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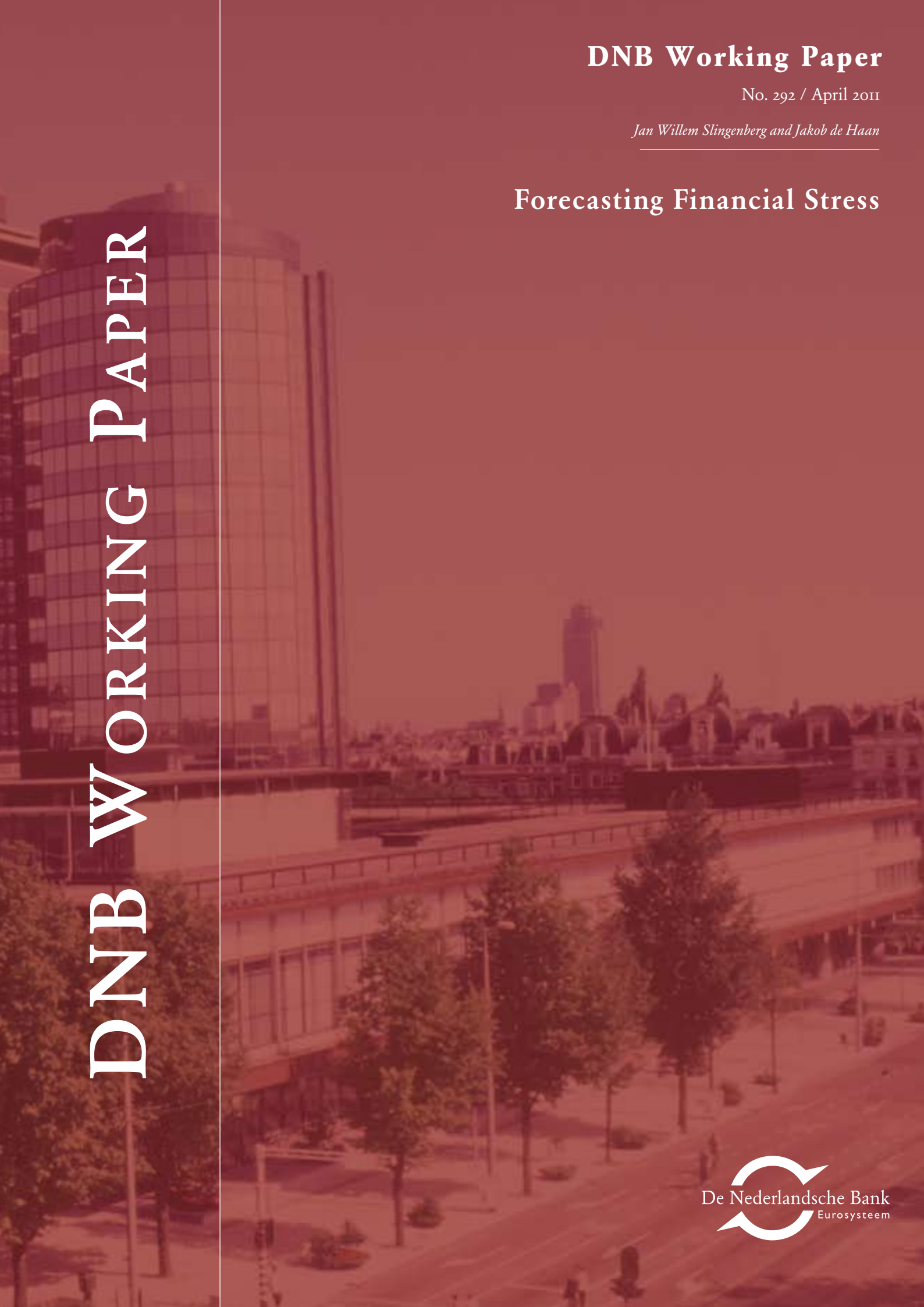
Forecasting Financial Stress



De Nederlandsche Bank
Eurosysteem

Forecasting financial stress

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* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

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Forecasting financial stress

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Abstract

This paper uses a Financial Stress Index (FSI) for 13 OECD countries to examine which variables can help predicting financial stress. A stress index measures the current state of stress in the financial system and summarizes it in a single statistic. We employ three criteria for indicators to be used in constructing a multi-country FSI (the index covers the entire financial system, indicators used are available at a high frequency for many countries for a long period, and are comparable) to come up with our FSI. Our results suggest that financial stress is hard to predict. Only credit growth has predictive power for most countries. Several other variables have predictive power for some countries, but not for others.

Key words: financial stress index, predicting financial stress

JEL-code: E5, G10

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1. Introduction

Financial crises often result from financial imbalances that at some point unwind, potentially causing widespread financial strains (Borio and Drehmann, 2009). Several papers suggest that credit and asset prices tend to grow at unusually high rates in periods prior to financial crises (Borio and Lowe, 2002).[1] In research on early warning indicators, crises are generally measured by simple binary variables and are treated as banking, debt, and/or currency phenomena, rather than system-wide events (Illing and Liu, 2006). Furthermore, in industrial countries financial crises occur at a low frequency, which makes it hard to examine regularities. Finally, the focus on crisis events does not lend itself to a quantification of stress levels prevailing during different stages of a particular crisis episode or during different financial crises in the same economy (Hollo et al., 2010).

Alternatively, some recent studies have therefore come up with a Financial Stress Index, be it for one country (Illing and Liu, 2006; Hakkio and Keeton, 2009) or for several countries (Cardarelli et al., 2009; Holmfeldt et al., 2009, Hollo et al., 2010). A stress index measures the current state of stress in the financial system and summarizes it in a single statistic. Financial stress can be defined as an interruption of the normal functioning of the financial system (ECB, 2009). It is difficult to provide a more exact definition, because episodes of financial stress are often different. However, certain key features are frequently associated with financial stress, like increased uncertainty about the fundamental value of assets, increased uncertainty about behavior of other investors, increased asymmetry of information, decreased willingness to hold risky assets, and decreased willingness to hold illiquid assets (Hakkio and Keeton, 2009). Financial stress is a continuum with financial crises at one extreme.

This paper uses a Financial Stress Index (FSI) for 13 OECD countries to examine whether a long list of variables can help predicting financial stress. We employ three criteria for indicators to be used in constructing a multi-country FSI: the index should cover the entire financial system, indicators used should be available at a high frequency for many countries for a long period, and they should be comparable. The novelty of our

[1] While performing fairly well with the benefit of hindsight, leading indicators based on those variables might work well in sample, but not out of sample. Borio and Drehmann (2009) assess the out-of-sample performance of those indicators over the period 2004 to 2008 and find that equity prices fail to issue warnings of the recent financial crisis.

paper is not that we develop yet another FSI. Our main contribution is that we examine to what extent financial stress can be predicted. We examine whether several variables that have been suggested in the literature - like credit growth and asset prices - have leading indicator properties.

The paper that comes closest to ours is Misina and Tkacz (2009) who try to identify leading indicators for the financial stress index of Illing and Liu (2006) for Canada. We extend their analysis in three directions: (1) more variables will be tested for their leading indicator properties both in sample and out of sample, (2) our analysis refers to 13 countries, and (3) a new stress index will be used to make cross country comparisons possible.

Our results suggest that financial stress is hard to predict. Only credit growth turns out to have some predictive power for most countries. Several other variables have predictive power for some countries, but not for others. In this respect our findings echo the conclusions of Rose and Spiegel (2009; 2010), who were unable to find consistent strong linkages between variables that are plausible causes of the Great Recession and the actual intensity of the recession.

The paper is structured as follows. Section 2 describes our FSI and compares it with alternative indicators. Section 3 outlines the variables used to test for their leading indicator properties and our methodology, while section 4 presents our main findings. Section 5 offers a sensitivity analysis. Section 6 concludes.

2. Constructing a Financial Stress Index

Table 1 shows the indicators used for constructing a stress index by Illing and Liu (2006), Hakkio and Keeton (2009), Cardarelli et al. (2009) and Holmfeldt et al. (2009).[2] To be included in a FSI that can be used for our purposes, an indicator should meet the following criteria. First, it should be available for many countries for a long period at a sufficiently high frequency. Second, it should be comparable across countries. Finally, the FSI should cover the entire financial system, i.e., money, bond, and equity markets,

[2] Other recent studies include Hollo et al. (2010), ECB (2009) and Yiu et al. (2010). Hollo et al. (2010) constructed their so-called Composite Indicator of Systemic Stress ("CISS") for the euro area as a whole (see section 5 for more details). The ECB (2009) developed a parsimonious global index of financial turbulence (GIFT) based on a limited set of indicators capturing stress in fixed income, equity and foreign exchange markets. This index is calculated for 29 main economies. Yiu et al. (2010) constructed a monthly financial stress index inspired by Illing and Liu (2006) for the Hong Kong financial system.

the banking sector, and the foreign exchange market (Hollo et al., 2010). On the basis of these criteria, our FSI takes into account: stock prices volatility, the corporate bond spread, the TED spread, the beta of the banking sector, and exchange rate volatility. We will explain these indicators first and then explain how we have combined them into an index.

[Insert Table 1 here]

Most financial stress indexes include stock price volatility assuming that large swings in stock prices indicate financial imbalances in the equity market. Our index also takes stock price volatility into account. Following Cardarelli et al. (2009), time-varying stock return volatility has been derived from a GARCH(1,1) specification (Bollerslev et al., 1992). Data come from the OECD.

FSIs also often include some indicator of interest rate differentials in the bond market. Unfortunately data for the government bond market is not available for the full sample period for all countries in our sample. However, data for the spread for the bond market, defined as corporate bond yield minus long-term government bond yield, are available for all the countries in the sample and this indicator is therefore included in our index. A rise in the spread reflects a flight to quality and liquidity.

