Financial stress indexes and financial crises

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Abstract

This paper develops a Financial Stress Index (FSI) for 28 OECD countries and examines how it is related to crises using a new database for financial crises. A stress index measures the current state of stress in the financial system and summarizes it in a single statistic. Our results suggest that even though the FSI is clearly related to the occurrence of crises, there is only a very weak relationship between the FSI and the start of a crisis, notably the start of a banking crisis. Policymakers should therefore be aware of the limited usefulness of FSIs as crisis indicator.

Key words: financial stress index, banking crises

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1. Introduction

Most research on early warning models uses crises dummies as dependent variable.[1] However, in industrial countries financial crises occur at a low frequency, which makes it hard to examine regularities. Therefore, several studies have come up with a Financial Stress Index (FSI), be it for one country (e.g. Illing and Liu, 2006) or for several countries (e.g. Carderelli et al., 2011). Such an index can be used as left-hand side variable in an early warning model (instead of a crisis dummy) or as a leading indicator of financial turmoil (Misina and Tkacz, 2009).

A financial stress index measures the current state of stress in the financial system by combining several indicators of stress into 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, such as 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.[2]

Financial stress indexes are widely used by policymakers as an instrument for monitoring financial stability. According to Oet et al. (2012, p. 2), such a "monitoring instrument may specifically support the ability to intelligently observe systemic risk and to continuously assess financial system conditions. This tool would enable the public to observe drivers of stress in the financial system, and—by providing alerts—help to diffuse the information uncertainty and give the risk managers time to counteract." The FSI can also be used to activate or deactivate particular policy instruments. For instance, in Sweden the stress index plays a role in discussions of signals that can be used to activate and deactivate countercyclical capital buffers (Johansson and Bonthron, 2013).

[1] See Babecký et al. (2011; 2013) and references cited therein. Chaudron and de Haan (2014) compare the three most widely used financial crisis indicators and conclude that they differ substantially.

[2] The level of financial stress is determined by several factors including the size of shocks hitting the system, accumulated imbalances in the financial system (e.g. the high share of illiquid assets, maturity mismatches, leverage), and (expectations of) the reactions of authorities responsible for financial stability (Holló, 2012). A FSI measures the financial system's current stress level, but does not explain the cause(s) of the stress.

Finally, FSIs may be used as indicator of the extent to which the monetary policy transmission is working. It may therefore be used to determine the timing of entry/exit of unconventional policy measures and strategies, such as the introduction and withdrawal of extraordinary liquidity support to the banking system (Holló, 2012).

This paper examines the relationship between financial stress and financial crises for a sample of 28 OECD countries using a new FSI index and a new database of financial crises, which is constructed based on the input of national experts. So far, only limited attention has been given to this issue. This is remarkable as the usage of FSIs as dependent variable in early warning models or as policy instrument to monitor financial stability presumes that FSIs are related to financial crises. As will be discussed more extensively in section 2, only three studies (Illing and Liu, 2006; Morales and Estrada, 2010; and Louzis and Vouldis, 2013) have examined this issue. Whereas previous studies are all based on one country only, we use a multi-country framework. Our results suggest that even though the FSI is clearly related to the occurrence of crises, there is only a very weak relationship between the FSI and the start of a crisis, notably the start of a banking crisis.

The paper is structured as follows. Section 2 offers a broad overview of the by now large literature on stress indexes and their usage. Section 3 describes our data. Section 4 examines the relationship between our FSI and financial crises. Section 5 presents a sensitivity analysis and section 6 concludes.

2. Financial stress indexes: An overview

Financial Stress Indexes have been constructed for one country (e.g. Illing and Liu, 2006; Hakkio and Keeton, 2009; Morales and Estrada, 2010; and Holló, 2012) or for several countries (e.g. Holmfeldt et al., 2009; Cardarelli et al., 2011; Slingenberg and de Haan, 2011; Holló et al., 2012; Cevik et al., 2013 and Islami and Kurz-Kim, 2013). In general, stress indexes for a single country combine more indicators into one statistic than multi-country stress indexes (see Table A1 in the Appendix for a comparison of several stress indexes). This is not surprising in view of data availability. Most studies use market data, but some (e.g. Holló et al., 2012) use both mixed market and balance sheet data, while Morales and Estrada (2010) consider only balance sheet data.

Authors employ different ways to combine indicators into an aggregate stress index. Whereas most studies take the average of standardized variables, others use

principal components (cf. Illing and Liu, 2006; and Hakkio and Keeton; 2009). More recently, Holló et al. (2012) employed portfolio theory based aggregation schemes that take into account the correlation structure of stress indicators in order to quantify the level of systemic stress.

