Bank Lending in a Cointegrated VAR Model

Filippo Maria Pericoli, Roberto Galli, Cecilia Frale, Stefania Pozzuoli
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Abstract

This paper aims at identifying the link between financial markets and the real sector of the economy. Following the literature on the topic, we select a small set of variables representing the principal financial and real dynamics observed for the Italian economy. As a first result, we find cointegration among the chosen set of variables. Thus we specify and estimate a Vector Error Correction Model which captures both the long-run and the short-term dynamics of the multivariate system. The main innovation of this work lies in investigating the link between lending and growth at a monthly frequency. Moreover, we allow the model to include a structural break due to the latest economic and financial crisis. The model obtained represents an innovative forecasting tool for improving the knowledge, nowcasting and short-term forecasting of the business cycle by exploiting shocks originating from the lending market that propagate to the real economy.

JEL Classification: C53, E47, E51.

Keywords: Bank Lending, Forecast, Cointegrated VAR.
1 Introduction

Credit aggregates are likely to contain substantial information about the state of the economy, given the overall recognized interrelation between financial factors, economic activity and asset markets. As matter of fact, the latest financial and economic crises has highlighted relevant links between real economy and financial transactions. Moreover, credit variables can provide useful indications about output and, indirectly, about inflationary pressures. As a consequence, it is fundamental to develop quantitative tools able to investigate over the link between short-term developments in the credit market and their fundamental determinants.

The idea that credit has an effect on business cycle is well know in the economic theory as for example Bernanke (1983) identified the collapse of the banking sector as one of the main determinants of the Great Depression. Following this idea, some papers in the 90s’ focused on the notion of the “financial accelerator” namely the mechanism for which credit market amplifies business cycle fluctuations (Kiyotaki and Moore (1997)). A more recent elaboration of this concept discusses the interrelation between credit growth and financial instability looking at historical episodes of asset prices booms in many OECD countries (Detken and Smets (2004)). On the same pattern Paasche (2001) finds a role for credit market in financial shocks propagation. All this considerations are particularly relevant for the Euro Area monetary union given the significant role played by the bank sector in that economy. As expected, many authors (see among others Angeloni et al. (2003)) find evidence of credit as channel for the monetary policy transmission and inflationary pressure development (Nicoletti-Altimari (2001)).

One common element of many studies on this subject is the econometric framework used. Given the non-stationary nature of credit variables the most followed approach relies on multivariate cointegration techniques, namely Vector Error Correction Models (VECM herinafter) that allows to identity long-run trends as well as short-term dynamics.

Following the approach of Calza et al. (2006), the aim of this paper is to build a model that provides a quantitative instrument to assess the short-term developments of real macroeconomic variables and the bank lending. The results of the model could provide policy makers with useful information about the state of the economy, the emergence of inflationary risks as well as the effect of monetary policies.

We use a VECM to identify long-run trends as well as short-term dynamics of the banking lending. In particular, the model includes real monthly GDP, a short-term interest rate (three-months euribor), consumer price inflation and loans to households and non-financial corporations. The empirical analysis refers to Italy for the sample January 1999 - March 2013.

Moreover, given the particular nature of the last crises which originally involved the financial sector and then propagated to the real economy, we include in the model a structural break to distinguish the period before and after the crises. To this aim we run the Johansen et al. (2000) and the Saikkonen and Lütkepohl (2000) cointegration tests to perform robust cointegration analysis
also in the presence of structural breaks.

Our approach has several new innovative features with respect to the existing literature. First, as the empirical application refers to data up to March 2013, the model allows to capture the effect of the latest crises on the pass-trough of credit variables to economic growth. Second, we extend the current literature proposing a cointegrated VECM with a structural break which is new in the literature in this context. Third, we built a model at higher frequency than the standard so as to better capture the dynamics of financial variables.

Preliminary results confirms the findings by Calza et al. (2006) about the existence of a long-run relationship between real GDP and credit variables. The empirical analysis reveals the presence of a structural break following the economic crisis, that has significantly shifted upward the long-run relationship between interest rate and inflation affecting negatively GDP’s growth.

The rest of the paper is organized as follow. Section 2 describes the dataset and the empirical application on Italian data along with preliminary analyses of the main variables under investigation. The multivariate econometric model is described in section 3 where cointegration tests with structural breaks are also presented. Finally conclusion ends.

2 The Data

In order to identify the interrelation among real GDP and credit markets, the following four variables have been considered: real loans to the private sector\(^1\) in log-levels \((l_t)\); real GDP at constant prices in log-levels \((y_t)\); inflation rate \((\pi_t)\), computed as the annualized monthly rate of change of the consumer price index (CPI hereinafter); 3-months Euribor interest rate \((r_t)\). Real loans to the private sector and the CPI have been seasonally adjusted by using the procedure TRAMO-SEATS.

