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The importance of the financial system for the real economy*

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Abstract

This paper analyses the importance of the financial system for the real economy using a Bayesian VAR model for the macro economy, completed with financial variables, with priors on the steady states. The results suggest that i) a substantial part of the forecast error variance of GDP growth is attributed to shocks to the financial variables, indicating the importance of the financial system. ii) The suggested model produces an earlier and stronger signal regarding the probability of recession, compared to a model without financial variables. iii) Finally, and most striking, the augmented model's forecasts for 2008 and 2009, conditional on the development of the financial variables, clearly outperforms the macro model. Furthermore, this drastic improvement in modelling GDP during the crisis does not come at the expense of predictive power. In this respect, the augmented model performs as well as the standard macro model. Taken together, the results thus suggest that the proposed model presents an accessible possibility to analyse the macro-financial linkages and the GDP developments during a financial crisis.

JEL Classification: E37, E44
Keywords: Transmission channels, Financial indicators, Macro economy, Business cycle, Credit cycle, Bayesian VAR

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1 Introduction

In late 2008, during the peak of the financial crisis, several markets at the heart of the financial system more or less stopped functioning. Liquidity in the interbank market dried up as banks refrained from lending money, even at short maturities. The price of many assets fell quickly and deeply, central banks cut their policy rates drastically and the situation was characterized by great uncertainty. The crisis deepened the incipient recession sharply and most economists and policy makers were, at the time, surprised by the dramatic effects on the real economy. But the close link between the financial system and the real economy is not only there in times of crisis; it is also in place under more normal economic circumstances. The effects are just less drastic.

In the wake of the financial crisis, researchers and policy makers have directed much more attention to the linkage between the financial system and the real economy, known as the transmission mechanism.[1] An important part of the increased attention is that several governments are now considering more far-reaching changes in supervisory and regulatory structures in order to protect the real economy from the recurrent malfunctioning of the financial sector.[2]

However, if regulation is to be successful, at least two conditions have to be fulfilled. First, policy makers need to have a qualitative knowledge of how the financial markets affect the real economy through the transmission mechanism. Second, policy makers need to have quantitative knowledge of the transmission mechanism in order to make a balanced choice of the magnitude of a specific regulative measure. To this end, we use a Bayesian VAR model, which has been successfully used in similar applied work (see e.g. Österholm (2010) and Jarocinski and Smets (2008) among others).

The purpose in this paper can, essentially, be divided into two questions: i) Is the financial system important for the development in the real economy? ii) If it is, what are the characteristics?

The paper has the following structure. Section 2 gives a description of how the financial system affects the real economy through different transmission channels.. In Section 3, four composite financial variables are defined that act as indicators for the transmissions channels using data from Sweden. In Section 4, a small macroeconomic VAR model is complemented with these four financial indicators in order to make an empirical assessment of the aggregate effects of the financial system on the real economy and vice versa. The model is estimated using Bayesian estimation methods with a prior on the steady state. In Section 5, an empirical analysis is made from a number of perspectives to answer the two questions we have posed. Section 6 concludes.

[1] See Basel Committee on Banking Supervision (2011).

[2] See Basel Committee on Banking Supervision (2012a,b).

2 The effects of the financial system on the real economy

The financial system mainly affects the real economy through the following transmission channels: the interest rate channel, the balance sheet channel, the bank capital channel and the uncertainty channel.[3]

The interest rate channel describes how the real economy is affected when market interest rates rise, for example because the central bank increases the repo rate. Rising market interest rates lead to higher financing costs for banks and consequently to higher lending rates.[4] This, in turn, leads to low consumption/investments by households/businesses.[5] Moreover, higher market rates can have a negative effect on the price of financial and real assets because the present value of future returns from these assets decreases. Consumption also decreases as a result of this wealth effect.

The balance sheet channel[6] describes how falls in asset prices, e.g. house prices and stock prices, reduce the value of assets held by households and businesses.[7] If the value of assets used as security for loans falls, lenders can tighten security requirements at the same time as the loan terms get worse, e.g. because the lending rate is higher or the borrower is not allowed to borrow as much as they may want to. This then draws down asset prices even more, leading to a financial accelerator effect. Ultimately this leads to lower consumption and less investment.

The bank capital channel describes how different types of risk associated with the operations of banks (e.g. market risk, credit risk and financing risk) worsen bank balance sheets by, for example, reducing the value of the bank's assets and equity.[8] However, banks must meet certain requirements concerning capital adequacy, solvency and liquidity. Banks can choose to either raise their lending rates (thereby increasing their profit and equity) and/or reduce their lending to be able to fulfil these requirements which lead to lower consumption and less investment.

The uncertainty channel describes how more uncertainty in the form of price fluctuations in financial markets, i.e. greater volatility, leads to higher precau-

[3]The interested reader is referred to Basel Committee on Banking Supervision (2011, 2012a,b), Antony and Broer (2010), Ministry of Finance (2013) and Gerke et al. (2012) for summaries of the latest research in this area.

[4]In principle, the policy rate is assumed to have an immediate effect on short-term market rates and lagged effect on long-term rates.

[5]Monetary policy can also affect the economy via the exchange rate channel'. An increase in the policy interest rate normally leads to exchange rate appreciation. A stronger exchange rate means lower import prices, with the result that some domestic demand moves from domestic to imported goods. This moderates the inflationary pressure and also leads to a weaker balance of trade. Moreover, monetary policy also affects the economy through other channels via expectations.

[6]Along with the interest rate channel it is also called the credit channel.

[7]See for instance Bernanke and Gertler (1989), Bernanke, Gertler and Gilchrist (1998), Kiyotaki and Moore (1997) and Holmström and Tirole (1997).

[8]See e.g. Stein (1998) and Van den Heuvel (2002, 2004).

tionary savings and lowers consumption as well as less investment.[9] The purpose of this paper is to better understand and model how the financial system affects the real economy through various transmission channels. This will be done by using a macroeconomic VAR model that includes financial variables that together capture the transmission mechanism between the financial system and the real economy.

3 Selecting the most important financial variables

In this paper, four composite financial variables are defined that act as indicators for the transmissions channels: The credit gap, the asset price gap, the lending rate and the financial stress index.

3.1 Asset price gap and credit gap

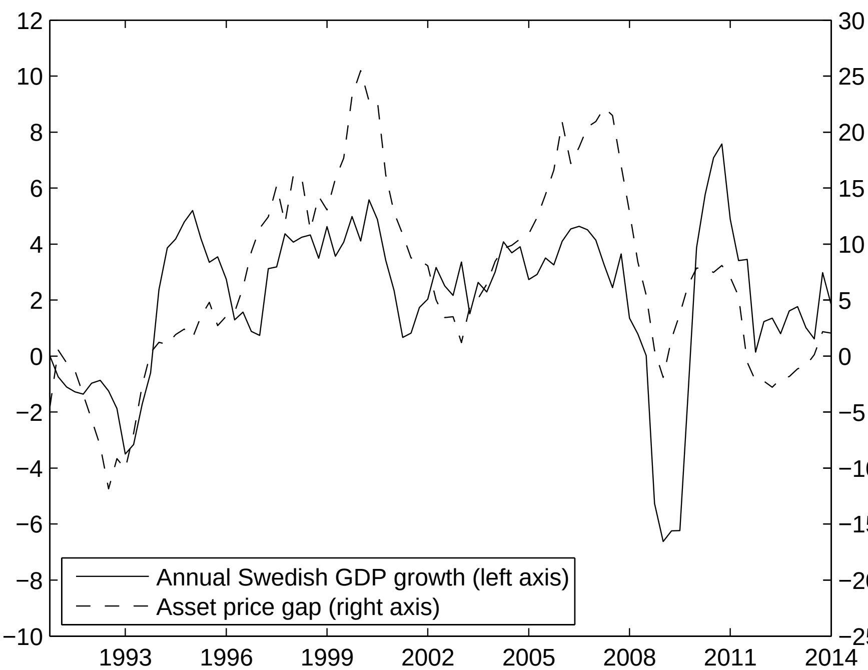

Figure 1: GDP growth (annual percentage change) and asset price gap

Developments among bank borrowers are the basis for the balance sheet channel described earlier. A fall in solvency, creditworthiness or wealth of households and firms has a negative impact on the development of the real economy.