Financial stress indexes have been used for different purposes. Cardarelli et al. (2011) use their stress index for 17 advanced economies from 1980 to 2007 to examine the relationship between financial stress and economic slowdowns. Their findings suggest that episodes of financial turmoil characterized by banking distress are more likely to be associated with deeper and longer downturns than episodes of stress mainly in securities or foreign exchange markets. Furthermore, recessions associated with banking-related financial stress tend to last at least twice as long as recessions which are not preceded by financial stress. Likewise, Cevik et al. (2013) employ a financial stress index for Bulgaria, the Czech Republic, Hungary, Poland, and Russia to examine the relationship between financial stress and economic activity. Their impulse response functions based on bivariate VARs show a significant relationship between financial stress and some measures of economic activity. Finally, Islami and Kurz-Kim (2013) construct a FSI for the euro area and examine its predictive ability for the real economy during the recent banking crisis and the euro-area sovereign debt crisis. These authors conclude that their FSI outperforms the Euro STOXX 50 volatility index. Their evidence suggests that the negative impact of financial stress on the real economy had a time lag of three months during the recent financial crisis and the euro-area sovereign debt crisis.

Oet et al. (2012) use their FSI to analyze the impact of financial deregulation. Their results suggest the frequency of systemic stress episodes remains consistent pre- and post-U.S. financial deregulation. However, in the post-deregulation period the speed of systemic stress propagation slows, but the length of the recovery from systemic stress also slows substantially.

Balakrishnan et al. (2011) develop a financial stress index for developing countries and examine the transmission channels of financial stress between advanced and developing countries. Likewise, using an FSI of 25 emerging markets, Park and Mercado (2013) report that that not only financial stress in advanced economies, but also regional and non-regional emerging market financial stress significantly increase domestic financial stress in emerging markets. Although domestic financial shocks

account for most of the variation in domestic FSI, regional shocks play an important role in emerging Asia.

Baxa et al. (2013) analyze whether and how the monetary policy of several central banks (the US Fed, the Bank of England, the Reserve Bank of Australia, the Bank of Canada, and Sveriges Riksbank) responded to episodes of financial stress over the last three decades. Using the financial stress index of Cardarelli et al. (2011), the authors find that central banks change their policy stances in the face of financial stress, but the magnitude of such responses varies substantially over time.

Some papers try to identify leading indicators of financial stress. For instance, Misina and Tkacz (2009) report that within a linear framework, domestic credit growth is the best predictor of the stress index 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. Slingenberg and de Haan (2011) extend the study by Misina and Tkacz (2009) expanding the analysis to 13 OECD countries. Their 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.

Finally, a few papers have examined the relationship between financial stress and financial crises. Louzis and Vouldis (2013) develop a systemic financial stress index for Greece. By comparing it with the results of an internal survey conducted within the Bank of Greece to determine the most stressful events for the Greek financial system, they evaluate their index based on its ability to match the results of the survey. They conclude that their index can timely identify the crisis periods as well as the level of systemic stress in the Greek financial system. Similar findings have been reported for Canada by Illing and Liu (2006) and Columbia by Morales and Estrada (2010). As pointed out before, single-country FSIs usually contain more composite indicators than multi-country FSIs. It therefore remains to be seen whether the conclusions of previous studies hold within a multi-country framework.

3. Data

3.1. Financial Stress Index

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. This criterion implies that some sectors, notably the real estate sector and securitization markets (cf. Oet et al., 2012), cannot be included. Second, it should be comparable across countries. Finally, the FSI should cover as much of the financial system as possible, i.e., money, capital markets, the banking sector, and the foreign exchange market (Holló et al., 2012). It is quite remarkable that several indices do not include the foreign exchange market (see Table A1 in the Appendix). Note that the indicator with the shortest available period determines the period for which the FSI is available.

On the basis of these criteria, we considered the variables shown in Table 1. We will explain these indicators first and then explain how we have combined them into an index. An additional criterion applied in constructing the FSI is that the variables should be related to our financial crisis measures in line with theoretical expectations.

Several financial stress indexes include stock price volatility assuming that large swings in stock prices indicate financial imbalances in the equity market (cf. Illing and Liu, 2006; Hakkio and Keeton, 2009; and Cardarelli et al., 2011). Our index also takes stock price volatility into account. Following Cardarelli et al. (2011), time-varying stock return volatility has been derived from a GARCH(1,1) specification (Bollerslev et al., 1992).

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 (cf. Hakkio and Keeton, 2009; Cardarelli et al., 2011; and Oet et al., 2012). The TED spread reflects credit risk and liquidity risk. It also captures stress in the banking sector as the premium captures counterparty risk. However, in our sample it turned out that this money market spread had hardly any relationship with our crisis indicators (discussed below) or even had the 'wrong' sign. We therefore decided against inclusion of this spread into our FSI.

Another indicator of stress in the banking sector that is included in our index is the so-called β of the banking sector (see also Illing and Liu, 2006; Cardarelli et al., 2011; and Oet et al., 2012), which is calculated as follows:

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

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.

The volatility of monthly changes in the nominal effective exchange rate is also included in our index (see also Illing and Liu, 2006; Cardarelli et al., 2011; and Islami and Kurz-Kim, 2013). 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., 2011).