The sample ranges from January 1999 to March 2013. Real loans are expressed as ratio to GDP deflator, according to the idea that in the long term nominal loans are homogeneous to prices. Inflation is included so as to test nominal versus real relationships. There is a mixed evidence in the literature on the convenience of using real versus nominal interest rates, though we found better results including directly inflation in the model instead of considering real interest rates.

According to the literature, a positive relation between real GDP and loans is expected as generally the demand of credit originates from investment prospects. Moreover, economic expansions can boost credit demand trough better future expectations.

In order to increase the number of observations and to promptly detect the impact of the monetary policy, the model is defined at the monthly frequency. To this aim there is an issue for GDP as it is released by the Italian National Statistical Institute (ISTAT hereinafter) only at the quarterly frequency. Fortunately, for Italy we can use the monthly GDP produced by the CEIS Tor Vergata University Economics Foundation which are coherent with official quarterly ISTAT

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\(^1\)Non financial corporations and households, including non-profit institutions.
series but available more timely and with temporal disaggregation. The data, available on-line from
the website of the CEIS Tor Vergata Economics Foundation, represent a temporal disaggregation
of official values based on a small sample factor model including relevant monthly indicators of
economic activity (for more details see Frale and Monteforte (2010)).

With regards to statistical sources, monthly data on bank lending are taken from the Bank of
Italy’s Statistical Bulletin and account for changes in the series due to the European regulation
BCE/2008/32 and to some changes to the supervisory statistical reports\footnote{The entry into force of the new Regulation ECB/2008/32 as of June 2010 and some changes to the supervisory reports have produced breaks in the time series on loans, deposits, securities other than shares and capital and reserves. Series on total assets and total liabilities also show a statistical break in June 2010 as a consequence of these discontinuities. In more detail, time series on loans include securitized or otherwise transferred loans which do not satisfy the criteria for derecognition as established in the international accounting standard IAS 39. The adoption of these criteria implied the re-recognition of assets that had previously been cancelled from the balance sheet, with a corresponding increase in some time series.}. The 3-months Euribor
is taken from the European Banking Federation/The Financial Markets Association and has been
chosen as the key reference rate for private credit. Monthly CPI data are from ISTAT.

The visual inspection of Figure 1, where variables other than interest rates are reported in
logarithmic terms, suggests a non stationary pattern for all the considered series with the only
exception of the annualized inflation rate. An increasing trend is clearly visible for private lending.
GDP series shows an increasing trend up to the last economic recession, while the 3-months Euribor
series is characterized by two boom and boost cycles around 2000 and 2008.

Data in first difference appears to be stationary, though a relevant negative spike is registered
in 2008 (see Figure 2) due to the economic crisis.

In order to formally evaluate the highest order of integration for the variables included in the
dataset, we performed univariate unit root and stationarity tests. To this aim we have implemented
(see Table 1) the following tests: the Augmented Dickey-Fuller test (Dickey and Fuller (1979),
column ADF), the Elliot-Rothenberg-Stock test (Elliot et al. (1996), column DF-GLS), the Phillips-
Perron test (Phillips and Perron (1988), column PP) and the Kwiatkowski-Phillips-Schmidt-Shin
test (Kwiatkowski et al. (1992), column KPSS). The deterministic components of the equation
chosen reflect the specific characteristics of the time series. At 5% significance value, ADF, DF-
GLS and PP tests produce evidence of a unit root in the levels of all the series with the only
exception of the monthly annualized rate of inflation. The KPSS test leads to the same conclusions.
As a second step, we have performed the same tests on differenced series. According to the results of
ADF, DF-GLS and PP tests, all the differenced series are stationary, while the results of the KPSS
test are less clear cut. To summarize, from univariate unit-root tests we conclude that real lending,
gross domestic product and the short-term interest rate are $I(1)$, as one operation of differentiation
suffices to achieve stationarity, while the monthly annualized rate of inflation is $I(0)$.

In order to verify if our conclusion on the degree of integration are robust to the presence of
structural breaks in the data generating processes of the series, we have also implemented the Zivot
and Andrews test (Zivot and Andrews, 1992, see Table 2) that permits an endogenous determination of the break points. From the results of the test it follows that our results are substantially unaffected. At the same time, there emerge some signs of instability in years 2008-2009.

Moving to a multivariate analysis, a preliminary visual inspection of the variables suggests the presence of high correlation between credit and GDP with possible cointegration. From a theoretical point of view, higher economic growth should stimulate investments that in turn should foster the demand of credit (Kashyap et al. (1993)). This implicitly assumes a long term relation between economic growth and lending. On the other hand, as argued by Friedman e Kuttner (1993), investments can also be countercyclical due to self-financing that can reduce the demand of lending to the bank sector in periods of economic expansions. A more formal assessment of the interconnections between lending and the real economy is presented in the following section.