Most stress indexes include a measure for the money market, like the TED spread, i.e., the yield difference between an unsecured inter-bank loan and a Treasury bill. Hakkio and Keeton (2009) show that the correlation between the TED spread and bond market spreads is often relatively low. The TED spread reflects credit risk and liquidity risk. It also captures stress in the banking sector as the premium captures counterparty risk.

Another indicator of stress in the banking sector that is included in our index is the so-called β of the banking sector, which is calculated as follows:

$$\beta = \frac{\mathrm{cov}(b,m)}{\mathrm{var}(m)} \qquad (1)$$

where β is the total change of the banking sector equity index and *m* is the total change of the market sector equity index. If beta exceeds 1, the returns for the banking sector are more volatile than the returns for the overall market.

Finally, the volatility of monthly changes in the nominal effective exchange rate is included in our index. Like stock price volatility, this indicator is derived using a GARCH(1,1) specification for the monthly change of the real effective exchange rate. This volatility reflects investors' uncertainty about the fundamental value of the currency and about the investment behavior of other agents (Cardarelli et al., 2009).

The FSI is calculated for 13 OECD countries: Australia, Belgium, Canada, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden, the UK and the US. Unless indicated otherwise, the data is obtained from the IMF. All variables are standardized, i.e. we subtract the mean and divide by the standard deviation. Our index is the un-weighted sum of the standardized variables. A justification for giving all the variables the same weight is that this makes the index easy to interpret. Gadanecz and Jayaram (2009) argue that using weighting factors may represent the financial system better, but Illing and Liu (2006) show that weighting does not make much of a difference.[3]

The interpretation of the FSI is very straightforward. If the index is above 0, it indicates stress; if it is below 0, the financial system is stable. A crisis is defined as a period where the index exceeds the threshold of one standard deviation.

Figure 1 shows the aggregate financial stress index for the countries in our sample, using GDP as weights. It is clear that episodes of severe international financial imbalances as identified by Cardarelli et al. (2009) coincide with strong increases of our index. For instance, the LTCM crisis of 1998 and the ERM crisis in 1992 show up very clearly. Also the banking crises in the Nordic countries in 1991 and the recent financial crisis are picked up by the index.

[Insert Figure 1 here]

Table 2 shows the correlation of our financial stress index and some other FSIs. The correlation coefficients are generally above 0.8, which indicates that the various indexes

[3] In contrast, Hollo et al. (2010) argue that if their index were calculated as a simple arithmetic average - which implicitly assumes perfect correlation across all sub-indices all the times - it would not be able to differentiate between the aggregate levels of stress prevailing, for example, in the aftermath of September 11, 2001 and during the first year of the current "subprime" crisis. That is why we apply one of their weighting schemes in the sensitivity analysis as (section 5).

are fairly similar. Particularly interesting is the index of Hakkio and Keeton (2009) for the United States. Even though we cannot use many of the variables suggested by these authors (see Table 1) as they are not available for all countries in our sample, the correlation between our index and the FSI of Hakkio and Keeton is 0.87.

[Insert Table 2 here]

3. Forecasting variables and methodology

Data

Early warning indicators of financial stress should satisfy 3 requirements: (1) the data should be available on a quarterly basis, (2) there should be an economic mechanism that relates the variable to economic stress, and (3) the data should be available for a sufficient number of countries in our sample.

The variables used in this study are drawn from the literature. Several studies suggest that a financial crisis is often preceded by a fierce credit expansion and asset price increases (Kindleberger and Aliber, 2005). Furthermore, there are numerous studies that empirically link asset prices and credit growth to the financial cycle (Borio and Lowe, 2002; Adalid and Detken, 2007; Goodhart and Hoffman, 2008). This literature suggests that developments in the credit and assets market can provide early warning indicators of financial stress. Indeed, Misina and Tkacz (2009) report that within a linear framework, domestic credit growth is the best predictor of the FSI for Canada at all horizons, resulting in marginally lower prediction errors compared to the base model, while asset prices tend to be better predictors of stress when they allow for nonlinearities. However, many other variables have been analyzed as well. For instance, Goldstein et al. (2000) have tested various variables for their forecasting power for currency and banking crises. Other authors have extended this research in different directions and tested a myriad of other variables. Lestano et al. (2003) summarize these studies, classifying the variables used into 4 categories: external sector, financial sector, real sector and foreign sector.

We follow the classification of Lestano et al. (2003). Table 3 shows the variables that we have examined. Column 1 presents the names of the variables, while columns 2

and 3 indicate the expected sign and the notation of the variables, respectively. Column 4 gives the economic intuition for the relation between the variable concerned and financial stress.

[Insert Table 3 here]

Methodology

The purpose of the present study is to find variables that are able to signal financial stress in subsequent periods. We use two different approaches. First, we estimate models for the entire sample period in which (lagged values of) the variables of interest are added to the lagged values of the stress index, to examine whether the variables of interest add explanatory power. That is, we estimate

$$FSI_t = a + \varphi_m FSI_{t-m} + \lambda_n X_{t-n} + \upsilon_t \quad (2)$$

Where X are the variables to be tested for their forecasting abilities as outlined in Table 3. The test is a t-test whether $\Sigma\lambda_n$ is significantly different from zero. To determine the number of lags for FSI (m) and X (n), Akaike's Information Criterion is used. In this approach, we test whether in sample the variables in X add explanatory power.

Alternatively, we follow Misina and Tkacz (2009) to examine whether the variables in X enhance the out of sample forecasting properties of the model. In order to evaluate the marginal contributions of the various explanatory variables, we compare augmented models with a simple linear benchmark in which the current FSI is simply a function of the k-quarter lagged FSI:

$$FSI_t = c + \beta FSI_{t-k} + \varepsilon_{1,t} \quad (3)$$

In the augmented models, additional explanatory variables X (potential leading indicators of financial stress) will be added one by one. For X we use the same number of lags (k) as for FSI:

$$FSI_t = c + \beta_1 FSI_{t-k} + \gamma X_{t-k} + \varepsilon_{2,t} \quad (4)$$

In order to come up with a dynamic forecast, the data set for each country will be split. The first half of the dataset will be used to estimate the parameters. The estimated

parameters of the benchmark and the augmented model will be used to forecast the FSI in the subsequent quarter. This means that the forecast is made for time *t+1* with all the information that is available at time *t*. Next, one quarter is added to the sample and the parameter estimates are updated using all information that is available at time *t+1*. The FSI forecast for the subsequent quarter *t+2* is based on these updated models. This procedure is repeated until the end of the sample for different lag lengths (k = 1, 2, 4 and 8).

In line with Misina and Tkacz (2009) and Lam et al. (2008) the root mean squared error (RMSE) will be calculated to evaluate the performance of the forecasting power of the benchmark and the augmented models:

$$\text{RMSE} = \sqrt{\sum \frac{1}{n} (\hat{FSI} - FSI)^2} \qquad (5)$$

where $(\hat{FSI} - FSI)$ is the difference between the forecasted financial stress index and the actual financial stress index. We will evaluate the forecasting abilities of the augmented and the benchmark models using the ratio of the RMSE of model (4) relative to that of model (3). When this ratio is below 1.0, the additional explanatory variable improves the forecast relative to the benchmark model. To determine whether the ratio differs significantly from 1, we again follow Misina and Tkacz (2009) and employ a test proposed by McCracken (2007).

Following Lam et al. (2008), we also test whether the augmented model forecasts the direction of change of the stress index correctly, using a direction of change (DoC) statistic. If a model predicts the direction of change of financial stress for a specific quarter correctly, the DoC statistic is one, while a zero will be assigned if the model does not predict the direction of change correctly. We then sum these statistics for the benchmark and the augmented model and use the ratio of these sums to calculate our DoC statistic. Again, a value of 1 of this statistic indicates that the models perform equally well, a value smaller than one indicates that the augmented model performs better and a value larger than one indicates that it performs worse.

4. Empirical results

We have tested 30 variables for their leading indicator properties.[4] Table 4 shows the results for equation (2). The results are rather disappointing. Only two variables (the MSCI stock index and the local stock index) come out significant in 7 out of the 13 models estimated. Interestingly, the coefficient of the stock indexes is negative, suggesting that higher stock prices reduce financial stress. Other variables that often have been suggested being related to financial stress, like credit and real estate prices, turn out to be insignificant in most regressions.

[Insert Table 4 here]

Next we focus on the forecasting properties of the variables identified in Table 3. Table 5 shows the results for the RMSE test, while Table A2 in the Appendix shows the results for the DOC test.

[Insert Table 5 here]

Various conclusions can be drawn from Table 5. First, the results differ substantially across countries. The number of variables with leading indicator properties ranges from 1 (Sweden at k=1) to 13 (Spain at k=2). Second, the variable that comes out most significant is credit growth. Especially business credit is able to improve the forecast in ten out of the thirteen countries for lag four. Misina and Tkacz (2009) also find that business credit is a good variable that performs well in Canada, but Rose and Spiegel (2009, 2010) do not find that credit growth is a leading indicator for the recent financial crisis in their cross country study. Interestingly, we also find that for k=2 oil prices and inflation turn out to be significant quite often.

Our results suggest that residential real estate and stock prices are not improving the forecast for most countries. This is in contrast to Borio and Lowe (2002), Adalid and Detken (2007), Goodhart and Hoffman (2008) and Hanschel and Monnin (2005). The

[4] Not all the time series for all the countries are available; Table A1 in the Appendix shows which variables are used for each country.

weak performance of the residential real estate variable may be caused by the way in which the index is constructed. Especially for the Euro zone countries data about real estate is very sparse and to construct this index a lot of interpolation and estimation is used. It is, of course, also possible that increasing housing prices take longer to lead to financial stress (recall that our maximum forecast horizon is eight quarters).