Finally, we considered two indicators of stress in the bond market, namely the inverse yield curve, i.e. the short-term interest rate minus the long-term interest rate, and the domestic long-term interest rate minus the US long-term interest rate as a measure of sovereign risk. Some other authors also include an indicator of the slope of the yield curve (e.g. Carderelli et al, 2011). According to these authors, "banks generate income by intermediating short-term liabilities (deposits) into longer-term assets (loans). Therefore, when there is a negative term spread – that is a negative sloping yield curve – bank profitability is seriously jeopardized." (p. 80). One of the few studies considering sovereign risk is Louzis and Vouldis (2013) who use the spread of Greek and German government bonds. In our index, we take the US as benchmark, which implies that this indicator is zero for the US.

Table 1. Indicators considered and FSI

FSI1	Stock price volatility derived from a one year rolling GARCH(1,1) specification
FSI2	TED-spread, which is the yield difference between a (3 month) unsecured interbank loan and the risk free rate (3 month)
FSI3	Beta of the banking sector, calculated as cov(return banking sector, total market)/variance(total market)
FSI4	Volatility of monthly changes in the nominal effective exchange rate as calculated by a one year rolling GARCH(1,1) specification
FSI5	Inverse yield curve - (long term interest rate - short term interest rate), i.e. short term interest rate - long term interest rate
FSI6	Long term interest rate - US long term interest rate (measure of sovereign risk). This variable is zero for the US
FSI	Calculate the total financial stress index as the unweighted sum of each financial stress index except FSI2 (FSI = FSI1 + FSI3 + FSI4 + FSI5 + FSI6). All are weighted equally important.

The FSI is calculated for 28 OECD countries: Australia (AU), Germany (BD), Belgium (BG), Canada (CN), Czech Republic (CZ), Denmark (DK), Spain (ES), Finland (FN), France (FR), Greece (GR), Hungary (HN), Iceland (IC), Ireland (IR), Israel (IS), Italy (IT), Japan (JP), Korea (KO), Mexico (MX), the Netherlands (NL), Norway (NW), New Zealand (NZ), Austria (OE), Poland (PO), Portugal (PT), Sweden (SD), Switzerland (SW), the United Kingdom (UK), and the United States (US).

All variables are standardized, i.e. we subtract the mean and divide by the standard deviation. Our index FSI is the un-weighted sum of the standardized variables included (i.e., FSI1, FSI3, FSI4, FSI5 and FSI6). 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.

Table 2 shows the correlation of our financial stress index and its components.

[3] In contrast, Holló et al. (2012) 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.

The correlation of the sub-indices is low, suggesting that they capture different dimensions of financial stress. FSI2 has a negative relationship with FSI, which is counterintuitive. That is way we decided not to include this sub-index in our financial stress index FSI.

Table 2. Correlations subcomponents and financial stress index

	FSI1	FSI2	FSI3	FSI4	FSI5	FSI6	FSI	FSIA
FSI1	1							
FSI2	0.12	1						
FSI3	0.19	0.06	1					
FSI4	0.21	0.02	0.09	1				
FSI5	0.00	-0.32	-0.15	0.05	1			
FSI6	0.15	-0.10	0.11	0.17	0.28	1		
FSI	0.58	-0.08	0.47	0.55	0.44	0.64	1	
FSIA	0.48	-0.02	0.45	0.39	0.31	0.54	0.81	1

As an alternative to the un-weighted sum of the standardized indicators, we follow Hollo et al. (2012) and calculate the alternative financial stress index FSIA as follows:

$$FSIA = y_t C_t y_t' \tag{2}$$

where $y = (w \circ s)$ and $w = (w_1, w_3, w_4, w_5, w_6)$ is the vector of (constant) sub-index weights, s is the vector of sub-indices (FSI1, FSI3, FSI4, FSI5, FSI6); $w \circ s$ 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. We use equal weights, i.e. w=0.2, for each sub-index. The sub-indices are constructed by attaching the value 1/N to the lowest value of a sub-index, 2/N to the second lowest value up to N/N for the highest value. This maps all values of each sub-index in the (0;1] domain. We attach these values considering the full sample, since the current analysis is not about real-time forecasting. The correlation weights Ct are time varying with persistence parameter lambda equal to 0.75 at the monthly frequency. This is close to the 0.93 value that Hollo et al. (2012) use at a weekly frequency (0.93^4). The results are not very sensitive to the exact value of this parameter. As shown in Table 2, the correlation between FSI and FSIA is 0.81.

3.2 Financial crises

We use the crises database of Babecký et al. (2011; 2013).[4] These authors provide a quarterly database of the occurrence of banking, debt, and currency crises for a panel of 40 developed countries over 1970– 2010; for a number of countries—e.g. those which experienced economic transition from a planned to a market economy—the data only start at the beginning of the 1990s. The database has been constructed using several sources, including country experts, mostly from national central banks.