[9]See Antony and Broer (2010).

One common feature of balance sheets and solvency of firms and households is that they are both affected by the price of financial and real assets. In order to capture the variations in both financial and real asset prices a summary index is therefore created based on how the share and property prices change in relation to their historical trends. A gap is generated for each of the stock and property markets as a first step towards creating a summary indicator. The stock price gap and the house price gap are defined as the deviation of the OMX index and the property price index from their trend divided by the trend.[10] In the second step the share price gap (20 per cent) and the property price gap (80 per cent) are combined in an asset price gap that summarizes the development of house and stock prices. Figure 1 shows that the asset price gap covaries with GDP growth. The peaks and troughs of the asset price gap coincide roughly with the peaks (2000, 2007) and troughs (1993, 2009) identified in the economic cycle.

As previously noted, economic shocks lead to a fall in the value of borrowers' assets at the same time as the value of their loans is unchanged. In such cases the borrowers' balance sheets look much worse than they had expected, with the result that they amortize part of their liabilities (consolidate their balance sheets). One way of illustrating this linkage is to compare the historical development of asset prices (the asset price gap) and liabilities (the credit gap).[11] As is seen in Fig. 2, changes in asset prices precede changes in credit gap by a number of quarters. So, asset prices and credit can reinforce each other through the financial accelerator effect'. The asset price gap together with credit gap summarizes developments for bank borrowers and is also the main indicator for the balance sheet channel.

3.2 The lending rate

As pointed out earlier, banks are regulated so that various risks in bank operations do not have too much effect on bank balance sheets. But, the central issue is what effect these risks have on bank balance sheets and income statements and ultimately on their pricing behaviour and lending. As in Karlsson, Shahnazarian and Walentin (2009) it is assumed that banks in Sweden operate on a market characterized by monopolistic competition. This means that the lending rate is suitable as a summary indicator for the bank capital channel. In a market with monopolistic competition the banks' lending rate is set as a

[10] The trend is calculated through a one-sided HP filter using a value of the weighting parameter equal to 400 000 (see e.g. Drehmann et al. (2010)). The Basel Committee suggests using this method to calculate the credit gap which is the deviation of the credit-to-GDP ratio from its long-term trend. A study by Drehmann et al. (2010) indicates that the credit gap has been useful in signalling financial crises in the past. This indicator is a key indicator for decision to activate the countercyclical capital buffer (CCyB) and also to decide the level of this buffer. CCyB is a time-varying capital requirement on top of the minimum requirement. In good times when systemic risks are typically building up, the CCyB should be activated to help banks build up capital. In times of adverse financial or economic circumstances, when losses tend to deplete capital and banks are likely to restrict the supply of credit, the CCyB should be released to help avoid a credit crunch.

[11] In technical terms the credit gap has been designed in the same way as the asset price gap.

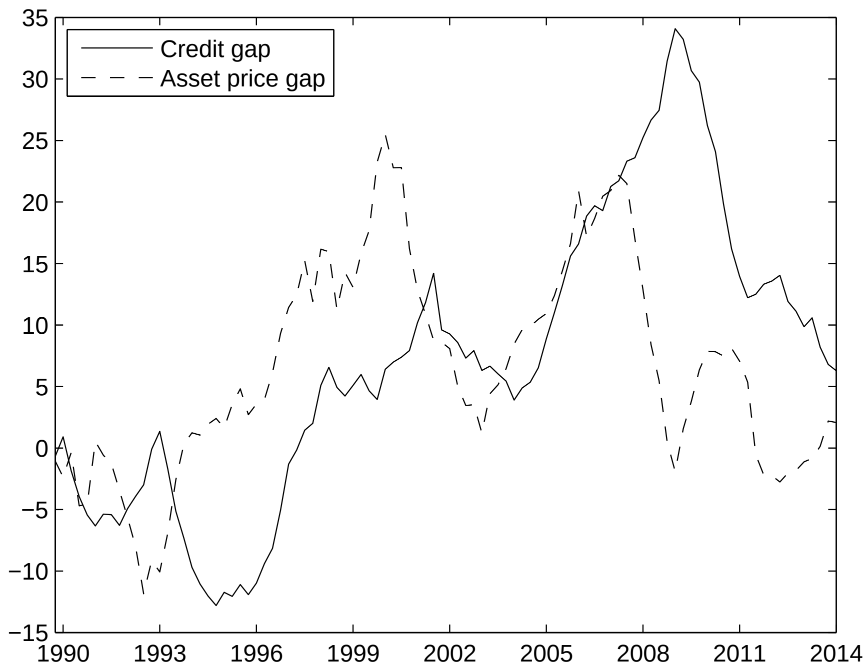

Figure 2: Credit gap and asset price gap

mark-up on their marginal costs.[12] The lending rate is therefore influenced both by the interest rate that banks themselves have to pay to borrow funds and the interest rate supplement added by banks when lending on to their customers. The lending rate that is used as an indicator is a combination of the interest rate that households and firms actually pay on their existing loans.[13] It appears to lead GDP growth (Fig. 3) with a delay of 1-2 years.

3.3 The financial stress index

The financial stress index summarizes uncertainty in financial markets and is also the main indicator for the uncertainty channel. It is a composite of (1) volatility in the stock market (measured as the standard deviation of the OMX index for the previous 30 days), (2) volatility in the currency market (measured as the standard deviation of the SEK exchange rate against the euro), (3) the spread between mortgage and government bonds (the mortgage spread) and (4) the spread between the inter-bank rate and the interest rate on treasury bills (TED-spread).[14] The four indicators are first standardized so that they can

[12] For a more detailed description of the market structure and loan pricing equation, see Arregui et al. (2013), Box 2.

[13] The lending rate is the weighted average of the interest rates for households (2/3) and the interest rate for firms (1/3).

[14] See e.g. Ministry of Finance (2013), Forss Sandahl et al. (2011) and Österholm (2010).

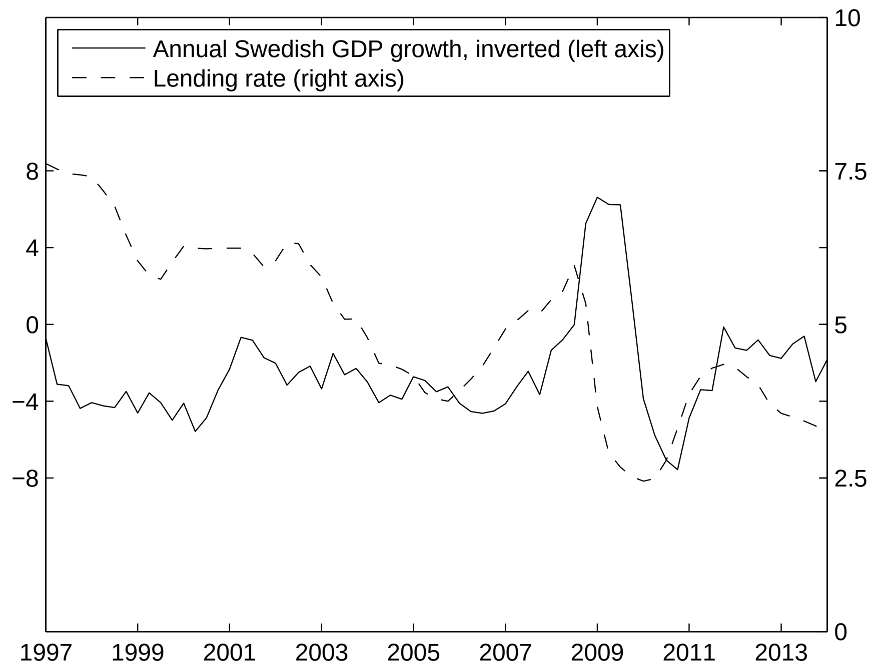

Figure 3: Inverted GDP growth (annual percentage change) and lending rate

be weighted to a composite financial stress index.[15] The weighting is done by giving each indicator the same weight. The resulting index is also standardized which means that the summary financial stress index has a mean of 0 and a standard deviation of 1 by construction, which facilitates interpretation of the index. When the series has a value of zero it is equal to its historical mean and the stress level should therefore be considered normal. With this standardization a value of 1 also means that the level of stress is one standard deviation higher than normal. The level of stress in financial markets in Sweden, measured using a financial stress index, shows clear covariation with GDP growth (Fig. 4).