The results for the DoC statistic as reported in Table A2 are again rather disappointing. The differences between the benchmark model and the augmented model are generally very small, suggesting that the variables tested for their leading indicator properties do not provide much information as to the direction of change of the FSI.

5. Sensitivity analysis

In this section we examine the robustness of our findings addressing the aggregation of indicators into our FSI and examining a non-linear relationship between potential leading indicators and our FSI.

First, we check whether our index depends heavily on the aggregation method chosen. As explained in section 2, our stress index is the un-weighted sum of the standardized indicators. As an alternative, we follow Hollo et al. (2010) and calculate the FSI as follows:

$$FSI = \sqrt{y_t C_t y_t'} \tag{6}$$

where y = (w*s) where w= (w_1,w_2,w_3,w_4,w_5) is the vector of (constant) sub-index weights, s is the vector of sub-indices; w*s is he Hadamard-product (i.e. element by element multiplication of the vector of sub-index weights and the vector of sub-index values in time t) and C_t is the matrix of time-varying cross-correlation coefficients ρ_{ijt} between the sub-indices i and j. So in this alternative stress index, the indicators are aggregated on the basis of weights, which reflect their time-varying cross-correlation structure. Figure A1 in the appendix shows for each country our FSI and the index calculated following Hollo et al. (2010). The graphs suggest that the use of this alternative aggregation method does not give qualitatively different results.

Next, we check for the existence of a non-linear relationship between the indicators and our FSI, following a similar method as van den End (2006). Extreme changes in the forecasting variables were included exponentially to allow for non-linear

effects of the forecasting variable on the stress index. Changes of more than two standard deviations were squared and added to the change in the growth rate. With the newly created forecasting variables the forecasting exercise was repeated. We did not find substantive differences in the number of improving variables compared with the linear model. The results for the non-linear effects models are available on request.

6. Conclusion

The aim of this paper was to identify variables that have leading indicators properties for financial stress. For that purpose, we first constructed a financial stress index (FSI) for 13 OECD countries (Australia, Belgium, Canada, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden, the UK and the US). We have used three criteria for indicators to be used in constructing our FSI (the index should cover the entire financial system, indicators used should be available at a high frequency for many countries for a long period, and they should be comparable) to come up with our FSI. Our stress index is very similar to other stress indexes that were previously developed. Episodes of severe international financial imbalances as identified by Cardarelli et al. (2009) coincide with strong increases of our index.

In order to test the leading indicator properties of some 30 variables that have been suggested in the literature, we used two different approaches. First, we estimated models for the entire sample period for which we have data in which (lagged values of) the variables of interest are added to the lagged values of the stress index, to examine whether the variables of interest add explanatory power. Second, we followed Misina and Tkacz (2009) to examine whether variables enhance the out of sample forecasting properties of the model.

The results that are found in this study are somewhat bleach. There are only a few variables that are able to improve the forecast for a high number of countries and when there are improvements in the forecast they are all rather marginal. Our results suggest that financial stress is hard to predict. Only credit growth turns out to have some predictive power for most countries. Several other variables have predictive power for some countries, but not for others. Notably, residential real estate and share prices are not performing as expected on the basis of the literature.

For policymakers it would be interesting to monitor the credit aggregates very closely. These variables seem to be the best leading indicators of financial stress. That does not mean, however, that this study makes it a straightforward exercise for policy makers. Most importantly, this is due to the fact that even for credit growth the results differ across countries.

References

Adalid, R. and C. Detken (2007). Liquidity Shocks and Asset Price Boom/Bust Cycles, *ECB Working Paper Series*, No. 732.

Bollerslev, T., R.Y. Chou and K.F. Kroner (1992). ARCH Modeling in Finance: A Review of the Theory and Empirical Evidence, *Journal of Econometrics,* 52, 1-2, 5-59.

Borio, C. and M. Drehman (2009). Assessing the risk of banking crises – revisited, *BIS Quarterly Review*, March 2009, 29-46.

Borio, C. and P. Lowe (2002). Asset Prices, Financial and Monetary Stability: Exploring the Nexus, *BIS Working Paper*, No. 114.

Cardarelli, R., Elekdag, S. and S. Lall (2009). Financial Stress, Downturns, and Recoveries, *IMF Working Paper*, WP 09/100.

End, J.W. van den (2006), Indicator and boundaries of financial stability, *DNB Working Paper,* 097/2006.

European Central Bank (2009). *Financial Stability Review December 2009*, Frankfurt/Main.

Gadanecz, B. and J. Kaushik (2009). Measures of Financial Stability – A Review, *IFC Bulletin*, No. 31.

Goldstein, M., Kaminsky G. and C. Reinhart (2000). Assessing financial Vulnerability: An Early Warning System for Emerging Market, Institute for International Economics.

Goodhart, C. and B. Hofmann (2008). House Prices, Money, Credit and the Macroeconomy, *ECB Working Paper Series*, No. 888.

Hakkio, C. and W. Keeton (2009). Financial Stress: What is It, How Can It Be Measured, and Why Does It Matter?, *Federal Reserve Bank of Kansas City - Economic Review*, Second Quarter, 5-50.

Hollo, D., M. Kremer and M. Lo Duca (2010), CISS – A "Composite Indicator of Systemic Stress" in the Financial System, ECB, mimeo.

Holmfeldt, M., Rydén, A., Strömberg, L. and M. Strömqvist (2009). How Has the Stress on the Financial Markets Developed? – An Index-based Discussion, *Riksbank Economic Commentaries* 13, http://www.riksbank.com/upload/Dokument_riksbank/Kat_publicerat/Ekonomiska%20kommentarer/2009/ek_kom_no13_09eng.pdf

Illing, M. and Liu, Y. (2006). Measuring Financial Stress in a Developed Country: An Application to Canada, *Journal of Financial Stability* 2, 3, 243–65.

Kindleberger, C. and R. Aliber (2005). *Manias, Panics, and Crashes: A History of Financial Crises,* 5th ed., John Wiley & Sons

Lam, L., Fung, L. and I. Yu (2008). Comparing Forecasting Performance of Exchange Rate Models, *Hong Kong Monetary Authority Working Paper* 08.

Lestano, L., Jacobs, J. and G. Kuper (2003). Indicators of Financial Crises Do Work! An Early Warning System for Six Asian Countries, *CCSO Working Papers* 2003-13.

McCracken, M.W. (2007). Asymptotics for out of sample tests of Granger causality, *Journal of Econometrics*, 140(2), 719-752.

Misina, M. and G. Tkacz (2009). Credit, Asset Prices, and Financial Stress, *International Journal of Central Banking* 5, 4, 95-122.

Rose, A.K. and M. Spiegel (2009). Cross-Country Causes and Consequences of the 2008 Crisis: International Linkages and American Exposure, *NBER Working Papers*, No. 15358

Rose, A.K. and M. Spiegel (2010). Cross-Country Causes and Consequences of the Crisis: An Update, *CEPR Discussion Paper* No. 7901.

Yiu, M. S., W.-Y. A. Ho and L. Jin (2010), A Measure of Financial Stress in Hong Kong Financial Market – The Financial Stress Index, Hong Kong Monetary Authority Research Note 02/2010, March 2010.

Table 1. Financial stress indexes: a comparison

Variable:	Hakkio and Keeton (2009)	Illing and Liu (2006)	Cardarelli et al. (2009)	Holmfeldt et al. (2009)
TED spread	√		√	√
2 year swap spread	√			
Off-the-run/on-the-run Treasury spread	√			
AAA/10 year Treasury spread	√			
Baa/AAA spread	√			
High yield bond/Baa spread	√			
Consumer ABS/5 year Treasury spread	√			
Slope of the yield curve		√	√	
Corporate bond spread		√	√	√
Commercial paper/T-bill spread		√		
Bid-ask spread on 90-day Government of Canada Treasury bills		√		
Covered interest differential with US		√		
Stock market returns			√	
Volatility stock prices/return	√	√	√	
Correlation between stock and Treasury returns	√			
Volatility of bank stock prices	√			√
Dispersion bank stock returns	√			
Rolling beta banking sector		√	√	
Exchange rate volatility		√	√	

Indicators in italics are included in our FSI.

Table 2. Correlation of different stress indexes and our FSI

Country:	Cardarelli et al. (2009)	Holmfeldt et al. (2009)	Hakkio and Keaton (2009)
Australia	0.897	0.833	--
Austria	0.883	0.842	--
Belgium	0.899	0.881	--
Canada	0.906	0.824	--
Denmark	0.894	0.861	--
Finland	0.829	0.808	--
France	0.905	0.898	--
Germany	0.902	0.870	--
Italy	0.889	0.793	--
Japan	0.839	0.792	--
Netherlands	0.912	0.874	--
Norway	0.867	0.807	--
Spain	0.836	0.773	--
Sweden	0.876	0.848	--
Switzerland	0.906	0.824	--
United Kingdom	0.895	0.872	--
United States	0.911	0.891	0.871