Figure 1 shows the number of countries in our sample that is in crisis at each point in time; this number peaked in the early 1990s and during the recent crisis.

Figure 1. Number of countries in crisis, 1980-2010

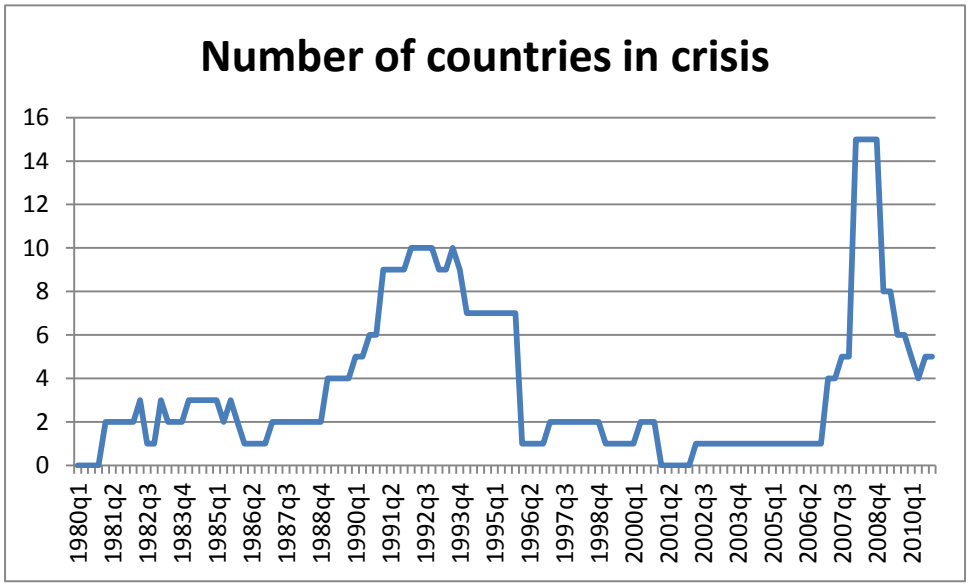
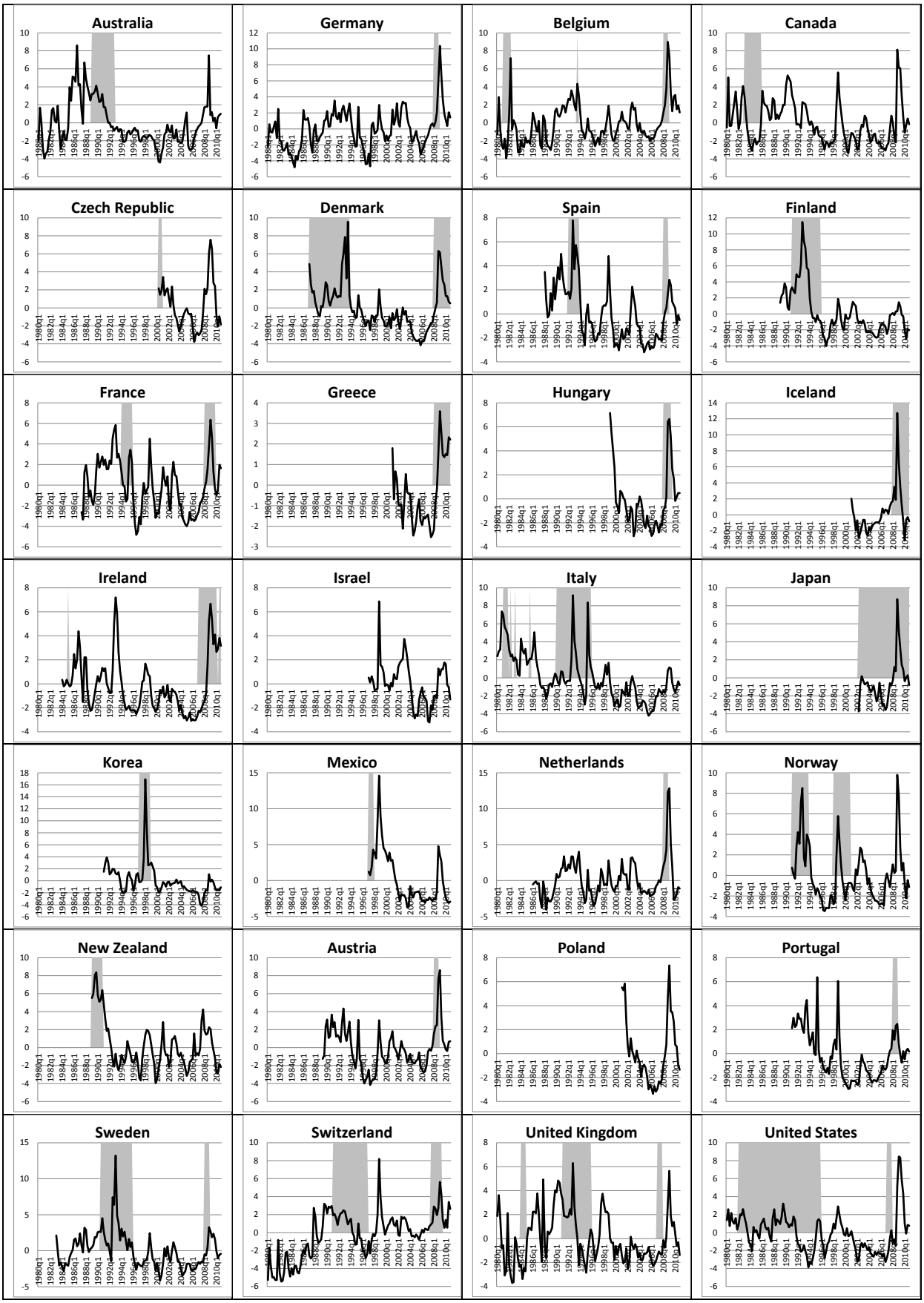


