equilibrium. In all the cases studied, the maximum is achieved in the first five periods, and it is included approximately between .2 and 1.5, depending on the case.

The response of the banks quality to an increase in the interest rate, at the impact, is negative, that is the non-performing loans over total loans decreases, but as the shock is absorbed, the banks quality indicator worsens, before converging to the equilibrium. Also in this case, in the majority of the cases analyzed, the response shows an inverted U-shaped curve, with a negative response at the impact. Moreover, the response at the impact reaches its minimum around -.6, while, once the interest rate goes back to the equilibrium, the response achieves its maximum around .9. Moreover, the maximum is attained in the first ten periods.

The response of the banking indicator to a shock associated to the inflation rate leads to puzzling results. In the majority of the cases, the response is statistically not significant and it is difficult to be interpreted from an economic viewpoint.

Comparing the banks quality impulse responses associated to a shock in the output gap and in the interest rate, we can conclude that the latter takes more time to be absorbed. Moreover, in both cases the impulse responses are statistical significant. These findings hold in the majority of the cases studied.

5.3.2 Feedback effect

Analyzing the feedback effect, the results are similar for the US, Switzerland and the fixed effect estimation, while statistically not significant results refer to the random effect estimation.

The first result of the analysis is that, without ambiguity, there exists a transmission channel working via output gap. An increase in the percentage of non-performing loans over total loans leads to a decrease in the output gap before converging again to the previous equilibrium. The same is true for the interest rate. A relative increase in the non-performing loans leads to a lower level of the interest rate. In both cases the response has a U-shaped curve. The output gap reaches the minimum between the third and fourth quarter before converging again to the equilibrium. The minimum is around -.5. Similar patters refer to the response of the interest rate, even if in this case the convergence process is slower: as a consequence the interest rate takes a longer period to converge again to the equilibrium.

Finally, the results referring to the inflation rate are puzzling, with impulse response functions statistically not different from zero.

In table 1, we summarize the results referring to the impulse response functions: from a general point of view there is evidence for real and feedback effects. This is true for the country specific analysis and for the pooled estimations. In the majority of the cases, real and feedback effects work via the link between the output gap, the interest rate and the indicator of the quality in the banking sector. The results referring to the inflation rate are, on the contrary, statistically not different from zero. Another important result is that the impulse response functions are not affected by the error specification implemented: different variables orders lead to similar results.

Table 1: Impulse response functions: real and feedback effects

		US	Switzerland	Fixed effect	Random effect
Real Effect	Output gap	YES	YES*	YES*	YES*
	Interest rate	YES	YES	YES	YES
	Inflation rate	NO	YES*	YES*	YES*
Feedback Effect	Output gap	YES	YES	YES	NO
	Interest rate	YES	YES	NO	NO
	Inflation rate	NO	YES	NO	NO

*Impulse response functions statistically different from zero only at the impact.

5.4-Interpreting the results

In order to interpret the results it is useful to study the properties of the banks quality indicator. As mentioned above, NPTL is equal to the ratio of bad loans over total loans. Specifically we have:

$$NPTL_t = \frac{BAD_t}{TOTAL_t} = \frac{1}{\frac{GOOD_t}{BAD_t} + 1}$$

NPTL increases if the ratio between good and bad loans decreases. This is possible in two cases. The fraction of non-performing loans over total loans can increase if good loans decrease more slowly than bad loans or if good loans decrease and bad loans increase. The other case when NPTL goes up is when bad loans are increasing faster than the good loans, or when the good loans are decreasing while bad loans are increasing. A similar argument can be used also for analyzing the case when NPTL decreases. On the one hand, NPTL can decrease if good loans increase faster than bad loans, or if good loans increase and bad loans decrease; on the other hand, NPTL decreases if bad loans decrease faster than good loans, or if bad loans decrease while good loans increase.

After a positive shock in the output gap, the banks quality indicator shows an inverted U-shape curve, with at the impact a negative response that implies a reduction of the ratio of the non-performing loans. The output gap shock can be interpreted as a temporary positive productivity shock. On the one hand, a first consequence of the shock is that the external financial premium decreases: firms find easier raise new funds using external sources. On the other hand, banks rank their clients based on their quality. At the impact, the borrowers receiving a loan are those of high quality. In the following periods, banks observe that, even if lower than before, the output gap is still larger than zero, so that they keep lending to borrowers the more and more of lower quality. Banks are adopting a flexible credit policy that is affected by the economic conditions. In particular, banks behavior could be crucial for amplifying economic booms but also for worsening recession periods: lending too much during booms and reducing more than necessary their credit supply in recessionary periods, due to the drastic increase in loan losses provisions. The financial accelerator (Bernanke and Blinder (1988), Bernanke and Gertler (1989)) and the flexible credit policy (Rajan (1994), Ruckers (2004) arguments combined together may explain the inverted U-shape response of the non-performing loans after a positive shock in output gap.

The banks behavior described above is predicted by many theoretical contributions[18] and it is consistent with previous empirical contributions. In particular, in two empirical contributions based on a Spanish dataset, Salas and Saurina (2002) and Jiménez and Saurina (2005) find evidence for not constant capital policy implemented by the banks. Specifically, during booming phase, banks are more prone to risk, so that they provide capital also to borrowers of lower quality. Our results are different from those of previous contributions. Specifically, Marcucci and Quagliariello (2008) find that the banking variable is positively related to the business cycle, so that deteriorations in the output gap lead to an increase of the stress level in the banking sector. These differences can be driven by the different variables used for describing the banking conditions: write offs in the Marcucci and Quagliariello (2008), non performing loans over total loans in our contribution. Moreover, Dovern et al. (2008) find weak and no evidence respectively for the real effect working via a demand and a supply shocks.

As claimed before, the real effect works also via interest rate. Specifically, at the impact, increasing the interest rate leads to a decreasing in the non-performing loans ratio, and then as the shock is absorbed, the non-performing loans increase before converging to the

[18] Rajan (1994) derives a model characterized by rational but short run looking bank managers, concerned about their reputation. The other feature of Rajan's model is that banks' earnings are the only information available in the market. These elements can justify a non-constant supply credit policy implemented by banks. Similar results are obtained by Rucker (2004) that develops a similar theoretical framework.

equilibrium. The response of the non-performing loans ratio may be explained using two alternative arguments: the cost-of capital channel and the balance-sheet channel. An increase in the interest rate can be interpreted as improving the criterion for selecting future borrowers. As a consequence, the quality of the banking system increases. However, the increase in the interest rate is going to worsening the lending conditions also for current borrowers. They have to face more demanding lending requirement, so that the fraction of non-performing loans increases. This effect may be amplified through the balance-sheet channel. An increase in the interest rate leads to a decrease in the value of the assets. Moreover, borrowers' net creditworthiness decreases so that agents have to satisfy more demanding lending requirements. As a consequence, the non-performing loans increase. Our results about the real effect working via interest rate are consistent with those obtained by Dovern et al. (2008).