Table 3. Variables tested for leading indicator properties

Variable	Sign	Notation	Intuition
Current account			
Real exchange rate	+	RER	Low exports, high imports and overvaluation of the currency lead to external weaknesses and deteriorations in the current account. If the deterioration is big enough to raise the ratio of current account to GDP, capital inflows could facilitate asset price booms and credit booms and subsequent stress on the capital market and banking sector when the bubbles burst. The external weaknesses can alter the competitiveness and subsequently lead to recession which provokes stress in the banking sector and on the capital markets because businesses and consumers going bankrupt and cut spending so that loans become non-performing.
Import growth	+	IMP	
Export growth	-	EXP	
Terms of trade	+	TOT	
Current account/GDP	+	CUA	
Capital account			
Foreign exchange reserves growth.	-	FEX	Declining reserves could indicate currency problems and thereby lead to stress as described above. If the capital inflow surpassing underlying current account deficits, domestic credit expansion can lead to a boom and current account deficits widens. The bubble can burst followed by a sudden reversal of the capital flow that drains reserves and leads to credit contraction. The composition of the capital inflow is another important factor. If it is dominated by short term loans there is a maturity and currency mismatch that can lead to banking and currency stress. And there is less risk of sudden withdrawals when the money is invested by FDI over portfolio investment.
Foreign direct investments/Portfolio investments	+	FDI	
Financial sector			
M1 and M2 growth	+	M1 and M2	Rapid growth in credit caused by monetary expansion could be associated with higher risk taking by lenders. If borrowers find it more difficult to service the debt the stress in the banking sector will increase due to an increase in non-performing loans. Contractions in bank deposits and sudden changes in the domestic interest rates could lead to problems in the banking sector and the capital market by affecting profits and the trust in the financial system. Big lending deposit rate spreads can signal loosing willingness that banks lend to each other or a decline in the loan quality. Loose monetary policy could lead to currency crises as well, see above for more information.
M2 money multiplier	+	M2M	
Domestic total credit	+	TCR	
Domestic business credit	+	BCR	
Domestic household credit	+	HCR	
Domestic housing credit	+	MCR	
Domestic interest rate	+	DIR	
Lending and deposit rate spread	+	L/DR	
Commercial bank deposits	-	CDP	
Ratio bank reserves to bank assets	-	BR/BA	
Real and public sector			
GDP growth	-	GDP	GDP reflects the general condition of an economy. If GDP goes down this signals weak economic performance and borrowers find it more difficult to service the loans, which leads to pressure on banks. Deteriorating performance of the bank can lead to a decline in the trust in the financial system. The inflation rate can affect the real interest rate, which affects the interest risk of banks, and can be important for the allocation between borrowers and lenders. Overinvestment can lead to losses that can affect banks, while savings can make the financial system more robust.
Inflation core	+	INFcor	
Inflation total	+	INFtot	
Investment/GDP	-	INV	
Savings/GDP	-	SAV	
Asset prices			
Residential real estate prices	+	RRE	A rise in asset prices can increase consumption due to the wealth effect. This increases economic growth. If asset prices suddenly drop the balance sheets of households and firms will shrink which leads to more non-performing loans and a weaker economic growth with accompanying consequences described above. If the loans are collateralised a decline in asset prices leaves lenders with more risk. The fall in stock prices increases stress in the system by a fall in profits from assets that investors hold and by a reduction in commission and fees.
Commercial real estate	+	CRE	
Stock prices	+	SPR	
Foreign sector			
Oil prices	+	OPR	The financial system and economy is internationally very connected. The domestic stress will be influenced by international events. The business
World gold price	+	GPR	

MSCI	+	MSCI	cycle will be influenced by the business cycles of other countries. The stress will be influenced by asset, credit and interest developments in foreign countries by affecting the capital flows.

The table indicates the sign of the relation between the explanatory variables and financial stress and gives the intuition about the relation.

Table 4. Estimates of Equation (2)

	Australia				Belgium				Canada				Denmark				Finland				France				Germany			
	Lag	t-statistic	p-value		Lag	t-statistic	p-value		Lag	t-statistic	p-value		Lag	t-statistic	p-value		Lag	t-statistic	p-value		Lag	t-statistic	p-value		Lag	t-statistic	p-value	
Real effective exchange rate	1	-0,834	0,407		3	1,049	0,305		1	0,226	0,822		1	-1,228	0,230		1	0,282	0,780		1	-0,972	0,341		1	-1,225	0,233	
Export	1	3,319	0,001	***	1	0,797	0,433		1	1,398	0,166		1	-0,089	0,929		1	0,084	0,934		1	0,924	0,365		1	-0,753	0,459	
Import	1	2,247	0,028	**	1	1,336	0,193		1	1,426	0,158		1	-0,095	0,925		1	-0,548	0,589		1	1,297	0,208		1	0,870	0,393	
Terms of trade		-	-		1	2,470	0,021	**	1	0,881	0,381		1	1,022	0,316			-	-			-	-			-	-	
Current account	1	-0,406	0,686		4	-1,637	0,116		1	-0,083	0,934		1	0,152	0,880		1	0,760	0,455		1	-0,952	0,351		1	-0,575	0,571	
Foreign exchange	1	-1,347	0,182		4	2,048	0,053	*	1	-1,947	0,055	*	1	-0,518	0,608		1	0,089	0,930		1	1,846	0,078	*	1	-1,164	0,256	
Foreign direct investment / portfolio investment	1	-1,627	0,108			-	-			-	-			-	-		1	1,591	0,125			-	-			-	-	
M1	1	0,121	0,904			-	-		1	0,909	0,366		1	-1,453	0,158			-	-			-	-			-	-	
M2	1	2,874	0,005	***		-	-		1	1,037	0,303		1	-0,464	0,646			-	-			-	-			-	-	
M2 multiplier	1	-2,429	0,018	**		-	-			-	-		1	-1,086	0,287			-	-			-	-			-	-	
Total credit	1	1,072	0,287		4	1,678	0,108			-	-		1	-0,953	0,349		1	-0,162	0,873		1	1,562	0,132		1	1,839	0,079	*
Business credit	1	2,105	0,039	**	3	3,034	0,007	***	1	0,348	0,729		1	0,059	0,953		1	1,409	0,173		1	1,321	0,200		3	6,412	0,000	***
Household credit	1	-1,374	0,174		4	-0,547	0,590		1	-1,161	0,249		1	-0,669	0,509		1	-1,372	0,184		1	0,821	0,420		1	0,300	0,767	
Housing credit	1	-0,501	0,618		1	-3,633	0,001	***	1	-0,533	0,596		1	-0,156	0,878		1	-2,271	0,033	**	1	1,249	0,225		1	-0,051	0,960	
Domestic interest rate	1	0,969	0,335			-	-		1	1,511	0,135			-	-			-	-			-	-			-	-	
Lending/deposit rate spread	1	-0,280	0,780			-	-		1	1,899	0,061	*		-	-			-	-			-	-			-	-	
Commercial deposits	1	2,824	0,006	***	1	-0,819	0,421			-	-		1	-0,580	0,567		1	0,534	0,598		1	0,191	0,850		1	1,439	0,164	
Bank reserves / bank assets	1	1,745	0,085	*	1	2,472	0,021	**		-	-		1	2,060	0,049	**	1	1,150	0,262		1	0,633	0,533		1	2,417	0,024	**
GDP	1	2,700	0,009	***	3	1,773	0,089	*	1	1,315	0,193		1	0,804	0,428		1	-0,516	0,611		1	2,087	0,048	**	1	-0,244	0,810	
Inflation (total)	1	2,227	0,029	**	3	3,335	0,003	***	1	1,230	0,223		1	0,203	0,841		1	1,439	0,164		1	-0,556	0,584		1	1,149	0,263	
Inflation (core)	1	1,644	0,104		1	0,605	0,551		1	-0,058	0,954		1	-0,563	0,578		1	1,418	0,170		1	-1,578	0,128		1	2,048	0,052	*
Investment % GDP	1	0,712	0,479		1	-0,551	0,587		1	0,872	0,386		1	-1,293	0,207		1	-1,818	0,082	*	1	0,134	0,895		1	1,232	0,230	
Savings % GDP	1	1,102	0,274			-	-		1	-1,095	0,277			-	-			-	-			-1,834	0,080	*	1	-0,174	0,863	
Stock Price	1	-1,991	0,050	*	1	-2,579	0,016	**	1	-0,901	0,371		1	-2,057	0,049	**	1	-1,133	0,269		1	-0,622	0,540		1	-1,532	0,139	
Residential real estate	1	-0,670	0,505		1	0,551	0,587		1	-1,401	0,166		1	-2,174	0,039	**	1	0,328	0,746		1	-0,622	0,540		1	2,708	0,013	**
Commercial real state		-	-			-	-			-	-			-	-			-	-			-	-		1	2,268	0,033	**
Oil price	1	2,759	0,007	***	3	2,220	0,037	**	1	1,555	0,124		1	-0,083	0,935		1	-1,118	0,275		1	0,128	0,899		1	-0,166	0,870	
MSCI	1	-0,901	0,370		1	-1,662	0,109		1	-1,477	0,144		1	-2,522	0,018	**	1	-1,435	0,165		1	-0,532	0,600		1	-2,597	0,016	**
Gold price	1	-0,595	0,554		4	2,486	0,021	**	1	0,176	0,861		1	-0,958	0,347		1	0,007	0,995		1	0,531	0,600		1	-0,433	0,669	