4 Methodology and data

4.1 The empirical models

In a classical VAR-model, the number of parameters, relative to the number of observations, is usually quite small. Inevitably, this leads to a great deal of uncertainty. As discussed in Robertson and Tallman (1999), reduction of the number of parameters most commonly boils down to utilizing some sort of prior restrictions. An alternative countermeasure to overparametrization is to shrink

[15]This is done by subtracting the mean from each series and then dividing it by its standard deviation. The standardized series then has a mean of zero and a standard deviation of 1.

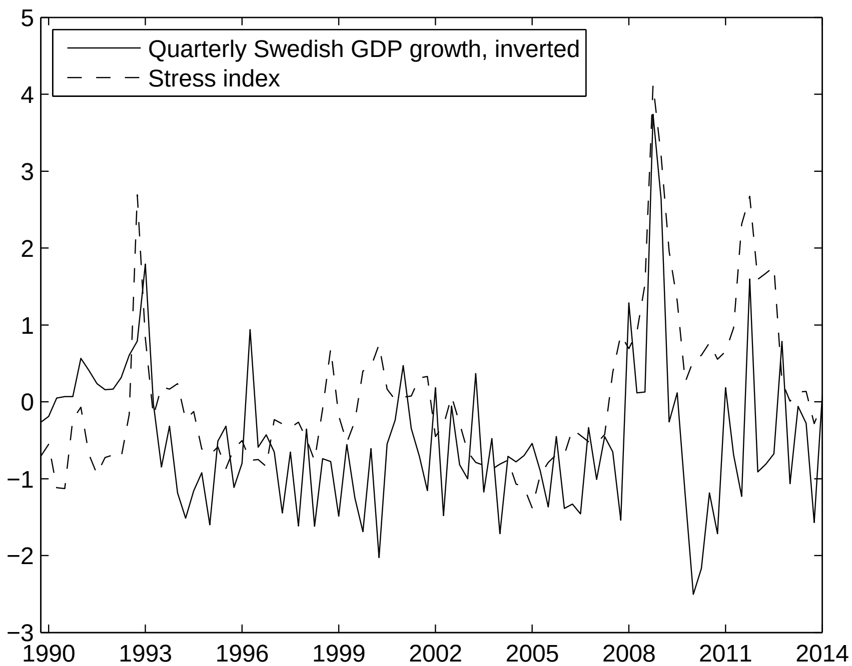

Figure 4: Inverted GDP growth (quarterly percentage change) and financial stress index (index units)

the parameters, which means that parameters are pulled towards zero in order to reduce the consequences of overfitting. In the context of the Bayesian approach, this means that a prior distribution centred on zero is assigned to the parameter. A set of hyperparameters, chosen by the researcher, controls the tightness of the prior. As the variance of the parameters decreases, the tightness of the prior increases. This means that the posterior estimate will deviate less from zero than it would with a less tight prior. Moreover, even though forecasts by a stationary VAR model converge to its unconditional mean, prior information regarding the unconditional means, or steady states, is usually not taken into account. Villani (2009) introduced a new prior in which prior information on the steady states of the variables are used explicitly.[16] In this paper, a Bayesian VAR (BVAR) model with informative priors on the steady states for the macro economy is therefore used to estimate the impact of the financial system on the real economy.[17]

[16]The approach presented byVillani (2009) has successfully been used in applied research in recent years (see e.g. Jarocinski and Smets (2008), Österholm (2010) and Clark (2011)).

[17]This type of model is often used to analyse different types of shocks. See, e.g. Sims (1992) and Gerlach and Smets (1995), for early contributions. The original models typically included three variables: a short term interest rate, the inflation rate and GDP growth. This paper expands the model by including unemployment so as to be able to take account of developments on the labour market. Since Sweden is a small, open economy, the currency

A VAR model is usually specified as

$$\mathbf{\Pi}(L)\mathbf{x}_t = \mathbf{\Phi}\mathbf{d}_t + \boldsymbol{\varepsilon}_t \tag{1}$$

where $\mathbf{\Pi} = (\mathbf{I}_n - \mathbf{\Pi}_1 L - \cdots - \mathbf{\Pi}_m L^m)$ is a lag polynomial of order m, $\mathbf{x}_t$ is an $n \times 1$ vector of stationary variables, $\mathbf{d}_t$ is a $k \times 1$ vector of deterministic variables, $\mathbf{\Phi}$ is an $n \times k$ coefficient matrix and $\boldsymbol{\epsilon}_t$ is an $n \times 1$ vector of multivariate normal error terms with mean zero and covariance matrix $\mathbf{\Sigma}$. However, in order to introduce the steady state prior, a slightly different formulation of the model in Equation 1 is useful, namely

$$\mathbf{\Pi}(L)(\mathbf{x}_t - \mathbf{\Psi}\mathbf{d}_t) = \boldsymbol{\varepsilon}_t \tag{2}$$

where $\mathbf{\Psi} = [\mathbf{\Pi}(L)]^{-1}\mathbf{\Phi}$. One may thus note that the unconditional mean is $E(\mathbf{x}_t) = \mathbf{\Psi}\mathbf{d}_t$, for which a prior is set explicitly.

We follow common practice (see e.g. Österholm (2010) and Adolfson et al. (2007)) and use a Minnesota style prior for the coefficient matrices in the lag polynomial $\mathbf{\Pi}(L)$. The hyperparameters are set according to the usual choice of an overall tightness of 0.2, a cross-variable tightness of 0.5 and a lag decay parameter of 1. The Minnesota prior, however, usually includes specifying a prior mean of 1 on the first own lag of the variables. Such a specification is not consistent with a steady state prior, so instead we set the prior mean for variables in levels to 0.9 and for growth or differenced variables the prior mean of the first own lag is set to 0.[18] The prior on the error covariance matrix $\mathbf{\Sigma}$ is the usual noninformative choice $p(\mathbf{\Sigma}) \propto |\mathbf{\Sigma}|^{-(n+1)2}$. Lastly, the prior on the coefficients for the deterministic part, $\mathbf{\Psi}$, is specified through 95 % probability intervals for the unconditional means.

We choose a lag length of 4 and estimate the models with a three-block Gibbs sampler.[19]

4.2 Data

For the full model, i.e. including the financial variables, we define the vector of variables as

$$\mathbf{x}_t = (GDPTCW_t, CGAP_t, AGAP_t, IL_t, ITB_t, ER_t, CPI_t, U_t, GDP_t, SI_t)' \tag{3}$$

where $GDPTCW_t$ is the log difference of foreign GDP[20], $CGAP_t$ is the credit gap, $AGAP_t$ is the asset price gap, IL_t is the lending rate, ITB_t is the interest on

rate and foreign GDP is also included in the set of variables. The exchange rate is also included to handle the exchange rate channel. The transmission channels are handled by the four financial indicators defined in previous section.

