# Charles University in Prague

Faculty of Social Sciences
Institute of Economic Studies


BACHELOR THESIS

# Measuring Financial Instability: A Survey


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## Declaration of Authorship

I hereby declare that I have compiled this thesis independently, using only the listed resources and literature. The author also declares that she has not used this thesis to acquire another academic degree.

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Prague, July 15, 2012

Signature

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## Abstract

This thesis aims to analyze how various theoretical definitions describe and assess financial stability, and how these definitions are actually being reflected in the measurement methods used to evaluate financial stability. The first section lists different theoretical approaches to defining financial stability, extrapolates main components that characterize these approaches, and compares these approaches based on the components. The thesis continues with a description and critical assessment of financial stability measurement methods. Special attention is paid to financial conditions and financial stress indexes, which are compared based on actual data for the United States. The last section explores to what extent these components are compatible with financial stability measurement methods listed in the previous section. This thesis also points out that most methods measure financial instability, as opposed to financial stability, perhaps because instability is less abstract and, thus, more convenient for an effective measurement. The thesis concludes that recent quantitative assessments of financial stability are real time assessments rather than strong predictive indicators of financial (in)stability and, thus, they do not offer policymakers enough time and information for timely policy actions. In this respect, it is likely that early warning systems will be gaining on importance.

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# Abstrakt

Tato bakalářská práce analyzuje různé teoretické přístupy k definování a měření finanční nestability. V první části práce jsou představeny různé alternativní přístupy a jejich hlavní principy jsou porovnány navzájem. Následně jsou popsány a kriticky zhodnoceny způsoby měření finanční stability a nestability. Hlavní pozornost je věnována indexům podmínek na finančních trzích a finančního stresu. Poslední část práce pak hodnotí, jak se jednotlivé aspekty finanční stability promítají do jednotlivých kvantitativních metod. Bakalářská práce ukazuje, že v současnosti převládá měření finanční nestability, pravděpodobně z důvodu, že jde o snáze popsatelný stav, a také proto, že panuje větší shoda na tom, jak se nestabilita projevuje. Naopak finanční stabilita je z důvodu její větší všeobecnosti mnohem méně použitelná pro potřeby kvantitativních metod. V současné době je většina prezentovaných přístupů k měření finanční (ne)stability zaměřená na popis aktuálního vývoje spíše než na predikci nastávajícího období nestability, a tedy nepřináší dostatečné informace a čas pro včasná preventivní opatření proti finanční krizi. Indikátory včasného varování jsou v tomto ohledu výjimkou mající určitou predikční schopnost, a proto by se v budoucnu mohly stát významným nástrojem makroprudenční politiky.



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| **Klasifikace JEL** | E44, E61, G01 |
| **Klíčová slova** | finanční stabilita, kvantitativní metody, finanční nestabilita |



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# Acronyms

| | |
|---|---|
| **A** | Annually |
| **CDS** | Credit default swap |
| **CITI FCI** | Citi Financial Conditions Index |
| **CL FSI** | Cleveland Financial Stress Index |
| **D** | Daily |
| **DD** | Distance to default |
| **ECB** | European Central Bank |
| **EWI** | Early warning indicator |
| **EWS** | Early warning system |
| **FCI** | Financial conditions index |
| **FSI** | Financial stress index |
| **FTD** | First-to-default indicator |
| **GDP** | Gross domestic product |
| **IMF** | International Monetary Fund |
| **IMF FSI** | International Monetary Fund Financial Stress Index |
| **KS FSI** | Kansan City Financial Stress Index |
| **LGD** | Loss given distress |
| **LIBOR** | London Interbank Offered Rate |
| **M** | Monthly |
| **OECD** | Organisation for Economic Co-operation and Development |
| **OECD FSI** | Organisation for Economic Co-operation and Development Financial Stress Index |
| **OIS** | Overnight index swap |
| **PD** | Probability of default |
| **REER** | Real effective exchange rate |

**STL FSI** Federal Reserve Bank St. Louis Financial Stress Index

**WB** World Bank

# Bachelor Thesis Proposal

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|---|---|
| **Author** | Jana Urbánková |
| **Supervisor** | PhDr. Jaromír Baxa |
| **Proposed topic** | Measuring Financial Instability: A Survey |

**Preliminary thesis content** The increased importance of financial sector stability has evoked the need of framework for financial instability analysis and policy. The main objective of this thesis is to conduct a survey of financial instability measurements methodologies. The first section explores definition of financial (in)stability. A major challenge complicating this section is that there is no broad consensus on definition of financial (in)stability. The second section discusses in details the measurements methodologies, its strengths and weaknesses. The third section outlines how different approaches to financial (in)stability measurement reflect particular aspects of theoretical definitions of financial (in)stability.

**Předběžná náplň práce** Rostoucí významnost stability finančního sektoru vyvolává tlak na vytvoření vhodného rámce pro analýzu a kontrolu finanční (ne)stability. Hlavním cílem této práce je poskytnout přehled metod vhodných pro měření finanční (ne)stability. První část práce nastiňuje problém definice finanční (ne)stability. Druhá část práce se zaměřuje na metodologii jejího měření, přednosti a úskalí jednotlivých přístupů. Závěrečná část práce posuzuje, jak různé přístupy k měření finanční (ne)stability reflektují její teoretickou stránku.

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Author Supervisor

# Chapter 1

# Introduction

The recent financial crisis revealed the importance of effective quantitative assessment of financial stability. It also demonstrated that previous efforts to keep individual financial institutions in a sound condition are not enough to maintain stability, and therefore a broader approach has to be adopted. Policymakers, especially central banks, have made significant effort to develop an effective framework to maintain financial stability. Despite these efforts, neither a single widely used definition of financial stability, nor its effective quantitative measurement has yet been developed. A well functional quantitative assessment of financial stability is one step ahead the stability definition. What exactly should we measure to assess financial stability? There are many questions about financial stability that follow, such as: Are all elements of financial stability measureable? Do we have functional system to jointly evaluate all elements of financial stability? To what extent can we predict future states of financial stability? The string of questions seems to be endless.

The objective of the thesis is to answer questions which concern different approaches to defining financial stability and difficulty to assess them by a quantitative technique. Presented quantitative methods also answer how and to what extent we can measure different aspects of financial stability. We assess each method according to its ability to reflect definitions of financial stability. The thesis proposes two approaches to the definition of financial stability. (1) Broader concept which seeks to define the term of financial stability. (2)Narrower concept that, on the contrary, attempts to describe what cannot be considered financial stability - the concept of financial instability. This thesis also points out that most methods measure financial instability, as opposed to financial stability, because instability is less abstract and, thus, more con-

venient for effective measurement; and that recent quantitative assessments of financial stability are real time assessments rather than strong predictive indicators of financial (in)stability. In this respect, early warning systems are exceptions with certain predictive power.

The thesis is structured as follows: Chapter 2 explores different financial stability definitions and breaks them up into two approaches. Each approach is assessed according to its ability to lay the ground for an analytical quantitative formulation of relationships within financial system. Chapter 3 shows main roles of measurement methods and proposes desirable characteristics of an ideal measure. In the Chapter 4, the thesis focuses on set of simple indicators and ratios which combine data available from balance sheets of financial institutions, macroeconomic variables, and market data, while single-statistic indicators of financial stability – financial stress and conditions indexes - are presented and mutually compared in the Chapter 5. The comparison concludes that financial stress indexes refer rather to concept of financial instability, while financial conditions indexes capture broader view of financial stability and can be embedded in a concept of financial stability. Unlike previous indicators, probabilities of multiple institutions' defaults presented in the Chapter 6 aim to analyze systemic risk and potential costs of multiple defaults. Early warning indicators even attempt to predict financial distress in advance. Their contributions and shortcomings are revealed in the Chapter 7. Chapter 8 presents an analysis of how theoretical elements of financial stability are reflected by quantitative methods presented in previous chapters. Chapter 9 concludes with summarizing results.

# Chapter 2

# Financial stability

## 2.1 Financial stability policy

Financial system consists of three main parts. (1) Financial markets channel excess funds from lenders to borrowers through money or capital market. (2) Financial intermediaries bring lenders and borrowers together in case the lenders do not directly obtain finance from financial markets. (3) Financial infrastructure facilitates the transfer of payments as well as trading.

Central banks adopt micro- and macro- prudential policies to keep financial system sound and to ensure financial stability. The traditional regulation, micro-prudential policy, aims at individual institutions to ensure that they are safe, sound, and able to fulfill its function and withstand the exogenous shocks. Its goal is to protect individual consumers against risk representing information asymmetry and a principal-agent problem. Nevertheless, micro-prudential approach does not take into account correlations and common exposures across institutions (see Table 2.1).

On the contrary, the objective of macro-prudential policy is to maintain a stability of the system as a whole. In this view, the primary sources of instability are endogenous processes, which are characterized by high interconnection and mutual dependence of financial institutions, their common behavior, and exposure to risk. The objective of macro-prudential policy is also to mitigate systemic risk and its dissemination in the system. Systemic risk is considered to have both time dimension and cross-sectional dimension. The time dimension reflects accumulation of vulnerabilities in economy over time. This accumulation is linked to the procyclicality in behavior of financial institutions. The cross-sectional dimension refers to a joint exposure of financial institutions to

common shocks and dissemination of contagion among these institutions. In other words, systemic risk can be seen as a risk that a small sized shock might cause a financial instability of the whole system through amplifying mechanisms.

Table 2.1: Macro- and micro-prudential policy perspectives

| | **Macro-prudential** | **Micro-prudential** |
|---|---|---|
| Proximate objective | Limit financial system/wide distress | Limit distress of individual institutions |
| Ultimate objective | Avoid output (GDP) costs | Consumer(investor/depositor) protection |
| Model of risk | Endogenous (in part) | Exogenous |
| Correletions and common exposures across institutions | Important | Irrelevant |
| Calibration of prudential controls | In terms of system/wide distress; top-down | In terms of risks of individual institutions; bottom-up |

*Source:* Borio (2003)

Ben S. Bernanke, chairman of the Board of Governors of the Federal Reserve System, describes systemic risk as follows:

> "Systemic risks are developments that threaten the stability of the financial system as a whole and consequently the broader economy, not just that of one or two institutions."

*Source:* Bernanke (2009)

Jean-Claude Trichet, president of European Central Bank, offers his own definition of systemic risk:

> "In the context of our economic environment, systemic risk is the threat that developments in the financial system can cause a seizing up or breakdown of this system and trigger massive damages to the real economy. Such developments can stem from the failure of large and interconnected institutions, from endogenous imbalances that add up over time, or from a sizable unexpected event."

*Source:* Trichet (2009)

These two definitions have in common an opinion that systemic risk is a long-term development, and that systemic risk does not appear suddenly but rises gradually. Both definitions include a notion of complexity of its impact. In addition, the definition of J.C. Trichet emphasizes the trigger events.

Both micro- and macro- prudential policy aims to keep financial stability and financial system sound, thus the definition of financial stability is essential for any further development. It would be vain effort to effectively manage financial stability without defying what it constitutes.

## 2.2 Explicit definition or hazy picture?

Even though financial stability is a policy objective of many central banks and topic of recent economic discussion, a single widely used definition of financial stability has not been developed yet.

Since the nature of financial stability cannot be described by a single definition, it is not easy to define only one single policy and operational framework for maintaining such kind of balance. This framework together with an assessment system is the keystone for avoiding future financial instability or, at least, mitigating its consequences.

What is the reason for vagueness of the definition of financial stability? For example, price stability is also a policy objective of many central banks, which have a relatively widely accepted framework to maintain it (see Table 2.2). Although some definitions of price stability specify a particular rate of increase of particular price index and other specify a range of rates of increase, the definitions are close enough, leading to a similar policy. The main difference between financial stability and price stability is a relative infancy of financial stability as a policy objective of central banks, and its greater abstractness.

What would be a desirable development? Ideally, an explicit definition of financial stability ought to be clearly determined and complemented by an operational framework, which can be described as a set of definitions, concepts and principles. This operational framework would allow to measure financial stability, and, moreover, it would make policy and operational tools for safeguarding that stability functional and easily applicable.

Currently, there are two approaches to the definition of financial stability. (1) Broader concept which seeks to define the term of financial stability. (2)Narrower concept that, on the contrary, attempts to describe what cannot be considered financial stability - the concept of financial instability.

Table 2.2: Price stability versus financial stability [1]

| | **Price Stability** | **Financial Stability** |
|---|---|---|
| General definition | Clear | A range of definitons |
| Operational definiton | Clear (variable and target), especially in inflation targeting | Typically not specified |
| Measurement | Relatively uniform | Large set of indicators, measurement methods, absence of one widely accepted approach |
| Legal base for central banks's role | Based on law | Based on interpretation of law |
| Scope of central bank's responsibilities | Full responsibility | Partial/shared responsibility, exact boundaries in some countries unclear, in others delineated by a memorandum of understanding |
| Research | Well developed | Developing |

*Source:* the author, Čihák (2006)

## 2.3 Financial stability

The first concept is followed by fewer authors due to its greater abstractness and broadness. Those two characteristics are immediately apparent from definition provided by Foot (2003) including the following four main elements.

- Monetary stability (defined as a stability of the value of money) which is according to Foot (2003) essential for financial stability, because financial stability cannot be achieved in a situation of rapid inflation.
- Employment levels representing linkage with the real economy need to be close to the economy's natural rate.
- Confidence in the operation of key financial institutions that requires banking system stability, and confidence in the operation of markets which causes that long-term savings and borrowings are smoothly allocated in both the personal and corporate sector.

[1] This comparison does not apply to all country. It serves as a simplification.

- Price stability of real and financial assets or, in other words, which means that volatility of prices does not represent threat to the monetary stability and to employment level close to the natural rate.

Broader view suggests that financial system is in 'the range of stability' if it is able to positively contribute to the performance of an economy and does not impede it (Schinasi 2004). In the concept of a range of stability, stability is viewed as a continuum rather than the equilibrium. A set of boundaries is constructed in this approach, ensuring balance of financial system. For a system to be considered stable, it must be also resistant to or be able to mitigate both the endogenous or exogenous shocks. Schinasi (2004) does not exclude the possibility that the financial system can itself be a source of imbalances, and therefore have a negative influence on the real economy.

More recent studies highlight the ability of the financial system to withstand shocks and maintain effective allocation of savings, transmission of information, and well functional payment system, or purely consistent credit supply needed for the growth of the real economy [Freedman & Goodlet (2007), Rosengren (2011)].

Although the above-listed definitions approach the concept of financial stability form different perspectives, the following features are common for most of definitions.

- Financial stability is a state of the financial system, which is viewed as a complex encompassing all the participants, and which describes interactions between these participants.