* significant at 10%; ** significant at 5%; *** significant at 1%

	Italy				Netherlands				Spain				Sweden				UK				USA				Number of times
	Lag	t-statistic	p-value		Lag	t-statistic	p-value		Lag	t-statistic	p-value		Lag	t-statistic	p-value		Lag	t-statistic	p-value		Lag	t-statistic	p-value		significant
Real effective exchange rate	1	-0,186	0,854		1	-1,075	0,294		1	-1,023	0,317		1	1,365	0,183		1	0,060	0,952		1	0,509	0,612		0
Export	1	0,212	0,834		1	2,433	0,023	**	1	-0,365	0,719		1	0,266	0,792		1	0,893	0,378		1	0,713	0,477		2
Import	1	0,531	0,600		1	2,874	0,009	***	1	-1,541	0,137		1	0,237	0,814		1	0,632	0,531		1	1,582	0,117		2
Terms of trade	1	-1,637	0,115			-	-			-	-			-	-			-	-			-	-		1
Current account	1	-0,641	0,528		1	0,082	0,935		1	-2,360	0,027	**	1	-0,781	0,441		1	-0,842	0,405		1	1,622	0,108		1
Foreign exchange	1	0,540	0,594		1	1,245	0,226		1	2,154	0,042	**	1	1,912	0,066	*	1	-0,371	0,713		1	2,065	0,042	**	6
Foreign direct investment / portfolio investment		-	-			-	-		1	1,086	0,289			-	-		1	1,183	0,244			-	-		0
M1		-	-			-	-			-	-		1	0,008	0,994			-	-		1	2,563	0,012	**	1
M2		-	-			-	-			-	-		1	1,088	0,286			-	-		1	1,236	0,220		1
M2 multiplier		-	-			-	-			-	-		1	-0,820	0,419			-	-			-	-		1
Total credit	1	-1,698	0,103		1	1,135	0,268		1	-0,984	0,336		1	-0,766	0,450		1	3,823	0,000	***	1	-0,815	0,417		2
Business credit	1	-0,894	0,381		3	6,421	0,000	***	1	-1,421	0,169		1	1,311	0,200		1	0,105	0,917		1	-0,184	0,854		4
Household credit	2	-3,102	0,005	***	1	0,784	0,442		1	-2,461	0,022	**	1	1,550	0,132		1	-0,897	0,375		1	0,600	0,550		3
Housing credit	2	-3,715	0,001	***	1	0,878	0,389		1	-2,333	0,029	**	1	1,091	0,285		1	-1,128	0,267		1	-1,254	0,213		4
Domestic interest rate		-	-			-	-			-	-			-	-			-	-		1	2,498	0,014	**	1
Lending/deposit rate spread		-	-			-	-			-	-			-	-			-	-		1	4,041	0,000	***	2
Commercial deposits	1	-2,231	0,036	**	1	-0,667	0,511		1	-1,019	0,319		1	0,561	0,580		1	1,914	0,063	*		-	-		3
Bank reserves / bank assets	1	-0,591	0,560		1	1,081	0,291		1	0,916	0,369		1	-0,274	0,786		1	2,121	0,041	**		-	-		5
GDP	1	-0,578	0,569		1	2,053	0,052	*	2	-6,494	0,000	***	1	-0,838	0,409		1	-0,036	0,972		1	-0,197	0,845		5
Inflation (total)	2	3,298	0,003	***	1	0,097	0,923		1	-0,612	0,546		1	1,199	0,240		1	1,410	0,167		1	1,512	0,134		3
Inflation (core)	1	2,219	0,037	**	1	0,353	0,727		1	-0,303	0,765		1	1,517	0,140		1	0,904	0,371		1	1,367	0,175		2
Investment % GDP	1	-0,728	0,474		1	-0,154	0,879		3	-6,013	0,000	***	1	1,139	0,264		1	-0,602	0,551		1	1,498	0,138		2
Savings % GDP		-	-			-	-			-	-		1	0,259	0,797			-	-		1	1,818	0,072	*	2
Stock Price	1	-3,429	0,002	***	1	-2,008	0,057	*	1	-4,520	0,000	***	1	-0,762	0,452		1	-3,463	0,001	***	1	-1,108	0,271		7
Residential real estate		-	-		1	0,686	0,500		1	-4,245	0,000	***	1	1,718	0,096	*	1	-0,681	0,500		1	-2,055	0,043	**	5
Commercial real state		-	-			-	-			-	-			-	-			-	-			-	-		1
Oil price	1	-0,115	0,909		2	4,238	0,000	***	1	-1,370	0,184		1	1,187	0,245		1	-0,254	0,801		1	1,805	0,074	*	4
MSCI	1	-2,590	0,016	**	1	-1,953	0,063	*	1	-3,893	0,001	***	1	0,294	0,771		1	-2,577	0,014	**	1	-2,311	0,023	**	7
Gold price	1	-0,561	0,580		1	-1,276	0,215		1	0,113	0,911		1	-0,421	0,677		1	-0,152	0,880		1	-0,009	0,993		1

For each country: the first column shows the optimal lag, the second and third the t-statistic and p-values and the last one indicates wheter the statistic is significant at: * 10%; ** significant at 5% or *** significant at 1%

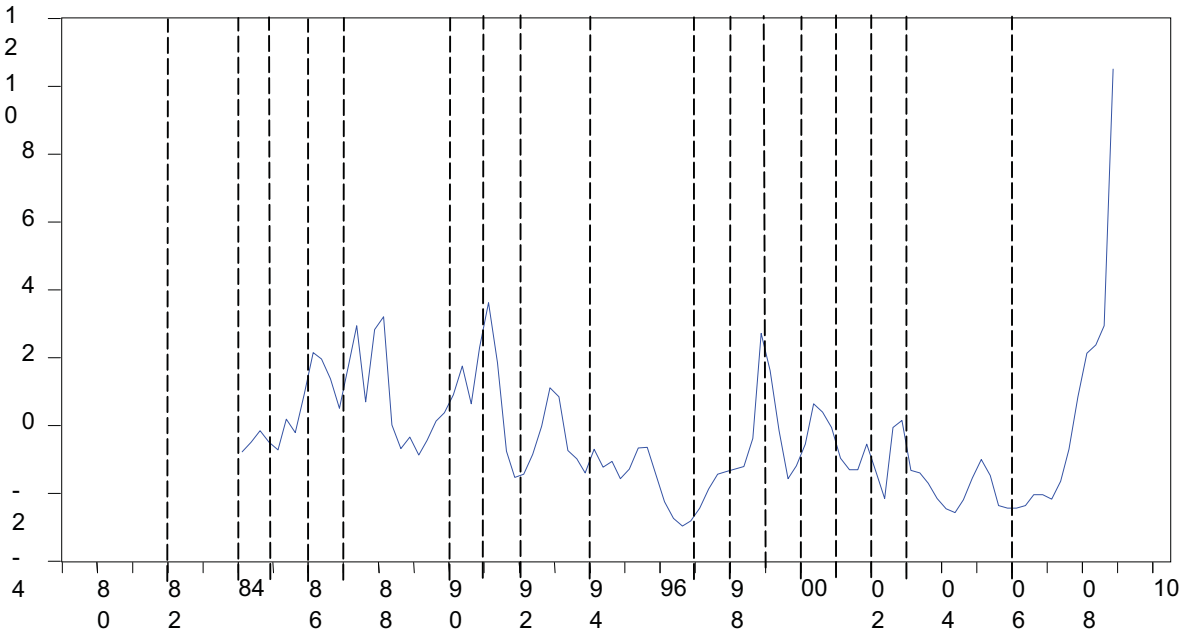
Table 5. Out of sample forecasting properties

Variables	Australia			Belgium			Canada			Denmark			Finland		
	L1.	L2.	L4.	L1.	L2.	L4.	L1.	L2.	L4.	L1.	L2.	L4.	L1.	L2.	L4.
Real effective exchange rate	1.033	1.012	0.991 **	1.179	1.052	1.019	1.074	1.002	1.014	1.042	1.047	0.990	1.015	1.010	1.014 **
Export	0.935 ***	0.966 ***	1.007	1.044	0.978 *	1.020	1.012	1.014	1.016	1.026	1.006	0.995	1.054	1.014	1.007 **
Import	0.980 ***	0.984 **	1.023	1.095	0.897 ***	1.010	1.009	1.003	1.010	1.020	1.006	1.016	1.025	1.040	1.031
Terms of trade	-	-	-	0.934 ***	1.050	1.183	1.016	1.004	0.995 *	0.978 **	0.950 ***	1.009	-	-	-
Current account	1.008	1.005	1.004	1.062	1.039	1.464	1.001	0.998	1.002	1.013	1.003	1.039	1.008	1.022	1.014
Foreign exchange	1.006	1.009	1.037	0.963 **	0.984 *	0.933 ***	0.995 *	1.000	1.009	1.024	0.914 ***	1.021	1.012	1.062	1.053
Foreign direct investment / portfolio investment	0.984 ***	1.011	1.005	-	-	-	-	-	-	-	-	-	0.980 ***	1.014	0.925 ***
M1	1.002	1.005	0.997	-	-	-	1.000	1.012	0.990 **	0.976 **	0.890 ***	0.996	-	-	-
M2	0.949 ***	0.976 ***	0.960 ***	-	-	-	1.012	1.016	1.007	1.008	0.916 ***	1.006	-	-	-
M2 multiplier	1.028	0.995 *	1.008	-	-	-	-	-	-	0.984 *	0.940 ***	0.999	-	-	-
Total credit	1.015	1.044	0.996	1.170	1.112	0.987 *	-	-	-	1.004	1.020	1.003	1.014	1.018	1.017
Business credit	0.986 ***	1.010	0.936 ***	1.160	1.021	0.934 ***	1.006	1.002	1.000	1.042	1.063	0.981 *	0.986 ***	1.019	0.956 ***
Household credit	1.007	1.017	1.050	1.070	1.022	0.930 ***	1.007	1.009	0.997	1.064	1.069	1.027	0.985 ***	1.054	1.031 *
Housing credit	1.007	0.997	0.982 ***	0.898 ***	1.010	0.981 *	1.009	1.005	1.003	1.055	1.083	1.006	0.932 ***	1.006	1.010 ***
Domestic interest rate	1.022	1.058	1.056	-	-	-	0.988 **	1.002	0.999	-	-	-	-	-	-
Lending/deposit rate spread	1.005	1.025	1.037	-	-	-	0.992 **	1.001	1.000	-	-	-	-	-	-
Commercial deposits	0.951 ***	0.973 ***	0.958 ***	0.994	1.012	1.008	-	-	-	1.002	0.952 **	1.009	1.005	1.004	0.979
Bank reserves / bank assets	1.006	1.014	1.017	0.922 ***	1.045	1.036	-	-	-	0.911 ***	1.090	1.068	1.081	1.052	1.043
GDP	0.954 ***	0.962 ***	0.996 *	1.075	0.867 ***	1.005	1.017	0.967 ***	0.994 *	1.000	1.022	1.025	1.018	1.023	1.024
Inflation (total)	0.960 ***	0.944 ***	0.995 *	0.971 **	0.820 ***	0.997	0.990 **	0.959 ***	1.005	1.024	0.997	0.947 ***	1.078	0.971 ***	0.940 ***
Inflation (core)	0.978 ***	0.975 ***	0.996	0.997	1.022	1.008	1.004	0.996	0.999	1.030	1.021	1.000	1.023	0.954 ***	0.966 ***
Investment % GDP	1.004	1.004	1.023	1.033	1.009	0.998	1.000	1.007	1.001	0.978 **	0.997	0.992	1.002	0.990 **	0.976
Savings % GDP	1.035	1.010	1.019	-	-	-	1.015	1.004	1.029	-	-	-	-	-	-
Stock Price	1.015	1.027	1.015	0.916 ***	1.015	1.011	1.046	0.972 ***	0.989 **	0.948 ***	1.025	1.003	1.060	1.054	0.975
Residential real estate	1.017	1.017	0.994 *	0.999	1.001	1.016	0.999	1.012	1.004	0.935 ***	0.984 *	0.918 ***	1.019	1.007	1.014
Commercial real estate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oil price	0.948 ***	0.830 ***	0.981 ***	1.010	0.797 ***	1.012	0.979 ***	0.943 ***	1.004	1.023	0.855 ***	0.940 ***	1.016	1.067	1.019
MSCI	1.036	1.051	1.021	1.009	1.004	1.018	1.022	1.015	1.005	0.917 ***	1.027	1.012	1.044	1.071	1.010
Gold price	1.006	0.997	0.985 **	0.994	1.009	0.916 ***	1.013	0.997	1.011	0.997	1.019	0.979 *	1.035	1.025	0.985 ***
Total number of significant variables per country and lag (using OOS-F statistic)	10	9	10	6	6	6	5	4	4	8	8	5	4	3	9