Figure 2 shows the financial stress index FSI for the countries in our sample. The figure also shows the crises according to Babecký et al. (2011; 2013). The figure suggests that FSI and the occurrence of financial crises are related. However, the relationship is not very strong. Frequently, the FSI is high while according to the crises data base there is no crisis, or vice versa. In the next section we examine the relationship between FSI and financial crises in more detail.

[4] For details, see: http://ies.fsv.cuni.cz/en/node/372.

Figure 2. FSI index and crisis periods (shaded areas), 1980Q1-2010Q4

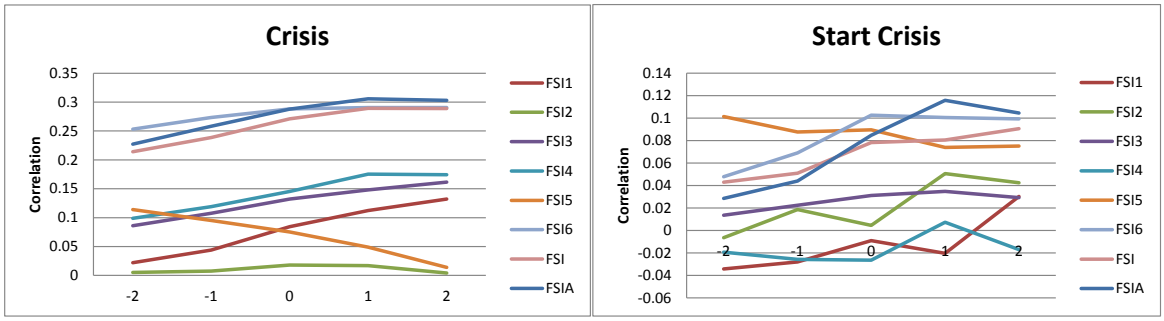


4. Financial crises and financial stress

4.1. Correlations

We use six sub-indices of financial stress (FSI1-FSI6) and two aggregate indices (FSI and FSIA) in our investigation of the relationship between financial crises and stress indices. As a first step, we look at the correlation between the indices and the occurrence and start of a crisis at up to two lags and leads of the indicators. For the start of the crisis, we only keep the first quarter of the crisis in the dataset and delete the other observations for as long as the crisis lasts.

Figure 3. Correlation between (components of) FSI and financial crises

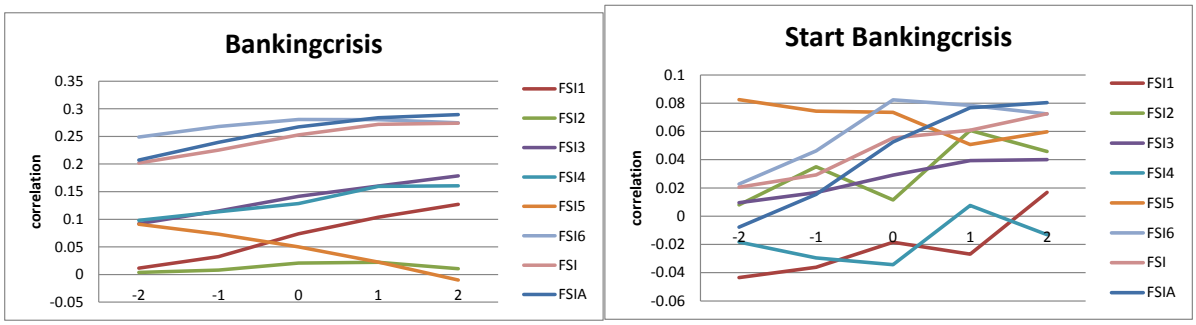


Note: The figures show the correlation for sub-indices F1…F6, FSI and FSIA and the occurrence of a financial crisis (left-hand side) and the start of a financial crisis (right-hand side). The horizontal axis shows the leads and lags of the stress indices. A high correlation at -2 means that the index is highly correlated with a crisis 2 quarters later on.