- Financial system is interconnected with the real economy, and the financial stability is assessed according to the potential consequences for the real economy. Therefore, a particular failure of the financial system does not have to be viewed as a threat to the financial stability, because the damage to real economy might not arise (Borio & Drehmann 2009).

- A stable financial system facilitates an efficient allocation of resources, and effectiveness of a wealth accumulation and other economic processes. Such kind of system is able to clearly assess, price, and allocate financial risk, and therefore fulfills its functions (Schinasi 2004).

In recent years, many central banks have adopted a special definition of financial stability (see Table 2.3). Most of these banks place an emphasis on

system's ability to fulfill its role of providing resistance against shocks. For example, the Bank of Japan adds confidence in the system into the definition, and the Reserve Bank of Australia and the Czech National Bank also point out to implications for the real economy.

Table 2.3: Selected central bank definitions of financial stability

| **Central bank** | **Source** | **Definition** |
|---|---|---|
| Bank of Canada | Financial System Review, 2011 | "Financial stability is defined as the resilience of the financial system to unanticipated adverse shocks, which enables the continued smooth functioning of the financial intermediation process." |
| Bank of Japan | www.boj.or.jp | "Financial system stability refers to a state in which the financial system functions properly, and participants, such as firms and individuals, have confidence in the system." |
| Czech National Bank | Financial Stability Report 2011/2012 | "The CNB defines financial stability as a situation where the financial system operates with no serious failures or undesirable impacts on the present and future development of the economy as a whole, while showing a high degree of resilience to shocks." |
| Central Bank of Iceland | Financial Stability Report 2010 | "Financial stability means that the financial system is equipped to withstand shocks to the economy and financial markets, to mediate credit and payments, and to redistribute risks appropriately." |
| Deutsche Bundesbank | www.bundesbank.de | "A stable financial system fulfils its central macroeconomic functions smoothly and at all times. This includes, in particular, the efficient allocation of financial resources and risks as well as the provision of an efficient and secure financial infrastructure." |

Continued on Next Page...

Table 2.3 – Continued

| Central bank | Source | Definition |
|---|---|---|
| ECB | Financial Stability Review, December 2011 | "Financial stability can be defined as a condition in which the financial system – comprising of financial intermediaries, markets and market infrastructures – is capable of withstanding shocks, thereby reducing the likelihood of disruptions in the financial intermediation process which are severe enough to significantly impair the allocation of savings to profitable investment opportunities." |
| Reserve Bank of Australia | www.rba.gov.au | "A stable financial system is one in which financial intermediaries, markets and market infrastructure facilitate the smooth flow of funds between savers and investors and, by doing so, help promote growth in economic activity. Conversely, financial instability is a material disruption to this intermediation process with potentially damaging implications for the real economy." |
| Slovak National Bank | www.nbs.sk | "Financial stability is defined as the condition when the financial system and its various components - such as financial markets, financial institutions, payment systems, securities transfer systems, settlement systems, etc. - reliably and smoothly perform all of their basic functions and are sufficiently resistant to adverse financial and economic shocks." |
| Swiss National Bank | www.snb.ch | "A stable financial system can be defined as a system whose individual components – financial intermediaries and the financial market infrastructure – fulfil their respective functions and prove resistant to potential shocks." |

*Source:* Authors survey

## 2.4 Financial instability

> "Financial instability occurs when shocks to the financial system interfere with information flows, so that the financial system can no longer do its job of channeling funds to those with productive investment opportunities."
>
> *Source:* Mishkin (1999)

The concept of asymmetric information, which leads to adverse selection and moral hazard problems, is the main attribute of this formulation. According to Mishkin, the adverse selection can be explained as a situation in which parties that take on a great risk are willing to take out a loan at a higher interest rate, because they are not so concerned with paying the loan off. Consequently, these parties tend to become selected borrowers. Moral hazard occurs after the money is lent to the borrowers and they behave in such a way that makes the repayment of the loan less likely. When a problem of strong asymmetric information occurs, the financial system is not able to fully recognize it and channel funds to individuals and corporations who have an opportunity of a productive investment. Moreover, a shock to the financial system makes the problem of asymmetric information even worse, and this complication may result in a lack of loans even for those individuals and corporations who would like to channel these funds into productive investment opportunities. This shortage of credit causes a decrease in spending and may ultimately result in contraction of economic activity. Mishkin stresses 4 factors that worsen asymmetric information problems: (1) deterioration in financial sector balance sheet that leads to a cut back on bank lending; (2) higher interest rates which increase the likelihood that the lender is lending at the cost of a great credit risk; (3) increase in uncertainty that causes a greater difficulty to screen out investments with low credit risk from those with high credit risk and (4) deterioration of nonfinancial balance sheets.

High volatility of asset prices and the inability of financial institutions to meet their contractual obligations are the main factor of financial instability. However, Crockett (1997) suggests that a minor volatility in asset prices or particular functional failure of a few financial institutions cannot be seen as financial instability, because there is no measurable effect on a real economic activity or a rate of inflation.

Ferguson (2003) considers financial instability in terms of possible threats to the real economic activity. If asset price stability, credit availability, or aggregate spending close to production ability of economy is not achieved then the financial instability is likely to occur.

Financial instability can be seen as an increased risk of a major collapse of the system or financial crisis. Davis (2003) links this collapse with inability of the financial system to effectively allocate credit and provide payment services. However, the asset price volatility is considered as a characteristic of financial instability, but not necessarily of financial crisis.

Allen & Wood (2006) differ from authors mentioned above in the sense of emphasizing an economic impact on a large number of parties, such as households, companies or governments, which could not foresee an adverse economic development and can be viewed as 'innocent bystanders'. Allen & Wood (2006) consider the non-financial institutions a possible source of financial instability, referring to the example of airlines after September 2001 or British Energy in 2003. Moreover, they exclude an efficient allocation of savings to investment from his definition, since inefficient allocation can be judged after a long period of time, if ever, and is, therefore, useless for a functional definition.

Borio & Drehmann (2009) also differ from other authors in the sense that they do not define features of financial instability but rather suggest that financial system is unstable whenever normal-sized shocks to the system result in an emergence of financial distress or crisis. They also stresse out consequences for the real economy and leave open the possibility that crisis occurs as a result of an endogenous financial cycle or exogenous shocks. Rosengren (2011) considers financial instability a situation in which the real economy is negatively influenced by instability of the intermediation credit supply caused by institutions, markets, payment systems, or financial system in general and accentuates the role of financial intermediation as a vital service for a well-functioning economy.

We can distill some common points.

- Financial instability is assessed according to consequences for the real economy.
- Financial instability occurs when financial system is not able clearly allocate and provide credit to market participants, and provide payment services.

- High volatility of asset prices is a typical characteristic of financial instability; however, high volatility might not necessarily be a cause of financial crisis.

## 2.5 Financial stability versus instability

We have already examined both approaches to defining financial stability. The first approach, defining financial stability is a broader concept that emphasizes complexity of financial system and its relation to the real economy. Within this approach stable financial system is viewed as positively contributing to the real economy and, therefore, fulfilling its function. On the other hand, financial stability concept is far away from explicit definition because financial system is intricate and complex, therefore, difficult to design or evaluate. Moreover, financial stability is a dynamic concept evolving over time, problematic to control and, innovation in such kind of system often brings about new sources of vulnerabilities.

An intention to narrow the definition of stability is apparent from the definitions presented above. Some earlier authors consider even monetary stability as an assumption for financial stability. However, later definitions specify effective allocation of savings, sufficient credit supply, and functional payment system. In this view, later definitions approach financial instability as a more measurable concept. The trend of definition narrowing is probably particularly forced by an increased need to effectively measure financial stability, even though at a cost of exclusion some important stability aspects.

Second concept, defining financial instability is relatively more factual, due to an excessive volatility and crises, which are better observable and quantifiable. The definitions of financial instability include specific components, such as credit availability, asset price stability, and provision of payment services with respect to impact on real economy.

Authors are not uniform if it is desirable to define financial stability as what it is at the cost of further practical inapplicableness, or it is more preferable to define financial stability as what it is not at the cost of oversimplification. Allen & Wood (2006) defend defining financial instability, and concludes that stability is incompletely observable because the stable financial system is that it dampens shocks, rather than amplifying them, however, stable financial system provides a different response to every new conceivable shock. Thus, they pro-

pose to define instability first and, subsequently, define stability as a property of an economic system resistant to instability.

On the other hand, Schinasi (2004) argues that defining financial stability is more useful policy objective explaining that defining financial instability as a policy objective could lead to sacrificing both private and social benefits of finance. He claims that definition of financial instability does not leave "open the possibility of assessing whether the private and social benefits of finance can be increased further". The risk of sacrificing these benefits is particularly compelling in undeveloped financial systems.

On the fringe of main stream economics, Minsky (1992) proposes the Financial instability hypothesis asserting that over period of financial stability encouraged excessive risk taking inevitably leads to the period of financial instability. Thus the financial stability and instability are closely tightened to a cyclical view of finance. This theory was precisely opposite to most central banks' policy which assumes that price stability, stable employment, or financial stability can be reached and financial instability can be prevented if sufficient protective measures are applied. Essentially, Minsky (1992) accords with observed 'paradox of financial instability' meaning that financial system may seem to be stable at the time when it is precisely instable and under stress (Borio & Drehmann 2009). From this view it is onerous to measure financial stability because it implicitly includes financial instability.

# Chapter 3

# The role of measurement

Measurement has two main roles. The first role is to evaluate how policymakers responsible for maintenance of financial stability carry out this task. For this purpose, the ex post measurement assesses whether the financial stability prevailed or not during a particular period. The second role is to support policymakers in their effort to implement new policies. This role requires ex ante measurement, an assessment of financial system at present.

To assess whether financial system was stable or not in a particular past period, policymakers should be able recognize financial distress or crisis ex post and find out whether this financial distress was the result of financial instability or extreme exogenous (unavoidable) shocks (Borio & Drehmann 2009). If the financial distress has not hit the economy, the task is onerous because the financial system can be unstable even if no financial distress occurred.

The ex ante measurement has a more problematic task to solve. Ex ante measurement serves as a basis for preventive action and, at the time when the financial distress occurs, the ex ante measurement fails to some extent to fulfill its role to enable prevention of a distress occurrence. The requirements for ex ante measurement are more demanding than are those for ex post assessment. The measurement should be rather leading, as opposed to contemporaneous; it should be able reliably capture the likelihood and cost of future financial distress in real time.

Before focusing on tools that are actually used in policy-making institutions, it might be useful to propose desirable characteristics of an ideal measure. An optimal measure should reflect a structure of economy linking set of variables, policy instruments and exogenous shocks. Such measure ought to permit ex post as well as ex ante financial distress identification. The ex post identifi-

cation should be able distinguish between distress caused by past exogenous shocks and endogenous forces, while the ex ante identification ought to generate reliable and leading assessment of future financial distress, for instance, in the way of expected cost of financial distress complemented by the probability distribution of distress. Policymakers could use this measure for calibration of discretionary actions taken to keep financial system safe.

The following four chapters focus on tools that are presently used by the policy-making institutions, including balance sheet and market indicators, financial stress and conditions indexes, probabilities of defaults, and more sophisticated early warning indicators. All these methods reflect actual and past economic conditions to produce assessment of current or future financial stability states. They are not intended to model different future scenarios such as stress test can do.

# Chapter 4

# Indicators based on balance sheet items and market data

Policymakers, especially central banks, have developed a set of simple indicators and ratios which combine data available from balance sheets of financial institutions, macroeconomic variables, and market data. These indicators are typically monitored monthly or quarterly, and their results are published in financial stability reports and on websites of central banks. The purpose of use of these indicators is to measure the current financial health and support macro prudential policy of central banks.

Stability of the real sector is assessed through a real GDP growth, price inflation, rate of public debt to GDP, real exchange rates, interest rates, etc. These indicators usually evaluate an overall performance of the economy, ability of central bank and government to manage public debt, inflation, and trade position in international comparison. Banking sector is assessed by indicators of capital adequacy, liquidity, nonperforming loans, and leverage. When evaluating the financial sector, data on equity prices, volatility, and spreads are considered. The purpose of evaluation of the financial sector is to assess availability of credits and market uncertainty. Financial markets usually promptly react to all economic events, and thus readily reflect market vulnerabilities.

Evaluation of financial stability of the household sector takes into consideration data on household debt, assets, and income. These indicators suggest an extent to which the households are able to bear unfavorable economic conditions and withstand unexpected shocks. The default rate and household debt directly influence the banking sector through credit availability. Consumption has a direct influence on GDP. Accordingly, corporate sector's health can be

gauged through number of defaults, debt to equity, and net foreign exchange exposure to equity. A detailed description of commonly used indicators classified into particular sectors can be found in Table 4.2.

The International Monetary Fund (IMF) in collaboration with the World Bank (WB) developed a system of 40 Financial Soundness Indicators. The 'core set' includes 12 indicators chosen solely from the banking sector. These indicators are considered to be the most important measurement tools, and therefore they have been constructed for each country (Table 4.1). The core set is close to the popular CAMELS methodology, except the fact that it does not include the management qualitative measure.[1] The 'encouraged set' covers other indicators from the banking sector, financial corporations, nonfinancial corporations, household, and real estate market (see Table A.1).

Table 4.1: Core set of Financial Soundness Indicators

| **Deposit taking institutions** | |
|---|---|
| Capital adequacy | Regulatory capital to risk–weighted assets |
| | Regulatory Tier 1 capital to risk–weighted assets |
| | Nonperforming loans net of provisions to capital |
| Asset quality | Nonperforming loans to total gross loans |
| | Sectoral distribution of loans to total loans |
| Earnings and profitability | Return on assets |
| | Return on equity |
| | Interest margin to gross income |
| | Noninterest expenses to gross income |
| Liquidity | Liquid assets to total assets (liquid asset ratio) |
| | Liquid assets to short–term liabilities |
| Sensitivity to market risk | Net open position in foreign exchange to capital |

*Source:* IMF.org

Under the auspices of IMF, and in co-operation with national authorities, a single methodology for the construction of Financial Soundness Indicators has been developed and is now being used across countries, allowing authorities to conduct a comparative analysis of financial health of different countries. The application of the indicators is much more easy compared to other measurements of financial stability, and therefore, FSIs are widely used by financial regulators.

[1] CAMELS is a method of evaluating the bank's overall conditions based on capital adequacy (C), asset quality (A), management quality (M), earnings (E), liquidity (L), sensitivity to market risk (S).

