Financial Instability, Credit Cycles and Monetary Policy*

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1 Introduction

There seems to be a general consensus among macroeconomists and central bankers that the global financial crisis of 2007-2009 to a large extent was driven by credit growth. The same goes for earlier financial crises, e.g. as shown by Reinhart and Rogoff (2009). In his opening address at the ECB Central Banking Conference in November 2010, the president of the ECB, Trichet (2010) argued that a central lesson from the financial crisis is that central bank policy makers need to pay more attention to financial instability and the amount of credit in the economy. At this point, however, the opinion amount macroeconomists seems more divided. Some macroeconomists argue that the recent credit expansion and resulting global financial crisis primarily was caused by a too expansionary central bank policy.[1] Others see it as a result of more structural problems in the economy, the financial deregulation of the banking sector especially.

This paper contributes to this discussion by studying empirically the relations between monetary policy, credit growth and financial instability using US data. The paper focuses on two separate but related questions. Firstly, does credit growth affect financial stability, i.e., asset price bubbles? Secondly, is it even - by means of standard monetary measures - possible for central banks to influence the long run credit cycles and build-ups of financial instability or are they rather a consequence of structural economic mechanisms?

*I have received valuable comments and suggestions from Michael Bergman, Bent Nielsen and Katarina Juselius.

[1]For example John B. Taylor, in the case of the US, argues that the Federal funds rate was too low for too long, refereeing to the period 2003-2005.

In the theoretical literature there are in principle two conflicting approaches; the *money view* and the *credit view*.[2] The first approach, i.e., the money view, is characterized by the assumption of perfect and risk free financial markets giving rise to the efficient market hypothesis (*hereafter EMH*) and the theorem of capital structure irrelevance (Modigliani and Miller, 1958). Hereby asset prices are only affecting the real economy through the substitution and wealth effect, with credit growth purely as a manifestation of risk less and "non-harming" shifts of purchasing power over time and various states of the economy. From the view of a central banker, the only important financial variables are money and bonds, as all other prices and interest rates are adjusted perfectly by the means of no-arbitrage conditions.[3]

The second approach, i.e., the credit view, assumes imperfect financial markets motivated by the periods of financial deregulation before the Great Depression and after the 1970s. The debt-deflation theory developed by Fisher (1933) argues that financial markets can have an utmost important impact on the business cycle, in particular in periods with over-indebtedness. More recent theories incorporate similar mechanisms into a general equilibrium framework. Both the Financial Accelerator and the Asset Boom-Bust theory assumes limited liability in credit contracts whereby credit growth has a risk shifting effect from borrowers to lenders (Stiglitz and Weiss, 1981; Bernanke and Gertler, 1989; Bernanke and Blinder, 1988; Allen and Gale, 2000b; Kiyotaki and Moore, 1997). Hereby lenders tend to be overly risk seeking driving vicious circle of asset price bubbles and uncovered credit growth accelerating both real economic booms and busts. Compared to the money view, credit growth is not just an indication of shifting but also of creation of purchasing power not resulting from any real increase in voluntary saving in the economy.

According to the credit view, policy makers should therefore be focused on the evolution in the credit amount. Where theories of imperfect markets differ somewhat, however, is on what primarily drives this evolution. On the one hand, the Financial Accelerator explains credit growth as a result of monetary policy affecting the net worth of banks, households and firms and thereby banks' willingness to supply credit. The Asset Boom-Bust theory, on the other hand, relates credit growth to financial liberalization and innovation. Both these channels appear to have been at work during the buildup to the current financial crisis. Rapid credit growth in most OECD countries together with both financial deregulation and long periods of expansionary monetary policy may have contributed to the crisis.

The empirical results regarding the importance of credit growth and its driving forces are quite inconsistent. One type of empirical analysis - typically done in a multiple country setup - considers the interaction between real economic and financial cycle

[2]These terms are used in Kakes (2000) and I will continue using the same terminology in this paper.

[3]The money view is primarily focused on the monetary policy working though the liability side of the banking sectors balance sheet. For example, in an IS-LM model there are only two financial assets, money and bonds, where the bond market represents the entire financial market (Kakes, 2000).

characteristics by the means of simple econometric analysis. Claessens et al. (2010) finds that especially credit and house price cycles have a large impact on the amplitude and depth of economic recessions as well as booms. Similar early warning systems often find... [MORE HERE]

More in line with the method of this paper, analyses using VAR-models often consider a single economy setup, either from a single country or a global aggregate of several. A group of these analyses make use of so-called factor-augmented VAR-models (*hereafter FAVAR*) (Bernanke and Kuttner, 2005). Helbling et al. (2010) estimate a global FAVAR-model on data from the G-7 countries including the real credit growth and different credit spreads. From an impulse response analysis, they find significant effects of credit shocks on real global business cycles. Eickmeier and Hofmann (2010), Gilchrist and Zakrajsek (2010), and Meeks (2009) also use FAVAR-models but are only considering the effects of shocks to credit spreads.[4] Still, they find significant real effects of credit shocks.

On point of concern regarding these models, however, is the assumption of linearity. According to the Asset Boom-Bust theory, business cycles can be separated into different parts with different mechanisms at work, especially when considering the importance of financial deregulation and credit cycles. Kaufmann and Valderrama (2007) estimate a Markov switching VAR-model (*hereafter MSVAR*) on Euro-area and US data including credit growth. They find evidence of a two-stage regime both in the Euro area and in the US, where the importance of credit shocks varies considerably. Atanasova (2003) considers a non-linear threshold VAR-model (*hereafter TVAR*) including credit spreads. [MORE HERE]

Another critical point is the exclusion of cointegration relations. The models thereby miss information on the long run relations between level variables, the long run error-correction mechanisms, and possibly suffer from excluded variable bias. However, limited research uses cointegrated VAR-models (*hereafter CVAR*) in relation to credit. As a robustness check Greiber and Setzer (2007) include a credit measure in a monetary CVAR-model analyzing the effect of money on the house prices in the US and Euroarea. Here they find that credit has limited effects.

This paper analyzes the relation between credit, monetary policy and financial instability while trying to deal with several of the problems mentioned above. First of all, unlike many earlier studies, I estimate a CVAR-model on levels variables from the US including, among others, a real money measure, the real amount of credit, and real house prices. By including a cointegration term, I am able to test the theoretical important long run relations in the data and hereby driving forces. Secondly, I explicitly test and model large persistent credit cycles seen over the last decades, consistently with theoretical literature of financial instability and historical regimes of financial regulation.

[4]Here they identify credit shocks as shocks to the credit spreads having a non-positive effect on the risk of default of the underlying obligation. They use the restriction formulation from Uhlig (2005).

Hereby I solve clear I(2)-problems while to some extend maintaining the interpretation and explanatory power of the changes in the financial regime. In the end, I analyze the fundamental driving mechanisms by the use of generalized and structural impulse response functions.

First of all, I find clear evidence of persistent and related I(2)-trends in real house prices and the real amount of credit. These persistent evolutions seem related to historical regimes of financial regulation [MORE HERE]

The rest of this paper is organized...[MORE HERE]

2 Data

In this section the data is presented together with a short historical description. I consider US monthly data through the period 1984:04-2010:06. The period is chosen in order to have a relatively constant parameter regime but still to be able to analyze the effect of changes in financial liberalization. The starting point marks the beginning of ”The Great Moderation” and the inflation targeting monetary policy regime with the Federal funds rate as policy instrument.[5] Another important characteristic of the data period is the process of financial deregulation and innovation. This also started in the early 1980s and gained momentum through the Reagan period, 1981-1989, and further moved in several regimes up until the global financial crisis.

Similar to the work of Helbling et al. (2010) I include two types of credit variables; the real credit amount (here in levels) and a corporate bond credit spread. For the quantity of money the real M2M[6] is included as done by Greiber and Setzer (2007) among others and the real GDP is included to measure the real economic activity. To analyze the effects on asset prices I include the real house prices. Along the lines of standard monetary VAR-models I include both the nominal own rate on money as well as a three month government interest rate. In summary the model consist of the following seven variables, also shown in figure 1:[7]

[5] In the period before the early 1980s, "The Great Inflation", monetary policy used the quantity of money as the primary policy instrument.