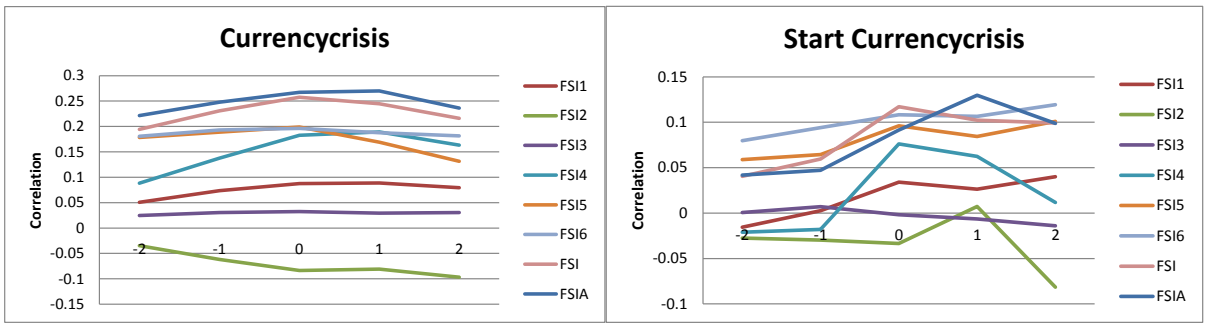
A first observation following from the graphs is that correlations between the stress (sub-)indices and the occurrence of crises are low; the correlations between the stress (sub-)indices and the *start* of a crisis are even very low. The FSI6 sub-index (measuring the interest rate differential with the US) has the highest correlation with the occurrence of a crisis, across all lags and leads, but the aggregate stress indexes FSI and FSIA come close. FSI5 (measuring the inverse slope of the yield curve) has the highest correlation with the start of a financial crisis when considering one or two leads. However, the correlation is still quite modest at 0.1. The lags of FSI6 and FSIA have a slightly higher contemporaneous correlation with the start of a financial crisis.

Figure 4. Correlation between (components of) FSI and types of financial crises

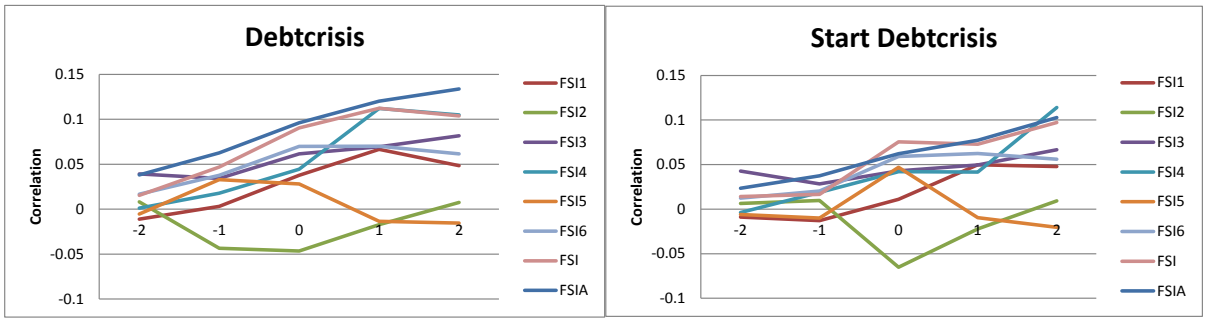
Panel A: Banking crises



Panel B: Currency crises



Panel C: Debt crises



Note: The figures show the correlation for sub-indices F1...F6, FSI and FSIA and the occurrence of different types of financial crises (left-hand side) and the start of different types of financial crises (right-hand side). The horizontal axis shows the leads and lags of the stress indices.

For banking crises—the most frequent type of crises (408 quarters, 29 starts) in our sample—the picture is very similar to that for all crises (panel A in Figure 4). FSI6 has the highest correlation with the occurrence of crises, while FSI5 has the highest correlation with the start of a crisis. The frequency of currency crises in our sample is

lower than that of banking crises (67 quarters, 17 starts). The aggregate stress indices FSI and FSIA have the highest correlation with the occurrence of a currency crises, while sub-index FSI6 has the highest correlation with the start of a currency crisis one or two quarters ahead (panel B in Figure 4). Debt-crises are very rare in our sample (only 7 quarters and 4 starts). Nonetheless, we compute the correlations and find that FSI3 has the highest correlation with both the total crisis episode and with the start of a debt crisis for two quarters ahead. For one quarter ahead, the total index FSIA performs best (see panel C in Figure 5).

4.2 Univariate (Panel) Logit-regressions

Next, we estimate univariate panel logit-models that explain the occurrence of a crisis (dummy variable is 1 if there is a crisis and 0 if not) by the one-period lag of the financial stress (sub-)indices and a country-fixed effect (see also Louzis and Vouldis, 2013). The results of the panel logit regressions as shown in Table 3 generally confirm results of the correlation analysis. Crises in general and banking crises (the most frequent type of crisis) are best explained by FSI6 and by the aggregate indices FSI and FSIA. Currency crises are best explained by FSI and FSIA and debt crises by FSI, FSIA, and FSI3.