On the other hand, critiques point out that some indicators are reported on low frequencies, and that they focus on the individual financial institutions without taking into consideration other entities. Moreover, the current crisis also revealed some weaknesses of Financial Soundness Indicators. According to IMF (2009), these indicators were not able to clearly distinguish the institutions that needed during the crisis a government intervention from those who did not. While the financial leverage indicators were particularly informative, the capital-to-asset ratios and non-performing loan data proved to have only a little predictive power. Due to off-balance sheet exposures, the key vulnerabilities were hardly anticipated and many failed institutions still met minimum capital requirements. As a response to the above listed deficiencies, the IMF (2009) suggests to include more indicators on leverage and stock market performance, and to redefine the capital adequacy ratios. While the Financial Soundness Indicators need to be broadened to better capture off-balance sheet exposure and complemented by other measurement methods to effectively assess financial condition of the developed countries, for countries with an undeveloped financial system and a lack of available reliable market data the Financial Soundness Indicators remain an essential evaluation tool.

Analogous to Financial Soundness Indicators, the European Central Bank (ECB) regularly monitors 'Macro-prudential Indicators'. These indicators are even broader than those monitored by IMF. Most central banks monitor a set of self-defined indicators and publish them regularly in the financial stability reports. These reports include policymakers' assessments of particular indicators, and hence an assessment of current financial stability of states and an estimation of their future development emphasizing potential threats.

Basic indicators are easily constructed and interpreted. These indicators are micro-based and they have to be examined jointly to provide an overall assessment of financial stability. Therefore, the final expertise can be negatively affected by a wrong interpretation of relationships among the basic indicators. Moreover, indicators such as non-performing loans or loan loss provisions are rather backward looking and contemporaneous, and do not provide sufficiency to be leading indicators of a financial distress. They can be useful in richer analysis or become forward-looking in case of being embedded in a framework of the dynamics of instability, e.g. endogenous cycle view (Borio & Drehmann 2009).

Table 4.2: Variables commonly used in financial stability reports

| **Sector** | **Measure** | **Frequency** | **What do they measure** | **Signalling properties** |
|---|---|---|---|---|
| Macroeconomic environment | GDP growth | Q or A | Strenght of the macroeconomy | Negative or low positive values signal economic slowdown, excessively high values indicate unsustainable growth |
| | Public finance deficit, debt | A,Q or M | Financial position of sovereigh debtor | High values ralative to GDP signal unsustainable government indebtedness |
| | Inflation | M or A | Rise in prices | High values of inflation indicate decrease of value of money, loss of confidence in central banks' policy and its inability to maintain financial stability, and structural weakness in the economy |
| | (Real) interest rates | D | Cost of credit | Real interest rates above certain limit can indicate economic growth above trend. Low or negative values can signal banks' struggle for deposits |
| | (Real) exchange rates | D | Over-/undervaluation of a curreancy | Appreciation of currency may lead to loss of export competitiveness and large capital inflows |
| | Balance of payments current account | A,Q or M | Trade position of country | Trade deficits have to be financed by capital inflows |
| | Foreign exchange reseres | D | Stability of country | Reserves below short–term foreign debts can signal problems |
| Banking sector | Capital adequacy | Q or A | Capital reserves for unexpected or expected losses | Low levels signal potential vulnerability of institutions in case of unexpected or expected losses |
| | Liquidity ratio | Q or A | Banks' ability to meet short-terms debts obligations | The higher the value of the ratio, the larger probability of repayment of debts |
| | Non-performing loans | Q or A | Riskiness of banking sector | High level of non-performing loans, excessive loan growth or increased leverage ratios can indicate crisis |
| | Growth in loans | M | | |
| | Leverage ratio | Q or A | | |

Continued on Next Page...

Table 4.2 – Continued

| **Sector** | **Measure** | **Frequency** | **What do they measure** | **Signalling properties** |
|---|---|---|---|---|
| Financial markets | Change in stock equity indexes | D | Net worth of firms comprising the index | Above–trend growth may indicate equity price bubble |
| | Bonds spreads | D | Riskiness of debt compared to risk–free instruments | High levels of spreads can indicate greater risk or change in risk apetite |
| | Market liquidity | D | Price of liquid instuments | High levels can indicate disruption in market liquidity |
| | Volatility | D | Intensity of price movements on markets | High volatility can indicate disruption of market liquidity |
| | House prices | Q, A or M | | Excessively high house prices indicate house price bubbles |
| Household sector | Household asssets (financial, real estate) | A,Q or M | Assets and debt can be used to compute net household assests. | Households' ability to weather economic downturn |
| | Household debt | A, Q or M | | |
| | Household income(labour income, savings income) | A, Q or M | Net disposal income | |
| | Household expenses (debt expenses, consumption) | A, Q or M | | |
| | Default rate | A, Q or M | Insolvencies in the household sector | Households' ability to meet payment obligations |
| Non–financial corporations | Total debt to equity | Q or A | Corporations' leverage | High levels signal problem with repayment of obligations |
| | Earnings to interest and principal expenses | Q or A | Corporations' ability to meet payment obligations relying on internal resources | Low levels signal inability to meet debt obligations |
| | Net foreign exchange exposure to equity | Q or A | Currency mismatch | Adverse currency moves may cause serious problems to corporate sector |
| | Corporate defaults | Q or A | Insolvencies in the corporate sector | Corporations' ability to meet payment obligations |

*Source:* Author's survey, Gadanecz & Jayaram (2009)

# Chapter 5

# Aggregate indicators

Recently, significant efforts of national authorities and financial institutions have been made to produce a single statistic indicator, which would include all relevant information on financial system stability. With regard to complexity of financial system, these efforts may seem to be a fruitless attempt of simplification.

The construction of composite index involves two main tasks: data selection and weighting schemes. The thesis focuses on two main streams of indicators. First, financial stress indexes specialize on financial market and are less concerned with other sectors of economy. Contrary, financial conditions indexes comprise broad spectrum of data from majority of economic sectors. The construction of both indexes involves a lot of alternatives. For example, either only the current data or also lagged financial variables can be included. In the same fashion, either a level of each variable or standardized variables can be used. Some approaches construct index by combining data series using chosen type of weights, others divide variables according to markets or themes and then constructs markets sub-indices. The overall index is then a combination of these sub-indices.

Another task is selection of weighting schemes. The most used principal component the analysis benefits from is its ability to capture an individual importance of each indicator from a large pool of indicators. The method transforms a number of correlated variables into a smaller number of uncorrelated variables by identifying orthogonal eigenvectors of the variance-covariance matrix of data. Each eigenvector (called a factor) represents a linear combination of data and can explain certain percentage of the overall variability in the original data. A single factor can explain majority of variability, as do three or

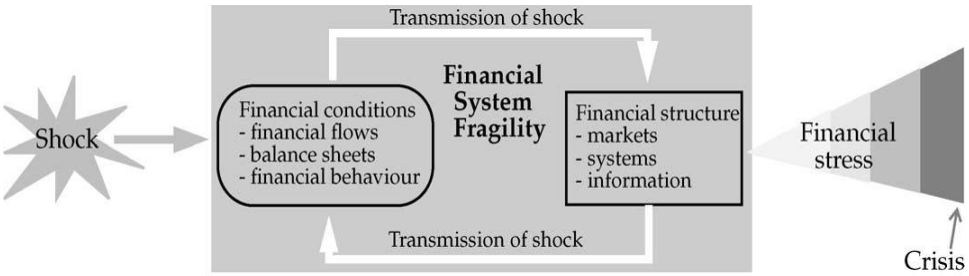
four eigenvectors. If more eigenvectors explain data variability, then weighted vector is created by taking the weighted sum of particular eigenvectors. Thus, variable strongly correlated with other variables receives higher weights, and small changes in strongly correlated variables have stronger effect than small changes in slightly correlated variables. Even though the principal component analysis is broadly used, some critiques aim at logical justification by reasoning that weights are subject to the quality and specialty of data.

Credit weights approach divides variables into sectors to which they pertain, giving each sector different weights relatively to its size. Equal weights or variance-equal weights, which subtract a mean from each observation and divide its sample by standard deviation, suffer from a lack of economic background. Another approach transforms variables based on their sample cumulative distribution function (CDF). The transformed variables are averaged (geometric or arithmetic mean). The average represents the level of index.

## 5.1 Financial stress indexes

According to Hakkio & Keeton (2009), financial stress is characterized by an increased uncertainty about fundamental value of assets, behavior of other investors, increased asymmetry of information, and decreased willingness to hold risky and illiquid assets. Carlson *et al.* (2012) add the notion of higher volatility and common movement of asset prices during a stress period. Financial stress increases with an expected financial loss and uncertainty, and is a product of a vulnerable structure and exogenous shocks (see Figure 5.1)(Illing & Liu 2006).

Figure 5.1: Financial system fragility




*Source:* Illing & Liu (2006)

Financial stress indexes (FSIs) are constructed to provide information about

fragility of financial markets and an exposure of financial sector to unfavorable economic conditions. FSIs are snapshots of contemporaneous level of stress and do not intend to have a strong power to predict future stresses or crises. Nevertheless, their lagged values can be used in a richer analysis that predicts future stresses or crises. Interpretation of indexes comprises a comparison with historical values.

Among developed models, works of Illing & Liu (2006) and Nelson & Perli (2007) represent two main streams. While Illing & Liu (2006) rather directly combine indicators into one statistic, Nelson & Perli (2007) use logit model and their index represents a probability of crisis occurrence. Carlson *et al.* (2012) emphasize that the stress index developed based on the logit model is descriptive and is not designed as an early warning system, since it does not predict the likelihood of financial crisis over any particular time horizon.

Nelson & Perli (2007) introduced financial fragility indicator, which includes 12 variables such as spread, volatility, and liquidity indicators. First, three sub-indexes are calculated based on the variables' levels, their rates of change, and their correlations. Second, some historical crisis period is defined as a benchmark, and estimated logit model examines whether three sub-indexes are behaving alike during that crisis period. Coefficients of sub-indexes from the logit regression are used as weights to combine the three sub-indexes into an overall index. This final index refers to a probability of a crisis occurrence. Carlson *et al.* (2012) follow methodology of Nelson & Perli (2007) with slightly different variables.

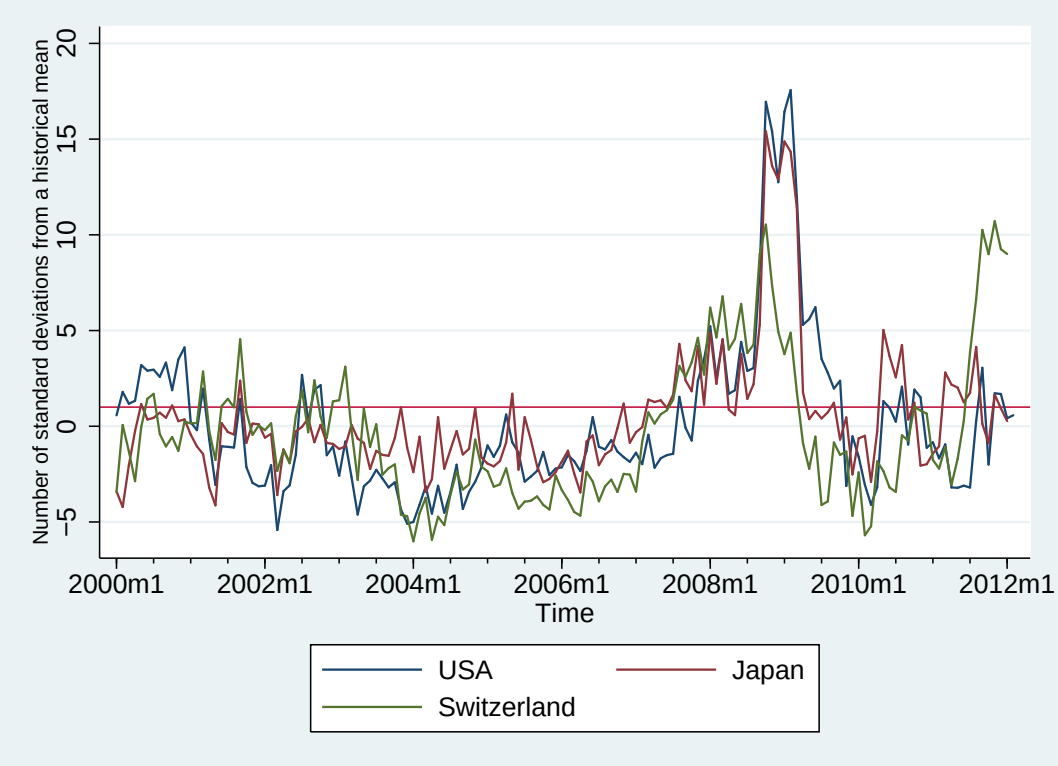
Illing & Liu (2006) constructed financial stress index for Canada (see Table 5.1). In their work, they tested several different variables and weighting schemes, and each index was assessed according to two criteria: the Type I error and the Type II error.[1][2] Among tested methodologies, variables chosen based on a literature review and combined using credit weights proved the best performance with 13% probability of Type I error and 33% probability of Type II error. On the contrary, the factor analysis proved to be a less convenient approach. Variables are chosen from banking, foreign exchange, debt, and equity market. The index ranges in value from 0 to 100, with 100 being the maximum historical value of the index.

[1]The Type I error is the probability that one rejects the null hypothesis when it is true. In our case, Type I error is the probability that the crisis is rejected when it really occurs.

[2]The Type II error is the probability that one rejects the alternative hypothesis when the alternative hypothesis is true. In other words, the crisis cannot be rejected, although, the crisis doesn't occur.

Using approach for Canadian index, Elekdag *et al.* (2009) developed financial stress index for 17 countries constructed as a variance-weighted average of three sub-indexes. However, the financial stress index includes variables different from those used in the index developed for Canada. The reason for this modification is that financial stress in a small open economy, such as Canada, has different specifications than common financial stress that is measured for 17 different countries.