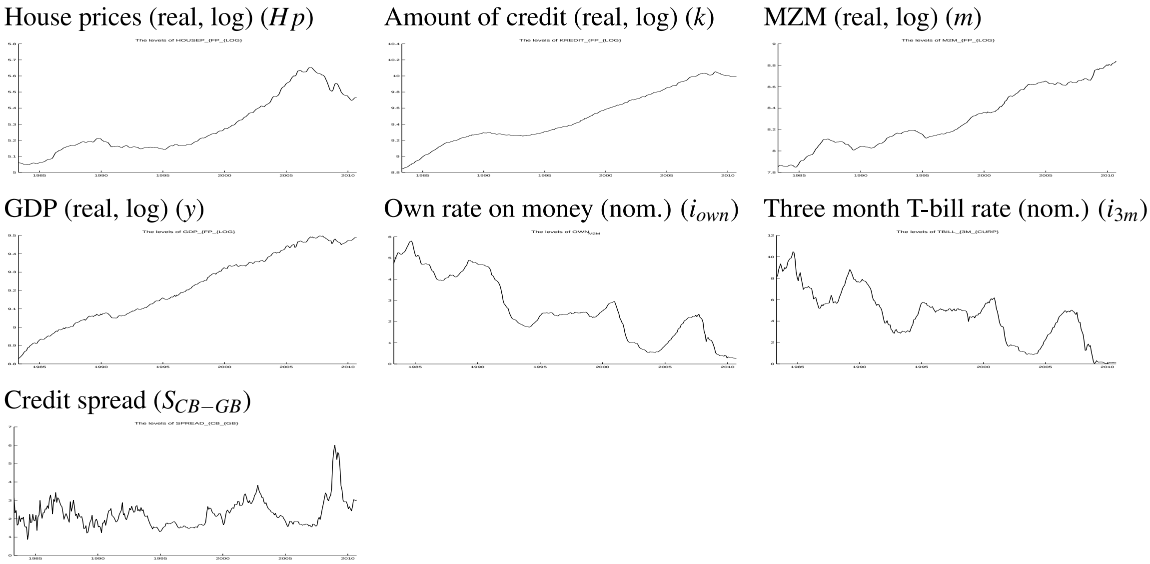
[6] The M2M measure is used in order to avoid the problems of ”the missing money of the 1990s”. Especially in the beginning of the 1990s, because of the financial innovation it seems that small time deposits have been substituted by different types of mutual fund products out side the standard money measure (Carlson and Keen, 1996).

[7] Data sources are shown in appendix **??**.

Table 1: The variables of the model

Hp_t	Real house prices (log)
k_t	The amount of credit outstanding (log)
m_t	The real quantity of money (M2M = M2 less small time deposits) (log)
y_t	Real GDP (log)
$i_{own,t}$	The nominal own rate on money
$i_{3m,t}$	The nominal 3 month Tbill rate
$S_{CB_GB,t}$	Corporate bond credit spread (Moodys BBB - 10 year government bond)

Figure 1: The variables of the model in levels



Returning to the discussion of having a constant parameter regime, several notable historical disturbing events is seen in the data. On the one hand, the global financial crisis is by many thought to be the end of "The Great Moderation", seen in the data as a jump in the credit risk spread and the real quantity of money while the interest rates, real house prices and credit falls rapidly. The Dot-com crisis of 2001, on the other hand, is only seen as a moderately higher credit spread and subsequently low interest rates. The house prices and credit growth were more or less unaffected.

Other things worth noticing is the trend breaks especially seen in the credit evolution over the sample period. The financial deregulation of the Reagan period seems associated with a high credit growth in the first part of the sample. From here on follows a period of almost zero growth in credit, which again changes to a positive trend from the middle of the 1990s until the global financial crisis. A possible explanation for this change is the sub-prime mortgages. According to Chomsisengphet and Pennington-Cross (2006) these started spreading in the first part of the 1990s, made possible by previous financial deregulations.[8] More so, an implicit government guarantee of the two mortgage credit institutions Fannie Mae and Freddie Mac affected the competition situation in the prime-mortgage market why other financial institutions had to seek alternative market segments (Berg and Bech, 2009, p. 90-91). These historical events will be considered in the following.

3 Econometrical method

I order to analyze financial instability, the CVAR-model appears suitable for several reasons. First of all, the model enables separate analysis of the short and long run mechanisms. Hereby it is possible to isolate hypothetical long run relations - in this case financial instability growing relations - generally very important and characteristic in macroeconomic theory. I relation to these long run relation, the model is able to identify equilibrium and disequilibrium causing variables - so-called *pushing and pulling forces* (Juselius, 2007, p. 88). Secondly, the CVAR-model uses vector formulation which enables estimation of multiple relation, general equilibrium and feedback effects. A third often argued strength of the CVAR-model is that it is identified by gradual steps of tests and restrictions, in concordant with the general-to-specific idea (*hereafter GTS*) (Juselius, 2007, p. 347).

3.1 The VECM-form

The CVAR-model can be written on several forms. When cointegration relations is not accounted for the model can be written as a VAR(k)-model with k autocorrelation lags:

$$x_t = \sum_{i=1}^{k} \Pi_i x_{t-i} + \Phi D_t + \varepsilon_t \tag{1}$$

where x_t is a vector of realized observations for the p variables of the model at time $t = 1,\ 2\ ,...,T$, the Π_i's are $p \times p$ matrices for the $i = 1,\dots,k$ lags of the model, and D_t is a vector of deterministic components such as dummies, constants and trends with coefficients vector ϕ. ε is a $p \times 1$ vector of error terms of each variables equation. The error terms are assumed multivariate normal distributed; $\varepsilon \sim N_p(0,\Omega)$[9] with a variance-covariance matrix Ω (Juselius, 2007, p. 59).

[8]Chomsisengphet and Pennington-Cross (2006) present data on sub-prime mortgages from 1995 but do stress that they might have been issued even earlier. The sub-prime mortgages was legally made possible by three financial liberalizing reforms in the Reagan period: *The Depository Institutions Deregulation and Monetary Control Act*, 1980; *The Alternative Mortgage Transaction Parity Act*, 1982; and *The Tax Reform Act*, 1986.

[9]The $\sim$ indicates "distributed as" and N_p indicates a multivariate normal distribution of dimension p.

To account for cointegration between the level variables the VAR-model in (1) can further be written on VECM-form;

$$\Delta x_t = \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \Pi x_{t-1} + \Phi D_t + \varepsilon_t \tag{2}$$

where $\Pi = -(I - \sum_{i=1}^{k} \Pi_i)$ and $\Gamma_i = -\sum_{j=i+1}^{k} \Pi_j$. The cointegration hypothesis can be verified as a test of whether the Π-matrix has reduced rank. If the Π-matrix has the rank r it means that the model contains r cointegration relations and $p-r$ common stochastic trends. Hereby the p variables in the model can be seen as a system of r long run relations with $p-r$ exogenous driven trends. To analyze the long run relations in the data, the Π-matrix can appropriately be written as the matrix product; $\Pi = \alpha\beta'$, where the β-matrix describes the structure of the long run relations while the α-matrix determines the possible error correction or overshooting tendencies of each variable to these long run relations. This gives some indication of which variables are driving the long run relations.

After the number of long run relations have been determined, these have to be identified on the basis of tests for theoretical consistent restrictions on the β-matrix. These tests should result from predefined hypothetical long run relations given by the economical theory of consideration. More on this in section 4.

3.2 The structural MA-form and impulse responses

In contrast to considering the error correction mechanisms, the CVAR-model on MA-form focuses on which of the variables are driving the model in the long run and which only have transitory effect. From (2) the model can be written on reduced MA-form;[10]

$$x_t = C \sum_{s=1}^{t} \varepsilon_s + C^*(L)\varepsilon_t + C\mu t + \tilde{X}_0 \tag{3}$$

where $\tilde{X}_0$ is a vector of initial values, $C^*(L) = \Sigma_{j=0}^{t} C_j^* L^j$ determines transitory effects from the stationary part of the the process while the C-matrix determines the permanent long run impact of shocks to the residuals.[11] The C-matrix can - as a parallel to the partition of the long run structure in the Π-matrix - be written as $C = \tilde{\beta}_\perp \alpha'_\perp$ where $\tilde{\beta}_\perp = \beta_\perp(\alpha'_\perp \Gamma \beta_\perp)^{-1}$. Here the $\alpha'_\perp$-matrix determines the construction of the $p-r$ common stochastic trends while the $\tilde{\beta}_\perp$ determines the weights on each residual in the common stochastic trends (Juselius, 2007, p. 255).