Variables	France			Germany			Italy			Netherlands			Spain		
	L1.	L2.	L4.	L1.	L2.	L4.	L1.	L2.	L4.	L1.	L2.	L4.	L1.	L2.	L4.
Real effective exchange rate	1.001	1.041	1.016	1.024	1.021	0.988	1.016	1.045	1.000	1.064	1.012	1.004	1.043	1.045	1.005
Export	1.004	1.015	1.000	1.032	1.016	1.069	1.027	0.986 *	0.974 **	0.902 ***	0.945 **	0.920 ***	1.288	1.045	1.177
Import	1.000	1.031	1.009	1.008	1.013	1.039	1.001	0.995	1.003	0.866 ***	0.906 ***	0.944 ***	0.985 **	0.916 ***	1.080
Terms of trade	-	-	-	-	-	-	0.973 **	0.914 ***	1.014	-	-	-	-	-	-
Current account	0.978 ***	0.973 ***	0.964 **	0.995	1.000	1.002	1.037	0.935 ***	0.872 ***	1.007	1.016	1.012	0.919 ***	0.951 ***	1.021
Foreign exchange	0.968 ***	0.938 ***	0.883 ***	1.102	1.073	0.887 ***	1.017	0.993	1.020	0.975 *	1.029	1.026	0.918 ***	0.965 **	1.011
Foreign direct investment / portfolio investment	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M2 multiplier	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total credit	1.009	1.018	0.929 ***	0.952 ***	0.914 ***	0.799 ***	1.061	1.037	1.052	0.983 *	0.951 **	1.000	0.990 *	0.946 ***	0.952 ***
Business credit	0.923	0.924 ***	0.946 ***	0.898 ***	0.865 ***	0.624 ***	1.035	1.071	0.949 **	1.032	0.804 ***	0.666 ***	1.086	0.936 ***	0.923 ***
Household credit	0.942	0.956 ***	0.982 *	1.086	1.006	0.858 ***	1.025	0.840 ***	0.925 ***	1.054	1.026	0.959 **	0.981 **	0.872 ***	0.816 ***
Housing credit	0.921	0.949 ***	0.979 **	1.066	0.983 *	0.874 ***	1.036	0.787 ***	0.885 ***	1.055	1.034	0.994	0.980 **	0.842 ***	0.794 ***
Domestic interest rate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lending/deposit rate spread	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Commercial deposits	1.020	1.019	1.022	1.014	1.002	0.995	0.932 ***	1.081	1.084	1.018	1.025	1.005	0.999	1.008	1.020
Bank reserves / bank assets	1.064	1.009	1.039	0.972 **	1.046	1.105	1.108	1.091	0.992	1.051	0.911 ***	1.086	1.067	1.036	1.127
GDP	1.063	0.994 *	0.941 ***	1.076	1.027	0.966 **	1.036	1.023	0.997	1.002	1.015	0.873 ***	0.785 ***	0.558 ***	0.681 ***
Inflation (total)	1.059	1.156	1.069	1.010	0.939 ***	0.850 ***	1.039	0.810 ***	1.098	1.015	1.005	1.012	1.011	1.024	1.020
Inflation (core)	1.003	1.032	1.027	0.958 **	0.933 ***	0.970 **	0.946 ***	0.799 ***	1.060	1.046	0.960 **	1.020	1.025	1.016	1.022
Investment % GDP	1.046	0.986 **	0.993	0.982 *	1.016	1.028	1.001	1.034	1.007	1.046	1.010	1.008	1.122	0.846 ***	0.624 ***
Savings % GDP	0.954	1.026	1.021	1.026	1.014	0.996	-	-	-	-	-	-	-	-	-
Stock Price	1.056	1.021	1.016	0.977 *	1.021	1.014	0.889 ***	1.012	1.052	0.976 *	1.016	1.008	0.665 ***	0.744 ***	1.065
Residential real estate	1.056	1.021	1.016	0.878 ***	0.792 ***	0.783 ***	-	-	-	1.007	1.002	1.031	0.761 ***	0.794 ***	0.860 ***
Commercial real estate	-	-	-	0.906 ***	0.835 ***	0.784 ***	-	-	-	-	-	-	-	-	-
Oil price	1.049	1.134	1.029	1.040	1.052	0.971 **	1.076	0.962 **	1.032	1.013	0.772 ***	0.961 **	0.987 *	1.150	0.994
MSCI	1.024	0.977 ***	1.022	1.012	1.039	1.023	1.017	1.132	1.095	0.990	1.023	0.998	0.686 ***	0.821 ***	1.060
Gold price	1.046	1.025	1.020	1.047	1.044	1.013	1.055	1.015	1.003	0.988	1.011	0.973 *	1.077	0.972 **	1.000
Total number of significant variables per country and lag (using OOS-F statistic)	2	8	7	8	7	11	4	8	5	5	7	7	11	13	7

Variables	Sweden			UK			USA			Total number of times a variable is significant across countries and lags		
	L1.	L2.	L4.	L1.	L2.	L4.	L1.	L2.	L4.	L1.	L2.	L4.
Real effective exchange rate	1.153	1.024	1.032	1.028	1.021	1.012	1.016	1.017	1.003	0	0	1
Export	1.042	1.003	0.985 *	0.994	0.976 **	1.005	1.011	1.012	1.002	2	5	5
Import	1.048	1.010	0.994	1.009	0.983 **	0.997	1.001	0.985 **	1.003	3	6	2
Terms of trade	-	-	-	-	-	-	-	-	-	3	2	1
Current account	1.002	1.006	0.994	1.037	1.071	1.028	0.993 **	0.992 **	0.994 *	3	4	3
Foreign exchange	1.087	1.033	1.076	1.024	0.997	0.997	0.999	1.012	0.993 *	5	4	4
Foreign direct investment / portfolio investment	-	-	-	0.997	0.992	0.999	-	-	-	2	0	2
M1	1.028	1.033	1.029	-	-	-	0.963 ***	1.020	1.010	2	1	1
M2	1.043	1.077	1.029	-	-	-	0.994 **	1.020	0.996 *	2	2	2
M2 multiplier	1.379	1.466	1.035	-	-	-	-	-	-	1	2	0
Total credit	1.027	1.039	0.923 ***	0.853 ***	1.061	0.987 *	1.049	1.021	0.989 **	4	3	7
Business credit	1.049	0.895 ***	0.942 ***	0.992 *	0.997	0.998	1.031	1.019	1.007	4	5	10
Household credit	1.171	1.026	1.053	0.977 **	0.997	0.971 **	1.023	1.047	1.010	3	3	8
Housing credit	1.074	1.012	1.039	0.970 **	0.995	0.971 **	1.001	0.989 **	0.979 ***	4	5	8
Domestic interest rate	-	-	-	-	-	-	0.965 ***	1.007	0.988 **	2	0	1
Lending/deposit rate spread	-	-	-	-	-	-	0.903 ***	0.998	1.021	2	0	0
Commercial deposits	1.036	1.048	1.040	0.953 ***	1.014	0.959 ***	-	-	-	3	2	2
Bank reserves / bank assets	1.085	1.671	1.425	1.017	0.933 ***	1.002	-	-	-	3	2	0
GDP	1.016	1.009	1.030	1.076	1.008	1.020	1.018	1.015	1.014	2	5	6
Inflation (total)	1.046	0.975 **	1.055	0.984 **	0.949 ***	0.987 *	1.032	1.033	1.046	4	8	5
Inflation (core)	1.011	0.859 ***	1.030	0.995	0.998	1.008	1.038	1.047	1.065	3	6	3
Investment % GDP	1.011	1.029	0.977 **	1.002	1.015	1.020	0.989 **	0.997	0.978 ***	3	3	3
Savings % GDP	1.015	1.006	0.970 **	-	-	-	1.028	1.012	1.038	0	0	1
Stock Price	1.018	1.033	1.018	0.877 ***	1.016	1.018	0.997	1.020	1.018	7	2	1
Residential real estate	0.963 ***	0.959 **	1.045	1.017	1.015	1.001	0.983 ***	1.009	0.983 ***	5	4	4
Commercial real estate	-	-	-	-	-	-	-	-	-	1	1	1
Oil price	0.992	0.785 ***	1.007	1.013	0.959 ***	0.978 **	1.022	0.966 ***	0.994 *	3	9	6
MSCI	1.058	0.982 *	1.021	0.925 ***	1.031	1.023	0.982 ***	1.017	1.024	4	3	0
Gold price	1.017	1.015	0.970 **	1.021	1.014	0.946 ***	1.008	1.005	0.995 *	0	1	7
Total number of significant variables per country and lag (using OOS-F statistic)	1	6	6	8	5	7	8	4	10			

Figure 1. Aggregate financial stress index and financial crises



In this graph the y-axis represents the value of the financial stress index, while the x-axis represents time. Vertical lines indicate crises dates as identified by Cardarelli et al. (2009).