[18]The results appear to be fairly robust to changes in the hyperparameters. In trying various other hyperparameters, no major difference to the results presented herein have been detected.

[19]In all cases the numerical evaluations are based on 20 000 draws, post-burn-in. Thinning the sample to reduce correlation among draws yields a posterior sample whose final size is 4 000. For details of the numerical methods, see Villani (2009).

[20]GDPTCW is defined as a weighted GDP in the US and the Euro area.

three-month treasury bills, ER_t is the first difference of the National Institute of Economic Research exchange rate index for the Swedish krona, CPI_t is the log difference of core consumer price index[21], U_t is the unemployment rate, GDP_t is the log difference of real Swedish GDP and SI_t is the financial stress index. The data are quarterly, ranging from 1989Q4 to 2014Q1. Figures of all variables are shown in Figs 5 and 6. In addition to the macroeconomic and financial variables the models uses a dummy variable for the period 1989 Q4-1992 Q4 to control for the shift in the Swedish exchange rate regime. In effect, the steady states (or unconditional means) of the variables are allowed to shift following 1992 Q4, since $\mathbf{d}_t$ in Equation 2 changes at this point as the dummy is switched off.

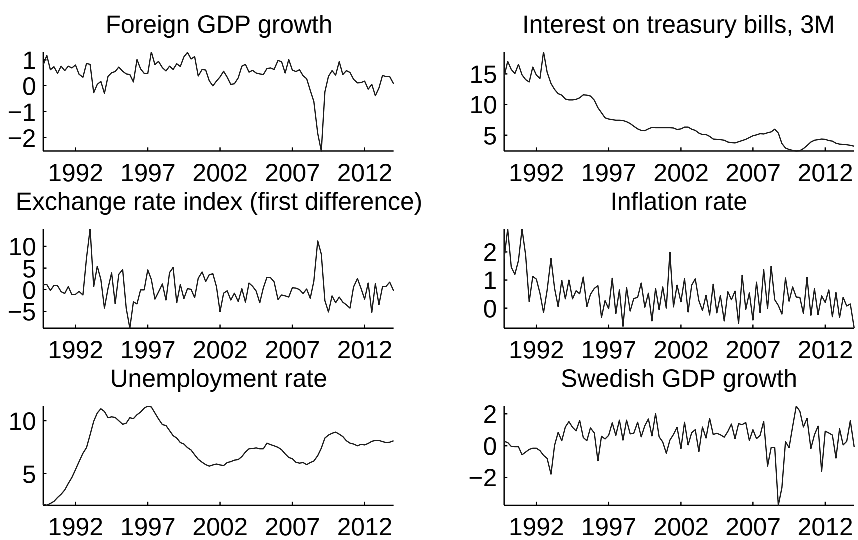

Figure 5: Macro variables

4.3 Steady state intervals

The priors on the unconditional means, or steady states, are given in Table 1 and are presented as 95 % probability intervals for the variable in question. These choices are similar to the previous literature (see e.g. Österholm (2010) and Adolfson et al. (2007)) and deviations therefrom are only cosmetic.[22] The Swedish GDP growth is assumed to have a steady state value centred on 0.5625

[21]The core consumer price index, CPIX, is CPI with households' mortgage costs and direct effects of indirect taxes excluded. For ease of notation, it will still be referred to as CPI throughout.

[22]Most of steady state priors follow the historical averages except for the unemployment. The steady state priors of credit gap and asset price gap are centred on 0 because of the definition of the gap and may therefore deviate from the historical averages. The steady state priors for interest rate and inflation are not allowed to follow their historical averages because Sweden has nowadays a floating exchange rate and a monetary policy with a inflation target.

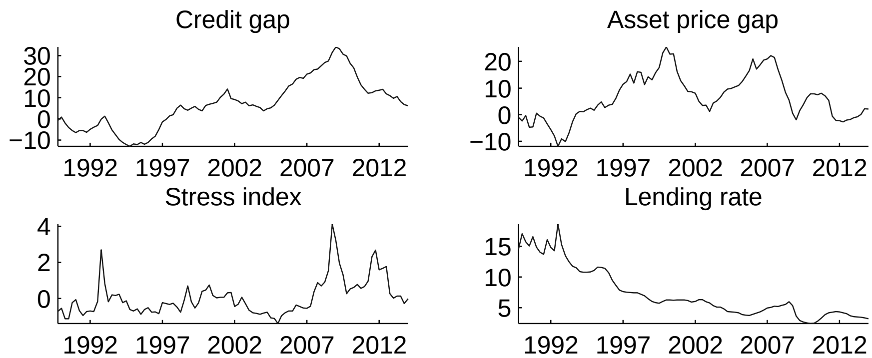

Figure 6: Financial indicators

%, which corresponds to a year-on-year (YoY) growth rate of 2.25 %. The foreign GDP growth is given a wider interval, with its centre being 0.5 %. The prior probability interval for inflation is centred on a YoY rate of 1.625 %, which is justified by the Riksbank's inflation target of 2 % implying a somewhat lower rate for the CPIX measure. The short-term interest rate has a prior unconditional mean of 3.75 % and the lending rate is given prior intervals which are identical to the short-term interest rates', but one percentage point higher. This roughly constitutes the historical spread between the two. The unemployment is centred on 6 % because of the fact that unemployment in Sweden has historically been low but did increase during the global financial crises.[23] The prior for the exchange rate is centred on 0, with quite wide intervals.

For the stress index, we centre the prior on 0 seeing that this is the mean of the series by construction. The credit gap and the asset price gap are both centred to 0 % as they are both gaps, which in the long run should be closed. The upper bound is set to 2 %, which is motivated by the credit gap being a key indicator for the decision to activate the countercyclical capital buffer and also to decide the level of this buffer. According to the rules the counter cyclical capital buffer will be activated when the credit gap is equal to or higher than 2 %. With this in mind, we therefore select 2 % as the upper limit of the prior interval for both credit gap and asset price gap.

In order to accommodate a belief that the Swedish economy does not affect foreign GDP, the latter is treated as block exogenous. This is achieved by using a hyperparameter set to 0.001 that further shrinks the prior variances around zero for parameters relating Swedish variables to foreign GDP.

[23]This is based on calculations made in a report from the Ministry of Finance (2011). An update of these calulations was done in the Spring Fiscal Policy Bill (Swedish Government, 2013, p. 71-72).

Table 1: 95 % prior probability intervals for the unconditional means[a]

Variables	95 % prior probability intervals 1992Q4 and earlier	1993Q1 and later
$GDPTCW$	$(0, 1)$	$(0.25, 0.75)$
$CGAP$	$(-4, 4)$	$(-2, 2)$
$AGAP$	$(-4, 4)$	$(-2, 2)$
IL	$(6.5, 9)$	$(4, 5.5)$
ITB	$(5.5, 8)$	$(3, 4.5)$
ER	$(-5.1, 5.1)$	$(-5, 5)$
CPI	$(0.375, 0.9375)$	$(0.25, 0.5625)$
U	$(4, 6)$	$(5.5, 6.5)$
GDP	$(0.25, 0.875)$	$(0.5, 0.625)$
SI	$(-3, 3)$	$(-1, 1)$

[a] Prior distributions for the unconditional means are all normal.

5 Empirical analysis

This section will try to answer four questions empirically. Is there any interaction between the financial system and the real economy? If so, what are its characteristics? And can the interaction help us improve our assessment of the probability of a crisis? And finally, can it help us make better estimates of the real economic effects of a crisis?

5.1 Conditional forecasts - can the interaction improve our estimates of crisis effects?

One way of analysing the potential gains of including financial indicators in the model is by conditioning on them to investigate how the forecasts change had we known their developments. In particular, it is illustrative to make forecasts before the crisis fully developed and compare the predictions from the financial model, conditional upon the financial indicators, with the macro model's unconditional predictions. If the model is reasonable, it should to some degree signal that times are worsening if we condition upon the financial development during the crisis.