Figure 5.2: IMF Financial Stress Index

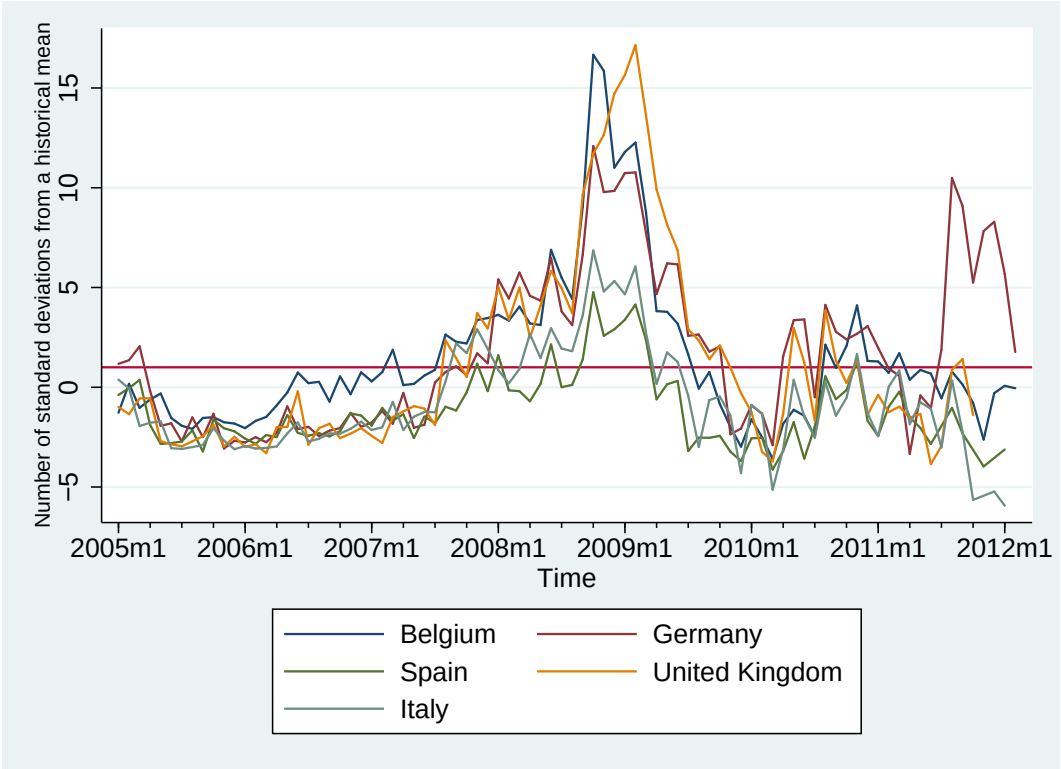



*Source:* Data provided by Stephan Danninger, IMF

Tytell *et al.* (2009) developed IMF financial stress index which is nearly the same as index developed by Elekdag *et al.* (2009). However, some differences can be found. The IMF Financial Stress Index includes two groups of countries - advanced and emerging - and for each group the index includes different variables, again, due to different sources of financial stress in advanced and emerging countries. The index is scaled as a standard deviation from the average conditions. A value of 1 or higher for advanced countries and 1.5 or higher for emerging countries signals financial crisis. According IMF Financial

Stress Index for the United States, Japan and Switzerland, financial crisis occurred first in Japan in March 2007, followed by financial crisis in Switzerland in July 2007, and unexpectedly financial crisis arose lastly in the United States in November 2007 (see Figure 5.2). This graph also reveals specifications of Switzerland. Although this country has not been hit so strongly by first wave of financial distress with respect to other countries, there is apparent current high stress exposure caused probably by currency restrains as visible in Figure A.1. Graphic comparison of different European countries since January 2005 to February 2012 is proposed by Figure 5.3.

Figure 5.3: IMF Financial Stress Index for selected European countries




*Source:* Data provided by Stephan Danninger, IMF

According to the graph, Belgium, United Kingdom and Germany, all of them economies with developed financial markets, were hit by crisis most intensively from the third quarter 2008 to the third quarter 2009. The graph shows that Germany is currently exposed to severe financial stress. On the contrary, Spain and Italy unexpectedly do not seem to be restrained by financial stress

despite their fiscal problems. These unexpected results are explained by Figure A.2 and Figure A.3. The first graph which covers period from January 2005 to Ferbruary 2012 reveals high German stress in corporate bond markets, in interbank lending and stock market. The second graph for Italy covers period from January 2005 to October 2011. Italy does not experience strong financial stress due to offsetting bank sector stress by positive development on corporate bond markets.

Hakkio & Keeton (2009) introduced Kansas City Financial Stress Index (KS FSI) for the United States. KS FSI was developed directly for the United States, while IMF FSI was constructed to evaluate stress across several countries. Therefore, KS FCI may be more precise in evaluating financial stress for the United States.

Federal Reserve Bank St. Louis developed stress index (STL FSI) for the United States similar to KS FSI. However, it overcomes some limitations of KS FSI by including more variables and, importantly, those variables are available weekly, because significant imbalances often occur in short frequency and weekly data have the ability to reveal them better and more readily (Kliesen & Smith 2010). Oet *et al.* (2011) present Cleveland Financial Stress Index for the United States, which also includes daily data from interbank markets, foreign exchange markets, credit markets, and equity markets. Consistent with findings of Illing & Liu (2006), credit weights are confirmed to be the best performing tool among tested weighting approaches.

Kritzman *et al.* (2011) have introduced a ratio which tries to infer financial stress from asset prices. The so called absorption ratio represents a fraction of a set of assets' total variance explained by a finite number of eigenvectors (principal components analysis). A high values refer to relatively compact financial system, which is prone to greater fragility and in which shocks propagate quickly. Low values of absorption ratio signal that markets are less tightly coupled and therefore less vulnerable to shocks. Brave & Butters (2011) developed financial conditions index based on variables from equity market, money market, and banking sector, using the principal component analysis and measuring the stress in the units of standard deviations that diverge from the average.[3]

[3]We are aware of the confusing terminology. Some financial stress indexes are called conditions indexes and vice versa. Here, we distinguish indexes according included variables and stress scale.

Table 5.1: Selected financial stress indexes

| Index | Freq. | Avail. | Bnking Sector | Securities Market | Others | Method | Interpretation | Countries |
|---|---|---|---|---|---|---|---|---|
| Nelson & Perli (2007) methodology | | | | | | | | |
| Financial fragility indicator, Nelson & Perli (2007) | W | 1994 | | liquidity premium, BBB risk spreads, AA risk spreads, high-yield spreads, 3-month Eurodollar confidence interval, long bond implied volatility, Eurodollar implied volatility, Treasury implied volatility, SP100 implied volatility (VXO), federal funds target – 2-year Treasury, | | Variables are reduced to 3 subindexes representing their level, their rate of change and correlation of variables; logit model estimates the probability of crisis occurence based on 3 subindexes. | Index ranges in value from 0 to 1 representing probabilities of crisis occurence | United States |
| Carlson *et al.* (2012) | D | 1994 | | 12 variables differ slightly from those used by Nelson & Perli (2007), few uncertainty measure replaced by measures of stress in funding | | Variables are reduced to 3 subindexes representing their level, their rate of change and correlation of variables; logit model estimates the probability of crisis occurence based on 3 subindexes. | Index ranges in value from 0 to 1 representing probabilities of crisis occurence | United States |

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Table 5.1 – Continued

| **Index** | **Freq.** | **Avail.** | **Bnking Sector** | **Securities Market** | **Others** | **Method** | **Interpretation** | **Countries** |
|---|---|---|---|---|---|---|---|---|
| Illing & Liu (2006) methodology | | | | | | | | |
| Financial stress index for Canada;Illing & Liu (2006) | D | 1981 | Banking sector $\beta$, inverted yield-curve | Risk spreads, turnover ratios, bid–offer spreads, TSX index | Exchange rate volatility | Credit weights | Index rages in value from 0 to 100, with 100 being the maximum historical value of the index | Canada |
| Elekdag *et al.* (2009) | M | 1980 | Banking sector $\beta$, TED spread, inverted term spread | Corporate bond spread,stock market returns, stock return volatility | Time-varying volatility of monthly changes in the nominal effective exchange rate | Variance-weighted average of three subindexes associated with the banking, securities, and foreign exchange market | Index rages in value from 0 to 100, with 100 being the maximum historical value of the index | Australia, Austria, Belgium,Canada, Denmark, Finland, France, Germany, Italy,Japan, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, and United States |
| IMF financial stress index for advanced countries, Tytell *et al.* (2009) | M;Q | 1981 | Banking sector $\beta$, TED spread, inverted term spread | Corporate spread, stock decline, time–varying stock volatality | Time–varying real effective exchange rate volatality | Variance-weighted average of three sub-indices | Positive values indicate financial strain and how many standart deviations conditions deviate from average conditions, value of 1 or higher is associated with crisis, | Australia, Austria, Belgium,Canada, Denmark, Finland, France, Germany, Italy,Japan, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, and United States |

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Table 5.1 – Continued

| **Index** | **Freq.** | **Avail.** | **Bnking Sector** | **Securities Market** | **Others** | **Method** | **Interpretation** | **Countries** |
|---|---|---|---|---|---|---|---|---|
| IMF Emerging Markets financial stress index, Tytell *et al.* (2009) | M;Q | 1997 | Banking sector $\beta$ | Stock market return, stock market volatility, sovereign debt spreads | Exhange market pressure index, | Sum of all standatized variables | Positive values indicate financial strain and how many standart deviations conditions deviate from average conditions, value of 1,5 or higher is associated with crisis | Argentina, Brazil, Chile, China, Colombia, Czech Republic, Egypt, Hungary, India, Indonesia, Israel, Korea, Malaysia, Mexico, Morocco, Pakistan, Peru, Philippines, Poland, Russia, Slovak Republic, Slovenia, South Africa, Sri Lanka, Thailand, and Turkey |
| United States - Federal reserve banks indexes | | | | | | | | |
| Federal Reserve Bank of Kansas City financial stress index, Hakkio & Keeton (2009) | M | 1990 | TED spread, idiosyncratic volatility of bank stock prices, cross–section dispersion of bank stock returns, | swap spreads, Treasury spreads, bond spreads, Baa/ Aaa spread, VIX index, negative value of correlation between stock and Treasury returns, | | Method of principal components | Each coefficient represents the effect of one-standard-deviation change in the variation on the index | United States |

Continued on Next Page...

Table 5.1 – Continued

| **Index** | **Freq.** | **Avail.** | **Bnking Sector** | **Securities Market** | **Others** | **Method** | **Interpretation** | **Countries** |
|---|---|---|---|---|---|---|---|---|
| Federal Reserve Bank of St. Louis financial stress index, Kliesen & Smith (2010) | W | 1993 | TED spread, LIBOR-OIS spread, yield curve, | Interest rates (2-year Treasury, 10-year Treasury, etc.), corporate index, bond index, VIX index,bond volatility index, | Breakeven inflation rate, | Method of principal components | Each coefficient represents the effect of one-standard-deviation change in the variation on the index | United States |
| Cleveland financial stress index, Oet *et al.* (2011) | D | 1991 | Banking sector $\beta$, bank bond spread, interbank liquidity spread, interbank cost of borrowing, yield curve spread, | Covered interest spread, corporate bond spread, liquidity spread, commercial paper spread,S&P 500 Share Prices, | Trade weighted US dollar exchange index | Credit weights | Units are expressed as standardized differences from the mean. | United States |

*Source:* Author's survey

## 5.2 Financial conditions indexes

Financial conditions indexes assess macroeconomic implications of developments in the financial sector and are usually constructed to analyze an impact on real economic activity of financial markets. Financial conditions index (FCI) includes broader set of variables such as cost of credit, real exchange rates, energy or oil prices, equity prices, etc. FCIs do not have strong predictive power and are rather contemporaneous assessment tools of financial conditions.

Some primary FCIs concentrate on yield curve and its predictive power of future economic activity [Stock & Watson (1989), Estrella & Hardouvelis (1991)]. Later works take into account also the credit risk measured by the commercial papers-Treasury bill spread ((Friedman & Kuttner 1993)), stock market variables (Zarnowitz 1992), or IS curve (Mayes & Virén 2001). Some central banks have constructed their own financial conditions indexes, which complement the macro-prudential indicators monitored by central banks and are published regularly in financial stability reports. Specifically, Financial Stability Condition Index for the Netherlands is an extended monetary index. Besides long-term, short-term interest rates and real effective exchange rate that are also included in the monetary index, Financial Stability Condition Index embraces, in addition, house prices, stock prices, institutions' solvency buffers and volatility of the stock price index (End 2006). In contrast to other FCIs, this index has its critical boundaries (concept of financial stability as a continuum). The lower boundary represents unfavorable conditions and a stress situation. Contrary, index values at the upper boundary represent favorable market conditions that could lead to an accumulation of financial imbalances. The index moves preferably within those boundaries.

Swiston (2008) uses vector autoregressions and impulse-response functions to construct a financial conditions index for the United States. Its goal is to assess an impact of high-frequency movements in financial markets on real economic activity. It focuses on the willingness of lenders to provide funds at the market interest rates with respect to GDP growth, arguing that a net tightening in lending standards of 20 percentage point reduces economic activity by 3/4 percent after one year and 1/4 percent after two years.

Citi Financial Conditions Index gauges the cumulative effect of financial market variables on economic activity (D'Antonio 2008). Each variable is weighted based on its effect on coincidence index as a dependent variable in regression stating corporate spreads and money supply to be the most signif-

icant variables. Bloomberg Financial Conditions Index aims to measure the overall stress in the U.S. money market, bond market, and equity market and to provide assessment of credit availability and cost of credit in financial market (Rosenberg 2009).

Guichard *et al.* (2009) built OECD Financial Condition Index for the United States, Japan, United Kingdom and Euro area as an extension of monetary condition index. Figure 5.4 and Figure 5.5 graphically compare quarterly data of OECD Financial Condition Index with quarterly output gap for the United States, Japan and Euro area over the period 1995 - 2012.