Table 4 shows the results if we estimate similar models for the start of financial crises. For crisis starts, FSI5 has the highest t-value for crises in general and banking crises. For the start of currency crises, FSI6 does best and for the start of debt crises FSI3 and FSIA.

We have also performed a simple logit-regression, by pooling the data without using the panel structure. This gives more observations for currency and debt crises, since the countries where these types of crises never occurred do not drop out. The results (available on request) are very similar to the panel-logit regressions.

Table 3. Logit panel regressions with one stress (sub-)index as explanatory variable for the occurrence of crises

	All crises	Banking crises	Currency crises	Debt crises
FSI(-1)	0.29	0.28	0.41	0.31
	(12.2)	(11.7)	(8.6)	(2.7)
FSIA(-1)	1.92	1.81	2.58	2.02
	(12.4)	(11.6)	(9.2)	(2.8)
FSI3(-1)		0.39		0.69
		(6.3)		(2.1)
FSI4(-1)			0.46	
			(5.2)	
FSI5(-1)	0.35			0.48
	(5.7)			(1.7)
FSI6(-1)	1.02	1.08		
	(14.1)	(13.9)		
N	2300	2300	950	304

Note: This table shows selected results from univariate logit regressions. The dependent variables are dummies indicating the occurrence of a crisis. Country fixed effects are included. T-values are shown in parentheses.

Table 4. Logit panel regressions with one stress (sub-)index as explanatory variable for the start of crises

	All crises	Banking crises	Currency crises	Debt crises
FSI(-1)	0.17	0.12	0.25	0.17
	(2.6)	(1.7)	(3.1)	(1.1)
FSIA(-1)	0.97	0.51	1.57	1.63
	(2.1)	(0.9)	(2.7)	(1.7)
FSI3(-1)		0.20		0.64
		(1.0)		(1.7)
FSI4(-1)			-0.78	
			(-0.9)	
FSI5(-1)	0.64	0.59		-1.19
	(3.8)	(3.3)		(-1.1)
FSI6(-1)	0.59		1.04	
	(3.4)		(4.1)	
N	1757	1715	891	301

Note: This table shows selected results from univariate logit regressions. The dependent variables are dummies indicating the start of a crisis. Country fixed effects are included. T-values are shown in parentheses.

4.3 Multinomial logit models

Finally, we run multinomial logit regressions that reveal which stress indices contribute to increasing the probability of a specific type of crisis. These regressions do not use the panel structure but simply pool all the observations. Sometimes a country faces multiple crises at the same time. In those cases, the crisis is coded according to the type with the lowest frequency. So, a country facing a banking and currency crisis at the same time is recorded as having a currency crisis as in our sample they occur less frequently. Debt crises are not considered here since they are very rare in our sample. Table 5 reports the marginal effects based on the regressions. The regressions shown at the left-hand side of the table refer to the occurrence of a banking or currency crisis, whereas the regressions shown at the right-hand side of the table use the start of a crisis as dependent variable. The top panels represent regressions with either FSI one quarter lagged or FSIA one quarter lagged as explanatory variable. The bottom panels use two of the most influential sub-indices FSI5 (inverse slope of the yield curve) and FSI6 (interest rate difference with the US) as explanatory variables.

Table 5. Estimated probabilities of crisis from multinomial logit model

	crisis			
	FSI(-1)=0	FSI(-1)=4.96	FSIA(-1)=0	FSIA(-1)=0.71
no crisis	83.3%	62.0%	89.1%	74.0%
banking	14.6%	27.3%	10.0%	21.2%
currency	2.1%	10.7%	1.0%	4.9%

	start crisis			
	FSI(-1)=0	FSI(-1)=4.96	FSIA(-1)=0	FSIA(-1)=0.71
no crisis	97.9%	95.7%	98.3%	97.2%
banking	1.3%	1.9%	1.2%	1.5%
currency	0.7%	2.3%	0.5%	1.3%

	FSI5(-1)=0		FSI5(-1)=2	
	FSI6(-1)=0	FSI6(-1)=2	FSI6(-1)=0	FSI6(-1)=2
no crisis	83.8%	54.8%	83.9%	51.9%
banking	14.3%	37.3%	11.2%	27.5%
currency	1.8%	8.0%	4.9%	20.6%

	FSI5(-1)=0		FSI5(-1)=2	
	FSI6(-1)=0	FSI6(-1)=2	FSI6(-1)=0	FSI6(-1)=2
no crisis	98.3%	94.7%	95.9%	89.7%
banking	1.2%	1.5%	3.1%	4.0%
currency	0.5%	3.7%	0.9%	6.3%

Starting in the top left panel, if FSI increases from 0 to 4.96 (i.e. two standard deviations), the expected probability of being in a crisis increases from 16.7% to 38.0%, while the probability of being in a banking crisis almost doubles from 14.6% to 27.3%. The probability of being in a currency crisis increases from 2.1% to 10.7%. For our other aggregate financial stress index, FSIA, an increase by two standard deviations (from 0 to 0.71) gives similar increases in the probabilities of being in a banking crisis or a currency crisis, but at lower levels.