Until now the model has been on reduced form. This form of the model is characterized by only conditioning on predetermined variables and deterministic components. Hereby the model could systematically omit important simultaneous effects in

[10]Here I consider the type of MA-form used in Juselius (2007, s. 85, 101-102).

[11]In the equation $C^*(L) = \Sigma_{j=0}^{t} C_j^* L^j$, L determines the lag operator.

the data. When these are not modeled, they show up as large non-diagonal elements in the variance-covariance matrix, Ω. Correlated error terms are in contrary to theoretical structural shocks hitting the economy exogenous and independently. In practice, in the structural form, the p residuals in the reduced form model are related to p underlying linear independent structural shocks (Juselius, 2007, p. 278):

$$u_t = \begin{pmatrix} u_{l,t} \\ u_{s,t} \end{pmatrix} = B\varepsilon_t \tag{4}$$

where u_t is a vector consisting of $p-r$ permanent and r transitory structural shocks, $u_{l,t}$ and $u_{s,t}$ respectively. B is a $p \times p$ restriction matrix. Inserting (4) in the reduced MA-form (3) the model can be rewritten on structural form;[12]

$$x_t = \underbrace{\tilde{\beta}_\perp \alpha'_\perp B^{-1}}_{\tilde{C}} \begin{pmatrix} \sum_{i=1}^{t} u_{l,i} \\ \sum_{i=1}^{t} u_{s,i} \end{pmatrix} + C^*(L)B^{-1} \begin{pmatrix} u_{l,t} \\ u_{s,t} \end{pmatrix} + C\mu t + \tilde{X}_0 \tag{5}$$

where the matrix product $\tilde{C} = \tilde{\beta}_\perp \alpha'_\perp B^{-1}$ determines the permanent effects and $C^*(L)B^{-1}$ determines the transitory effects.

By multiplying by the B^{-1}-matrix and thereby including current effects in the model we also include $p \cdot p$ new coefficients. To achieve just-identification the model should therefore be subject to an additional $p \cdot p$ restrictions on the B and/or $\tilde{C}$-matrix. In the literature there are several ways to do this (Lütkepohl and Krätzig, 2004, p. 163-171). One way is to imposed restrictions so that the structural shocks satisfy the two conditions; *i*) all the structural shocks are linearly independent ($u_t \sim N(0, I_p)$) and *ii*) the structural shocks are separated in $p-r$ permanent and r transitory shocks. By $(p+1)p/2$ restrictions on the B-matrix the first condition ($u_t \sim N(0, I_p)$) is insured[13] while another $(p-r)r$ zero-restrictions on the last r columns of $\tilde{C}$-matrix ensures the second condition. The remaining restrictions ensure an identified ordering of the permanent and transitory shocks and should be made such that each shock can be given a clear interpretation (Juselius, 2007, p. 279).

From this formulation it is possible to do impulse response function analyses (Lütkepohl and Krätzig, 2004, s. 167). [MORE HERE]. The vector process of impulse responses is defined as:

$$GI_x(n, \delta, \Omega_{t_1}) = \mathrm{E}(x_{t+n} | \varepsilon_t = \delta, \Omega_{t_1}) - \mathrm{E}(x_{t+n} | \Omega_{t_1}) \tag{6}$$

where ...

[12] Likewise the VECM-form can be written on structural form: (2) multiplied through by the matrix B; $B\Delta x_t = B\Gamma\Delta x_{t-1} + B\alpha\beta' x_{t-1} + B\Phi D_t + u_t$, where $u_t = B\varepsilon_t$, $u_t \sim N(0, \Sigma)$, $\Sigma = B\Omega B'$.

[13] The condition $u_t \sim N(0, I_p)$ requires that the structural shocks are independent; imposing $(p-1)p/2$ restrictions on the non-diagonal elements of the B-matrix. A standardized distribution requires additional p restrictions on the diagonal of the B-matrix. In sum these restriction are; B'=$[\alpha'\Omega^{-1}\alpha^{-1/2}\alpha'\Omega^{-1}, (\alpha'_\perp\Omega\alpha_\perp)^{1/2}\alpha'_\perp]$ (Juselius, 2007, s. 278-279).

3.3 Generalized impulse responses

It is important to note that the additional restrictions, ordering and interpretations of the structural form cannot be tested, which is a critical an0d controversial point of the model (Juselius 2007, p. 232, 287; Lütkepohl and Krätzig 2004, p. 195). Another way to do impulse response function analysis is to consider so-called generalized impulse responses. Here no exogenous ordering of the shock is required..

This type of impulse response analysis describes the dynamics of a given variable when the model i hit by a one standard deviation shock to the residuals in the equation of another variable, given all current effect described by the historical variance-covariance matrix, Ω, is taken into account. Hence, it is important to note that this is not an underlaying exogenous theoretical consistent shock, which makes it difficult to interpret [MORE HERE]

3.4 Analyzing different economical regimes

Considering the economical evolution of the US economy especially regarding the financial system calls for measures of different economical regimes. By the theory of non-linear VAR model... An alternative is explicit to model deterministic terms into the model or simply to split the sample [MORE HERE].

4 Theoretical considerations

Before start analyzing the data it is preferable to have a theory consistent hypothetical framework of how to test and restrict the model. Here I present an overview of the different relation and driving trends I expect to find i the data given the theoretical literature.

As this paper considers how the quantity of money affect the amount of credit in the economy, I should expect to find a long run money demand relation. By monetarist theory, e.g. from the Beaumol-Tobin model or a money in the utility function CCAPM model, such a relation can be expressed as (Greiber and Lemke, 2005):

$$m_t - \beta_{11} y_t + \beta_{12}(r_{3m,t} - r_{own,t}) - \beta_{12} S_{CB,t} + c_{11} \quad \sim \quad I(0) \tag{7}$$

where all β_{1i}'s are expected positive: from standard monetary theory, the money demand should increase when the alternative cost of holding money $(r_{3m,t} - r_{own,t})$ falls or when the economic activity (y_t) increases. From the money in the utility function CCAPM model or others, higher uncertainty in the financial markets introduces a flight to equality effect where investors seek to hold more money, i.e. money demand increases when the credit risk spread $(S_{CB,t})$ increases Cook and Choi (2007); Greiber and

Lemke (2005). In the literature there exists many variants of the money demand relation; different extensions nonetheless in relation to the recent financial deregulation and innovation and different measures of both money, the alternative cost of holding money and the transaction motive Carstensen (2003). To account for the latter, house prices are sometimes included, argued by the wealth effect (Greiber and Setzer, 2007; Boone and Noord, 2008). Often theories consider the money velocity, assuming that the money elasticity wrt. output, β_{11}, equals unity, but in empirical analyses it often is fount to be somewhat smaller.

Excess liquidity is represented by money supply exceeding the level of money demand given by (7). The relevant hypothetical question of the monetary boom-bust theory is whether excess liquidity affect real house prices positively and credit spread negatively. More so, it is interesting to test whether real credit and GDP also are positively affected.

Another important theoretical relation I will consider is that of the credit view. The Asset Boom-Bust model gives rise to the following long run relation (Allen and Gale, 2000a):[14]

$$Hp_t - \beta_{21}(k_t - y_t) + \beta_{22}S_{CB,t} + \beta_{23}i_{3m} + c_{21} \quad \sim \quad I(0) \tag{8}$$

where again all β_{2i}'s are expected positive: increases in the amount of credit relative to GDP is associated with limited liabilities and thereby risk shifting between house owners and their banks. Falling credit spreads are... Falling interest rates... This ultimately results in increasing house prices and real GDP. According to the Asset Boom-Bust theory, this is the process financial instability why the relevant question is whether house prices and GDP are affected positively by excess credit to GDP in (10).