3 The Model

As a first step of the multivariate empirical analysis we estimate a VAR model for the following four variables whose univariate properties have been analysed in the previous paragraph: logged real lending to the private non financial sector, logged real gross domestic product, short-term nominal interest rate and annualized monthly inflation rate. That is, we estimate the following VAR(k) model:

$$X_t = \mu_0 + A_1X_{t-1} + \ldots + A_kX_{t-k} + \epsilon_t, \quad t = 1, 2, \ldots, T$$

$$\epsilon_t \sim IN(0, \Omega)$$

where $X_t$ is a $(4 \times 1)$ vector containing the aforementioned four variables at date $t$, $\mu_0$ is a vector of intercepts, $A_i$ are $(4 \times 4)$ matrices of parameters $(i = 1, 2, \ldots, k)$; $\epsilon_t$ is the $(4 \times 1)$ vector of errors that is assumed independently and multinormally distributed.

In order to identify the maximum lag length of the VAR model, we look at the results of the following five criteria: the sequential modified LR statistic at 5% level, the Final prediction error, the Akaike information criterion, the Schwartz information criterion and the Hannan-Quinn information criterion. The five aforementioned criteria reach their minimum respectively at $k = 5, 5, 5, 2, 3$. Therefore we decided to select $k = 5$ for the previous VAR parametrization, where the variables enter the model in levels.

The analysis developed in the previous paragraph has verified that the maximum order of integration for the set of considered variables is one, that is the variables included in the VAR are $I(0)$ or $I(1)$. Therefore we can investigate over the existence of linear combinations among these variables that generate $I(0)$ processes, meaning that there exist long-run relationships among lending, growth, interest rate and inflation. To this aim we follow the methodology developed by Johansen
et al. (2000) in order to test for cointegration in presence of structural breaks in the data generating process. In detail, we have chosen to test cointegration allowing for a shift in intercept model, that is the model denoted by $H_c(r)$ in Johansen et al. (2000). Taking into account the findings of the previous paragraph, which reveal the possibility of a structural break in the last part of the sample, we identified the optimal breakpoint on the basis of mean-reverting properties of the long-run residuals of the associated cointegrated VARs. As a result of this analysis, we have chosen to place the structural break in January 2009, when the financial crisis consistently propagated to the real side of the global economy, in the aftermath of the Lehman Brothers collapse.

In table 3 we report the results of the Johansen’s cointegration test among the four variables of interest, where it is allowed for a structural break in the form of a level-shift in the cointegrating vectors. At the 5% significance value, the test concluded in favour of two cointegrating relations among the four variables, that is our choice in the following analysis, meaning that among the four selected variables there exist two relationships which drive the long-run behavior of the system. In table 4 it is reported the result of the Saikkonen and Lütkepohl (2000) cointegration test, where it is also allowed a structural break in the form of a level-shift in the cointegrating vectors. This test also confirms the previous finding, i.e. that the cointegrating rank of the system is equal to two.

In order to write the VECM model with a structural break in a compact form we follow Johansen et al. (2001). To this aim, let us denote $T_0 < T_1 < T_2$ respectively the dates when the first regime begins, when the first regime ends and when the second regime ends. According to these conventions, $T_1 + 1$ is the date when the structural break occurs. In order to write the VECM model in a convenient form, we define the impulse dummy variable $D_t$:

$$D_t = \begin{cases} 
1 & \text{for } t = T_1, \\
0 & \text{otherwise}
\end{cases}$$

so that $D_{t-i}$ is an indicator function for the i-th observation in the second period. Moreover, let us define the intervention dummy variable $E_t$:

$$E_t = \sum_{i=k+1}^{T_2-T_1} D_{t-i} = \begin{cases} 
1 & \text{for } T_1 + k + 1 \leq t \leq T_2 \\
0 & \text{otherwise}
\end{cases}$$

Thus, the VECM model with one structural break in the constant in the cointegrating space occurring at date $T_1 + 1$, can be written as follows:

$$\Delta X_t = \alpha \left( \begin{array}{c} \beta \\ \gamma \end{array} \right) \left( \begin{array}{c} X_{t-1} \\ E_t \end{array} \right) + \sum_{i=0}^{k-1} \Gamma_i \Delta X_{t-i} + \sum_{i=1}^{k} \kappa_i D_{t-i} + \epsilon_t$$

(2)
Therefore, we estimated the VECM model defined by the previous equation choosing a cointegrating rank equal to 2 for the system. Consequently, we proceeded to restrict the long-run part of the system to identify the cointegrating vectors. The three exclusion restrictions chosen to identify the cointegrating vectors are the following: real loans and real GDP are not included in the first cointegrating vector, while the short-term interest rate is excluded from the second cointegrating vector. The $\chi^2(1)$ statistic associated to the test on the validity of the chosen restrictions is equal to 1.615 and therefore the restricted model can be safely accepted (p-value equal to 0.204). Moreover, in order to explore the possibility of reducing the dimensionality of the system, we tested the hypothesis of weak-exogeneity of the four variables of the system with respect to the long-run parameters, i.e. the $\beta$ vectors. The results of the individual tests of weak-exogeneity, where the null corresponds to the hypothesis that the rows of the $\alpha$ matrix consist of zero vectors, are the following: the test for the short-term interest rate gives a $\chi^2(3)$ statistic of 9.543 (p-value equal to 0.023); the test for real loans rate gives a $\chi^2(3)$ statistic of 21.779 (p-value equal to 0.000); the test for the inflation rate gives a $\chi^2(3)$ statistic of 17.288 (p-value equal to 0.001); the test for real GDP gives a $\chi^2(3)$ statistic of 13.064 (p-value equal to 0.005). Thus we can exclude at high significance level that one of the four considered variables is weakly-exogenous.