Focusing on the feedback effect, also in this case the results are robust to the different dataset employed, the different periods considered and the error terms identification applied. The results are consistent with the credit crunch effect discussed in several papers[19]. Specifically, the feedback effect works via output gap and interest rate.

Output gap responds to an increase in the non-performing loan ratio with a U-shaped curve. The balance-sheet argument may be useful for understanding this behavior: the lower quality of the loans leads to a deterioration of the borrowers' creditworthiness. This implies that the external finance premium increases, that is lending externally becomes more costly. The lower ability of raising new funds implies a lower amount of investments that it turns out to decrease the output gap. A contraction in the capital available may come also from the supply side via the capital requirement channel. Specifically, if the quality of the banking sector worsens and the capital requirements for the banks become more demanding, banks can react in two different ways. On the one hand, they can raise new capital, or, on the other hand they can decrease their lending. The former measure is more costly in a crises period than the latter, so that banks prefer decreasing loans. As a consequence, there are less investment possibilities and it turns out that the economic system suffers a contraction[20]. As the shock is absorbed, banks increase their credit supply, so that the output gap recovers.

Analyzing the reaction of the interest rate after a shock in the banks quality indicator, the results show a decreasing in the interest rate that draws a U-shaped curve. This pattern can be interpreted as a policy measure implemented by monetary authorities in order to contain the impact of the shock in the banking sector. After the shock, the interest rate decreases and as the shock is absorbed it goes back to its equilibrium value.

[19] See for instance Peek and Rosengren (1995) and Bernanke and Gertler (1995).

[20] Bernanke and Lown (1991) claim that other elements that can affect the size of the feedback effect are the capital buffer available for the banks, the amount of credit reduction, the effects of such reduction on credit costs, the degree of substitutability between loans and bonds and the share of output accounted for by bank-dependent firms.

An important difference with respect to previous contribution is that our study is the only one where there is clear evidence for the feedback effect: Hoggarth et al. (2005), Dovern et al (2008), Marcucci and Quagliariello (2008) in some way find the existence of the real effect, but they disregard or they do not find at all feedback effect.

6-Conclusions

In this paper, we estimate a non-linear VAR, based on four variables (output gap, non-performing loans, interest and inflation rate), in order to capture real and feedback effects linking the macroeconomic system to the banking sector. Our study is based on country specific and pooled data analyses. On the one hand, we focus on US and Swiss data. On the other hand, in order to check the robustness of the results, we implement a pooled data analysis enriching the initial dataset including also the information referring to other countries. This choice is due to the length of the dataset. In fact, only for the US and Switzerland the dataset is sufficiently large for a country specific analysis.

The impulse response functions have been estimated using the local projections approach, a method employed, among others, by Jordà (2005). This approach is alternative to the classical approach based on moving average representation. Specifically, we use a direct forecast approach instead of an iterated forecast approach.

The results suggest that there is evidence for real and feedback effects. These findings are robust to the different dataset employed, the different periods considered and the error terms identification applied. The findings of the country specific and pooled data approaches lead to consistent results. The same is true, using different variables orders for the errors identification: the responses are of the same order and magnitude.

In particular, the results agree on the fact that output gap and interest rate are the main channels for the transmission of real and feedback effects, while the inflation rate plays a marginal role in the transmission mechanism.

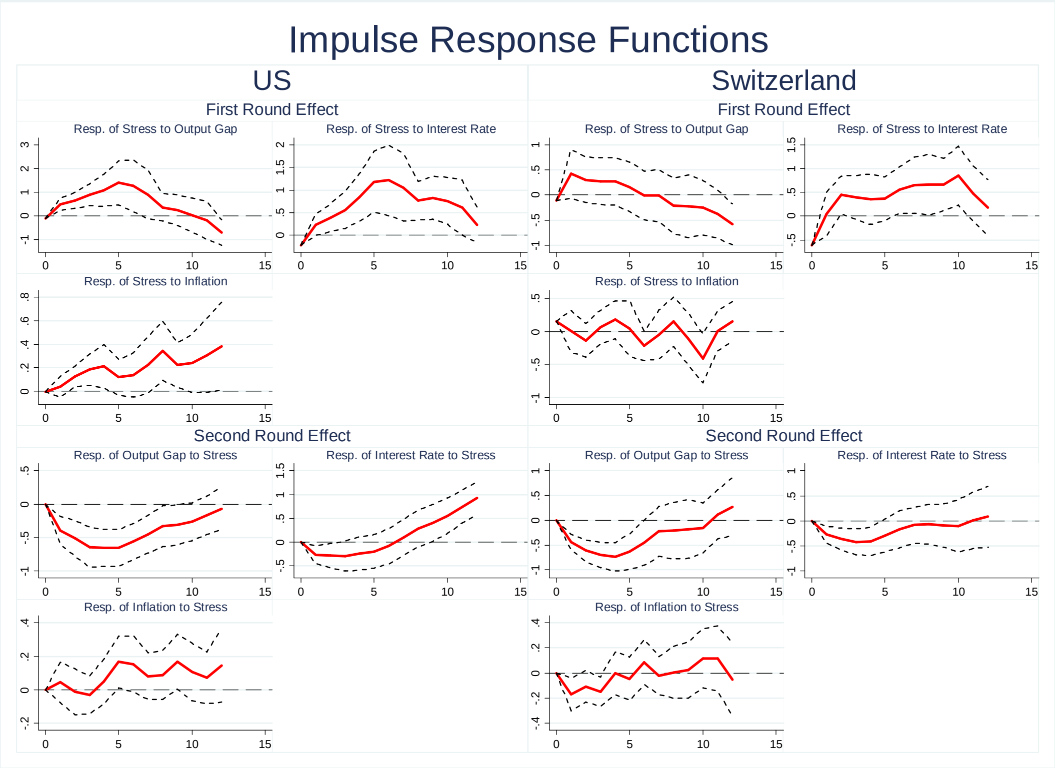
The main findings suggest that the percentage of non-performing loans over total loans increases during booming periods, and the same is true when the interest rate increases, even if in both cases at the impact the quality in the banking sector improves. The results referring to the output gap can be explained by the financial accelerator and the flexible credit supply policy arguments, while the findings related to the interest rate shock may be justified using the cost-of the capital and the balance-sheet channels.