Typically an aggregate demand (AD) relation is also found:

$$y_t^D - y_t^P - \beta_{31}i + c_{31} \quad \sim \quad I(0) \tag{9}$$

where $y_t^D - y_t^P$ is the output gap, i.e. output demand minus potential output, which often is approximated by GDP minus a deterministic trend[15]. Again β_{31} is expected positive. I some cases the AD relation is extended by asset prices argued by the wealth effect **?**. More so, according to the Financial Accelerator effect it could be argued that med relation should be extended with credit; during economic downturns many firms and households are credit restricted.

According to the expectations hypothesis a long run term structure relation should also be found. Here interests rates should cointegrate when corrected for their differences in duration and liquidity and default risk. This would result in the following long

[14]This concrete long run relation is my own interpretation of their theory.

[15]The approximation of the output gab as GDP minus a deterministic trend is not ... from a theoretical perspective.

run relation:

$$r_{own,t} - \beta_{41} r_{3m,t} ?? \beta_{42} S_{CB,t} + c_{31} \quad \sim \quad I(0) \tag{10}$$

Here again all β_{4i}'s are expected positive: the own rate on money should follow the T-bill rate though especially corrected for the higher liquidity and therefore lower liquidity risk on currency and checkable deposits.

Other long run relations could be found as well: a relation between the credit risk spread and real GDP as argued by theory of irrational procyclical expectations, often considered in VAR-models focusing and the real effect of credit risk shocks .[16] Further possibly a policy rule of the central bank or a Tobins Q housing demand relation could be found.

Regarding the structural shocks in the model, I expect to find at lest three; a real economic shock, a nominal or monetary policy shock and a financial/credit shock. Especially a positive monetary policy shock and financial/credit shock should influence house prices positively, in favor for the monetary boom-bust theory and the Asset Boom-Bust theory respectively.

5 Empirical findings

In this section I set up and analyze the model; both the long run structure of the VECM-form and later the generalized and structural impulse response functions of the MA-form.

First step is to find a well-specified model. Here both a statistical and economical argument have to be considered. Statistical specification means checking that the model approximately follows the underlying statistical conditions assumed in the estimation process, and economical specification means that it includes the theoretical relevant variables, deterministic terms etc. Here several aspects has to be considered and tested for: lag length, inclusion of deterministic terms, error term distribution problems and cointegration rank including I(2)-specification.

[16]As business cycle theory states that economic booms are followed by times of low economic growth, economic booms should rationally result in low expectations of future economic growth - counter cyclical expectations. Theories of irrational procyclical expectations argues for the opposite, leading to financial instability. Here low credit risk spreads often is taken as a proxy for high risk appetite in the financial markets, which to some extend means that the market expects high economic growth in the near future.

5.1 I(1)-specification

Here I check for lag length (k)[17] and whether the error terms of the model is approximately normal distributed.[18] Table 2 shows the information criteria and the LM test for lag length determination (Juselius, 2007, p. 71).

Table 2: Test for lag length

Model	k	Log-like	SC	H-Q	LM(1)	LM(k)
VAR(4)	4	10023.240	-54.581	-57.372	**0.125**	0.049
VAR(3)	3	9983.461	-55.208	-57.657	0.005	**0.243**
VAR(2)	2	9924.841	**-55.719**	**-57.825**	0.000	0.030
VAR(1)	1	9666.814	-55.003	-56.766	0.000	0.000

Note: SC: Schwarz Criterion, H-Q: Hannan-Quinn Criterion, LM(k): LM-Test for autocorrelation of order k

According to the information criteria and the LM(k)-test, the model seems well specified with two lags. Further I check for extraordinary large residuals inconsistent with the normality assumption. The following error terms especially violates the normality assumption; 1984:11, 2005:09, 2005:11, 2006:09, 2008:02, 2008:05, 2008:08, 2008:10, 2008:11. These dates can all be related to historical events, most of them to the global financial crisis. Only for 2008:08 I also include a shift dummy restricted to the cointegration space as it marks one of the biggest shocks to the US economy in recent times; the beginning of the second face of the financial crisis with the crash of American investment bank Lehman Brothers.[19]

Table 3: Misspecification test

Normality	Autocorrelation			Heteroscedasticity (ARCH)	
DH:$\chi^2(14)$	LB(82):$\chi^2(3920)$	LM(1):$\chi^2(49)$	LM(4):$\chi^2(49)$	LM(1): $\chi^2(784)$	LM(4): $\chi^2(3136)$
203.149 [**0.000**]	4673.646 [**0.000**]	83.654 [**0.001**]	57.598 [0.187]	1093.277 [**0.000**]	3740.223 [**0.000**]

Univariate tests	ΔHp	Δk	Δm	Δy	Δi_{3m}	Δi_{own}	S_{CB}
Normality (p-value)	0.189	0.061	**0.000**	**0.010**	**0.000**	**0.000**	**0.000**
Skewness	0.167	0.212	0.126	0.270	-0.303	-0.060	0.313
Kurtosis	3.355	3.532	**4.351**	3.773	**5.029**	**4.246**	**5.782**
ARCH(2) (p-value)	0.095	0.047	**0.005**	0.948	**0.011**	**0.025**	**0.000**

Note: ***i***) Tests: DH is a Doornik-Hansen test, LB is the Ljung-Box, LM(k) is a LM test for autocorrelation and ARCH of order k. ***ii***) In the univariate tests clear signs of non-normality is marked bold.

[17] In the MA-form the lag length is equivalent to the number of autocorrelation terms in the stochastic error term (k) and in the VECM-form the number of short run difference terms ($k-1$).

[18] As these test often has a circular structure - meaning that each test assumes that the rest of the models well specified - I test on the model with all final deterministic terms included.

[19] The American investment bank Lehman Brothers filed for bankruptcy protection September 15, 2008. The filing marked the largest bankruptcy in U.S. history.

Hereafter I test for misspecification of the model. As seen from table 3 the Doornik-Hansen test reject general normality of the model. When further considering the general LM-tests this non-normality seems related to some degree of general heteroscedasticity. Considering the univariate tests, especially the interest rate variables seems to have some over kurtosis (>3) and ARCH. As this should not make a problem for the estimation process the model seems fairly good specified (Juselius, 2007, p. 75, 110).

5.2 Cointegration rank and I(2)-specification

As indicated in section 2, long persistent cycles in both the real amount of credit and house prices gives an indication of possible I(2)-trends in the data.[20] I(2)-trends become critical for the estimation process in finite samples and correct interpretation of the model. Therefore these should be checked for and possibly specified (Juselius, 2007, s. 291).

From the unrestricted root calculation shown in table 7 I find that in a I(1)-model even with six I(1)-trends there is still an unrestricted root close to the unit circle (0.946), indicating at least one double unit root.[21] Table **??** in appendix **??** shows the I(2)-trace test, which also gives an indication of two I(2)-trends in the data.

Table 4: Largest unrestricted root of the Π-matrix model without broken trends

r	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
p-r	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
ρ_{max}	0.990	0.988	0.984	0.960	0.958	0.963	0.946	0.852

Table 5: The I(2)-trace test in the model with broken trends

p-values		s2 = p-r-s1							
p-r	r	7	6	5	4	3	2	1	0
7	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	1		0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	2			0.000	0.000	0.000	0.000	0.000	0.000
4	3				0.000	0.000	0.000	0.000	0.000
3	4					0.000	0.000	0.015	0.002
2	5						0.024	0.019	0.038
1	6							**0.151**	**0.145**

[20] Problems of I(2)-trends in a I(1) cointegrated VAR-model is often found in models including house prices (). Not many cointegrated VAR-models includes credit and non (that I know of) consider possible I(2)-trend in the data.