Lastly, in order to increase the estimates efficiency, we have followed a sequential elimination procedure that has removed insignificant coefficients from the short-run part of the restricted VECM system. In the following we report in matrix form our final estimated results, obtained from a two-stage procedure where at the first stage we have estimated the cointegrating vectors by applying the Johansen procedure, while at the second stage we have applied OLS to estimate the full restricted system. The removal of insignificant coefficients has been done following a system testing procedure and a threshold value for the t-statistic equal to 2 has been chosen as the criterium for establishing the set of coefficients which should be included in the restricted system.

The two estimated cointegrating vectors are reported in the two rows of the estimated ($\hat{\beta}$) matrix, that is the second numerical array on the first row of equation 3.

The first cointegrating vector represents the positive relationship existing in the long-run between the 3-months nominal interest rate and consumer price inflation. This cointegrating vector is a Fisher-type equation. In the euro area institutional framework this vector can be interpreted as a monetary policy reaction function, i.e. a Taylor rule describing the behavior of the European Central Bank that sets the interest rate with the only objective of stabilizing the rate of consumer

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3The Fisher equation defines the one-for-one adjustment of the nominal interest rate ($i$) to the expected inflation rate ($\pi^e$). It derives from the so-called Fisher hypothesis that states, according to the principle of money neutrality, the independence of the real interest rate ($r$) from monetary variables. In formulas: $i = r + \pi^e$. 

7
price inflation around a given target.

\[
\begin{pmatrix}
\Delta r_t \\
\Delta l_t \\
\Delta \pi_t \\
\Delta y_t
\end{pmatrix} = 
\begin{pmatrix}
-0.020^{***} & - \\
0.001^{***} & -0.014^{***} \\
- & -4.410^{***} \\
-0.000^{***} & -0.004^{***}
\end{pmatrix}
\begin{pmatrix}
1.00 & -0.751^{***} & - \\
- & 1.00 & 0.090^{***} & -3.363^{***}
\end{pmatrix}
\begin{pmatrix}
l_{t-1} \\
\pi_{t-1} \\
y_{t-1}
\end{pmatrix}
+ 
\begin{pmatrix}
-0.565 & 10.108^{***} \\
29.692^{***} & 0.238
\end{pmatrix}
\begin{pmatrix}
\text{Const} \\
E_t
\end{pmatrix}
+ 
\begin{pmatrix}
0.481^{***} & - & - & 9.638^{***} \\
- & - & 0.001^{***} & - \\
- & - & -0.476^{***} & - \\
0.003^{***} & - & 0.000^{***} & 0.811^{***}
\end{pmatrix}
\begin{pmatrix}
\Delta r_{t-1} \\
\Delta l_{t-1} \\
\Delta \pi_{t-1} \\
\Delta y_{t-1}
\end{pmatrix}
+ 
\begin{pmatrix}
- & - & 0.023^{***} & - \\
- & - & - & -0.295^{***} \\
- & - & 0.000^{***} & -0.108^{**} \\
- & - & - & 4.0427^{**} \\
- & - & 0.000^{***} & -
\end{pmatrix}
\begin{pmatrix}
\Delta r_{t-3} \\
\Delta l_{t-3} \\
\Delta \pi_{t-3} \\
\Delta y_{t-3}
\end{pmatrix}
+ 
\begin{pmatrix}
-0.171^{***} & - & - & - \\
- & - & - & - \\
- & - & - & -1.985^{***} \\
- & - & - & -0.004^{**}
\end{pmatrix}
\begin{pmatrix}
D_{t-1} \\
D_{t-2} \\
D_{t-3} \\
D_{t-4} \\
D_{t-5}
\end{pmatrix}
+ 
\begin{pmatrix}
\epsilon_{1t} \\
\epsilon_{2t} \\
\epsilon_{3t} \\
\epsilon_{4t}
\end{pmatrix}
\begin{pmatrix}
\Delta r_{t-4} \\
\Delta l_{t-4} \\
\Delta \pi_{t-4} \\
\Delta y_{t-4}
\end{pmatrix}
\]  
(3)

The second cointegrating vector describes the long-run relationship between real lending, real GDP and inflation rate, where real lending is positively related to overall activity levels and negatively related to consumer price inflation which is in turn directly linked to the policy rate and thereby to the cost of lending. We find that the long-run parameter of GDP is equal to 3.4, a figure bigger than 1.3 found by Gambacorta an Rossi (2007) or 1.5 found by Calza et al. (2006), although their works has been made before the crisis. It is to point out that the relatively high parameter in the long-run relationship between lending and GDP is likely to reflect the omission of some variables from the model such as wealth or house purchases that are not captured by GDP transactions. As regards the coefficient of the inflation rate, we find a value equal to -0.1. This figure underlines the link between inflation and lending rate via the policy rate.