Focusing on the feedback effect, results confirm the existence of credit crunch. The contraction of the output gap after a shock on the banking sector, can be explained by the balance-sheet channel and the capital requirement channel; while reaction of the interest rate after a banking sector shock can be interpreted as a response of the monetary authorities in order to reduce the negative impact of the worsening of the quality in the banking sector.

In our knowledge, this is the first contribution that develops a two dimension analysis: both country specific and across countries analysis are taken into account. Moreover, it is the first contribution where there is clear evidence for real and feedback effects. However, there are still several points to be investigated: it is important to improve the dataset quality in order to obtain more precise estimations; it could be interesting enlarging the analysis to other countries with similar features of the countries already taken into account.

Appendix

Figure 1 and 2: Cholesky



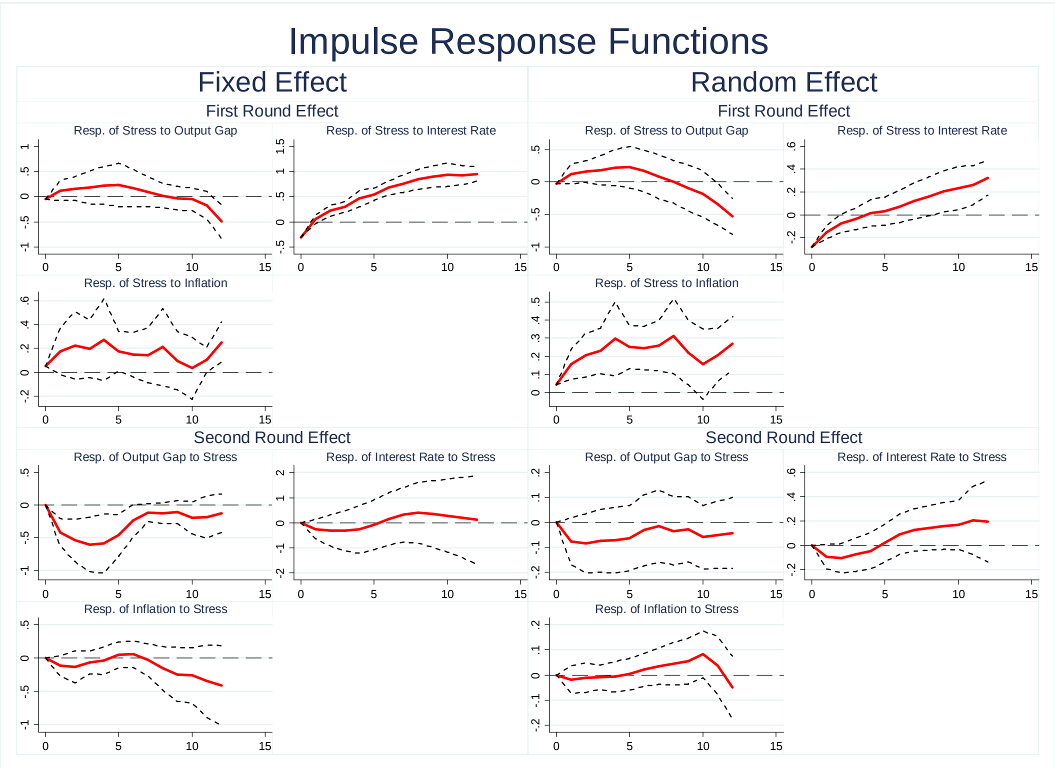
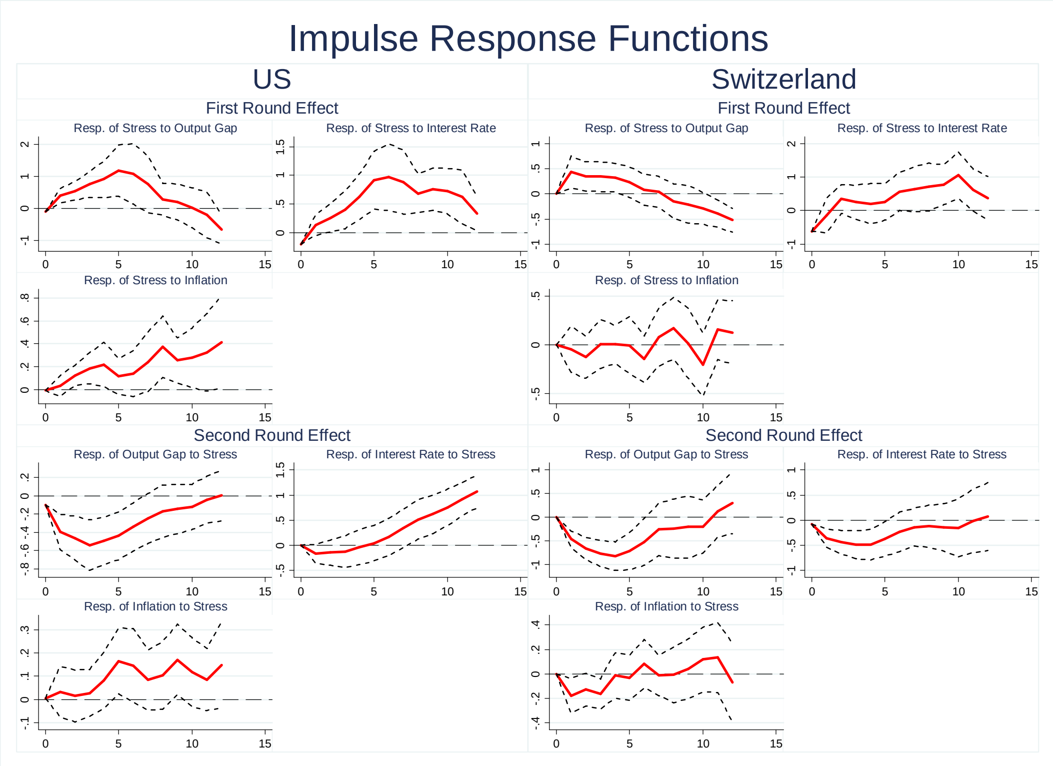


Figure 1 and 2: These graphs show the impulse response functions referring to real and feedback effects, obtained using a quadratic specification. The shock has a magnitude of one standard deviation. The dash lines are the 95% confidence bounds on the impulse response.