The top right panel in Table 5 shows that an increase by two standard deviations in FSI doubles the likelihood of a crisis starting next in the next period from 2.1% to

4.3%. The probability of a banking crisis starting rises from 1.3% to 1.9%, while this probability for a currency crisis increases from 0.7% to 2.3%. For the FSIA index a similar pattern emerges.

For the sub-indices, we analyse the impact of two of the most influential factors: the inverse slope of the yield curve (FSI5) and the interest differential with the US (FSI6). We also discuss the conditional effects of an increase in one sub-index given a certain value of the other. Turning to the sub-indices in the bottom left panel, if FSI5=0, an increase in FSI6 by 2 standard deviations increases the probability of being in a crisis from 16.2% to 45.2% (most likely, a banking crisis (37.3%)). If FSI5=2 and FSI6 increases by 2 standard deviations, the probability of being in a crisis increases from 16.1% to 48.1%. Interestingly, if FSI5=2 the increase in FSI6 has a relatively large impact on the probability of being in a currency crisis (from 4.9% to 20.6%). So, if a country has a high interest differential with the US (i.e. FSI6 is large), it has a high risk of being in a currency crisis. If the yield curve is normal, this will most likely be a banking crisis (37% vs. 8% for a currency crisis). However, in case of an inverse yield curve a currency crisis is almost as likely (20.6% vs. 27.5% for a banking crisis). This pattern is consistent with a situation in which a country is defending its currency through higher short-term interest rates.

For the start of a crisis (bottom right panel in Table 5), an increase in FSI6 by 2 standard deviations increases the probability of a currency crisis starting by a factor 7. The probability of the start of a banking crisis is hardly affected. The effect of an increase of FSI5 is more similar across types of crises.

We have also performed all analyses (correlation graphs, univariate logit and multinomial logit) with a stricter crisis definition. This stricter definition registers a crisis only when two independent sources confirm that a country experienced a crisis episode. The results from this analysis are qualitatively similar to the results we presented and are available from the authors upon request.

5. Conclusion

The aim of this paper was to identify the relationship between financial stress and financial crises. For that purpose, we first constructed a financial stress index (FSI) for 28 OECD countries. We have used four 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, they should be

comparable, and indicators should be related to financial crisis in line with theoretical expectations) to come up with our FSI. We started with 6 sub-indices. However, as it turned out that the TED-spread had a counter-intuitive relationship with our financial crises data, it was not included in our index. To check whether aggregation affects our findings, we followed a similar approach suggested by Holló et al. (2012).

The results found in this study are somewhat bleach. It turns out that our stress indices as well as the sub-indices are related to the occurrence of a crisis, although in different degrees. However, the relationship between our stress indices and the start of a crisis is rather weak. Our results therefore suggest that policymakers should not strongly rely on these stress indices in assessing financial stability. Likewise, researchers should be aware that using crisis dummies and stress indices in early warning models may yield different results in view of the weakness of the relationship between crisis dummies and financial stress indices.

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Appendix 1. Table A1. Financial stress indexes: a (selective) comparison

Variable:	Illing and Liu (2006)	Hakkio and Keeton (2009)	Cardarelli et al. (2011)	Slingenberg and de Haan (2011)	Oet et al. (2012)	Louzis and Vouldis (2013)	Islami and Kurtz-Kim (2013)
Countries:	Canada	US	17 advanced countries	13 advanced countries	US	Greece	Euro area
TED spread		√	√	√	√		
3 month LIBOR - FRR					√		
2 year swap spread		√					
Euribor German T-bill spread						√	
Euribor - Eonia							√
Covered interest spread					√		
Liquidity spread					√		
Off-the-run/on-the-run Treasury spread		√					
CP – Treasury Bill rate					√		
AAA/10 year Treasury spread		√			√		
Treasury yield curve 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	√	√	√	√	√	√	
Stock prices						√	
Correlation between stock and Treasury returns		√					
Earnings-price ratio minus 10 year bond rate							√
Volatility of bank stock prices		√				√	
Dispersion bank stock returns		√					
(Rolling) beta banking sector	√		√	√	√		
Idiosyncratic risk of bank stock prices						√	

Bank bond spread					√		
(Banks) CDS spreads						√	√
Deposit gap						√	
Loan gap						√	
Interest margin						√	
Exchange rate volatility	√		√	√	√		√
Government bond spread vis-à-vis Germany (US)						√	
Volatility bond yields						√	
Correlation German bond yield and stock returns						√	
Volatility of future oil price							√
Commercial real estate spread					√		
Residential real estate spread					√		
Asset-backed security spread					√		
Commercial mortgage-backed security spread					√		
Residential mortgage-backed security spread					√		