The impact of the structural break on the long-run relationships driving the system is reported in the first raw of the estimated (\hat{\gamma}) matrix, in the first numerical array on the second raw of equation\(3) From our estimates it follows that there is a statistically significant structural break of
the level-shift type in the first cointegrating vector. Given the sign of the parameter multiplying the level-shift, our model implies that starting from January 2009, the interest rate has been on average higher of what it would have been, on the basis of the parameters estimated in the first subsample. In other words, the linear curve representing the relationship between the interest rate and rate of inflation has shifted downward in the aftermath of the financial and economic crisis.

Estimated residuals (see figure 3) pass the Portmanteau test of no autocorrelation up to 12 lags (P-value=0.22). On the contrary, the hypothesis of normality can be accepted only for residuals relative to the equations for monthly changes in inflation (Jarque-Bera test p-value=0.91), while it is rejected for other residuals. On the whole we believe that these results are quite satisfactory, even if they might be improved for example by changing the specification of the deterministic components of the short-term side of the model in order to attenuate the excess of kurtosis which characterize residuals. This issue is left for future research.

Moreover, from the long-run residuals (see figure 4) of the model it follows that the cointegrating residuals are mean-reverting once it is taken into account a break of the level-shift type in the long-run part of the system, that is in the cointegrating relationships. The most commonly employed tests signal a substantial stability of the system over the timespan considered (see figures 5-8).

With regards to the short-run dynamics of the system, the results of the tests for Granger-causality and for instantaneous Granger-causality strongly reject the hypotheses that some of the variable do not exhibit leading properties with respect to some other variable of the system (see tables 5, 6). These results point to a strong dynamic interaction among the set of considered variables and justify the estimation of a multivariate VECM system rather than separate univariate time series model.

Following Lütkepohl, we exploit the results of the cointegration analysis to simplify the identification of structural shocks. Indeed, given a system with four variables (K=4) and a cointegrating rank equal to two (r=2), it follows that there are two (r=2) transitory shocks and two (K-r=2) permanent shocks. In order to just-identify the structural shocks, K(K-1)/2 (6 in our case) restrictions are needed. From the fact that long-run multipliers of the two transitory shocks are by definition equal to zero, we obtain 4 independent restrictions (r(K-r)=4). Thus, two more restrictions are required. In detail, one additional restriction (r(r-1)/2=1) is needed to identify transitory shocks and another one (((K-r)(K-r-1))/2=1) is needed to identify permanent shocks. Our identification strategy is the following: we have chosen to over-identify the structural innovations by imposing 5 additional restrictions which represent our theoretical (for the long-run) and empirical (for the instantaneous impact) arguments for identification. In detail, we assume that real GDP (y) does not affect monetary variables (r,π) in the long-run. Moreover, we impose zero-restrictions on the following instantaneous effects: short-term interest rate (r) on real loans (l); real loans (l) on short-term interest rate (r), and inflation (π) on real loans (l). Therefore, if we denote by \( \Xi B \) the matrix containing the long-run impact of structural innovations and by \( B \) the instantaneous effects of the
structural innovations, we place the following restrictions:

$$\Xi B = \begin{bmatrix} * & 0 & 0 & 0 \\ * & 0 & 0 & * \\ * & 0 & 0 & 0 \\ * & 0 & 0 & * \end{bmatrix} \quad B = \begin{bmatrix} * & 0 & * & * \\ 0 & * & 0 & * \\ * & * & * & * \\ * & * & * & * \end{bmatrix}$$ (4)

The Impulse Response Functions are reported in figure [9], which gives a clear picture of the main impact of the identified structural shocks.

Finally, we report out of the sample forecasts of the four variables of the system over a 12 months horizon (see figures [10]), for the period April-2013/March 2014. Generally speaking our projections seem quite reasonable and in line with projections that are currently formulated and published by professional forecasters.

A preliminary rolling exercise on GDP forecasts shows that projections of this model are characterized by a Root Mean Squared Error in line with the literature in the field (see table [7]). This analysis has been realized within a full-information forecasting framework, i.e. without taking into account the lag associated to time series releases and revisions of data. Therefore, this exercise can be regarded as an optimistic assessment of forecast accuracy. A more accurate real-time assessment is an issue left open for future research.