Figure 3 and 4: Alternative Method



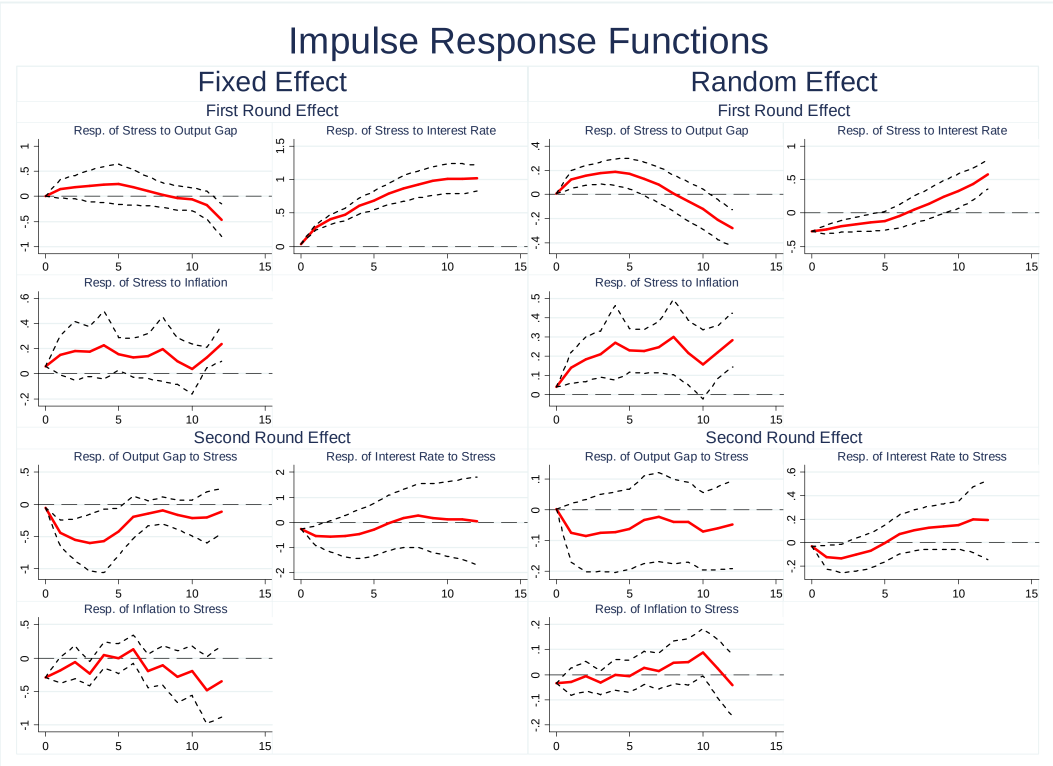
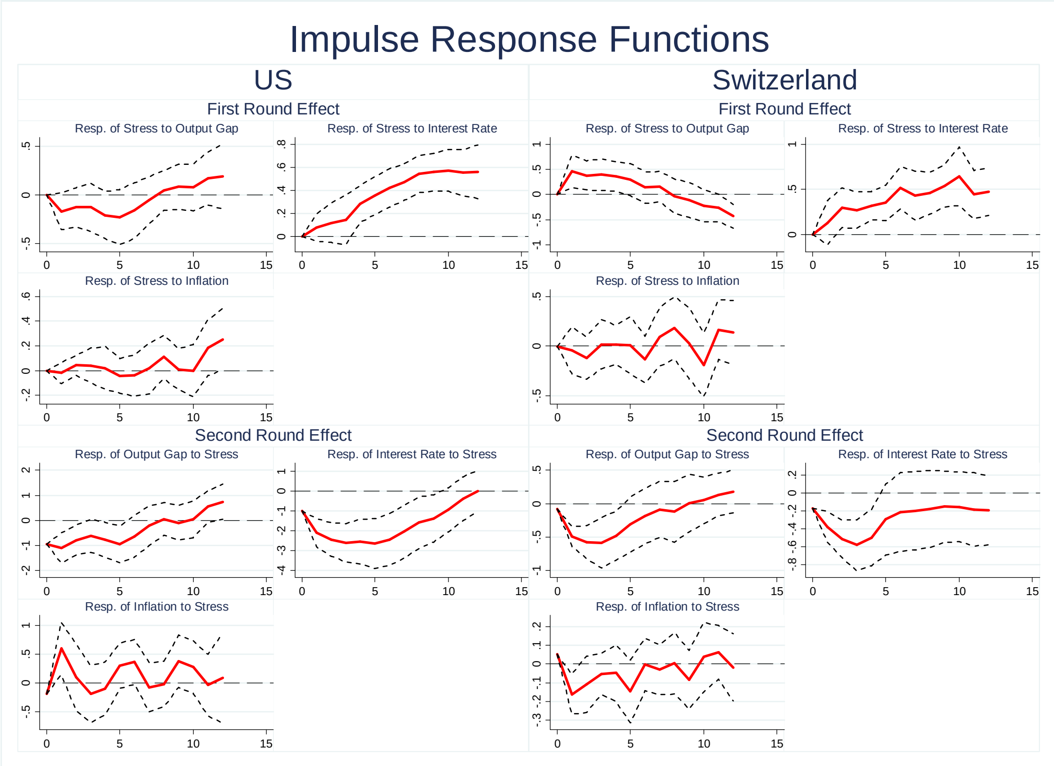


Figure 3 and 4: These graphs show the impulse response functions referring to real and feedback effects, obtained using a quadratic specification. The shock has a magnitude of one standard deviation. The dash lines are the 95% confidence bounds on the impulse response.

Figure 5 and 6: IRF obtained by Cholesky identification based on variables order as in previous contributions.