This hypothetical exercise is carried out as follows. The two models are estimated three times each using data up to and including: 2007Q4, 2008Q1 and 2008Q2 respectively. Each time, both models make forecasts of GDP growth in 2008 and 2009, where the financial model's forecasts are conditional on the four financial variables throughout 2008 and 2009.

Figs 7 and 8 display the financial and macro models' predictions for annual growth in 2008 and 2009, respectively. As expected, the financial model provides forecasts that are more in line with the outcomes. In Fig. 7, for the model estimated at 2007Q4 the negative growth in 2008 is not anticipated, but a

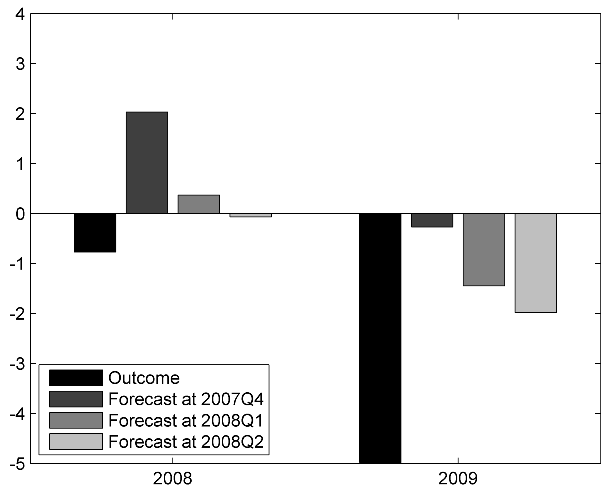

Figure 7: Financial model's forecasts of annual GDP growth in 2008 and 2009
Note: Forecasts are conditional on the financial variables and foreign GDP growith in 2008 and 2009

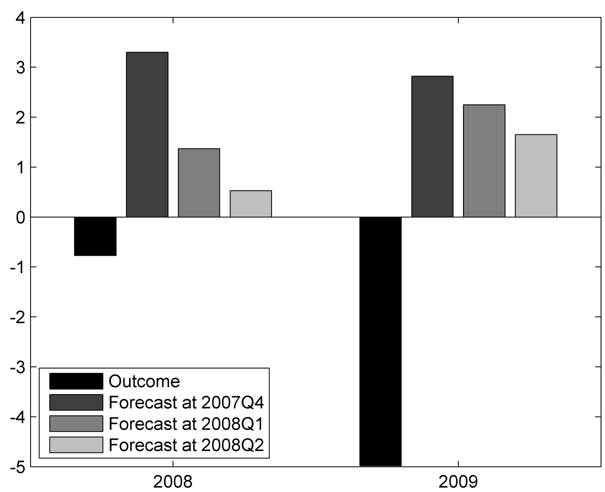

Figure 8: Macro model's forecasts of annual GDP growth in 2008 and 2009
Note: Forecasts are conditional on foreign GDP growth in 2008 and 2009

downturn in 2009 is predicted, although not the full size of it. Estimating the model at 2008Q1 and 2008Q2 gives more pessimistic forecasts that are closer. This should be contrasted to Fig. 8 and the macro model's predictions; the pattern of more pessimistic predictions as the estimation sample is increased

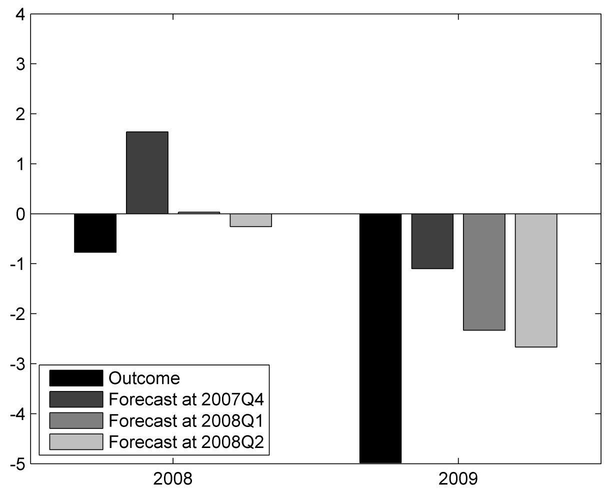

Figure 9: Financial model's forecasts of annual GDP growth in 2008 and 2009
Note: Forecasts are conditional on the financial variables in 2008 and 2009

persists, but they are far from the financial model's.

These forecasts illustrate what is perhaps the greatest advantage of augmenting a traditional macro model with financial variables. The financial model is more flexible and it is possible to carry out forecasts conditional on developments in financial markets, which previously has often been neglected.

When estimating the model, some alternatives have also been considered. In particular, when the model is estimated on data up through late 2007 or early 2008, the sum of the coefficients for lagged foreign GDP in the equation for Swedish GDP is negative. Thus, conditioning on the growth development in the United States and the Euro area alone yields more optimistic predictions than the unconditional forecast. Similarly, only including the financial variables in the conditioning set pulls the forecasts downward compared with Fig. 7, as displayed in Fig. 9. With other prior specifications, the positive effect of a negative foreign development still remains. The estimated negative relationship is, however, not present in a full sample estimation, but is then instead positive.

The Bayesian approach directly accommodates the inclusion of prior beliefs such as this, where it is reasonable to assume that a negative foreign development should have negative consequences for domestic growth. The easiest approach is to set the appropriate prior means to non-zero numbers, or to use more sophisticated methods such as discarding draws where the sum of the coefficients is negative. Doing so does, indeed, give better forecast in the sense that they are more negative and hence closer to the truth (Fig. 10). We believe, however, that such steps need to be taken very carefully and that this instead might serve as suggestion for future work. In the following, we therefore adhere to the specification described in the previous section.

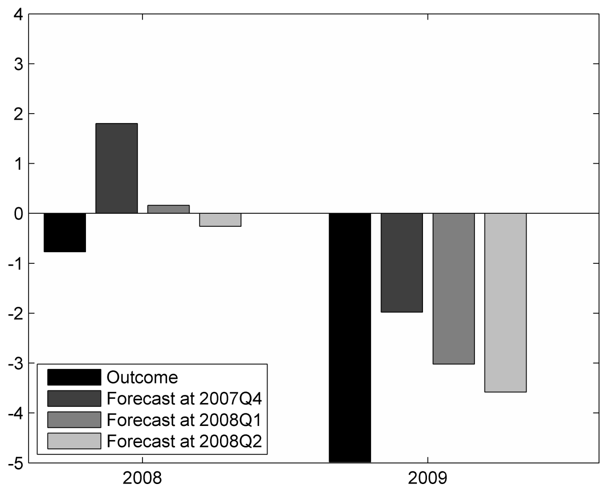

Figure 10: Financial model's forecasts of annual GDP growth in 2008 and 2009
Note: In this example, the prior mean of the first lag of $GDPTCW$ in the GDP equation is set to 0.9 in order to incorporate a belief of a positive relationship between foreign GDP and domestic GDP. The forecasts are made conditional on the financial indicators and foreign GDP growth during 2008 and 2009.

5.2 Variance decomposition - is there an interaction?

In order to answer our first question, if there is an interaction, we perform a forecast error variance decomposition. Such a procedure estimates how much of the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables. The decomposition is presented in Fig. 15.

In order to more clearly see what part can be attributed to the traditional macro variables and to the financial variables, the variables are combined into three groups: macro variables, financial indicators and Swedish GDP growth.[24] The decomposition of the forecast error variance of Swedish GDP growth, with respect to these groups, is presented in Fig. 11.