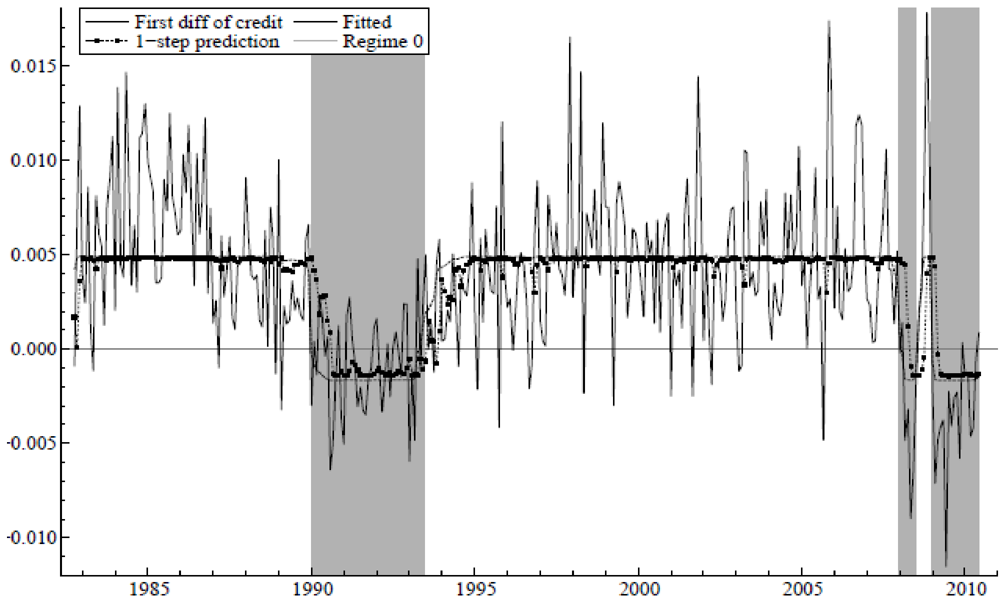
[21] In general, it is not easy to say when the root is to large, but a root well above 0.9 is normally considered to close to the unit circle (Juselius, 2007, s. 297).

There are generally two ways of dealing with I(2)-trends in the data; stochastically by running an I(2) cointegrated VAR-model or deterministically, removing the I(2)-trends by including deterministic broken trends restricted to the cointegration space. As considered in the data section, the changes in the underlying trends seems attributed to different historical economic regimes. In in this paper, I will therefore model them deterministically on the basis of both the statistical and economical argument, allowing me to give an economical interpretation.

Here I focus on the I(2)-trends in the real credit. To statistically determine the dates of possible chances in the underlying I(2)-trends in the credit level I run a simple univariate two stage Markov switching model including credit in the first difference as the regressant and a constant as regressor. In the appendix **??** I show the actual and fitted values of this regression. In general, I find three big regime shifts: 1990:01, 1993:07 and 2008:01 plus a temporary regime during the financial crises 2008:08-2008:12.

```
Regime classification based on smoothed probabilities
Regime 0                  months  avg.prob.
    1990(1) - 1993(6)       42       0.964
    2008(1) - 2008(7)        7       0.906
    2009(1) - 2010(6)       18       0.989
  Total: 67 months (20.06%) with average duration of 22.33 months.
Regime 1                  months  avg.prob.
   1984(4) - 1989(12)       88       0.992
   1993(7) - 2007(12)      174       0.984
   2008(8) - 2008(12)        5       0.862
  Total: 267 months (79.94%) with average duration of 89.00 months.
```

Figure 2: The univariate two stage Markov switching model



Considering the economical arguments as discussed in the data section, there is a economical reason for all three regime shifts (almost hitting the same dates); the first one being the end of the Reagan period of financial deregulation, the next being the start of the sub-prime mortgage lending period and the last one being the global financial crisis. I will include the three broken trend in 1990:01, 1993:07, 2008:01. To account for the temporary regime during the financial crises 2008:08-2008:12 I include a shift dummy 2008:08, as mentioned earlier.

Hereafter, I do the same check for I(2)-trends as done in the model without broken trends. Table 6 shows the unrestricted root calculation of the model with all three broken trends included. In a model with four I(1)-trend I find the largest unrestricted root to be 0.922. By the I(2)-trace test i find indication of five I(1)-trends and possibly still one I(2)-trends (with p-value = 0.055). Even so, there might still remain some I(2)-trends in the data but compared to the model without broken trends these seem as minor problems.

The largest unrestricted roots indicates a rank of four weil the trace test indicated a rank of five. Hereby the model would have three or two common stochastic trends respectively. As a model with two common stochastic trends would be in conflict with the economical argument presented in section 4, I estimate the model with a rank of four.

Table 6: Largest unrestricted root of the Π-matrix in the model with broken trends

r	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
p-r	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
ρ_{max}	0.968	0.966	0.955	0.922	0.921	0.852	0.792	0.778

Table 7: The I(2)-trace test in the model with broken trends

p-values		s2 = p-r-s1							
p-r	r	7	6	5	4	3	2	1	0
7	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	1		0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	2			0.000	0.000	0.000	0.000	0.000	0.000
4	3				0.000	0.000	0.000	0.000	0.000
3	4					0.002	0.009	0.015	0.002
2	5						0.047	**0.055**	**0.177**
1	6							0.447	0.518

5.3 The VECM-form

In this section I test, identify and analyze med model on VECM-form. To identify and test the model in accordance with the economical questions of this paper, I test the theoretical consistent long run relations considered in section 4.

First of all, I test for a money demand relation (7) in the model, which is accepted with p-value = 0.189:

$$m-y+\underset{(5.64)}{0.04}(i_{3M}-i_{own})-\underset{(-8.94)}{0.36}Hp-\underset{(-5.88)}{0.07}S_{CB-GB}-\underset{(-5.41)}{0.25}S_{08:08} \sim I(0) \quad (11)$$

To this relation both the real quantity of money, real GDP and real house prices are significantly error correcting.[22] Hence, excess money supply results in rising house prices and real GDP, supporting the monetary boom-bust theory. Real credit is negative related to excess money supply.

Assuming I(2)-trend in the real house prices, it seem puzzling that they should be included in this relation. When including broken trends to the relation to correct for it, only the broken trend in 2008:08 is slightly significant and the coefficient estimates in (11) are quite robust, meaning that these possible regime shifts - if they are present in the house prices - also are present in the money supply.

Secondly, I test for an Asset Boom-Bust model relation (10). Here I find β_{21} so close to unity that I choose to restrict it accordantly. The relation is accepted with p-value = 0.110:

$$Hp-(k-y)+\underset{(2.95)}{0.02}i_{3M}-\underset{(-0.45)}{0.01}S_{CB-GB}-\underset{(-3.96)}{0.22}S_{08:08}-\underset{(-3.68)}{0.001}T \sim I(0) \quad (12)$$

Both real house prices and GDP is significantly error correcting to this relation while credit is unrelated.[23] The relation therefore seems driven by credit, and higher credit relative to GDP is associated with higher real house prises and GDP in favor of the Asset Boom-Bust model.

The model with 7 variables and four long run relations, with S_{CB-GB} (Moodys BBB - 10 y government bond):

[22] The error correcting coefficients are: $\alpha_1'(Hp,k,m,y,i_{own},i_{3m},S_{CB-GB}) = \left[\underset{(3.03)}{0.02},\underset{(-3.09)}{-0.03},\underset{(-3.53)}{-0.05},\underset{(5.93)}{0.06},\underset{(2.56)}{0.30},\underset{(-1.49)}{-0.84},\underset{(-0.39)}{-0.29}\right]$.

[23] The error correcting coefficients are: $\hat{\alpha}_1'(Hp,k,m,y,i_{own},i_{3m},S_{CB-GB}) = \left[\underset{(-5.52)}{-0.03},\underset{(0.65)}{0.01},\underset{(1.03)}{0.01},\underset{(-5.77)}{-0.05},\underset{(-2.43)}{-0.21},\underset{(2.71)}{1.12},\underset{(-3.05)}{-1.65}\right]$.