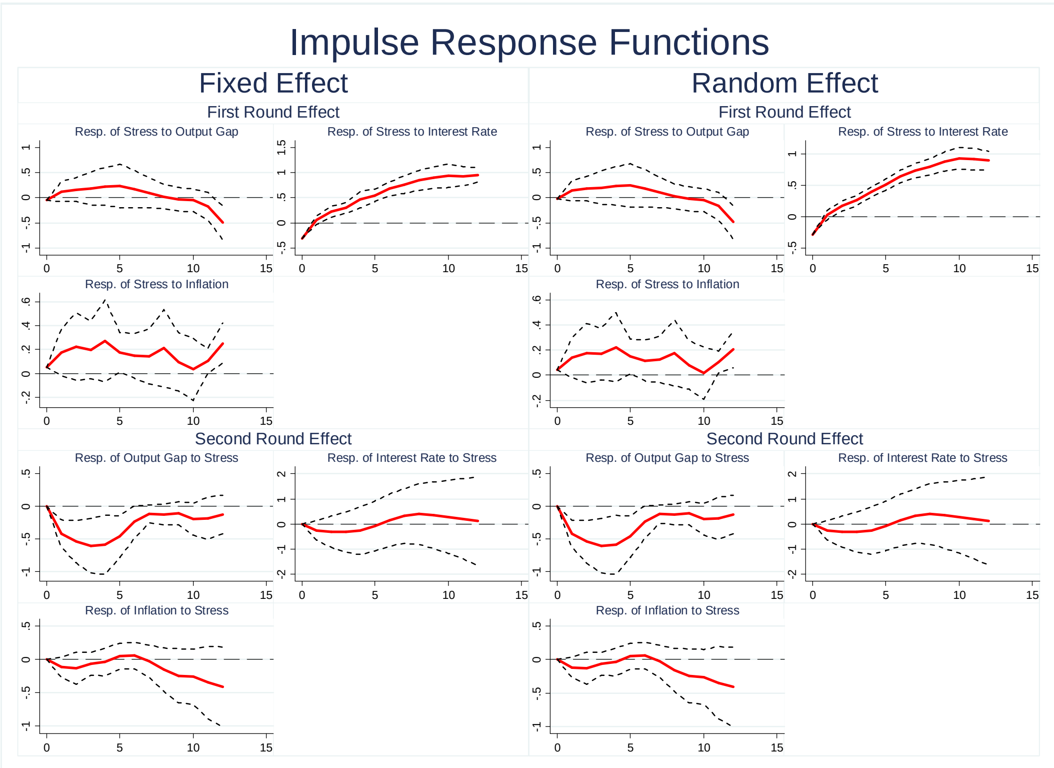


Figure 5 and 6: These graphs show the impulse response functions referring to real and feedback effects, obtained using a quadratic specification. The shock has a magnitude of one standard deviation. The dash lines are the 95% confidence bounds on the impulse response.

Table 1: Statistical features of the variables included in the dataset

US		Obs	Mean	S. Dev.	Skewness	Kurtosis	Min	Max
	GAP	103	-.0129	1.1637	-.573	4.26	-4.44	2.3
Real	INFL	102	.74	.59	-2.12	15.2	-2.8	2.19
	INTR	103	5.28	2.43	.096	2.56	.61	11.44
Banking	NPTL	102	2.01	1.09	.40	1.57	.7	4.39

SWITZERLAND		Obs	Mean	S. Dev.	Skewness	Kurtosis	Min	Max
	GAP	103	-.03	1.44	-.074	2.16	-3.15	2.8
Real	INFL	102	.445	.641	.21	2.8	-1.34	1.87
	INTR	103	3.41	2.45	.86	2.88	.251	9.33
Banking	NPTL	85	0	1	.291	3.37	-2.26	2.8

PANEL		Obs	Mean	S. Dev.	Skewness	Kurtosis	Min	Max
	GAP	816	-.0327	1.6	-.755	9.5	-12.6	7.8
Real	INFL	1020	.81	.86	1.98	14.8	-3.05	8.01
	INTR	983	6.3	3.95	.89	3.2	.25	24
Banking	NPTL	531	2.22	2.34	1.86	8.2	-2.26	13.9

*For the Swiss case the banking variable, can take also negative values. If the index lies above(below) zero, then the stress of the banking system is above(below) the average. This feature of the Swiss data could have affected the statistic details for the panel dataset

Table 2: Correlations

Variable	Panel	US	CH
NPTL and GAP	-.0399	-.23	.34
NPTL and INFL	-.0188	.16	.24
NPTL and INTR	.0471	.37	.316
Obs	507	102	85

US=United States of America, CH=Switzerland

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Table 3: Information about the dataset

	US	**Switzerland**	**Pooled**
Period covered	From 1984.Q1 to 2009.Q3	From 1989.Q3 to 2009.Q3	From 1989.Q3 to 2004.Q3
Output gap	The output gap has been generated considering the difference between the cycle and the trend component of the GDP in local currency, at current price and seasonal adjusted. HP-filter has been used. OECD data set.		
Interest rate	3-month or 90-day rates and yields have been used depending on the case as a short term interest rate. OECD data set.		
Inflation rate	The inflation rate has been computed using the CPI for all items. OECD data set.		
Bank fragility	Non-performing loans over total loans and Hanschel and Monnin (2005) indicator. Federal Reserve of St. Louis, Suisse National Bank and Sanchis-Arellano datasets,		

Table 4: Selection order criteria

US, sample: 1985q1 - 2009q1 **Obs=97**

lag	LR	FPE	AIC	HQIC	SBIC
0		1.15566	11.4962	11.5391	11.6024
1	756.3	.000661	4.02918	4.24384	4.56005
2	96.827	.000339	3.36085	**3.74724***	**4.31642***
3	46.417*	.000294*	3.21223*	3.77034	4.59248
4	19.157	.000338	3.34463	4.07447	5.14959

US, sample: 1985q1 - 2007q2 **Obs=90**

lag	LR	FPE	AIC	HQIC	SBIC
0		.421062	1.4865	1.5313	1.5976
1	727.84	.000185	2.75494	2.97896	**3.31046***
2	66.547	.000126	2.37109	**2.77432***	3.37102
3	36.943*	.00012*	2.31617*	2.89861	3.76051
4	16.979	.000143	2.48307	3.24473	4.37182

SWITZERLAND, sample: 1988q1-2008q2 **Obs=81**

lag	LR	FPE	AIC	HQIC	SBIC
0		2.66852	12.333	12.3805	12.4513
1	469.66	.012022	6.92986	**7.16707***	**7.52108***
2	31.721	.0121	6.93331	7.36028	7.99751
3	32.2	.012162	6.93083	7.54757	8.46801
4	47.868*	.01014*	6.73493*	7.54143	8.74509

*indicates lag order selected by the criterion. LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SBIC: Schwarz Bayesian information criterion, HQIC: Hannan-Quinn information criterion