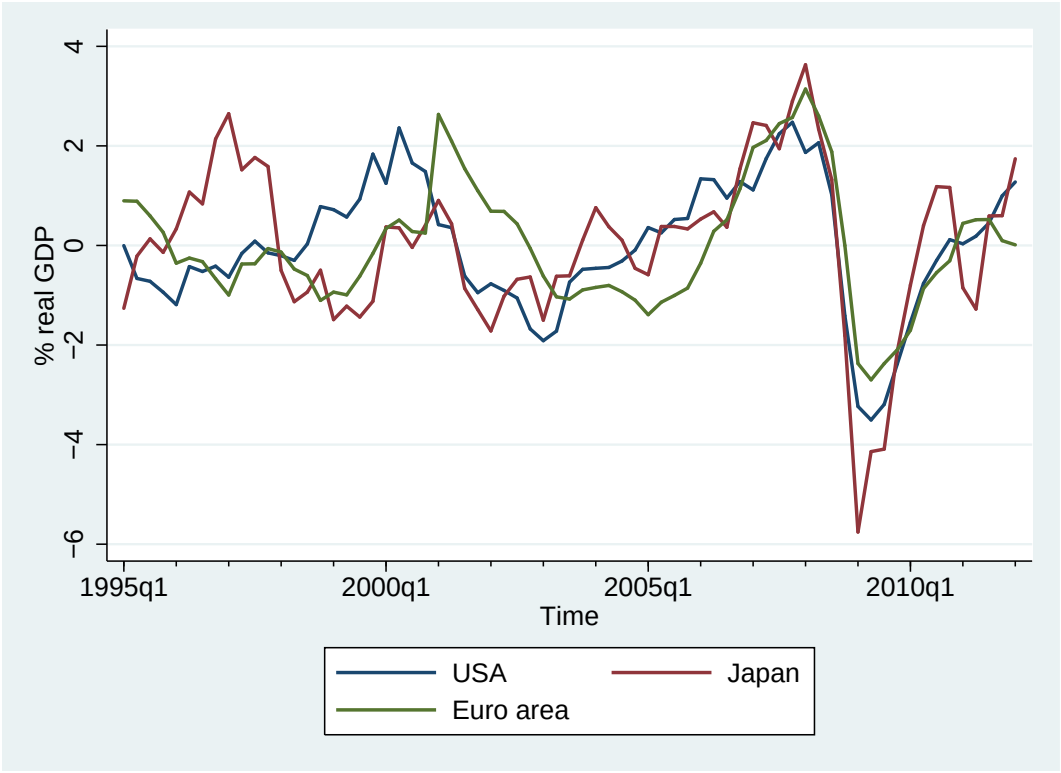
Figure 5.4: OECD Financial Conditions Index


*Source:* Data provided by Stéphanie Guichard, OECD

The output gap was constructed based on quarterly real GDP data using Hodrick-Prescott filter with lambda 1600 to identify time trend in log level real GDP and to compute the cyclical components expressed in percentages. Comparison of output gap for the United States, Euro area and Japan with respective OECD FCI and its lagged values reveals that OECD FCI is closely

linked to the real economy (see Table A.2). Lagged OECD FCIs with the highest correlation with output gaps were identified for the United States, Japan and Euro area, respectively. Results show that OECD FCI for the United States best anticipates movements in output gap 2 quarters ahead and OECD FCI for Euro area 4 quarters ahead, while OECD FCI for Japan best anticipates movements in current output gap (see Figure A.4, Figure A.5 and Figure A.6).

Figure 5.5: Output gaps




*Source:* Eurostat, author's computation

Recently, Hatzius *et al.* (2010) constructed a new financial condition index that tries to overcome a problem of unbalanced panel data. The index is built up from 5 variables at the beginning of the 1970s, continuously adding the next available variables, so that it finally includes data on 45 variables. Hatzius *et al.* (2010) also attempt to eliminate the influence of endogenous movements related to business cycle fluctuations or of monetary policy influences, so that the index represents only exogenous shifts (financial shocks) in financial conditions, influencing or predicting future economic activity.[4] Hatzius *et al.* (2010)

[4]He distinguishes between financial shocks, exogenous shifts in financial conditions, and

present a comparison of predictive power of financial condition indexes and single financial indicators and conclude that, on average, the FCIs outperformed financial indicators and the best FCIs outperformed the stock market index (the best single financial indicator among tested indicators). Matheson (2011) developed financial conditions index for the United States and Euro area, also using the dynamic factor model. Table 5.2 proposes a detailed description and comparison of particular FCIs.

endogenous embodiment of financial variables of the past economic activity that itself predict future economic activity. If only variables with endogenous embodiment were in disposal, past economic activity itself would contain all the relevant predictive information and there would be no reason to construct a financial condition index.

Table 5.2: Selected financial conditions indexes

| **Index** | **Freq.** | **Avail.** | **Bnking Sector** | **Securities Market** | **Others** | **Method** | **Interpretation** | **Countries** |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Swiston (2008) | Q | 1992 | Three-month LIBOR, lending standards, | Yields on corporate bonds,bond spreads, equity returns, | real GDP, the GDP deflator, oil prices, real efective exchange rate, | The reduced–form forecasting equation, weights are generated based on variables effect on GDP(vector autoregressions and impulse-response functions) | In percentage points of annualized GDP growth | United States |
| Citi Financial Conditions Index, D'Antonio (2008) | M | 1984 | | Wilshire 5000 index, corporate spreads | U.S. dollar index, effective mortage rate, money zero maturity supply, energy prices | The reduced–form forecasting equation, weights are generated based on variables effect coincidence index | In terms of standard deviations from average, positive index refers to an expansionary force on the economy | United States |
| OECD Financial Conditions Index, Guichard *et al.* (2009) | M | 1995 | Credit standards, | Stock market capitalisation, bond spreads, real short–term and long–term interest rates, | Real exchange rate, | The reduced–form forecasting equation, weights are generated based on variables effect on GDP | A unit decline in the index implies a tightening in financial conditions sufficient to produce an average reduction in the level of GDP by 1% after 4-6 quarters | United States, Japan, European Union, United Kingdom |

Continued on Next Page...

Table 5.2 – Continued

| **Index** | **Freq.** | **Avail.** | **Bnking Sector** | **Securities Market** | **Others** | **Method** | **Interpretation** | **Countries** |
|---|---|---|---|---|---|---|---|---|
| Bloomberg Financial Condition Index, Rosenberg (2009) | D | 1991 | TED spread, Libor-OIS spread | S&P 500 Share Prices, VIX index, Treasury spreads, | | Equally weighted sum of these 3 sub-indexes (money market, bond market, equity market) | In terms of standard deviations from average, positive index refers to an expansionary force on the economy | United States |
| Hatzius *et al.* (2010) | Q | 1970 | Banks CDS spreads, 3-month LIBOR/OIS,bank credit quantities, idiosyncratic bank stock volatility | Corporte spreads, Treasury spreads, T-bills spreads, Wilshire 5000, commercial paper outstanding, broaker dealer leverage, VIX,... | Prices of oil | Dynamic factor model | Index measured in terms of number of standard deviations away from historical mean. | United States |
| Matheson (2011) | M | 1994 | Bank credit standards, bank credit, 3-month LIBOR/OIS spread, | Bond spreads, stock indexes, money supply, equity prices, corporate spreads, | | Dynamic factor model | Index measured in terms of number of standard deviations away from historical mean. | United States, Euro area |

*Source:* Author's survey

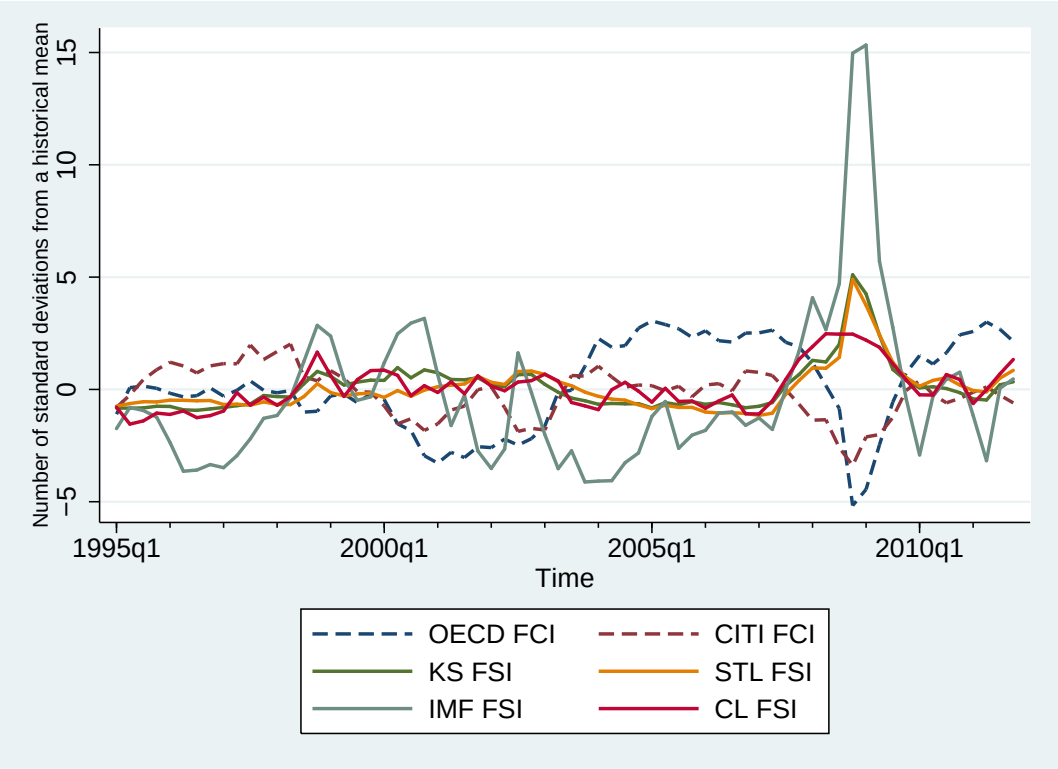
## 5.3 Financial stress indexes versus financial conditions indexes

In previous chapters, two concepts of aggregated financial indexes were described. Even though they are constructed in a similar way, they differ significantly in terms of interpretation and purpose. The aim of this section is to perform an analysis of mutual relations between these indexes, and compare the findings with the theory.

- The data

For purpose of this analysis, we compare 6 indicators for the United States, since we believe that efficient analysis requires that both kinds of indexes refer to the same country and the same period of time. Our analysis covers a period from the first quarter of 1995 to the fourth quarter of 2011 (for detailed description see Table A.3). Based on literature review, the following financial stress indexes and financial conditions indexes are examined: OECD Financial Conditions Index, Citi Financial Conditions Index, Kansas City Financial Stress Index, Federal Reserve Bank St. Louise Financial Stress Index, IMF Financial Stress Index and Cleveland Financial Stress Index. All indexes are expressed in the terms of standard deviations from its historical mean, allowing for an easy comparison. Additionally, an analysis of Kansas City Financial Stress Index and Citi Financial Conditions Index demonstrates how both types of indexes performed during the recent crisis covering a period from January 2007 to May 2012.

Figure 5.6: Comparision of indexes for the United States




- Findings

Based on Figure 5.6, we conclude that FCIs and FSIs are largely mutually inverted. Thus, in a period of strong financial distress, FSIs reach highest values referring to negative effects of a crisis. Contrary, FCIs fall down to their minimal values during period of financial distress. Financial stress indexes developed by reserved banks are strongly correlated affirming similar construction methodology, while the IMF FSI is much more polarized and thus more distinctly separate periods of stress against calm periods confirming the different construction methodology used for IMF FSI (see Table 5.1).

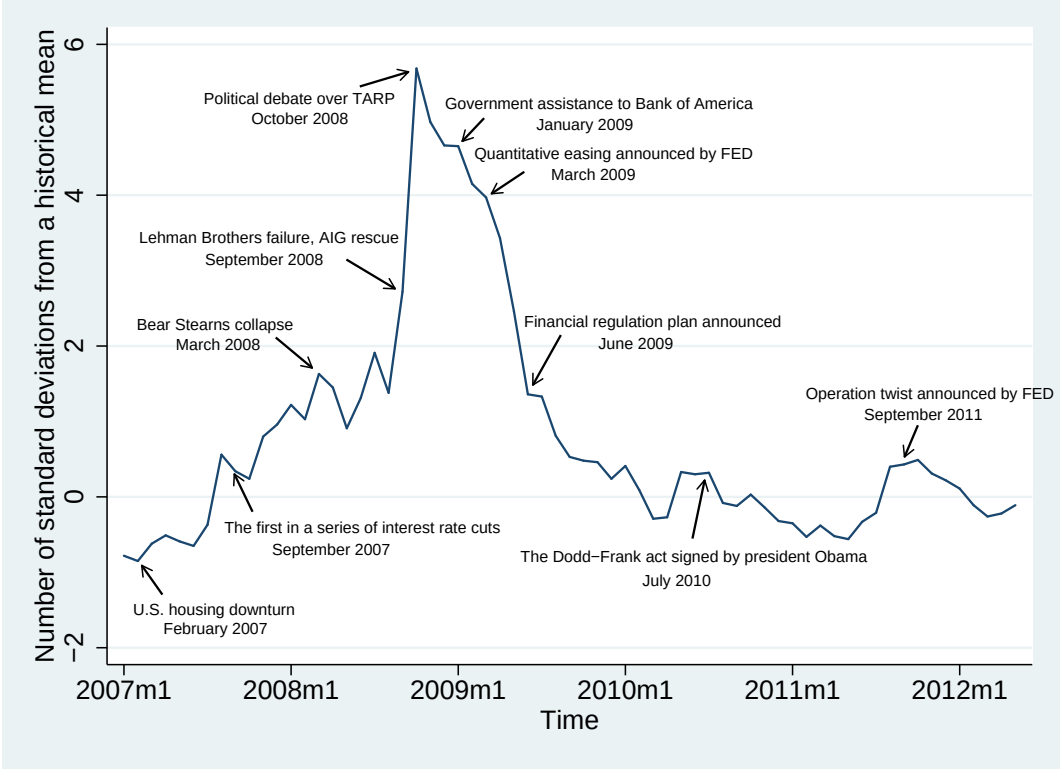
The correlation matrix confirms what graph has suggested (see Figure 5.3). While all financial stress indexes are strongly correlated with pairwise correlations higher than 0.7, the correlation between CITI FCI and OECD FCI is weaker. This finding could refer to the fact that different FSIs capture narrower set of similar indicators from financial markets. However, FCIs use broader set of variables and thus different FCIs refer to different indexes.