Table 8: The credit CVAR-model on ECM-form (US, monthly, period: 1983:04 - 2010:09, p-value: 0.57)

	Hp	k	m	y	i_{own}	i_{3M}	S_{CB-GB}	$S_{08:08}$	$BT_{90:01}$	$BT_{93:07}$	$BT_{08:01}$	T
$\hat{\beta}_1$	**−0.35** (−11.85)	-	**1.00** (–)	**−1.00** (–)	**−0.04** (−7.34)	**0.04** (7.34)	**−0.07** (−7.05)	**−0.20** (−5.09)	-	-	-	-
$\hat{\beta}_2$	**1.00** (–)	**−1.00** (–)	-	**1.00** (–)	-	**0.01** (3.01)	**0.08** (7.69)	0.08 (1.82)	**0.00** (−13.09)	-	-	**0.00** (9.07)
$\hat{\beta}_3$	**−0.85** (−15.49)	**1.00** (–)	-	**−2.22** (−14.22)	-	−0.01 (−1.77)	-	-	-	-	-	**0.00** (7.3)
$\hat{\beta}_4$	-	-	**−7.13** (−15.1)	-	**1.00** (–)	**−0.67** (−26.67)	**0.33** (6.83)	**0.71** (3.35)	-	-	-	**0.02** (14.41)

	ΔHp	Δk	Δm	Δy	Δi_{own}	Δi_{3M}	ΔS_{CB-GB}
$\hat{\alpha}_1$	−0.01 (−0.67)	**−0.03** (−2.29)	**−0.03** (−1.93)	**0.04** (3.09)	**−0.76** (−5.35)	1.20 (1.77)	−0.57 (−0.64)
$\hat{\alpha}_2$	**−0.02** (−3.74)	**−0.04** (−4.8)	**−0.05** (−4.63)	0.01 (0.94)	**−0.24** (−2.54)	**0.91** (2.04)	**−2.49** (−4.24)
$\hat{\alpha}_3$	0.01 (1.39)	**−0.03** (−4.32)	**−0.03** (−2.63)	**0.03** (3.26)	**0.33** (3.6)	−0.78 (−1.75)	**−1.35** (−2.3)
$\hat{\alpha}_4$	0.00 (0.58)	0.00 (−0.46)	**0.01** (2.63)	0.00 (0.85)	**−0.13** (−7.35)	0.15 (1.77)	0.00 (0.02)

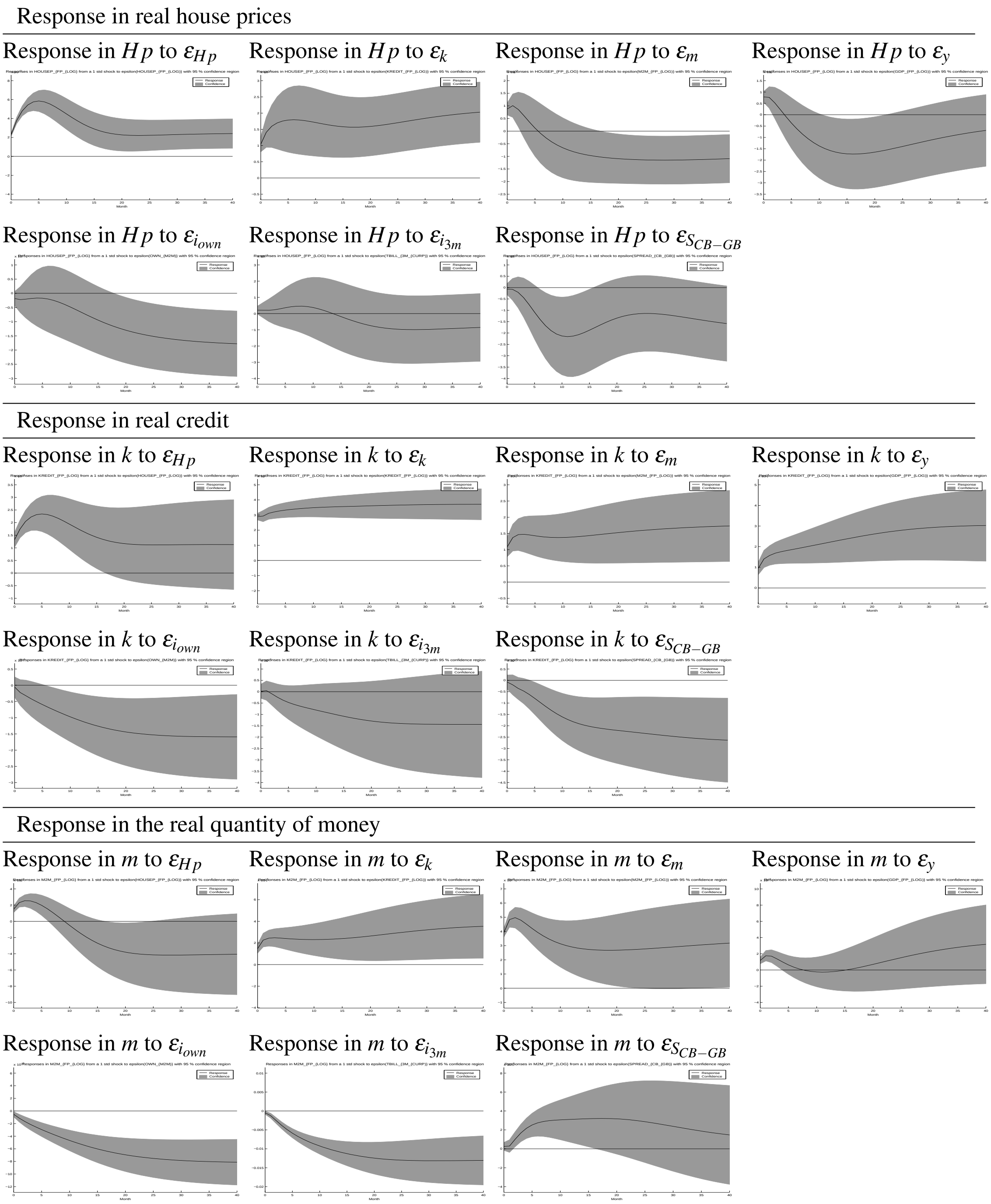
Note: ***i***) P-values are shown in the parenthesis. ***ii***) Significant coefficients are marked **bold**. ***iii***) Significant error correcting coefficients are marked **red** ind the α-matrix.

The long run relations:

$$
\begin{aligned}
\text{Money Demand:} \quad m-y &= -0.04\,(i_{3M}-i_{own}) + 0.35\,Hp + 0.07\,S_{CB-GB} + 0.2\,S_{08:08} \\
\text{Asset Boom-Bust:} \quad Hp &= (k-y) - 0.01\,i_{3M} - 0.08\,S_{CB-GB} - 0.08\,S_{08:08} + 0\,BT_{90:01} - 0\,T \\
\text{AD/credit relation:} \quad k &= 0.85\,Hp + 2.22\,y + 0.01\,i_{3M} - 0\,T \\
\text{Interest rate relation:} \quad i_{own} &= 7.13\,m + 0.67\,i_{3M} - 0.33\,S_{CB-GB} - 0.71\,S_{08:08} - 0.02\,T
\end{aligned}
$$

5.4 Generalized impulse response functions

Figure 3: Generalized impulse response functions

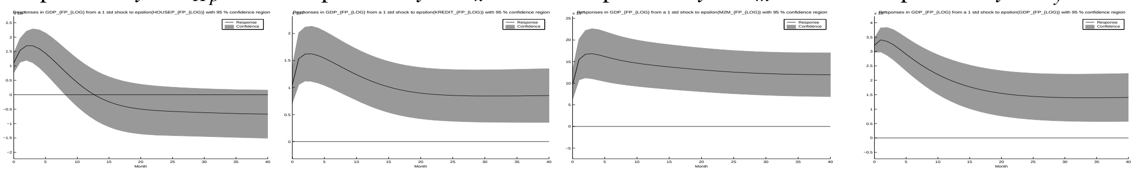


Note: ***i***) Impulse-response for each individual variable to a positive one-std. shock to one of the error terms of the reduced-form model (ε) ***ii***) The gray bands are 95 % confidence bounds calculated by bootstrap-simulation with 500 replications.