Table 5: Unit root test

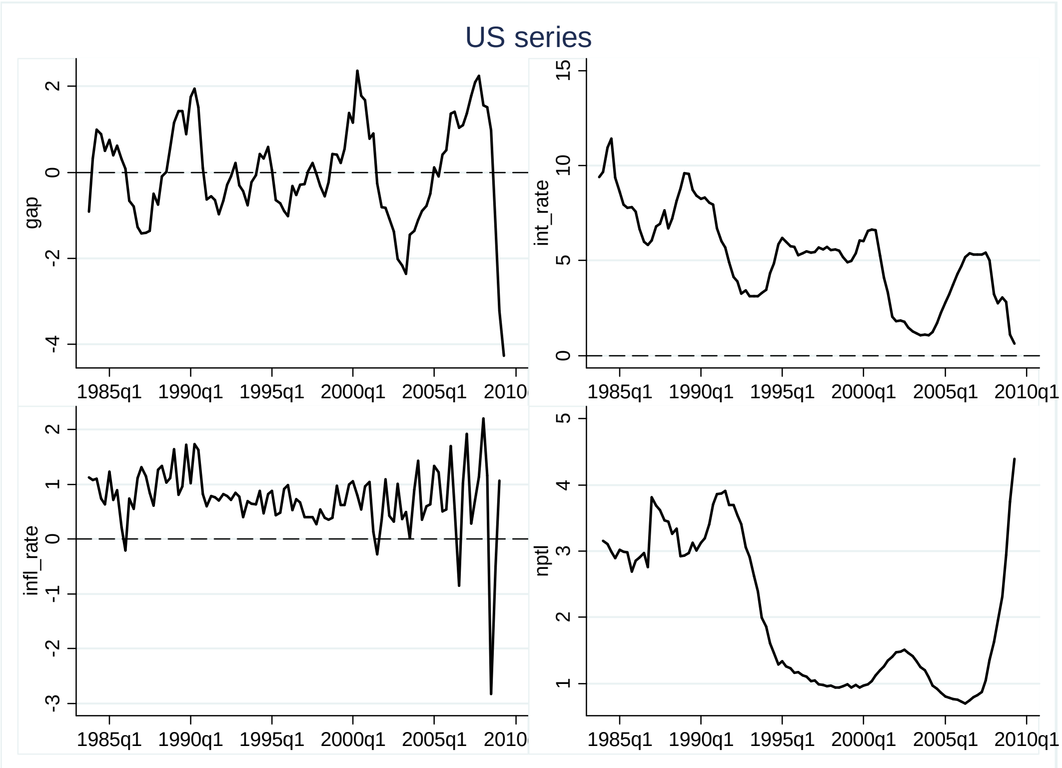
US	test stat	1% Critical	5% Critical	10% Critical	p-value	obs	info
Output gap	-2.516	-2.365	-1.661	-1.29	.0068	101	d+l(1)
Stress	-1.813	-2.368	-1.662	-1.291	.0365	97	d+l(4)
Int. Rate**	-2.009	-2.365	-1.661	-1.29	.0237	101	
Infl. Rate	-7.867	-3.51	-2.89	-2.58	0	101	

d=drift, d+l(n) drift and n lags

SWITZERLAND	test stat	1% Critical	5% Critical	10% Critical	p-value	obs	info
Output gap	-1.825	-2.364	-1.66	-1.29	.0335	102	d
Stress	-9.217	-3.51	-2.89	-2.58	.0113	84	
Int. Rate**	-1.443	-2.365	-1.661	-1.29	.0761	101	d+l(1)
Infl. Rate	-9.217	-3.51	-2.89	-2.58	0	101	

d=drift, d+l(n) drift and n lags

Graphs of the series for the different countries



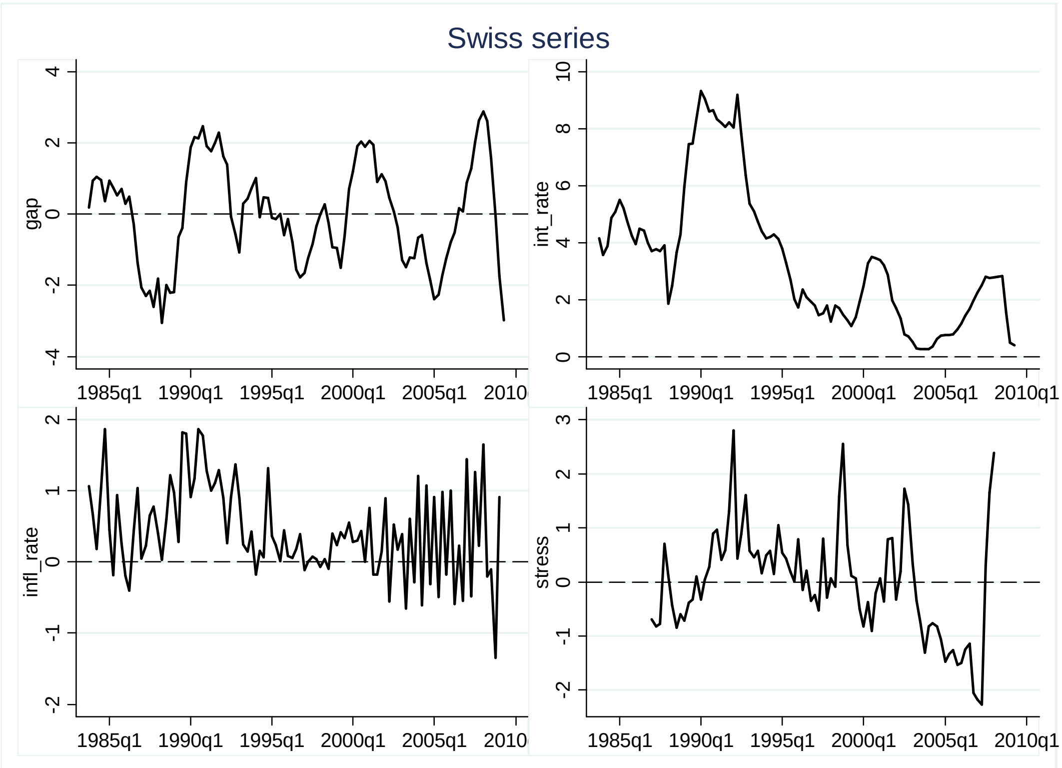


Table 6a, Linear specifications, US

	stress	gap	inte	infl
l1_stress	1.025***	-.2***	-.137**	.0144
	(.0283)	(.0636)	(.0553)	(.0785)
l1_gap	.0473	.807***	-.0834	-.0467
	(.0323)	(.06)	(.0757)	(.129)
l1_inte	-.0129	.0716**	1.002***	.0545
	(.0147)	(.0273)	(.0428)	(.0614)
l1_infl	-.061	.382***	.238*	.185**
	(.0510)	(.0899)	(.123)	(.0933)
Constant	.0735	-.296**	.00330	.282
	(.057)	(.133)	(.199)	(.216)
Observations	101	101	101	100
R-squared	.965	.832	.944	.093

Robust standard errors in parentheses. *** p<.01, ** p<.05, * p<.1

Table 6b, Quadratic specifications, US

	stress	gap	inte	infl
l1_stress	1.14***	-.709**	-.371	-.348
	(.192)	(.299)	(.39)	(.58)
l1_gap	-.008	.88***	-.104	-.043
	(.0369)	(.0644)	(.0683)	(.141)
l1_inte	.0682	-.0230	1.011***	.0468
	(.0491)	(.0692)	(.145)	(.0975)
l1_infl	-.0906**	.409***	.265***	.159*
	(.0358)	(.0754)	(.0961)	(.0945)
l1_stress2	-.0336	.126*	.0519	.0851
	(.0430)	(.0671)	(.0871)	(.116)
l1_gap2	.0616***	-.0858**	-.0872**	.0457
	(.0147)	(.0358)	(.0381)	(.0498)
l1_inte2	-.00504	.00544	-.00177	.000782
	(.00378)	(.00601)	(.0152)	(.00711)
l1_infl2	.0588***	-.0648*	.087*	-.0316
	(.0153)	(.0333)	(.0498)	(.0503)
Constant	-.343	.526	.219	.582
	(.281)	(.357)	(.569)	(.525)
obs	101	101	101	100
R-squared	.975	.851	.948	.113