Appendix

Table A1. Details about the source and the use of the explanatory variables

	Australia	Belgium	Canada	Denmark	Finland	France	Germany	Italy	Netherlands	Spain	Sweden	United Kingdom	United States
Current Account													
Real effective exchange rate change	U (1)	U (1)	U (1)	U (1)	U (1)	U (1)	U (1)	U (1)	U (1)	U	U (1)	U (1)	U (1)
Import growth	U (2)	U (2)	U (2)	U (2)	U (2)	U (2)	U (2)	U (2)	U (2)	U (5)	U (2)	U (2)	U (2)
Export growth	U (2)	U (2)	U (2)	U (2)	U (2)	U (2)	U (2)	U (2)	U (2)	U (5)	U (2)	U (2)	U (2)
Terms of trade change	N (-)	U (3)	U (3)	U (3)	N (-)	N (-)	N (-)	U (3)	N (-)	N (-)	N (-)	N (-)	N (-)
Current account / Gdp change	U (2)	U (2)	U (2)	U (2)	U (2)	U (2)	U (2)	U (2)	U (2)	U (5)	U (2)	U (2)	U (2)
Capital Account													
Foreign exchange reserve growth	U (3)	U (3)	U (3)	U (3)	U (3)	U (3)	U (3)	U (3)	U (3)	U (1)	U (3)	U (3)	U (3)
Foreign direct investment/portfolio investment	U (3)	N (-)	N (-)	N (-)	U (3)	N (-)	N (-)	N (-)	N (-)	U (3)	N (-)	U (3)	N (-)
Financial sector													
M1 growth	U (3)	N (-)	U (3)	U (3)	N (-)	N (-)	N (-)	N (-)	N (-)	N (-)	U (3)	N (-)	U (3)
M2 growth	U (3)	N (-)	U (3)	U (3)	N (-)	N (-)	N (-)	N (-)	N (-)	N (-)	U (3)	N (-)	U (3)
M2 Multiplier	U (3)	N (-)	N (-)	U (3)	N (-)	N (-)	N (-)	N (-)	N (-)	N (-)	U (3)	N (-)	N (-)
Total credit growth	U (4)	U (4)	N (-)	U (4)	U (4)	U (4)	U (4)	U (4)	U (4)	U (4)	U (4)	U (4)	U (4)
Business credit growth	U (4)	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*
Household credit growth	U (4)	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*
House credit growth	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*	U (4)*
Domestic interest rate	U (3)	N (-)	U (3)	N (-)	N (-)	N (-)	N (-)	N (-)	N (-)	N (-)	N (-)	N (-)	U (3)
Lending and deposit rate spread	U (3)	N (-)	U (3)	N (-)	N (-)	N (-)	N (-)	N (-)	N (-)	N (-)	N (-)	N (-)	U (3)
Commercial bank deposits	U (3)	U (3)	N (-)	U (3)	U (3)	U (3)	U (3)	U (3)	U (3)	U (3)	U (3)	U (3)	N (-)
Bank reserves / bank assets	U (3)	U (3)	N (-)	U (3)	U (3)	U (3)	U (3)	U (3)	U (3)	U (3)	U (3)	U (3)	N (-)
Real sector													
GDP growth	U	U	U	U	U	U	U	U	U	U	U	U	U
Inflation core	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)
Inflation total	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)
Investment / GDP	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)	U (5)
Savings / GDP	U (5)	N (-)	U (5)	N (-)	N (-)	U (5)	U (5)	N (-)	N (-)	N (-)	U (5)	N (-)	U (5)
Asset prices													
Residential real estate	U (1)	U (1)	U (1)	U (1)	U (1)	U (1)	U (1)	N (-)	U (1)	U (1)	U (1)	U (1)	U (1)
Stock prices	U (3)	U (5)	U (3)	U (5)	U (5)	U (3)	U (3)	U (3)	U (3)	U (5)	U (3)	U (5)	U (3)
Commercial real estate	N (-)	N (-)	N (-)	N (-)	N (-)	N (-)	U (3)	N (-)	N (-)	N (-)	N (-)	N (-)	N (-)
	1990q1	2002q2	1990q1	2001q4	2002q4	2002q4	2002q4	2002q4	2002q4	2002q4	2001q4	1999q1	1985q2

U = used as forecasting variable for that specific country
N = not used as forecasting variable for that specific country
(1) = Source: Bank for International settlements
(2) = Source: Organisation for Economic Co-operation and Development
(3) = Source: The International Financial Statistics database
(4) = Source: National Central Bank of that specific country
(5) = Source: Dutch Central Bank
* = time series that determines the sample size

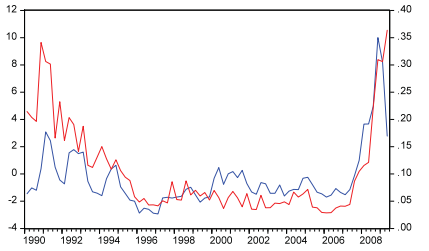
Table A2. Direction of Change statistics

Variables	Australia			Belgium			Canada			Denmark			Finland				France				Germany		
	L1.	L2.	L4.	L1.	L2.	L4.	L1.	L2.	L4.	L1.	L2.	L4.	L1.	L2.	L4.		L1.		L2.	L4.	L1.	L2.	L4.
Real effective exchange rate	0.941	1.030	1.000	1.154	1.000	1.000	1.030	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	**	1.000		1.000	1.000	1.000	1.000	0.889
Export	0.914	0.971	1.000	1.000	1.077	1.250	0.971	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	**	1.000		1.000	1.000	1.000	1.100	1.000
Import	0.970	1.000	1.033	1.071	1.077	1.111	1.000	1.000	1.000	1.067	1.000	1.091	1.000	1.000	1.000		1.000		1.000	1.000	1.000	1.000	1.000
Terms of trade	-	-	-	1.000	1.167	0.909	1.030	1.000	1.000	1.000	1.000	1.000	-	-	-		-		-	-	-	-	-
Current account	0.970	1.000	1.000	1.000	1.273	1.111	1.000	1.000	1.000	1.067	1.000	1.000	1.000	1.000	1.000		1.000	***	1.000	1.000	1.000	1.000	1.000
Foreign exchange	1.000	1.000	1.033	1.000	1.000	0.909	1.000	1.000	1.000	1.000	1.077	1.000	1.000	1.000	1.000		1.000	***	1.000	0.917	1.000	1.000	0.727
Foreign direct investment / portfolio investment	0.970	1.000	1.000	-	-	-	-	-	-	-	-	-	1.000	1.000	1.000	***	-		-	-	-	-	-
M1	1.000	1.000	1.000	-	-	-	1.030	1.000	1.000	1.000	1.000	1.000	-	-	-		-		-	-	-	-	-
M2	0.970	0.971	0.969	-	-	-	1.000	1.000	1.000	1.000	1.000	1.000	-	-	-		-		-	-	-	-	-
M2 multiplier	1.000	1.000	1.000	-	-	-	-	-	-	1.000	1.000	1.000	-	-	-		-		-	-	-	-	-
Total credit	0.941	1.030	1.000	1.154	1.077	1.111	-	-	-	1.000	1.077	1.000	1.000	1.000	1.000		1.000		1.000	1.000	0.929	0.917	0.727
Business credit	0.970	1.000	0.969	1.071	1.077	0.769	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	***	1.000		1.000	1.000	1.000	0.917	0.727
Household credit	0.889	1.000	0.969	1.071	1.273	0.909	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	*	1.000		1.000	1.000	1.083	1.000	0.667
Housing credit	0.970	1.000	0.969	1.071	1.167	1.111	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	***	1.000		1.000	1.000	1.083	1.000	0.615
Domestic interest rate	0.970	1.063	1.069	-	-	-	1.000	1.000	1.000	-	-	-	-	-	-		-		-	-	-	-	-
Lending/deposit rate spread	1.000	1.030	1.033	-	-	-	1.000	1.000	1.000	-	-	-	-	-	-		-		-	-	-	-	-
Commercial deposits	0.970	0.971	0.969	1.000	1.000	1.111	-	-	-	1.000	1.000	1.000	1.000	1.000	1.000		1.000		1.000	1.000	0.929	1.000	0.800
Bank reserves / bank assets	0.970	1.030	1.000	1.000	1.000	1.111	-	-	-	1.067	1.077	1.091	1.000	1.000	1.000		1.000		1.000	1.000	1.000	1.000	1.143
GDP	0.970	1.000	1.000	1.250	1.077	1.000	1.063	1.033	1.000	1.067	1.000	1.000	1.000	1.000	1.000		1.167		1.000	1.000	1.000	1.000	0.889
Inflation (total)	0.970	0.971	0.969	1.000	1.077	1.111	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	***	1.000		1.000	1.000	1.000	0.917	0.800
Inflation (core)	1.000	0.971	0.969	1.000	1.000	0.909	0.971	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	***	1.000		1.000	1.000	1.000	1.000	0.727
Investment % GDP	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000		1.000	1.000	1.000	1.000	0.889
Savings % GDP	1.032	1.063	1.000	-	-	-	1.030	1.000	1.000	-	-	-	-	-	-		1.000		1.000	1.000	1.083	1.000	1.000
Stock Price	0.970	1.030	1.000	1.154	1.167	0.909	1.030	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000		1.000	1.000	1.000	1.000	1.000
Residential real estate	0.941	1.000	0.969	1.000	1.000	1.111	1.000	1.000	1.000	1.000	1.000	0.857	1.000	1.000	1.000		1.000		1.000	1.000	0.929	0.917	0.727
Commercial real estate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-		-	-	1.000	0.917	0.727
Oil price	0.941	1.000	1.000	1.071	1.167	1.111	1.000	1.000	1.000	1.000	1.000	1.000	1.071	1.000	1.000		1.000		1.000	1.000	1.000	0.917	1.000
MSCI	0.970	1.063	1.069	1.071	1.077	1.000	1.097	1.033	1.000	1.000	1.000	1.000	1.071	1.000	1.000		1.000		1.000	1.000	0.929	1.000	1.000
Gold price	0.970	1.000	1.000	1.000	1.167	0.909	1.000	1.000	1.000	1.000	0.933	1.000	1.000	1.000	1.000	***	1.000		1.000	1.000	1.000	1.000	0.889