4 Concluding Remarks

We estimate a multivariate model to disentangle the long-run trends and the short-term dynamics of the bank lending sector in Italy. The analysis is based on Vector Error Correction Model and take into consideration a possible structural break in the economy due to the latest crises. We extend the existing literature in two directions. First, we find evidence of a structural break in the interrelation among credit variables, inflation and the real economy due to the latest crises. Second, we propose a monthly model respect to the current literature that only focus on quarterly data. The high frequency of our dataset allows us to better capture the dynamics of financial variables with respect to macroeconomic data. To this aim we use the monthly GDP produced by the CEIS Tor Vergata University Economics Foundation, which is coherent with ISTAT values but is published more timely and in disaggregated terms. Our analysis identifies two cointegrating relations when allowing for a structural break of the level-shift type representing respectively the Taylor’s rule and the real lending demand curve. On the whole we believe that our model can be considered as a valuable forecasting tool that can integrate and improve forecasting scenarios originated from more standard short-term econometric models that generally do not take into account signals originating from the credit market. Under this respect we believe that our model can be regarded as a first attempt to measure the real impact originating from episodes of financial distresses that hit the
real economy through the credit channel. Many relevant issues remain open for future research. In our view, future analyses should investigate over the possibility of improving the model and its forecasting performance with a different specification of the deterministic part of the model itself. Moreover, it may be fruitful to include in the model exogenous variables such as the world trade, capable of capturing, at least partially, the macroeconomic volatility following the collapse of the financial system by the end of year 2008. Lastly, it may be potentially relevant to distinguish between lendings for households and lendings to non financial corporations.
References


Figures and Tables

Figure 1: Variables in log-levels, monthly data for the period January 1999 - March 2013
Figure 2: Variables in log-differences, monthly data for the period January 1999 - March 2013
Table 1: Unit root tests, monthly data for the period January 1999 - June 2012

<table>
<thead>
<tr>
<th>Model type</th>
<th>Model type</th>
<th>ADF$^1$</th>
<th>DFGLS$^2$</th>
<th>PP$^3$</th>
<th>KPSS$^4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logarithm of real lending</td>
<td>Trend and intercept</td>
<td>3.16</td>
<td>-0.24</td>
<td>2.66</td>
<td>0.31</td>
</tr>
<tr>
<td>Logarithm of gross domestic product</td>
<td>Trend and intercept</td>
<td>-1.78</td>
<td>-0.90</td>
<td>-1.36</td>
<td>0.32</td>
</tr>
<tr>
<td>Monthly annualized inflation rate</td>
<td>Intercept</td>
<td>-6.91</td>
<td>-3.38</td>
<td>-11.76</td>
<td>0.08</td>
</tr>
<tr>
<td>Short-term interest rate</td>
<td>Trend and intercept</td>
<td>-2.31</td>
<td>-2.10</td>
<td>-1.98</td>
<td>0.68</td>
</tr>
<tr>
<td>∆ (Logarithm of real lending)</td>
<td>Trend and intercept</td>
<td>-12.47</td>
<td>-12.44</td>
<td>-13.30</td>
<td>0.25</td>
</tr>
<tr>
<td>∆ (Logarithm of gross domestic product)</td>
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<td>-4.26</td>
<td>-3.70</td>
<td>0.05</td>
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<tr>
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<td>0.11</td>
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<td>∆ (Short-term interest rate)</td>
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<td>-5.85</td>
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<td>-5.79</td>
<td>0.11</td>
</tr>
</tbody>
</table>

1 Augmented Dickey Fuller test. The null hypothesis of the test is that the process has an unit root. At 5%-significance, the critical value for the model with trend and intercept is -3.44, while the critical value for the model with only the intercept is equal to -2.88.

2 Elliot, Rothenberg and Stock test. The null hypothesis of the test is that the process has an unit root. At 5%-significance, the critical value for the model with trend and intercept is -2.96, while the critical value for the model with only the intercept is equal to -1.94.

3 Phillips and Perron test. The null hypothesis of the test is that the process has an unit root. Critical values are the same as in the ADF test.

4 Kwiatkowski, Phillips, Schmidt and Shin test. The null hypothesis of the test is that the process is stationary. At 5%-significance, the critical value for the model with trend and intercept is 0.15, while the critical value for the model with only the intercept is equal to 0.46.
Table 2: Unit root tests allowing for structural breaks, monthly data for the period January 1999 - March 2013