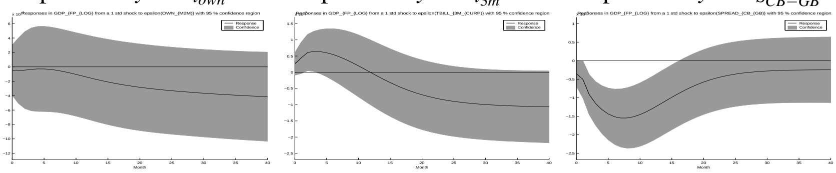
Figure 4: Generalized impulse response functions

Response in real GDP

Response in y to ε_{Hp} | Response in y to ε_k | Response in y to ε_m | Response in y to ε_y

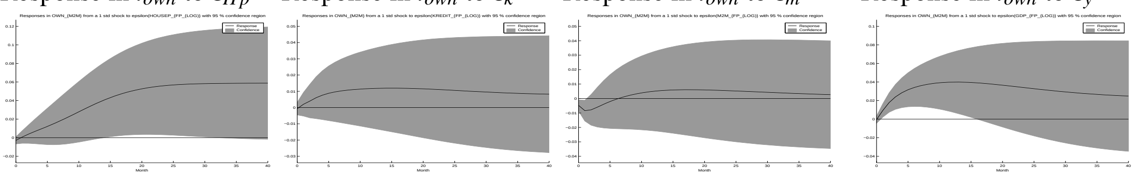


Response in y to $\varepsilon_{i_{own}}$ | Response in y to $\varepsilon_{i_{3m}}$ | Response in y to $\varepsilon_{S_{CB-GB}}$

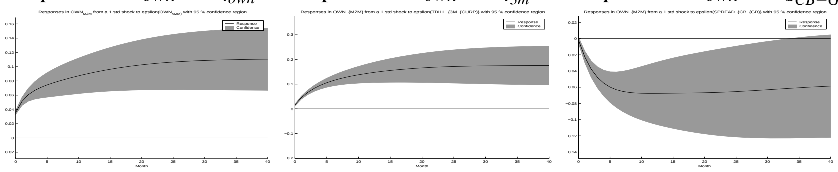


Response in the nominal own rate on money

Response in i_{own} to ε_{Hp} | Response in i_{own} to ε_k | Response in i_{own} to ε_m | Response in i_{own} to ε_y

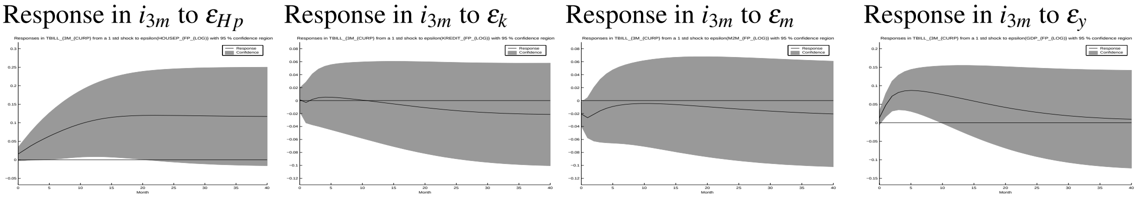


Response in i_{own} to $\varepsilon_{i_{own}}$ | Response in i_{own} to $\varepsilon_{i_{3m}}$ | Response in i_{own} to $\varepsilon_{S_{CB-GB}}$

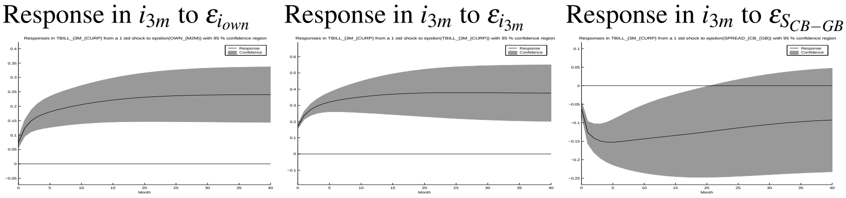


Response in the nominal three month government T-bill rate

Response in i_{3m} to ε_{Hp} | Response in i_{3m} to ε_k | Response in i_{3m} to ε_m | Response in i_{3m} to ε_y



Response in i_{3m} to $\varepsilon_{i_{own}}$ | Response in i_{3m} to $\varepsilon_{i_{3m}}$ | Response in i_{3m} to $\varepsilon_{S_{CB-GB}}$

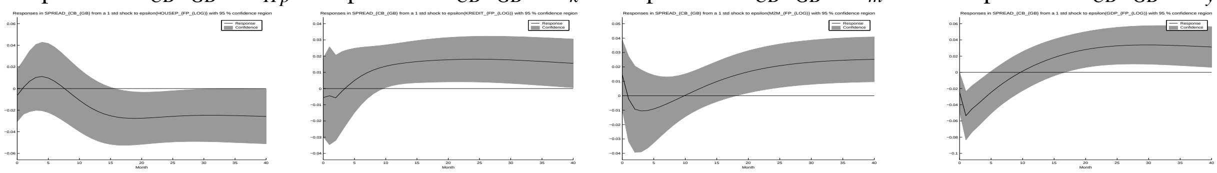


Note: ***i***) Impulse-response for each individual variable to a positive one-std. shock to one of the error terms of the reduced-form model (ε) ***ii***) The gray bands are 95 % confidence bounds calculated by bootstrap-simulation with 500 replications.

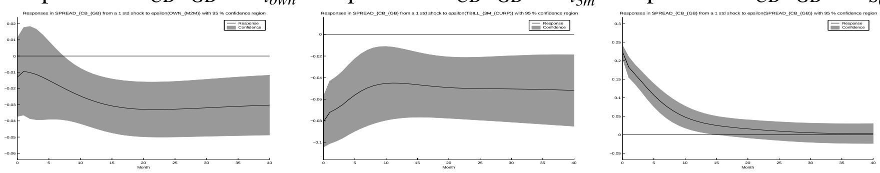
Figure 5: Generalized impulse response functions

Response in the credit spread

Response in S_{CB-GB} to ε_{Hp} Response in S_{CB-GB} to ε_{k} Response in S_{CB-GB} to ε_{m} Response in S_{CB-GB} to ε_{y}



Response in S_{CB-GB} to $\varepsilon_{i_{own}}$ Response in S_{CB-GB} to $\varepsilon_{i_{3m}}$ Response in S_{CB-GB} to $\varepsilon_{S_{CB-GB}}$



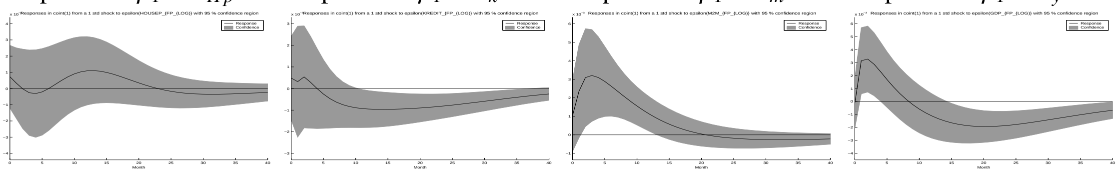
Note: ***i***) Impulse-response for each individual variable to a positive one-std. shock to one of the error terms of the reduced-form model (ε) ***ii***) The gray bands are 95 % confidence bounds calculated by bootstrap-simulation with 500 replications.

Generalized impulse response functions for the cointegration relations:

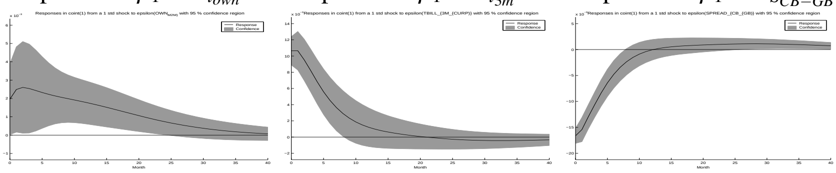
Figure 6: Generalized impulse response functions for the cointegration relations

Response in the money demand cointegration relation (β_1)

Response in β_1 to ε_{Hp} | Response in β_1 to ε_k | Response in β_1 to ε_m | Response in β_1 to ε_y

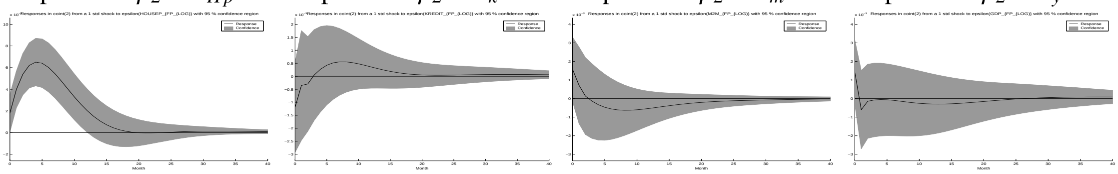


Response in β_1 to $\varepsilon_{i_{own}}$ | Response in β_1 to $\varepsilon_{i_{3m}}$ | Response in β_1 to $\varepsilon_{S_{CB-GB}}$