Robust standard errors in parentheses. *** p<.01, ** p<.05, * p<.1

Table 7a, Linear specifications, Switzerland

	stress	gap	inte	infl
l1_stress	.626***	-.196***	-.154**	-.061
	(.113)	(.0531)	(.0727)	(.063)
l1_gap	.158**	.935***	-.0253	-.0242
	(.0611)	(.0537)	(.0673)	(.045)
l1_inte	.0565	.0220	.974***	.191***
	(.0346)	(.0346)	(.0333)	(.0262)
l1_infl	-.194	.148	.216**	-.346***
	(.135)	(.122)	(.1)	(.106)
Constant	-.0615	-.0914	-.0242	-.0303
	(.147)	(.11)	(.0884)	(.107)
Observations	84	85	85	85
R-squared	.570	.862	.959	.406

Robust standard errors in parentheses. *** p<.01, ** p<.05, * p<.1

Table 7b, Linear specifications, Switzerland

	stress	gap	inte	infl
l1_stress	.676***	-.195***	-.16**	-.00533
	(.111)	(.0538)	(.0645)	(.0585)
l1_gap	.173***	.923***	-.0403	-.0504
	(.0647)	(.0544)	(.0671)	(.0466)
l1_inte	.157*	.181*	1.046***	.0874
	(.0871)	(.103)	(.0941)	(.079)
l1_infl	-.355	-.0124	.0572	-.859***
	(.241)	(.181)	(.13)	(.151)
l1_stress2	-.101	.0222	.0612	.0116
	(.076)	(.0293)	(.0580)	(.0426)
l1_gap2	.0326	-.00114	.0199	.0351
	(.0362)	(.0314)	(.0393)	(.0298)
l1_inte2	-.0141	-.0173	-.00723	.0105
	(.00917)	(.0112)	(.0102)	(.0084)
l1_infl2	.175	.158	.117	.412***
	(.159)	(.145)	(.141)	(.127)
Constant	-.142	-.352*	-.236	.0315
	(.205)	(.197)	(.199)	(.145)
Observations	84	85	85	85
R-squared	.603	.868	.961	.529

Robust standard errors in parentheses. *** p<.01, ** p<.05, * p<.1

Table 8a, Linear specifications, Fixed Effect

	stress	gap	inte	infl
l1_stress	.933***	-.0750**	-.0360	-.0418
	(.0342)	(.0252)	(.0328)	(.0250)
l1_gap	.0227	.827***	.0738	.00968
	(.0203)	(.0456)	(.0527)	(.0226)
l1_inte	.0232**	.0176	.906***	.106**
	(.00939)	(.0160)	(.0354)	(.0342)
l1_infl	-.0363	.155**	.131**	-.226
	(.0345)	(.0644)	(.0524)	(.135)
Constant	.0448	-.00793	.340**	.349**
	(.0667)	(.0738)	(.121)	(.120)
Obs	498	507	507	506
R-squared	.915	.718	.924	.137
# of countries	10	10	10	10

Robust standard errors in parentheses. *** p<.01, ** p<.05, * p<.1

Table 8b, Quadratic specifications, Fixed Effect

	stress	gap	inte	infl
l1_stress	.867***	-.156***	-.101	-.0381
	(.0896)	(.0284)	(.0554)	(.0343)
l1_gap	.0169	.831***	.0798	.00279
	(.0255)	(.0478)	(.0572)	(.0164)
l1_inte	.0596	.0753**	1.001***	.0518
	(.0334)	(.0256)	(.0443)	(.0611)
l1_infl	-.100**	.285***	.212***	-.214
	(.0400)	(.0847)	(.0278)	(.191)
l1_stress2	.00552	.00626***	.00459	.000385
	(.00527)	(.00183)	(.00286)	(.00151)
l1_gap2	.0128	.0211	-.0117	.0393***
	(.0110)	(.0214)	(.0157)	(.00347)
l1_inte2	-.00261	-.00411*	-.00725*	.00434
	(.00200)	(.00198)	(.00332)	(.00341)
l1_infl2	.0432**	-.0826*	-.0352	-.0266
	(.0165)	(.0426)	(.0280)	(.0524)
Constant	.0314	-.0867	.207*	.417**
	(.0824)	(.0552)	(.0985)	(.177)
Obs	498	507	507	506
R-squared	.919	.726	.926	.163
# of countries	10	10	10	10

Robust standard errors in parentheses. *** p<.01, ** p<.05, * p<.1

Table 9a, Linear specifications, Random Effect

	stress	gap	inte	infl
l1_stress	.962***	-.0108	-.0140	-.00957
	(.00689)	(.00957)	(.0109)	(.00778)
l1_gap	.0354**	.863***	.0680*	.0452*
	(.0164)	(.0347)	(.0353)	(.0249)
l1_inte	.00962*	-.0235*	.920***	.0558***
	(.00538)	(.0131)	(.0206)	(.0136)
l1_infl	-.0321	.172**	.109**	-.127**
	(.0286)	(.0669)	(.0447)	(.0545)
Constant	.0391	.0243	.239***	.449***
	(.0513)	(.0723)	(.0765)	(.0682)
Obs	498	507	507	506
# of countries	10	10	10	10

Table 9b, Quadratic specifications, Random Effect

	stress	gap	inte	infl
l1_stress	.950***	-.0388	-.0467**	.00271
	(.0222)	(.0262)	(.0231)	(.0230)
l1_gap	.0319*	.868***	.0688*	.0467*
	(.0164)	(.0352)	(.0353)	(.0250)
l1_inte	.0453**	.0393	.993***	.0615*
	(.0211)	(.0410)	(.0391)	(.0369)
l1_infl	-.0997***	.291***	.177***	-.112
	(.0340)	(.0706)	(.0585)	(.102)
l1_stress2	.00139	.00229	.00270	-.00113
	(.00193)	(.00246)	(.00227)	(.00188)
l1_gap2	.00611	.00250	-.00534	.0141
	(.00714)	(.0212)	(.0192)	(.0123)
l1_inte2	-.00283**	-.00458	-.00519	-.000802
	(.00139)	(.00317)	(.00388)	(.00326)
l1_infl2	.0460***	-.0728**	-.0383	-.0117
	(.0107)	(.0339)	(.0332)	(.0437)
Constant	-.0333	-.114	.0933	.408***
	(.0823)	(.110)	(.0897)	(.108)
Obs	498	507	507	506
# of countries	10	10	10	10