<table>
<thead>
<tr>
<th>Variable</th>
<th>Endogenous break allowed</th>
<th>ZA (^1)</th>
<th>Minimum t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logarithm of real lending</td>
<td>Intercept</td>
<td>1.14</td>
<td>2003m12</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>-1.39</td>
<td>2008m02</td>
</tr>
<tr>
<td></td>
<td>Intercept and trend</td>
<td>-1.90</td>
<td>2006m10</td>
</tr>
<tr>
<td>Logarithm of gross domestic product</td>
<td>Intercept</td>
<td>-3.26</td>
<td>2008m02</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>-3.28</td>
<td>2006m11</td>
</tr>
<tr>
<td></td>
<td>Intercept and trend</td>
<td>-4.02</td>
<td>2008m02</td>
</tr>
<tr>
<td>Monthly annualized inflation rate</td>
<td>Intercept</td>
<td>-7.41</td>
<td>2010m10</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>-7.11</td>
<td>2009m05</td>
</tr>
<tr>
<td></td>
<td>Intercept and trend</td>
<td>-8.07</td>
<td>2008m08</td>
</tr>
<tr>
<td>Short-term interest rate</td>
<td>Intercept</td>
<td>-4.19</td>
<td>2008m11</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>-2.70</td>
<td>2007m09</td>
</tr>
<tr>
<td></td>
<td>Intercept and trend</td>
<td>-3.71</td>
<td>2008m11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>Endogenous break allowed</th>
<th>ZA (^1)</th>
<th>Minimum t</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\Delta) (Logarithm of real lending)</td>
<td>Intercept</td>
<td>-14.09</td>
<td>2003m12</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>-14.03</td>
<td>2007m03</td>
</tr>
<tr>
<td></td>
<td>Intercept and trend</td>
<td>-14.40</td>
<td>2006m01</td>
</tr>
<tr>
<td>(\Delta) (Logarithm of gross domestic product)</td>
<td>Intercept</td>
<td>-4.72</td>
<td>2009m04</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>-4.37</td>
<td>2001m06</td>
</tr>
<tr>
<td></td>
<td>Intercept and trend</td>
<td>-4.84</td>
<td>2009m07</td>
</tr>
<tr>
<td>(\Delta) (Monthly annualized inflation rate)</td>
<td>Intercept</td>
<td>-16.22</td>
<td>2009m02</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>-16.07</td>
<td>2001m04</td>
</tr>
<tr>
<td></td>
<td>Intercept and trend</td>
<td>-16.24</td>
<td>2009m02</td>
</tr>
<tr>
<td>(\Delta) (Short-term interest rate)</td>
<td>Intercept</td>
<td>-6.35</td>
<td>2008m11</td>
</tr>
<tr>
<td></td>
<td>Trend</td>
<td>-5.94</td>
<td>2001m09</td>
</tr>
<tr>
<td></td>
<td>Intercept and trend</td>
<td>-6.77</td>
<td>2008m11</td>
</tr>
</tbody>
</table>

\(^1\) Zivot and Andrews test. The null hypothesis of the test is that the process has a unit root in the presence of one structural break endogenously determined. At 5%-significance, the critical value for the model with break in the intercept is -4.80, the critical value for the model with break in the trend is -4.42, while the critical value for the model with break both in the intercept and in the trend is -5.08.
Table 3: Johansen cointegration test, monthly data for the period January 1999 - March 2013, one break in level in January 2009

<table>
<thead>
<tr>
<th>Cointegrating rank</th>
<th>Trace statistic</th>
<th>5% Critical value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r = 0$</td>
<td>94.56</td>
<td>64.16</td>
<td>0.000</td>
</tr>
<tr>
<td>$r = 1$</td>
<td>52.81</td>
<td>43.15</td>
<td>0.004</td>
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<tr>
<td>$r = 2$</td>
<td>15.22</td>
<td>25.85</td>
<td>0.556</td>
</tr>
<tr>
<td>$r = 3$</td>
<td>3.87</td>
<td>10.79</td>
<td>0.747</td>
</tr>
</tbody>
</table>

Critical values are obtained by simulation, with 10,000 random walk of length 1,000. The test has been conducted with a number of lag equal to 5.

Table 4: Saikkonen and Lütkepohl cointegration test, monthly data for the period January 1999 - March 2013, one break in level in January 2009

<table>
<thead>
<tr>
<th>Cointegrating rank</th>
<th>Trace statistic</th>
<th>5% Critical value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r = 0$</td>
<td>64.19</td>
<td>40.07</td>
<td>0.000</td>
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<tr>
<td>$r = 1$</td>
<td>32.47</td>
<td>24.16</td>
<td>0.003</td>
</tr>
<tr>
<td>$r = 2$</td>
<td>6.78</td>
<td>12.26</td>
<td>0.352</td>
</tr>
<tr>
<td>$r = 3$</td>
<td>0.29</td>
<td>4.13</td>
<td>0.653</td>
</tr>
</tbody>
</table>

The test has been conducted with a number of lag equal to 5.
Figure 3: Residuals of the VECM model, monthly data for the period June 1999 - March 2013

- Residuals of D(Real Lending)
- Residuals of D(Real GDP)
- Residuals of D(3-months Euribor)
- Residuals of D(CPI rate of change)
Figure 4: Long-run residuals, monthly data for the period June 1999 - March 2013

Long-run residuals: first cointegrating vector

Long-run residuals: second cointegrating vector
Figure 5: Model stability, recursive eigenvalues

Figure 6: Model stability, test of eigenvalues’ stability
Table 5: Test for Granger-causality