Table 5.3: Correlation table

| | **OECD FCI** | **CITI FCI** | **KS FSI** | **STL FSI** | **IMF FSI** | **CL FSI** |
|---|---|---|---|---|---|---|
| OECD FCI | 1.0000 | | | | | |
| CITI FCI | 0.4981 | 1.0000 | | | | |
| KS FSI | -0.6328 | -0.7545 | 1.0000 | | | |
| STL FSI | -0.5800 | -0.7238 | 0.9302 | 1.0000 | | |
| IMF FSI | -0.4975 | -0.6719 | 0.9163 | 0.8036 | 1.0000 | |
| CL FSI | -0.3392 | -0.6852 | 0.8233 | 0.7664 | 0.7128 | 1.0000 |

*Source:* Author's computations

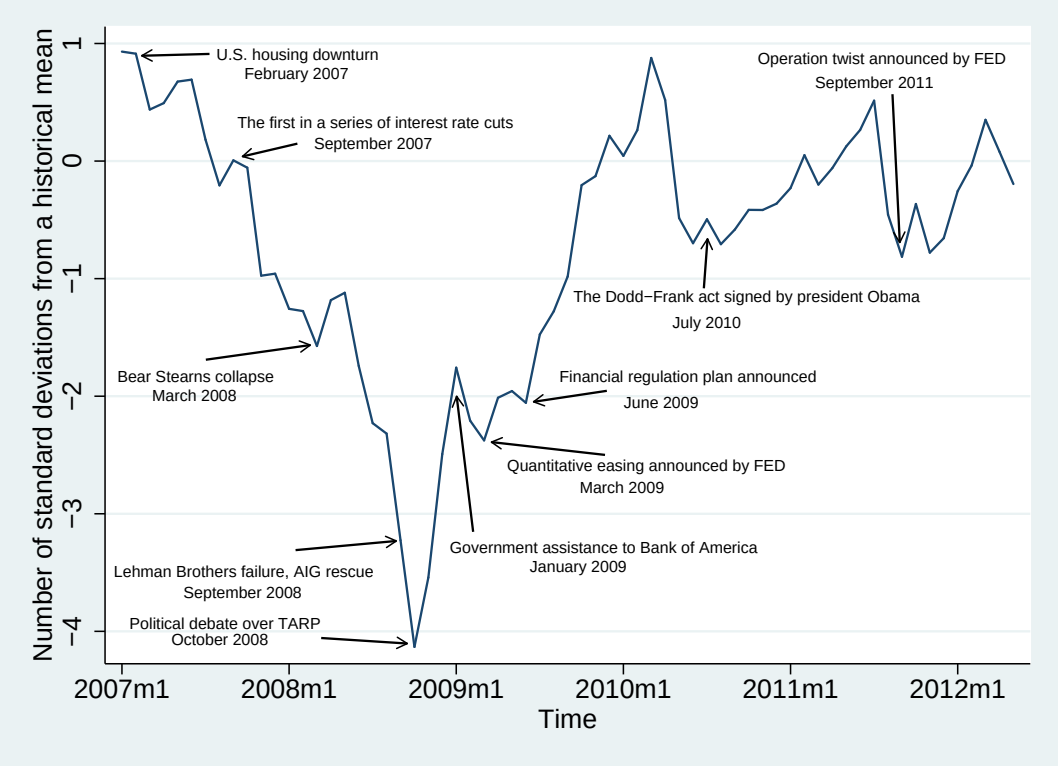
Figure 5.7: Kansas City Financial Stress Index




*Source:* Author's graphics

To analyze how FCIs and FSIs performed during recent crisis, serious economic events are mapped on Kansas City Financial Stress Index and Citi Financial Conditions Index. This analysis reveals how significant events such as

Figure 5.8: CITI Financial Conditions Index




*Source:* Author's graphics

Lehman Brothers failure were reflected by single-statistic indicator (see Figure 5.7 and Figure 5.8). During examined period, Kansas City Financial Index reached broad interval of values deviating by almost 7 standard deviations, while values of Citi Financial Stress Index deviate by 5 standard deviations at most. One reason could be that recent crisis hits more strongly financial markets which FSIs focus on, while FCIs reflect distress in broader scale, which weaken the weights of distress in financial markets. The graphs confirm that both indexes are real time assessment of current financial distress or economic conditions and their ability to relatively promptly reflect significant economic events.

# Chapter 6

# Probability of defaults

## 6.1 Individual institutions' probabilities of default

The proximate objective of micro-prudential policy is to keep sound each individual institution. To do that policymakers need a tool which would allowed them to assess soundness of individual institution with required accuracy. Probability of individual institution's default can meet these requirements with particular success. Generally, it can be estimated based on economic variables, financial ratios, market data and ratings data.

The most widespread approach, ratings, captures the soundness of individual financial institutions such as investment banks, companies, government agencies, etc. They combine information from financial institution's balance sheet with a judgment of a future performance of institutions to estimate the probability of institution's default or expected loss. Ratings are constructed as single statistics, which make them easily comprehensible, and they are issued by credit ratings agencies or by supervisory authorities. In reality, rating agencies are being accused of slow adjustment of particular ratings to unfavorable conditions which is assumed to be one of the key factors of the recent crisis (the financial crisis inquiry commision 2011). Despite policymakers' post-crisis efforts to enhance competition between agencies, to promote transparency, and to reduce the conflicts of interest, the ratings are still prone to be subject of misunderstanding and of inadequate overvaluation of ratings credibility.

Recently, the 'z-score' has been gaining on attention. It is accounting-based indicator defined as an equity capital plus return on asset (both expressed as a percent of assets) divided by standard deviation of return on assets. The advantage of z-score is that it can be used for institutions that lack available

market data. On the other hand, the accounting data are prone to be manipulated and, therefore, dependent on quality of accounting framework (Čihák 2007).

Several indicators have been developed based on prices of financial instruments. The Merton's model is the most popular, especially the KMV Merton's model developed by KMV corporation in the late 1980s.

According to Merton (1973), shareholders hold a call option on the asset value of a company. When the asset value falls below the face value of its debt, the company becomes insolvent and the shareholders' call options are worthless. Due to analogy to option valuation, basic option pricing models are adjusted to estimate the value of debt and equity issued by the company and to derive distance to default for the company's debt describing how many standard deviations the shareholders' call options are in-the-money. The smaller the distance, the probability of default is higher. Hence, the probability of institution's default is the probability of call options expiring out-of-the-money and is a function of three major factors: the market value of the company's assets, the asset volatility and the degree of leverage.

The market value is a measure of the present value of the future free cash flows produced by the firm's assets; the asset volatility represents uncertainty with respect to market value of the firm's assets; and the probability of default of individual firms grows with a higher liability to asset ratio. Nevertheless, these three underlying values for Merton's model – the market value of the firm's assets, the asset volatility and the degree of implied leverage – are not directly measurable and have to be estimated by Black-Scholes pricing method.

An advantage of probabilities of defaults based on the market data lies in the fact that these probabilities are available at a relatively high frequency. At the same time, the market data are useful only if they represent a market that is liquid, transparent, and robust. They cannot be used if the security is not publicly traded, or the trading is limited.

One step forward, probabilities of collective defaults are assessed based on the market value of assets of a number of firms in a certain sample, taking into account volatility and correlation of these assets.

## 6.2 Probabilities of multiple defaults

For micro-prudential policy purposes, individual institution's probabilities of default are sufficient quantitative assessment, while macro-prudential policy

has greater requirements such as evaluating correlations and common exposures across institutions. The aggregation of individual institution's probabilities of default to systemic indicator referring to the probability of multiple defaults and to systemic risk is a challenging task.

In principal, when the probabilities of default of individual institutions are estimated, the probability of multiple defaults can be derived by averaging, using different weights for individual institutions based on their systemic importance. Basic averaging can lead to misleading results, because it does not reflect different sizes or importance of institutions. Weights based on systemic importance of each institution overcome this trouble to some extent, however, not fully.

Another possibility is to consider financial system as a portfolio of individual financial institutions and analyze the distribution of losses and probabilities of defaults (see Table 6.1). This approach better captures correlations and common exposures across institutions than the weighted averaging since variations are allowed to offset each other. Due to this fact, the probability of multiple defaults derived from portfolio of institutions is usually lower than the same probability derived by weighted averaging. The probability of multiple defaults derived from both portfolio approach and weighted averaging depends on a sample of firms that is considered.

End & Tabbae (2005) use the macro financial risk model applying the Merton model to put options of the banking, insurance and pension sector to construct a system-wide stability measure for Netherlands. This measure estimates the probability and the potential loss of stress in the financial system.

Gravelle & Chan-Lau (2005) propose indicator based on the expected number of defaults among a particular number of firms and institutions (expected number of defaults) to assess systemic risk in the corporate sector in Korea, Malaysia, and Thailand using equity prices and balance sheet data. Drawbacks are apparent, such as that the expected number of defaults is not comparable across financial systems with different number of institutions. This measure does not take into account the different systemic importance of institutions (Čihák 2007).

Pascual *et al.* (2006) use an nth-to-default credit default swap basket of large complex financial institutions. The indicator refers to risk-neutral probabilities of multiple defaults. However, this approach does not reflect different institutions' sizes and is more convenient for market participants than for financial stability assessment (Čihák 2007).

Čihák (2007) proposes a measure of default risk in the system derived from the distribution of systemic loss. His indicator combines three elements: probabilities of default in individual financial institutions, loss given default in the institutions, and correlation of defaults across the institutions. This measure is bottom-up, built from individual defaults to systemic loss.

Different approach derives 'prices of insurance against systemic distress' representing the premium that need to be paid for insurance against loss that exceeds certain threshold with given probability (Tarashev & Zhu 2008).

Basurto & Goodhart (2009) propose measurement of banking stability which regards banking system as a portfolio of banks and derives the system's multivariate density reflecting a banks' distress dependence.

The advantage of those indicators is their close linkage to the financial sector, to the business cycle, and their systemic risk sight. Contrary, despite several simplifying assumptions, these indicators are intricate to construct.

Table 6.1: Indicators based on probability of defaults

| **Indicator** | **Advantages** | **Disadvantages** |
|---|---|---|
| Average distance to default (DD), z-score, probability of default (PD) | Easy to calculate from individual institutions' values | Does not reflect contagion (correlation across failures); does not reflect differences in loss given default in institutions, even though that can be partially adressed by weighting; DD requires liquid market in financial institutions' stocks; liquid bond or CDS markets required if those markets are used to estimate PDs |
| Portfolio DD or portfolio z-score | Easy to calculate; ulike simple averaging, reflects to some extent the differences in institution sizes and correlation across institutions | Does not fully reflect contagion, correlation across failures; does not fully reflect differencies in loss given default in institutions |
| First-to-default (FTD) and n-th-to-default indicator | Clear theoretical underpinnings for the nth-to-default indicator | Do not fully reflect different loss-given-defaults (LGDs) in institutions; FTD does not measure systemic risk |
| Expected number of defaults (END) indicator | Relatively easy to interpret | Does not reflect different LGDs in institutions; difficult to calculate, not a closed-form expression; focuses only on central tendency of the ditribution; depends on total number of institutions |
| Distribution of systemic loss | Captures differencies in loss given default in institutions; captures correlation across institutions failures; focuses only on central tendncies | Difficult to calculate in some cases |

*Source:* Čihák (2007)

# Chapter 7

# Early warning indicators

Early warning indicators (EWIs) are constructed to identify risks to financial stability in advance in order to predict timing and occurrence of future crisis. These indicators look for relations between values of particular variables and past crisis periods, and these relations serve as a basis on which EWIs deduce future crisis periods. EWIs can be used to assess risks of a single financial institution as well as a financial system as a whole (Borio 2003).

Gramlich *et al.* (2010) mention two fundamental assumptions behind the early warning system (EWS):

- Causality (stability of relations) exists between crises and crisis-driving factors.
- Crisis driving factors can be identified ex ante.

EWIs are built on a statistical principal. They try to find relationships in historical data, and based on these findings predict and assess any future crisis. Therefore, EWIs are forward-looking rather than contemporaneous measurement methods of financial stability and systemic risk. Since EWIs often predict events in the very near future, they are more useful for investors rather than for macroprudential policy decision makers (Borio & Drehmann 2009). EWIs rely on past relationships, which do not have to hold in the future, due to an evolving financial system that requires redefinitions of these relationships after a certain time interval.

Most of early literature on macro based models deals with currency crisis (Krugman 1979), sovereign crisis (Manasse *et al.* 2003), and banking crisis (Kaminsky & Reinhart 1999). Recently, the focus has shifted to financial crisis (Babecký *et al.* 2011).

In EWS an occurrence of crisis is usually defined by a binary index or by a continuous index [in this respect, continuous index represents crisis incidence rather than crisis occurrence (Babecký *et al.* 2011)]. In early works, the authors defined crisis as a binary state – crisis or no crisis [(Kaminsky 1998), (Kaminsky & Reinhart 1999), (Edison 2003), (Demirgüç-Kunt & Detragiache 1998)]. The historical list of crisis occurrences is usually determined based on consensus of authors and literature reviews. Nevertheless, this approach has been criticized for a lack of ability to capture situations in which strong market vulnerabilities are about to trigger a crisis that at the end does not occur. Some authors tend to overcome this shortcoming by including more state indexes in EWS (Bussiere & Fratzscher 2006).

More recently, authors have concentrated on continuous view of financial distress and crisis incidence represented by indexes that combine different variables into one continuous index [Misina & Tkacz (2008) uses the index developed by Illing & Liu (2006) for Canada, Hanschel & Monnin (2005) use similar type of index for Switzerland]. The continuous indexes capture situations in which strong vulnerabilities are about to trigger a crisis, but they are not sufficiently strong to produce a crisis state in the bipolar view of crisis occurrence. Continuous indexes overcome the problem of a lack of variation in binary approach, and they also partially solve the problem of dating the exact timing of crisis occurrence.

Among other methods, some authors use either the distance-to-default measure (Carlson *et al.* 2009) or another metric that assess systemic risk based on probabilities of defaults.

Authors choose different potential independent variables to explain crisis occurrence. Babecký *et al.* (2011) propose the following three approaches: a) a survey of theoretical papers with a relatively narrow set of indicators and data transformations, b) a systematic literature review encompassing all detected indicators and data transformations, and c) a selection of all the variables and certain transformations in a selected database.

Early works can be classified according to two most widespread methodologies: non-parametric estimation (Kaminsky & Reinhart 1999) and econometric models (Demirgüç-Kunt & Detragiache 1998).

## 7.1 Signals models – non-parametric estimation

The logic behind this model implies that if an individual variable crosses a particular threshold value and thus moves from normal to abnormal state, the financial crisis is likely to occur within a certain period. Kaminsky & Reinhart (1999) point out four steps.

- Define crisis
- Agree on a list of variables as leading indicators for risk
- Define threshold values
- Determine the period between signal and crisis

For each independent variable, threshold value is determined on the basis of minimizing Type I error and Type II error. There is a trade-off between Type I and Type II error, which is summarized by the noise-to-signal ratio.[1] Generally, the Type II error is less relevant, since its consequences are less costly compared to consequences of Type I error; and Type II error is more likely to occur because several protective steps can be applied to avoid a crisis. Each independent variable is transformed into a binary variable based on a comparison with a respective threshold value. Then the binary variable is compared with a crisis binary or continuous index to construct an accurate predictive measure.

Table 7.1: Signal scenarios

| | **Crisis** | **No crisis** |
|---|---|---|
| Signal | Predicted crisis | Type II error |
| No signal | Type I error | Predicted normal state |

*Source:* The author

If the binary indicator signals a crisis within a certain period of time, and the crisis really occurs, then the crisis is correctly predicted (see Table 7.1). The more independent indicators signal a crisis, the higher the probability that such crisis will occur. To capture the overall strength of predicted crisis, the

[1]The noise-to-signal ratio is a ratio of the fraction of Type II error over 1 minus the fraction Type I errors

composite index can be derived by simple counting the issued signals, and averaging them or using different weights for them.