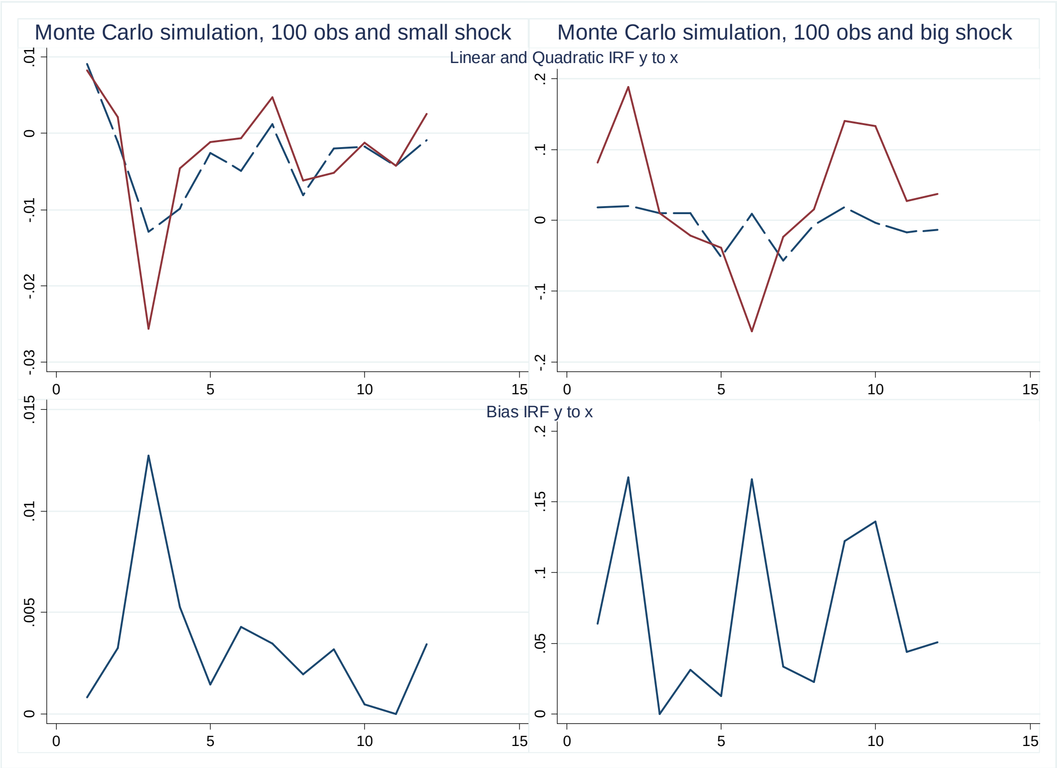
Table 10: Marginal effect test for the quadratic specification

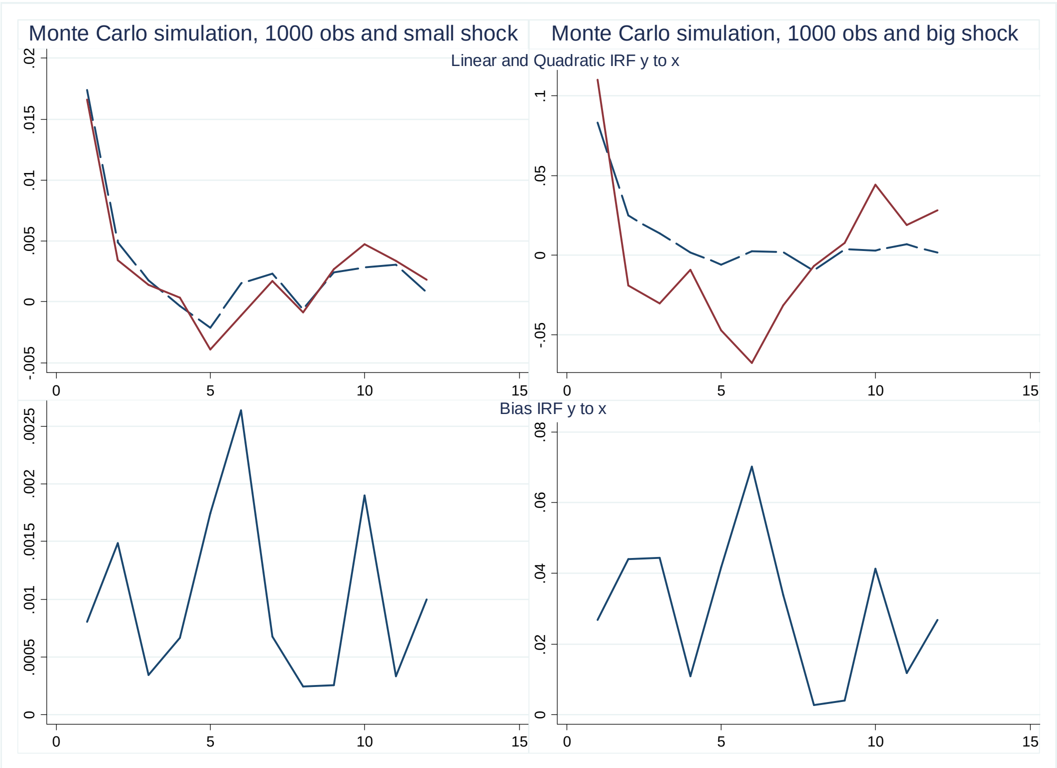
Marginal effects on stress	US	Switzerland	FE	RE
Output gap	-.0079514 (.0368802)	.1720736*** (.0644244)	.0160558 (.0254396)	.0314538*** (.0163695)
Interest rate	.0148967 (.0138096)	.0609113 (.0413715)	.02668** (.0101183)	.0095677 (.0059684)
Inflation rate	-.003449 (.0483081)	-.199844 (.1399888)	-.0300226 (.0246652)	-.0250867 (.0253453)

Marginal effects of stress on the other variables	US	Switzerland	FE	RE
Output gap	-.20191*** (.0626226)	-.1952*** (.0538032)	-.12778*** (.0210433)	-.02858* (.0167404)
Interest rate	-.16202** (.0679832)	.06228 (.0394185)	-.080861* (.042997)	-.03461** (.0150766)
Inflation rate	-.00386 (.1206054)	.12826 (.1231906)	-.03639 (.0287288)	-.002334 (.015149)

*** p<.01, ** p<.05, * p<.1

Monte Carlo Simulation





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