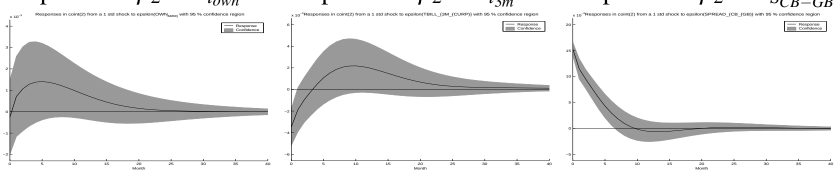


Response in the Asset Boom-Bust cointegration relation (β_2)

Response in β_2 to ε_{Hp} | Response in β_2 to ε_k | Response in β_2 to ε_m | Response in β_2 to ε_y

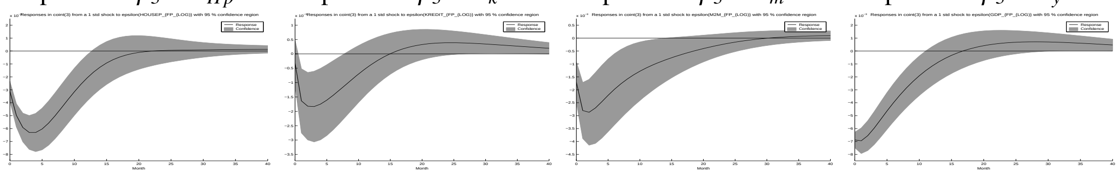


Response in β_2 to $\varepsilon_{i_{own}}$ | Response in β_2 to $\varepsilon_{i_{3m}}$ | Response in β_2 to $\varepsilon_{S_{CB-GB}}$

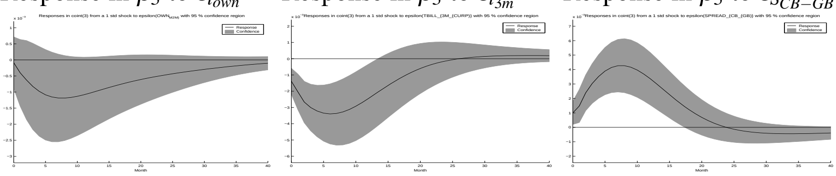


Response in the AD/credit relation cointegration relation (β_3)

Response in β_3 to ε_{Hp} | Response in β_3 to ε_k | Response in β_3 to ε_m | Response in β_3 to ε_y



Response in β_3 to $\varepsilon_{i_{own}}$ | Response in β_3 to $\varepsilon_{i_{3m}}$ | Response in β_3 to $\varepsilon_{S_{CB-GB}}$



Note: ***i***) Impulse-response for each cointegration relation to a positive one-std. shock to one of the error terms of the reduced-form model (ε) ***ii***) The gray bands are 95 % confidence bounds calculated by bootstrap-simulation with 500 replications.

5.5 The structural MA-form

Further, I estimate the model on structural MA-form. First I try to estimate a fairly standard model where the long run shocks are ordered as follows: *i*) a real economic shock, *ii*) a monetary policy shock and *iii*) a credit/risk appetite shock.

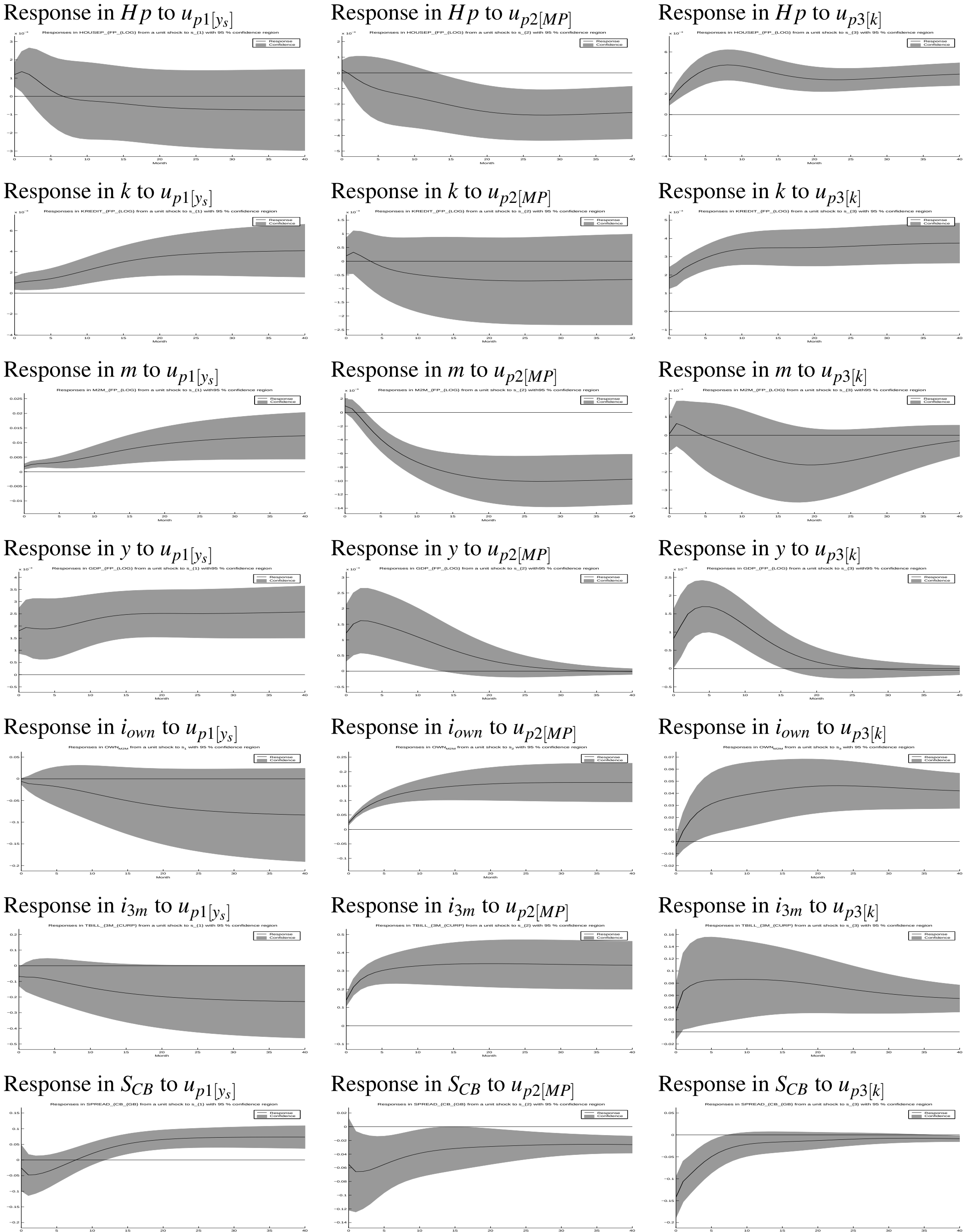
Here I assume that the Central Bank does not respond to the amount of credit outstanding, but only real economic shocks. Regarding the third shock, credit/risk appetite shocks, it could be discussed how to make sure that this is not related to output and thereby especially credit default risk. The variables will be ordered as follows:

Table 9: Order of the permanent and transitory shocks

Ticker	**Permanent shock**	**Transitory shock**
Hp_t		3
k_t	3	
m_t	2	
y_t	1	
$i_{own,t}$		4
$i_{3m,t}$	(2)	2
$S_{CB,t}$	(3)	1

In total, to get a just identified model I have to place $p \cdot p = 49$ restrictions on the B- and/or $\tilde{C}$-matrix. By $(p+1)p/2 = 56$ restrictions on the B-matrix I make sure that the assumption $u_t \sim N(0, I_p)$ is satisfied. By $(p-r)r = 12$ zero-restrictions on the last r columns of the $\tilde{C}$-matrix I make sure that the p long run and r short run shocks are separated. The last 12 restrictions order the shocks in accordance with table 9. The impulse response functions of the long run structural shocks are seen below.

Figure 7: Impulse response functions to the permanent structural shocks



Note: ***i***) Impulse-response for each individual variable to a positive structural shock of one std. ***ii***) The gray bands are 95 % confidence bounds calculated by bootstrap-simulation with 500 replications.

6 Conclusions

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