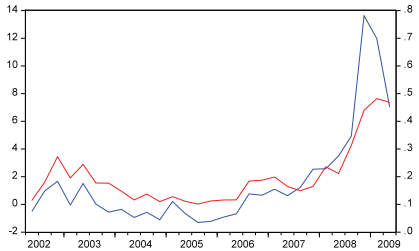
Variables	Italy			Netherlands			Spain			Sweden			UK			USA		
	L1.	L2.	L4.	L1.	L2.	L4.	L1.	L2.	L4.	L1.	L2.	L4.	L1.	L2.	L4.	L1.	L2.	L4.
Real effective exchange rate	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.067	1.000	1.000	0.952	1.000	1.000	1.000	1.028	0.941
Export	1.000	1.000	0.909	1.000	1.000	1.000	1.077	0.923	1.000	1.000	1.000	1.000	0.952	1.000	1.000	1.000	1.057	1.032
Import	1.000	1.000	0.909	1.000	1.000	1.000	1.000	0.923	1.000	1.067	1.000	1.000	0.952	1.000	1.000	1.000	1.000	1.000
Terms of trade	1.000	1.000	1.000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Current account	1.000	1.000	0.833	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.063	1.000	1.028	1.000
Foreign exchange	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.067	1.000	0.929	1.000	1.000	1.000	1.000	1.028	1.032
Foreign direct investment / portfolio investment	-	-	-	-	-	-	-	-	-	-	-	-	0.952	1.000	1.000	-	-	-
M1	-	-	-	-	-	-	-	-	-	1.000	1.000	1.000	-	-	-	1.000	1.028	0.941
M2	-	-	-	-	-	-	-	-	-	1.000	1.000	1.000	-	-	-	1.000	1.088	1.032
M2 multiplier	-	-	-	-	-	-	-	-	-	1.067	1.000	1.000	-	-	-	-	-	-
Total credit	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.143	1.077	1.000	1.000	1.000	1.000	1.000	1.028	1.000
Business credit	1.000	1.000	0.833	0.933	0.929	0.917	1.000	1.000	0.923	1.067	0.933	0.929	0.952	1.000	1.000	1.000	1.028	0.970
Household credit	1.000	1.000	0.833	1.000	1.000	0.917	1.000	1.000	0.923	1.067	0.933	1.000	0.952	1.000	1.000	1.024	1.028	1.000
Housing credit	1.000	0.923	0.833	1.000	1.083	1.000	1.000	1.000	0.923	1.067	0.933	1.000	0.952	1.000	1.000	1.000	1.028	0.970
Domestic interest rate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.977	1.000	1.000
Lending/deposit rate spread	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.977	1.000	0.941
Commercial deposits	0.923	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.952	1.000	1.000	-	-	-
Bank reserves / bank assets	1.000	1.000	0.909	1.000	1.083	1.100	1.000	1.000	1.000	1.067	0.933	1.083	1.000	1.000	1.000	-	-	-
GDP	1.000	1.000	0.909	1.000	1.000	1.000	0.933	0.857	0.923	1.000	1.077	1.000	1.000	1.000	1.000	1.000	1.000	0.914
Inflation (total)	1.000	1.000	1.000	1.000	1.083	1.000	1.000	1.000	1.000	1.067	1.000	1.000	1.000	1.000	1.000	1.000	0.949	0.914
Inflation (core)	1.000	1.000	1.000	1.000	1.083	1.000	1.000	1.000	1.000	1.067	0.933	1.000	1.000	1.000	1.000	0.977	0.974	0.914
Investment % GDP	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.923	0.857	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.941
Savings % GDP	-	-	-	-	-	-	-	-	-	1.067	1.000	1.000	-	-	-	1.000	1.000	0.941
Stock Price	1.000	1.000	0.909	1.000	1.000	1.000	1.000	0.923	1.000	1.067	1.077	1.000	1.000	1.000	1.000	1.000	0.949	0.970
Residential real estate	-	-	-	1.000	1.000	1.000	1.000	0.923	0.923	1.067	0.933	1.000	1.000	1.000	1.000	1.000	1.000	0.970
Commercial real estate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oil price	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.067	0.933	1.000	0.952	1.000	1.000	1.000	1.028	1.000
MSCI	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.923	1.000	1.000	0.933	1.000	1.000	1.000	1.000	0.977	0.949	0.970
Gold price	1.000	1.000	0.909	1.000	1.000	1.000	1.000	1.000	1.000	1.067	1.077	1.000	0.952	0.947	1.000	1.000	1.028	1.000

Figure A1. FSI using alternative aggregation method

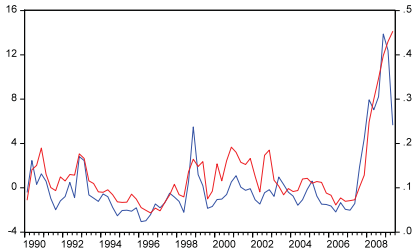
Australia



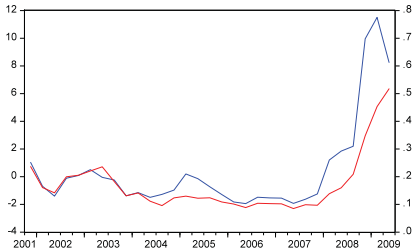
Belgium



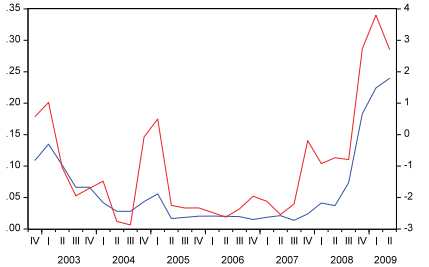
Canada



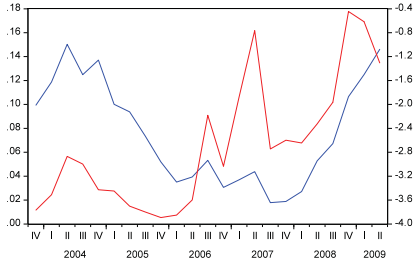
Denmark



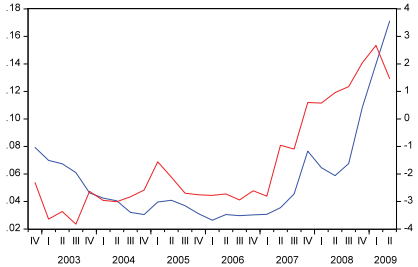
Spain



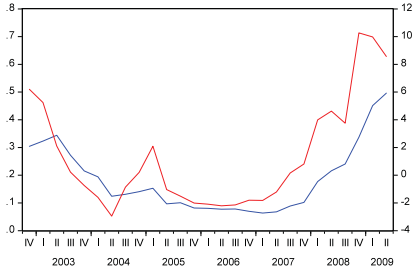
Finland



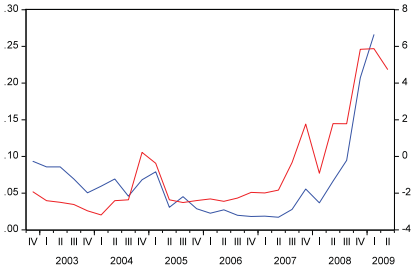
France



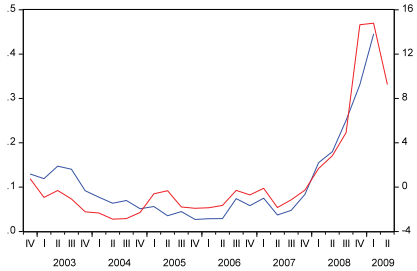
Germany



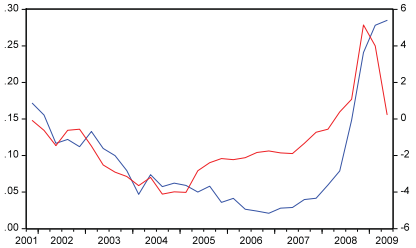
Italy



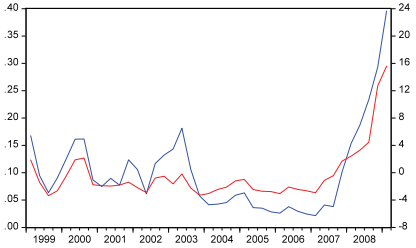
Netherlands



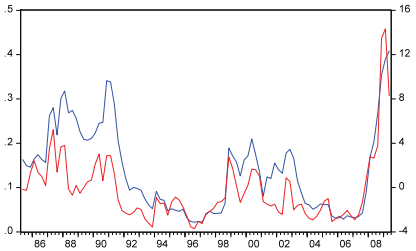
Sweden



United Kingdom



United States



Blue line: FSI; red line: adjusted FSI

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