Several disadvantages of signal approach are apparent. First, the transformation of variables into binary variables involves a significant loss of information. Second, the economic system evolves over time, which brings new sources of crisis. Hence, a fixed set of variables can perform differently over time. Also the threshold values are calibrated for a certain period and, therefore, an out-of-sample performance can be less accurate.[2] Third, the way how to aggregate information provided by each indicator is heavily dependent on the judgment without an explicit economic background.

With reference to the Kaminsky (1998), Kaminsky & Reinhart (1999) took the first step in the construction of a system of early warning. They use 16 macroeconomic variables that represent leading indicators for 20 countries for a spanning period of 1970-1995 (For more details see Table 7.2). Each macroeconomic variable is assessed and transformed into the binary variable on a standalone basis. Threshold for each variable is static and determined to minimize the in-sample noise-to-signal ratio for each variable. Nevertheless, this model has also some limitations and drawbacks. Data which are not available at the time when prediction is made can be used, and at the same time data may be chosen to brace up out-of-sample performance at the cost of tenuous economic background (Borio & Drehmann 2009).

Lowe & Borio (2002) built their model on the work of Kaminsky & Reinhart (1999), differing in some areas. The main contribution of Lowe & Borio (2002) is that prediction is made exclusively on information available at the time of prediction. In his model, a combination of indicators, rather than just the single indicators, is used, allowing to determine contribution of various combinations of indicators to the optimal threshold. For example, a banking crisis is predicted for horizons of 1 to 3 years ahead, because it is not possible to predict a precise timing of a crisis and flexible horizons bring broader coverage. The prediction is not made based on absolute values of variables, but the variables are expressed in the form of gaps, which are defined as a ratio of variable's value to GDP deviating from its trend by a specific amount. Threshold values are expressed as percentage deviations from the trend.[3] The gap form of variables leads to a

[2]When developing statistical models, the term out-of-sample performance refers to the model's performance on data that was not in the sample used to calibrate the model's parameters.

[3]Excepting the threshold values for the credit gap which are defined in terms of deviation in the percentage points of the actual credit ratio from the trend ratio

dynamic rather than static form of thresholds.

Edison (2003) extended the EWS developed by Kaminsky & Reinhart (1999) by including more variables. Borio & Drehmann (2009) updated the previous analysis in Lowe & Borio (2002) by including property prices for data spanning from 1970 to 2003. After an assessment of how EWIs predicted recent financial crisis, it was concluded that: a) indicators signal a potential crisis occurrence for a couple years in advance; b) EWIs better reveal a banking risk than a risk that originated in a foreign sector in particular countries due to limited amount of available indicators in an increasingly globalized word.

Despite these facts, Borio & Drehmann (2009) found the EWIs as a potentially useful tool for identifying vulnerabilities associated with credit and asset price booms.

Table 7.2: Selected signal models

| **Authors** | **Year** | **Data** | **Factors and Main Findings** |
|---|---|---|---|
| Kaminsky & Reinhart (1999) | 1998, 1999 | 20 coutries, identifying 76 episodes of currency crisis and 26 banking crisis, of these 18 episodes are common currency and banking crisis, 1970-1995. | Real exchange rate appreciation, equity prices, money multiplier are the most important three factors. However, they have a large Type I error, failing to issue a signal in 73%-79% of the observations during the 24 months preceding the crisis for twin crises and 12 months for banking crises. Thresholds are stated in absolute values. |
| Lowe & Borio (2002) | 2002 | 1960-1999, 34 countries | Relying on the asset prices, credit and investment gaps (gaps refer to the ratio of credit to GDP which deviates from its trend by a specific amount, respectively for asset price and investment gaps) using horizon of 1, 2 and 3 years. |
| Borio & Drehmann (2009) | 2009 | 1980-2003 and test out of sample 2004-2008; 18 industrial countries | Test the behaviour of credit and asset prices (equity and property using gaps from a long-term trend) in the prediciton of financial crisis both in-sample and out-of-sample, with low noise-to-signal ratio over 1 and 3 year horizons. |

Continued on Next Page...

Table 7.2 – Continued

| Authors | Year | Data | Factors and Main Findings |
|---|---|---|---|
| Alessi & Detken (2009) | 2008 | 1970-2007, 18 OECD countries. | Propose 18 real-time and financial indicators for costly asset price booms and find some specifications would have issued persistent warning signals prior to the current crisis. The most robust indicators were: global private credit, long term nominal bond yield, housing investment, short-term nominal interest rate, real equity price index and real GDP. |
| Casu *et al.* (2011) | 2012 | 1980-2009, 30 OECD countries | The model represent improvement of out-of-sample performance in 3-years horizon, with the Type I error under 36%, however the Type II error are significantly higher. |

*Source:* the author, Casu *et al.* (2011)

## 7.2 Logit models

Logit and probit models aim to estimate how the probability of experiencing a crisis is influenced by a set of an independent variables. An advantage of these parametric models is that they take into account interdependencies of explanatory variables. Unlike the signal model, the discrete-dependent variables approach does not transform independent variables into the binary state by comparing the variables with a threshold value. That means that all values of these variables are used for estimation of crisis incidence. Logit models are characterized by their non-linearity meaning that the marginal effect of a change in independent variables of the probability of an outcome is not constant but depends on a precise state of the independent variables. Nevertheless, the results of a logit analysis are more difficult to interpret.

The logit models can be described as follows. The dependent variable expresses the crisis occurrence either by binomial variable (crisis or no crisis) or multinomial index. To distinguish between the crisis period and normal state, some authors make their decisions based on literature review and others establish more arbitrary system of conditions. The probability of crisis occurrence is a function of a set of explanatory variables. The estimate of the crisis probability is obtained by maximizing the likelihood function.

Demirgüç-Kunt & Detragiache (1998) estimate the probability of a banking crisis using the multivariate binomial logit model for data of 65 countries for a period of 1980-1994. This model is binomial in a sense that in each period of time the country is either experiencing a crisis or it is not. Multivariate model allows for more independent variables that explain the crisis.

Bussiere & Fratzscher (2006) also use the multivariate logit model for 20 countries for a period of 1993-2001. Unlike Demirgüç-Kunt & Detragiache (1998), Bussiere & Fratzscher (2006) does not use binomial model and rather replaces the bipolar view of a crisis occurrence by a three state theory.[4] They conclude that his multinomial logit model with three states partially overcomes the 'post-crisis bias', meaning that the binominal logit models fail to distinguish between tranquil period and post-crisis periods because economic variables are adjusted before reaching a more sustainable level.

Demirgüç-Kunt & Detragiache (2005) compare the signal and the logit models and conclude that the logit model surpasses the signal model in its performance. Davis & Karim (2008) compare these two models for a banking crisis and conclude that the logit model better reveals global stress, while the signal model is more suitable for predicting country-specific crisis.

The first generation of indicators focused on currency crisis, banking crisis, and sovereign crisis. After the recent crisis, the focus has shifted to financial crisis and distress, leading to replacement of logit and probit models by more innovative techniques to construct efficient EWS. The new EWIs were expected to overcome previous generation in its predictive power and reflex growing interconnections of the global economy. EWIs newly cover larger samples of both developing and developed countries, including 100 countries, as opposed to previous major interest solely in the developing countries that suffered from the currency crisis, banking crisis, and sovereign crisis.

Rosenberg (2009) tries to find causes of the recent crisis using the Multiple Indicators Multiple Causes model for 107 countries. They conclude that despite a broad set of variables in a flexible statistical framework, they are unable to predict most of the incidence, and, therefore, are skeptical about the predictive power of EWIs. Babecký *et al.* (2011) constructed EWS for 40 EU and OECD countries for the 1970-2010 period, using the panel vector autoregression that allows to examine dynamic linkages between crisis incidence and a set of variables. They pre-selected variables by Bayesian model averaging

[4]They make distinction between a)a tranquil regime, b) a pre-crisis regime, c)and post-crisis, recovery regime.

and extracted 23 indicators out of previously 50 considered based on literature review. They conclude that while GDP, global credit, and commodity prices are the main sources of risk in the global realm, housing prices are the most important domestic indicators. Their results also point out the importance of time lags of leadings indicators included in the model.

# Chapter 8

# How theory meets practise

## 8.1 Early warning systems?

As mentioned previously, an operational framework is the core stone of the assessment of financial stability, and each well-established operational framework should include a measurable definition of financial stability and the process of its measurement.

In previous chapters, theoretical definitions of financial stability and widely used financial stability measurement methods have been introduced.

Based on surveyed definitions, it can be concluded that consequences for the real economy, cost of credit, credit allocation, and asset prices stability are the prevailing elements of the various definitions. In this chapter, measurement methods are assessed according to these elements derived in Chapter 2.

- Ability to involve all participants, institutions, markets and interaction between them into measurable yardstick
- Ability to evaluate consequences for real economy
- Ability to incorporate cost of credit and credit availability restraint into a measure
- Ability to reflect asset price volatility

In addition to elements derived from theoretical definitions, methods are evaluated according their predictive power, as well as their ability to assess systemic risk.

Indicators derived from balance sheet and market data comprise individual assessments of different sectors of economy. They do not have a significant

predictive power and are, at best, real time assessments; some of them are even backward looking. However, central banks and institutions compose their own sets of these indicators for purpose of monitoring financial system stability; most of them include data on asset price volatility, cost of credit, and lending standards. The GDP, GDP growth, inflation, and investments capture the real economy performance. Indicators of bank capital adequacy, asset quality, and liquidity can be helpful in warning against high systemic risk when being used simultaneously. However, recent crisis revealed an inability of these indicators to estimate systemic risk by themselves. Therefore, these factors should be complemented with a more sophisticated approach to monitor systemic risk adequately.

Composite indexes are one step forward. FSIs provide one-statistic assessment of stress and unfavorable conditions of financial markets, comparing the current state with a historical benchmark. These indexes do not attempt to estimate future states of financial distress, they rather offer a simplified and practical formulation of current financial market restrains. The data included in the indexes focus mainly on the securities market complemented by few indicators of capital availability. The one-statistic indicators do not clearly capture consequences for the real economy. But the consequences can be inferred from similar historical events or level of stress.

Analogous to FSIs, FCIs are real time one-statistic assessments that comprise a broader set of data than FSIs. Besides data from securities market, they include information on cost of credit, credit availability, commodity prices, real exchange rates, and interest rates. The broader data set implies that FCIs aim to assess how financial system influences the broader macroeconomic conditions. In respect to theoretical definitions, FCIs are closer to the broad financial stability definition, while FSIs could be assigned to the instability approach. The FCIs reached their peaks during period 2005-2007, precisely when the accumulation of imbalances was intensive. This fact confirms that FCIs do not provide enough timely warning to policymakers. In this regards, FCIs reflect Minsky's hypothesis or the 'paradox of instability' proposed by Borio & Drehmann (2009) meaning that financial system may seem to be stable at the time when it is precisely instable and under stress. Consequences for the real economy are not embedded in the one-statistic approach, but can be inferred from a similar historical event.

Probabilities of individual defaults are a one-statistic real time assessment of individual institutions. For purposes of financial stability assessment, the indi-

vidual institutions need to be evaluated together and preferably complemented by a systemic importance of each institution. They may be constructed by several different methods based on accounting data, macroeconomic data, market data or ratings. The higher systemic importance and probability of default of an individual institution, the higher real loss can be expected. Probabilities of multiple defaults are a one-statistic real time assessment of common exposure to default risk of several institutions. This method takes into account individual institutions and relations among them. Its main advantage is that it captures systemic risk into one single statistic. They can be supplemented by a loss given default, referring to the real economy consequences.

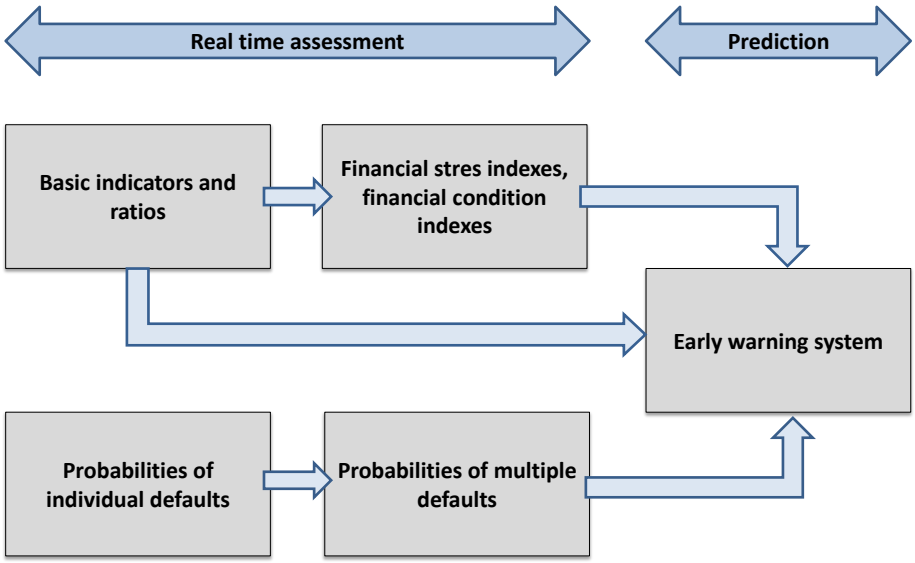
Early warning indicators aim to predict occurrence of future crisis or distress within a defined period of time. They can predict probability of crisis occurrence or as a binary, yes or no, state. Early warning system links the last periods of distress expressed by either a binary statistic or a continuous index with different indicators (asset price volatility, credit standards, GDP, etc.) and tries to detect basic relationships in historical data. The costs of crisis are not directly provided, but some rough idea can be derived from the past episodes of crisis.

The EWS completes and encloses the above mentioned measurement methods (see Figure 8.1). In our survey, we presented two ways of assessment of individual institutions – indicators based on balance sheet items and market data (basic indicators), and probabilities of individual defaults. The next step implies the aggregation of individual indicators into more general and broader metrics. For this purpose, the financial indexes and probabilities of multiple defaults appeared to be suitable.

In addition, the EWS adds one characteristic missing in other methods. The EWS is constructed to be a primarily predictive tool, while other methods are more or less a real time assessment.

Early warning system combines different real time indicators and their lag values to produce a prediction about future states of financial stability. For prediction of crisis, EWS uses composite indicators as well as indicators of individual institutions and sectors. These indicators are both installed into endogenous cycle view models. While financial indexes and probabilities of multiple defaults usually represent a crisis incidence, indicators based on the balance sheet items and market data (basic indicators) try to explain the crisis. Thus, EWS can be seen as a third step in financial stability assessment, because it has a higher predictive power.