Fig. 11 clearly shows the importance of the financial indicators: in total, they account for approximately 30 % of the forecast error variance of GDP, which is only slightly less than the share attributed to the traditional macroeconomic variables. The credit gap accounts for the largest share of the forecast error variance of GDP growth, itself excluded. In the first period, more than 15 % of the variance can be linked to the credit gap.

As for the reverse relationship, rows 2-4 and 10, respectively, in the last column in Fig. 15 display the share of the forecast error variance of the respec-

[24] The group macro variables consists of foreign GDP growth, short-term interest rate, inflation rate, exchange rate and unemployment rate and the financial indicators group is, as before, credit gap, asset price gap, stress index and lending rate.

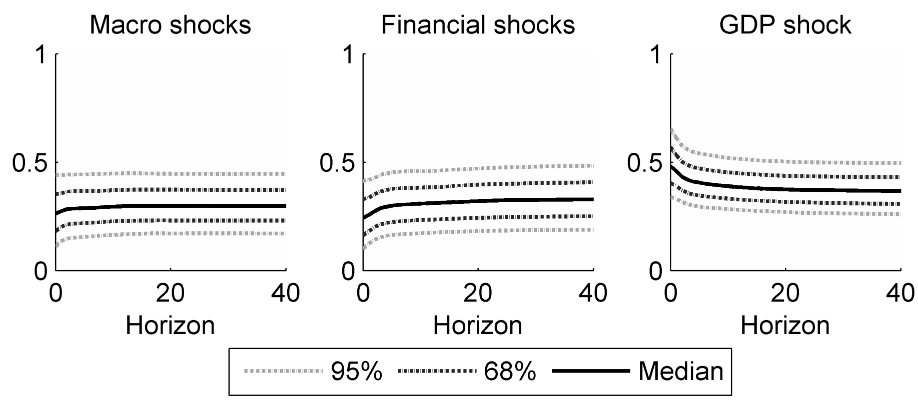

Figure 11: Median forecast error variance decomposition of GDP growth with respect to macroeconomic variables, financial indicators and GDP growth itself

tive row variables that can be attributed to exogenous shocks to Swedish GDP growth. In all four cases, they are essentially zero throughout all 40 quarters. Thus, there seems to be no clear evidence of the real economy affecting the financial sector.

The decomposition allows for two conclusions. First, an interaction appears to exist as the financial indicators account for a substantial part of the forecast error variance of Swedish GDP growth. Evidence of an effect in the opposite direction, however, is not found. Second, the results indicate that the credit gap is of particular importance.

5.3 Impulse responses - what are the characteristics of the interaction?

The second question, concerning the characteristics of the interaction, we aim to answer using the impulse response functions of the model. The impulse response functions are calculated using the Cholesky decomposition of the error covariance matrix, in which the order of the variables is the same as in Equation 3. The median impulse response functions are shown in Fig. 16 in the Appendix, where each column corresponds to a one SD shock of the variable in its header. Overall, the impulse response functions are qualitatively in line with what one would expect. Most of the impulse responses are uncertain and insignificant, meaning that one should be careful in interpreting them.[25] However, a lending rate shock seems to have a significant negative impact on GDP and reaches its largest effect after two quarters. For subsequent quarters, the effect slowly goes back to zero. Moreover, we see that a positive shock of asset price gap is

[25]For a more structural analysis, a structural VAR model with an identification scheme that allows for analyses of combined financial shocks is a possible option (see Villani (2009) for details).

estimated to lead to a credit gap increase, indicating the existence of a financial accelerator effect. At the same time, the shock has a positive impact on GDP.

An impulse response analysis is not a suitable tool to answer the previously asked question about the importance of the financial system for the real economy. To be able to answer this question we use two different approaches, namely whether the inclusion of financial variables improves the models ability to estimate recession probabilities and to foresee a financial crisis.

5.4 Recession probabilities - can the interaction help us predict?

It is not only the point predictions that contain relevant information when making a forecast, but in a setting like this it is straight-forward to make probabilistic statements to create a more complete picture. Österholm (2012) performs an alternative forecasting exercise with a steady state BVAR for the US. The focus of the paper is what the model's estimated probability at 2008Q2 is of a coming crisis, with a crisis defined as two consecutive quarters of negative growth. For any given quarter t, the defined recession probability can be expressed as $P(GDP_{t+1} < 0 \cap GDP_{t+2} < 0|\mathbf{x}_1, \ldots, \mathbf{x}_t)$, where GDP as before denotes the growth of GDP. The probability is estimated by dividing the number of draws where both $\widehat{GDP}_{t+1}$ and $\widehat{GDP}_{t+2}$ are negative with the size of the posterior sample. Fig. 12 provides a plot of the estimated probability for t between 2006Q1 and 2013Q4.[26]

Beginning in 2007 and ending right before the crisis unfolded in 2008Q3, both models' probabilities of recession steadily increased. The financial model shows a more rapid increase, but up through 2008Q1, the two models' estimated probabilities are more or less the same. Standing in 2008Q2, however, the financial model's probability of negative growth in both 2008Q3 and 2008Q4 is 20 %, whereas the corresponding estimate from the macro model is 15 %. Beginning in late 2010, the probability of a recession is again slowly increasing following the events leading up to the intensification of the Eurozone crisis, with the European Central Bank re-activating its Securities Markets Program in August 2011. This is directly reflected in the financial model's estimated recession probability, but is at the same time barely visible in the macro model's because of its lack of financial indicators. This indicates that the more complete picture given by the inclusion of financial indicators is important, as it provides information about the developments in the financial markets, which are likely to eventually transmit into the real sector.

[26] We have also generated the model's estimated probability of a coming crisis between 2006Q1 and 2013Q4 at 2008Q2, with a crisis defined as one quarter of negative growth. The estimated probability is even better when the model only needs to estimate one quarter. These estimates are available upon request.

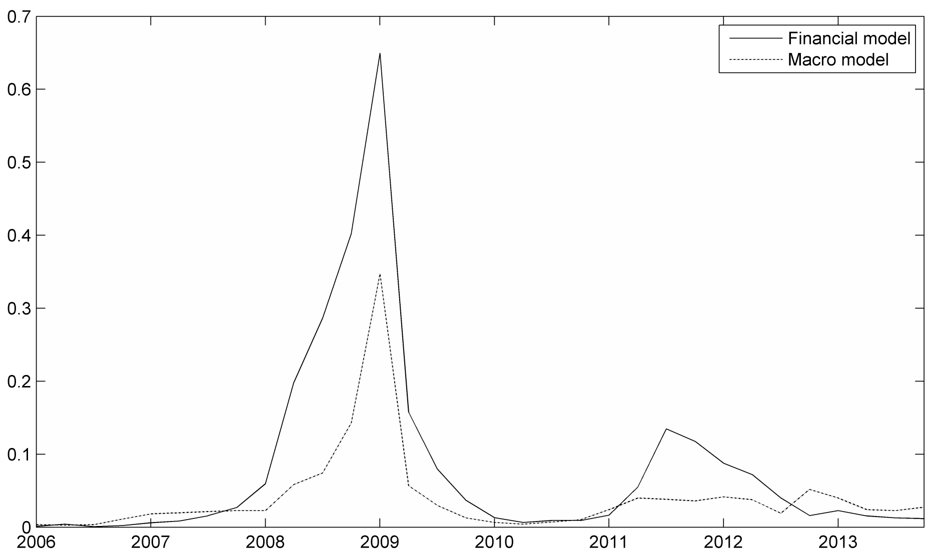

Figure 12: Future recession probabilities

5.5 Forecast evaluation

A pseudo out-of-sample forecast evaluation is conducted with respect to the model's ability to forecast Swedish GDP growth.[27] For the sake of comparison we estimate two main models: i) a macro model without the financial indicators (abbreviated by MAK), and ii) the main financial model, i.e. the macro model with four financial indicators (referred to as FIN). For the MAK model, the endogenous variables are GDPTCW, ITB, ER, CPI and GDP, with GDPTCW being block exogenous. For FIN, the financial variables CGAP, AGAP, SI and IL are also added. The steady state prior, as discussed in Section IV, is employed for both models. The evaluation also includes three simpler alternatives for reference. The first is an AR(1) model, the second the most recent observation and the third the mean over the most recent two years.