<table>
<thead>
<tr>
<th>Causing</th>
<th>Caused</th>
<th>Test statistic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$l \pi y$</td>
<td>2.2162</td>
<td>0.0052</td>
</tr>
<tr>
<td>$l$</td>
<td>$r \pi y$</td>
<td>1.0163</td>
<td>0.4362</td>
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<tr>
<td>$\pi$</td>
<td>$r l y$</td>
<td>4.1902</td>
<td>0.0000</td>
</tr>
<tr>
<td>$y$</td>
<td>$r l \pi$</td>
<td>2.0544</td>
<td>0.0108</td>
</tr>
<tr>
<td>$r l$</td>
<td>$\pi y$</td>
<td>1.5132</td>
<td>0.0708</td>
</tr>
<tr>
<td>$r \pi$</td>
<td>$l y$</td>
<td>3.6617</td>
<td>0.0000</td>
</tr>
<tr>
<td>$r y$</td>
<td>$l \pi$</td>
<td>1.8813</td>
<td>0.0117</td>
</tr>
<tr>
<td>$l \pi$</td>
<td>$r y$</td>
<td>2.9934</td>
<td>0.0000</td>
</tr>
<tr>
<td>$l y$</td>
<td>$r \pi$</td>
<td>1.9906</td>
<td>0.0065</td>
</tr>
<tr>
<td>$\pi y$</td>
<td>$r l$</td>
<td>3.2203</td>
<td>0.0000</td>
</tr>
<tr>
<td>$r l \pi$</td>
<td>$y$</td>
<td>3.3779</td>
<td>0.0000</td>
</tr>
<tr>
<td>$r l y$</td>
<td>$\pi$</td>
<td>1.2819</td>
<td>0.2082</td>
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<td>$l \pi y$</td>
<td>$r$</td>
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<td>$r \pi y$</td>
<td>$l$</td>
<td>1.9207</td>
<td>0.0191</td>
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</tbody>
</table>

$r, l, \pi$ and $y$ represent respectively the short-term interest rate, logged real lending, the annualized monthly inflation rate and the logged GDP. The $H_0$ of the test is "the x variable does not Granger-causes the y variable".

Table 6: Test for instantaneous Granger-causality

<table>
<thead>
<tr>
<th>Causing</th>
<th>Caused</th>
<th>Test statistic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$l \pi y$</td>
<td>4.6241</td>
<td>0.2015</td>
</tr>
<tr>
<td>$l$</td>
<td>$r \pi y$</td>
<td>26.2891</td>
<td>0.0000</td>
</tr>
<tr>
<td>$\pi$</td>
<td>$r l y$</td>
<td>29.5151</td>
<td>0.0000</td>
</tr>
<tr>
<td>$y$</td>
<td>$r l \pi$</td>
<td>0.3889</td>
<td>0.9425</td>
</tr>
<tr>
<td>$r l$</td>
<td>$\pi y$</td>
<td>29.6102</td>
<td>0.0000</td>
</tr>
<tr>
<td>$r \pi$</td>
<td>$l y$</td>
<td>26.4721</td>
<td>0.0000</td>
</tr>
<tr>
<td>$r y$</td>
<td>$l \pi$</td>
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<td>0.2697</td>
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<td>$l \pi$</td>
<td>$r y$</td>
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<td>0.2697</td>
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<tr>
<td>$l y$</td>
<td>$r \pi$</td>
<td>26.4721</td>
<td>0.0000</td>
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<tr>
<td>$\pi y$</td>
<td>$r l$</td>
<td>29.6102</td>
<td>0.0000</td>
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<tr>
<td>$r l \pi$</td>
<td>$y$</td>
<td>0.3889</td>
<td>0.9425</td>
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<tr>
<td>$r l y$</td>
<td>$\pi$</td>
<td>29.5151</td>
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<tr>
<td>$l \pi y$</td>
<td>$r$</td>
<td>4.6241</td>
<td>0.2015</td>
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<tr>
<td>$r \pi y$</td>
<td>$l$</td>
<td>26.2891</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

$r, l, \pi$ and $y$ represent respectively the short-term interest rate, logged real lending, the annualized monthly inflation rate and the logged GDP. The $H_0$ of the test is "the x variable does not instantaneously Granger-causes the y variable". 
Table 7: Rolling analysis of GDP forecast accuracy

<table>
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<tbody>
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<td>February 2011</td>
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<td>0.42</td>
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<tr>
<td>March 2011</td>
<td>0.18</td>
<td>0.38</td>
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</tr>
<tr>
<td>April 2011</td>
<td>0.16</td>
<td>-0.12</td>
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<td>June 2011</td>
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<tr>
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<tr>
<td>August 2011</td>
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<td>-0.06</td>
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<tr>
<td>September 2011</td>
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<td>-0.47</td>
<td>-0.06</td>
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<tr>
<td>December 2011</td>
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<td>January 2012</td>
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</tbody>
</table>

RMSFE

<table>
<thead>
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</thead>
<tbody>
<tr>
<td>2-step ahead</td>
<td>0.55</td>
</tr>
</tbody>
</table>
Figure 9: Impulse Response Functions

SVEC Impulse Responses
Figure 10: Forecasts from the VECM model, for the period July 2012 - June 2013

Time Series Forecasts (CI 95.0%)