The out of sample forecast evaluation is carried out in the following way. The period 2006Q2 to 2014Q1 is used as the evaluation period and the models make recursive forecasts for these periods. This means that in a first step the models are estimated using data from 1990Q2 to 2006Q1, after which forecasts are made for the next one to eight quarters. In a second step, the models are re-estimated using data from 1990Q2 to 2006Q2 and the forecasts are then redone with the same time horizons as before.[28] This then continues in the

[27]Forecast evaluations with respect to the other variables are available from the authors upon request.

[28]In the evaluation the latest regular outcome figures for the national accounts have been used as an outcome series for GDP, i.e. up to and including 2014Q1. One reason why a real time series has not been used for GDP is that the evaluation is not primarily intended to evaluate the absolute forecasting ability of the models including financial variables, but its

same way moving one quarter ahead in each stage. With this procedure each model has at most 32 forecasts (one quarter horizon) down to 25 forecasts (eight quarter horizon), which make up the forecast series that are evaluated. Each model's forecast series is then compared with the actual outcome series and the forecasting abilities of the models are summarized by the root mean square error (RMSE) with a lower value indicating better forecasting ability. The models' RMSE values are presented in Fig. 13.

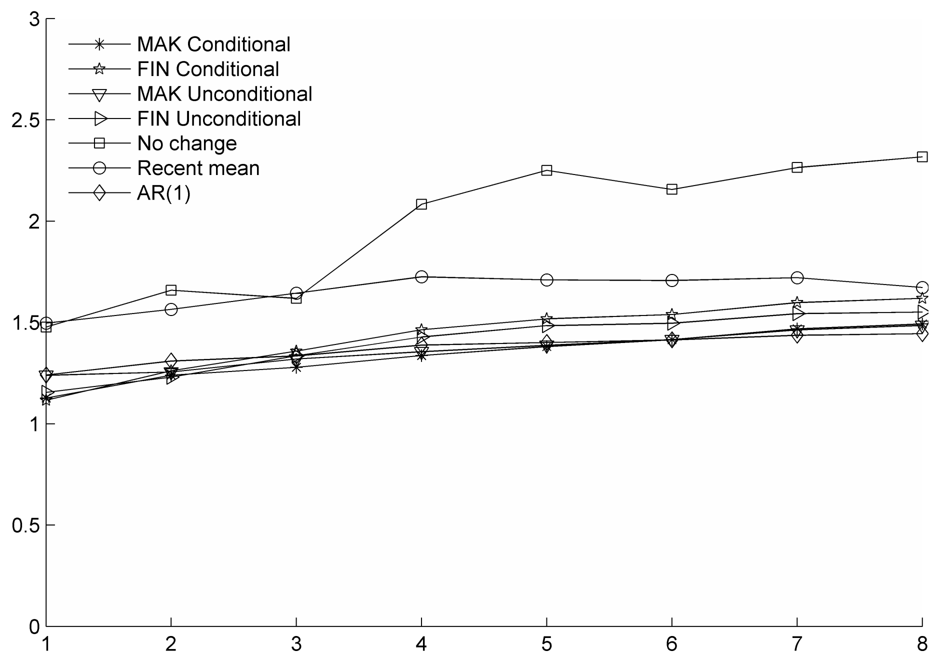

Figure 13: Root mean square errors (RMSE) for predictions of Swedish GDP growth

The results in Fig. 13 show that, in terms of point predictions evaluated by RMSE, there is no major difference between the smaller, basic macro model and the larger model with financial indicators. The figure also includes the RMSE values of these two models, where the forecasts are conditioned upon the foreign GDP variable. This is done in order to rid the model of possibly predicting badly due to an inability to forecast foreign GDP; because of the imposed block exogeneity, the equation for foreign GDP is essentially just an AR(4). The conditional forecasts are improved compared with their unconditional counterparts, even beating the benchmark AR(1) over all eight quarters. The unconditional forecasts have lower RMSE than the AR(1) for the first three quarters, but

forecasting ability relative to models that exclude such variables, in order to use this as a test of the added value of including the financial variables. However, the forecasting ability of these models is evaluated relative to the forecasts of a simple AR model so as to obtain an indication of whether the model has added value in forecasting ability.

for the entire evaluation period the difference is less than 0.1. Thus, one may conclude that in terms of forecasting accuracy, there is in essence no difference between the macro model and the financially augmented model.[29]

5.6 Future forecasts

As a closing part of the empirical analysis, we study what the future might hold. For comparison, we include both the macro and the financial models with all three priors considered in the forecast evaluation. The forecasts are presented as annual growth rates in Fig. 14.

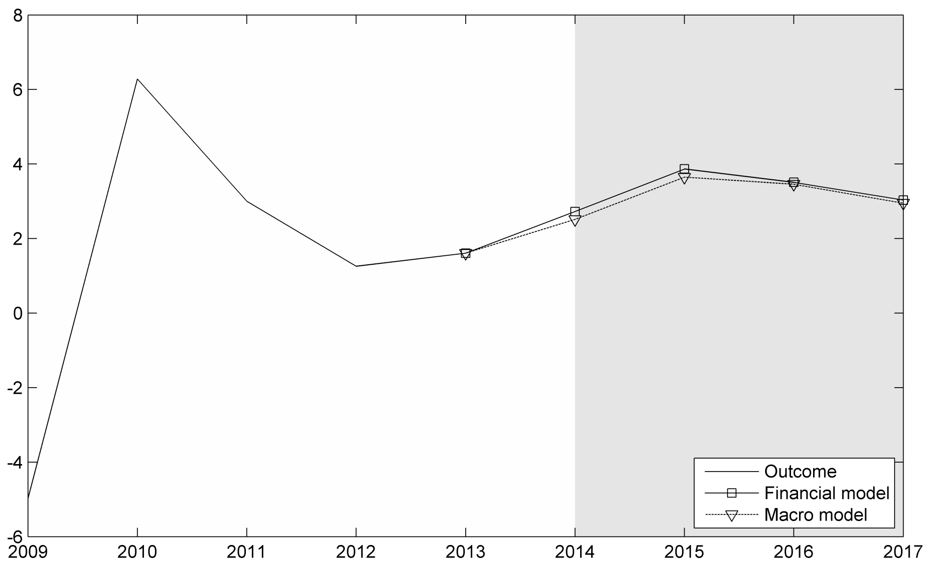

Figure 14: Forecasts of annual Swedish GDP growth
Note: Models are estimated on data up to and including 2014Q1.

The financial model (solid line with markers) is slightly more optimistic than the macro model (dashed line with markers) in its forecast for the coming years. The qualitative development is the same: increased growth in 2014 and 2015, followed by lower growth in 2016 and 2017. Quantitatively, the differences are very small.

[29]The forecasts have also been evaluated by mean absolute error and bias, which are available upon request. The results and conclusion from these measures are in line with what is presented here. All models have a minor negative bias, but the size, around -0.2 to -0.4, is similar in size to the AR(1) model's. However, due to the small sample, one or two larger misses have a quite large effect on the bias calculation.

6 Conclusion and comments

The focus of this paper has been to answer two main questions: i) Is the financial system important for the development in the real economy? ii) If it is, what are the characteristics? A decomposition of the forecast error variance of Swedish GDP growth reveals that the financial indicators explain almost 30 % of the variance, which is close to the share of the variance attributed to standard macroeconomic variables. Of the financial indicators, the credit gap presents itself as the main contributor accounting for about 15 % of the forecast error variance. In the opposite direction, the relationship is less clear. Shocks to GDP explain essentially nothing in any of the financial variables. Hence, the model gives indications that, yes, the interaction exists, but it is mainly one-way.

To see the characteristics of the interaction, two different approaches were used, namely whether the inclusion of financial variables improves the models ability to estimate recession probabilities and to quantify the effects on GDP of a financial crisis. The results indicate that the financial model, to a larger extent than the macroeconomic model, acknowledges the increasing distress preceding the crisis. The financial model's estimated probability of a recession is stronger at an earlier date than the macroeconomic model's, thus connecting the financial turmoil to greater uncertainty surrounding the growth of the economy. Similarly, but more importantly, the financial model produces a much more accurate forecast of the depth of the crisis, when comparing forecasts made in the quarters just before the outbreak of the crisis. Conditional on the financial indicators, the model's forecast of Swedish GDP growth over the coming two years is substantially lower and thus more accurate than the macro model's forecast.

Furthermore, this considerable increase in explanatory power does not come at the expense of lower predictive power. There is no loss to point predictions, in terms of root mean square error (RMSE), by expanding a classical macroeconomic model with financial variables. Compared with the traditional macroeconomic model, there is in essence no difference as to their forecasting performances.

Concluding, the proposed macro-financial model sees improved estimates of recession probabilities and a drastic improvement in modelling the GDP effects from the 2008 financial crisis, without losing predictive power.

For future research, there are many interesting extensions one could make. The inclusion of stochastic volatility in the steady state prior, as proposed by Clark (2011), appears to be a promising alternative. Similarly, allowing the model to have time-varying or regime-switching parameters could be interesting ways of incorporating nonlinearities, which might improve the model even further.

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A Appendix

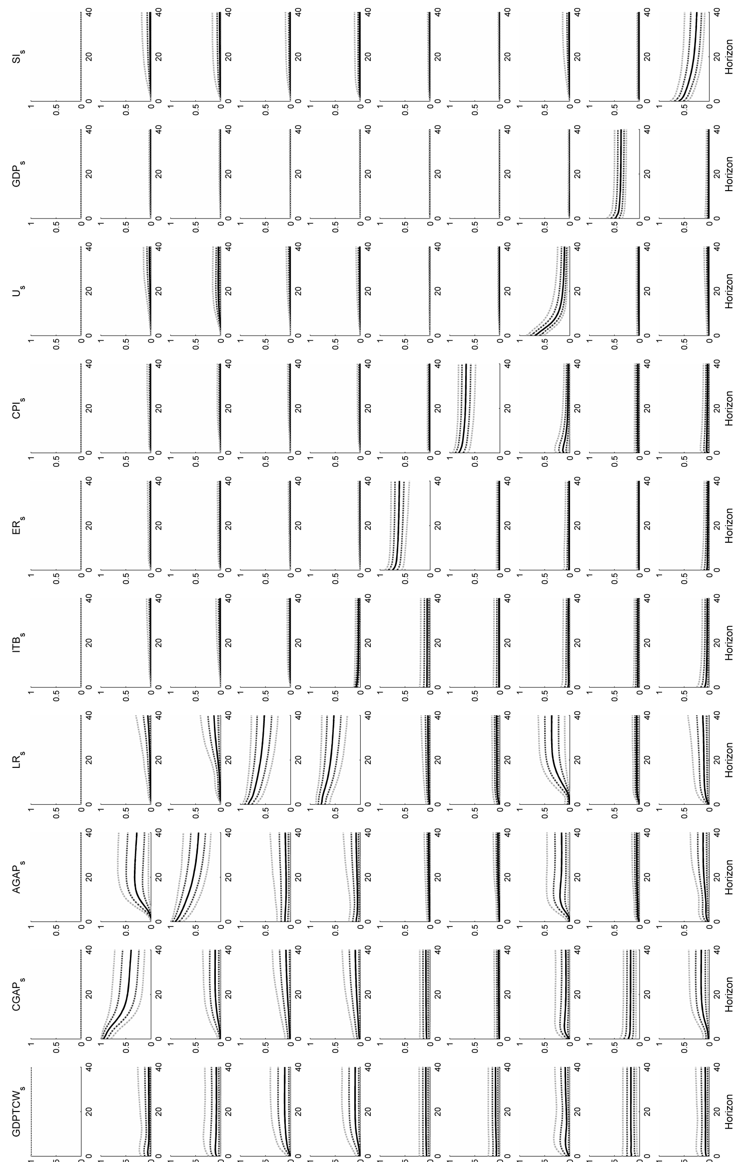

Figure 15: Forecast error variance decomposition

Note: Shocks have been orthogonalized using a Cholesky decomposition, in which the ordering is the order in which the variables appear in the figure.

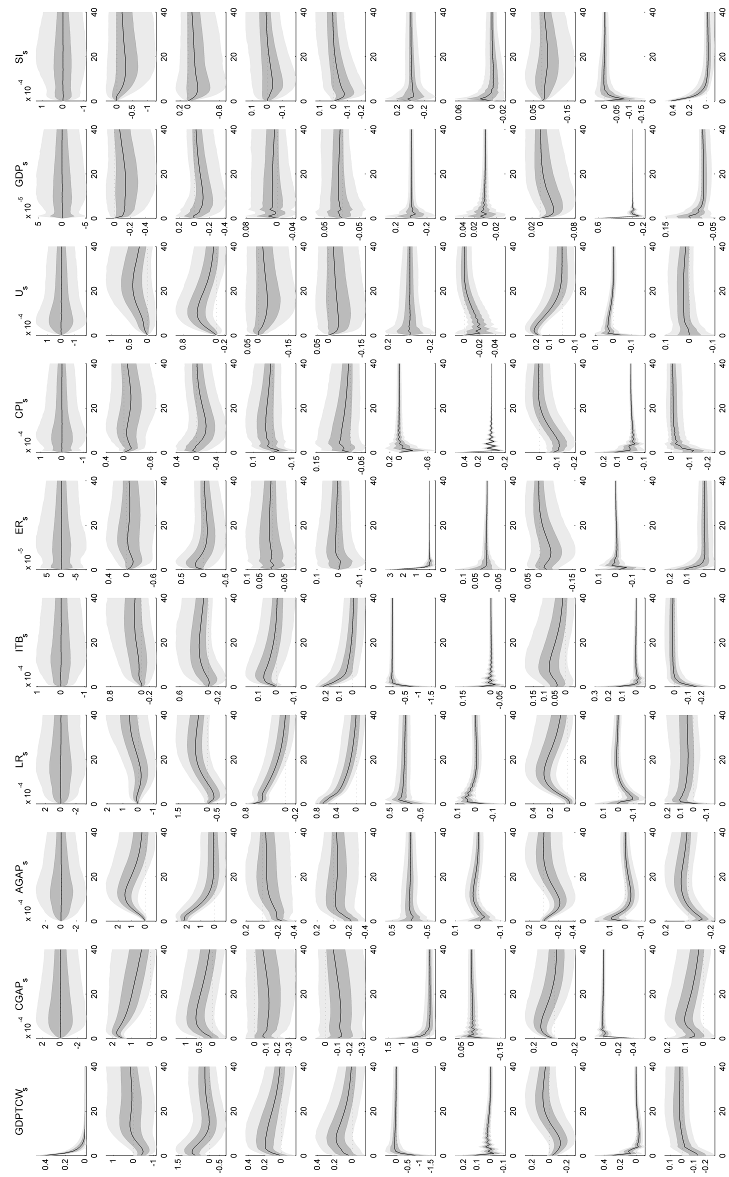

Figure 16: Impulse response functions

Note: Shocks have been orthogonalized using a Cholesky decomposition, in which the ordering is the order in which the variables appear in the figure.