Figure 8.1: System of measurement methods




*Source:* The author

Why are EWIs so compelling? Policymakers need to be warned early against crisis in order to be able take protective actions to partially avoid the crisis occurrence. However, protective actions need to be determined and implemented in advance. Even though currently developed EWS that focus on financial stability fall short of expectations, the EWS is still under development, and many new methodologies are examined. Therefore, it is likely that EWS wil becomel in future the right tool to use to successfully predict financial distress.

Table 8.1: Overall assessment of measurement methods

| **Method** | **Real time assessment/ predictive power** | **Single/ multiple statistic** | **Consequencies for the real economy** | **Cost of credit and its availability** | **Asset price stability/ volatility** | **Systemic risk** |
|---|---|---|---|---|---|---|
| Basic indicators | Real time assessment, some indicators are rather backward looking | Multiple statistics from several sector of economy | Inflation, GDP and GDP growth provide rather backward assessment of financial stabilily consequencies for the real economy | Cost of credit and availability is assessd by interest rates indicators or market liquidity indicators | Equity indexes, market volatility indexes, house prices indicators reflect asset price stability | No clear link to systemic stability or risk |
| Financial stress indexes | Real time assessment | Single indicator, aggregated assessment of financial stress on financial markets | It does not aim to capture consequencies for real economy, however long high stress period on financial markets negativelly influence real economy through several channels | Most of FSIs include few variables on capital availability | FSIs reflect uncertainty about the value of assets and include data on asset price volatility, spreads or market indexes | Unclear relationship to systemic stability and risk |
| Financial conditions indexes | Real time assessment | Single statistic, aggregated assessment of macroeconomic implications of developments in the financial sector | FCIs measure consequencies for real economy to high degree | Cost of credit and availability is fundamental aspect of FCIs | FCIs include asset price volatility, however those indicators are used to asses their macroeconomic consequencies. | Unclear relationship to systemic stability and risk |
| Probability of individual defaults | Real time assessment, low predictive power | Individual assessment of different financial institutions | No clear link to consequencies for the real economy | Do not directly measure or comprise cost of credits | Merton model uses asset prices for estimating probabilities of defaults | Do not capture the correlations and common exposures across institutions |

Continued on Next Page...

Table 8.1 – Continued

| **Method** | **Real time assessment/ predictive power** | **Single/ multiple statistic** | **Consequencies for the real economy** | **Cost of credit and its availability** | **Asset price stability/ volatility** | **Systemic risk** |
|---|---|---|---|---|---|---|
| Probabilities of multiple defaults | Real time assessment, low predictive power | Single statistic, aggregated assessment of financial stability and systemic risk | Some measurements comprise also losses given defaults or this loss can be inferred | Do not directly measure or comprise cost of credits | Some measurement methods partially reflect asset prices | Aims to measure systemic risk |
| EWI | Forward looking, predictive power usually up to 3 years | Individual statistic refering to occurence of futuru crisis, aggregated assessment and prediction of finanical stability | According to the strength of predicted crisis, some rough idea of the costs can be derived from historical experience | Cost of credit and its availability are used to preditct crisis | Asset prices serve as a predictor of crisis | Aims to reveal systemic risk in advance |

*Source:* The author survey

# Chapter 9

# Conclusion

Despite the fact that financial stability is a policy objective of many central banks and topic of recent economic discussion, its single widely used definition has not yet been developed. This thesis proposes two broad approaches to the definition of financial stability. (1) Broader concept which seeks to define the term of financial stability emphasizes complexity of the financial system, its interconnectedness with the real economy and fulfillment of its roles. (2) Narrower concept that, on the contrary, attempts to describe what cannot be considered financial stability - the concept of financial instability - emphasizes an ability of the financial system to provide credit to market participants, provide payment services, and keep stable volatility of asset prices. The concept of financial instability is relatively more factual due to its components are better observable and quantifiable.

Quantitative methods are one step beyond the definition of financial stability. They tempt to transform theoretical definitions into measurable yardstick for purpose of evaluating past policymakers' performance as conductors of financial stability policy, and enhancing their efforts in preventive actions against future financial distress.

This thesis points out that the indicators based on balance sheet and market data need to be embedded into broader financial stability framework to produce its overall assessment. Even some of them did not reveal the financial distress during recent crisis pointing at requirement of their additional redefinition and reexamination. Despite these facts, they are still unsubstitutable evaluation tool for countries with undeveloped financial system lacking day-to-day reliable market data, and meaningful financial stability tool for developed countries. Unlike previous indicators, financial stress indexes refer mainly to

stress on financial markets and produce single-statistic real-time assessment. Based on IMF Financial Stress Index data, the thesis shows that Italy and Spain are unexpectedly exposed to less financial stress than Germany despite their fiscal problems, for the reason that Germany suffers from high stress in corporate bond market, while Italy experiences a positive development in this market. IMF Financial Stress Index also confirms the recent high stress in Switzerland caused by currency restrains. Financial stress indexes judge financial stability in a narrower sense, thus, they may be attached to concept of financial instability, while financial conditions indexes rather refer to concept of financial stability. The thesis compares OECD Financial Conditions Index with output gap for the United States, Japan and Euro area and discovers close linkage between Conditions Index and the real economy confirming broader view of financial stability in a framework of these indexes. Probabilities of multiple defaults have contributed to the financial stability maintenance by better capturing systemic risk, systemic importance of individual institutions and potential loss given these defaults. Four so far presented methods - indicators based on balance sheet and market data, financial stress and conditions indexes, probabilities of defaults - are rather real time assessment of financial stability. However, the fifth method, the early warning indicators, proved to be predictive tool and can be regarded as a third step in stability analysis behind multiple and single statistic real-time assessment methods.

Pre-crisis prudential policy was merely preoccupied by stability of individual institutions assuming that the financial system is sound if each financial institution is sound. Based on this assumption, micro-prudential tools were set up with respect to individual institutions leaving out of consideration their systemic importance. The crisis ended the period of the Great Moderation, and policymakers have been forced to change the policy stance to financial stability concerns. The regulatory and supervisory framework moved toward macro-prudential orientation. The macro-prudential shift in policy stance has been inevitably followed by change in requirements on quantitative methods. The attention moved from indicators based on balance sheet and market data, and probabilities of individual institutions towards probabilities of multiple defaults and early warning systems capturing better interconnectedness of financial institutions and thus systemic risk. Early warning indicators are still in development and need to be better set up for stability purposes. Nevertheless, they are likely to be promising way of future prudential policy and a topic of further research.

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# Appendix A

# Appendix

Table A.1: Financial Soundness Indicators

| Core set | |
|---|---|
| Deposit-takers | |
| Capital adequacy | Regulatory capital to risk–weighted assets |
| | Regulatory Tier 1 capital to risk–weighted assets |
| | Nonperforming loans net of provisions to capital |
| Asset quality | Nonperforming loans to total gross loans |
| | Sectoral distribution of loans to total loans |
| Earnings and profitability | Return on assets |
| | Return on equity |
| | Interest margin to gross income |
| | Noninterest expenses to gross income |
| Liquidity | Liquid assets to total assets (liquid asset ratio) |
| | Liquid assets to short–term liabilities |
| Sensitivity to market risk | Net open position in foreign exchange to capital |
| Encouraged set | |
| Deposit-takers | Capital to assets |
| | Large exposurres to capital |
| | Geographical distribution of loans to total loans |
| | Gross asset position in financial derivatives to capital |
| | Gross liability position in financial derivatives to capital |
| | Trading income to total income |
| | Personnel expenses to noninterest expenses |
| | Spread between reference lending and deposit rates |
| | Spread between highest and lowest interbank rate |

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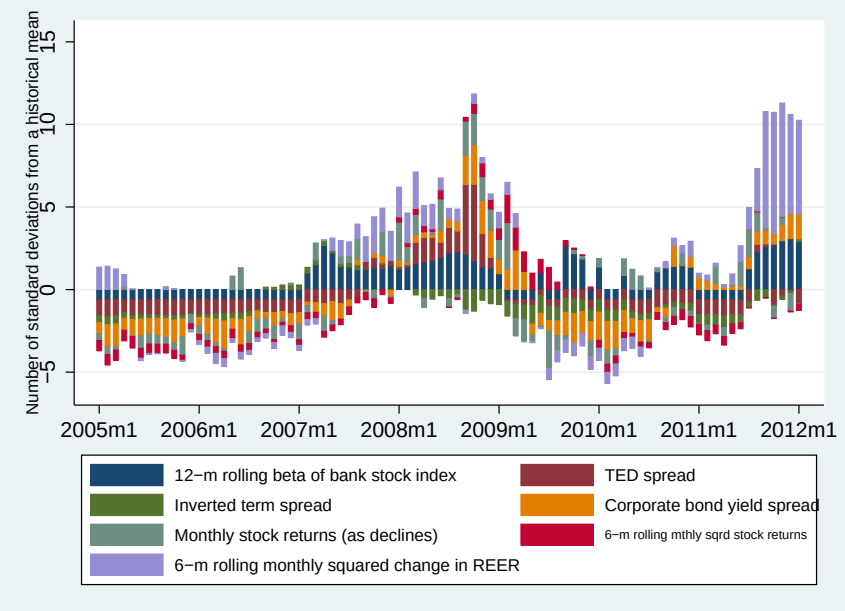
Table A.1 – Continued

| Encouraged set | |
|---|---|
| | Customer deposits to total (noninterbank) loans |
| | Foreign-currency-denominated loans to total loans |
| | Foreign-currency-denominated liabilities to total liabilities |
| | Net open position in equities to capital |
| Other financial orporations | Assets to total financial system assets |
| | Assets to GDP |
| Nonfinancial corporations sector | Total debt to equity |
| | Return on equity |
| | Earnings to interest and principal expenses |
| | Net foreign exchange exposure to equity |
| | Number of applications for protection from creditors |
| Households | Household debt to equity |
| | Household debt service and principal payments to income |
| Market liquidity | Average bid-ask spread in the securities market |
| | Average daily turnover ratio in the securities market |
| Real estate market | Residential real estate prices |
| | Commercial real estate prices |
| | Residential real estate loans to total loans |
| | Commercial real estate loans to total loans |

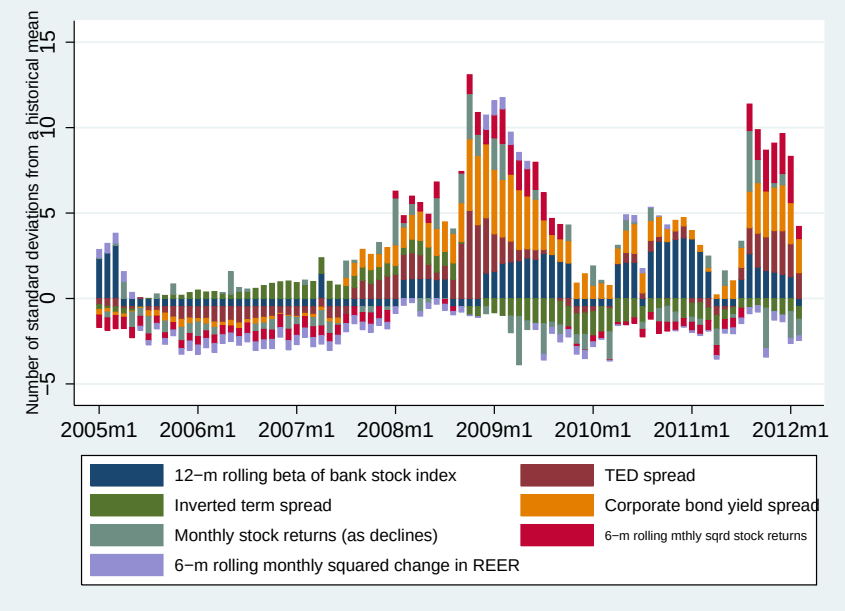
*Source:* IMF.org

Figure A.1: Components of IMF Financial Stress Index for Switzerland



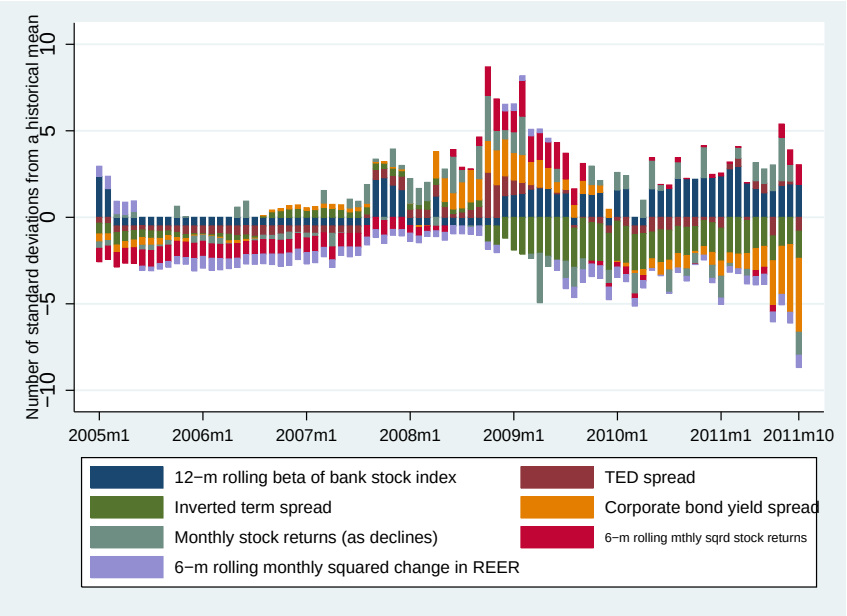

*Source:* Data provided by Stephan Danninger, IMF

Figure A.2: Components of IMF Financial Stress Index for Germany




*Source:* Data provided by Stephan Danninger, IMF

Figure A.3: Components of IMF Financial Stress Index for Italy




*Source:* Data provided by Stephan Danninger, IMF

Table A.2: Correlation table - output gap for Euro area, the United States and Japan with respective OECD FCI and its lagged values

| | Output gap | | |
|---|---|---|---|
| | **Euro area** | **United States** | **Japan** |
| OECD FCI | -0.0234 | 0.3866 | 0.6797 |
| OECD FCI 1Q lagged values | 0.2370 | 0.5602 | 0.6115 |
| OECD FCI 2Q lagged values | 0.4209 | 0.6413 | 0.4813 |
| OECD FCI 3Q lagged values | 0.5641 | 0.6383 | 0.3398 |
| OECD FCI 4Q lagged values | 0.6387 | 0.5673 | 0.1898 |
| OECD FCI 5Q lagged values | 0.6253 | 0.4734 | 0.0281 |

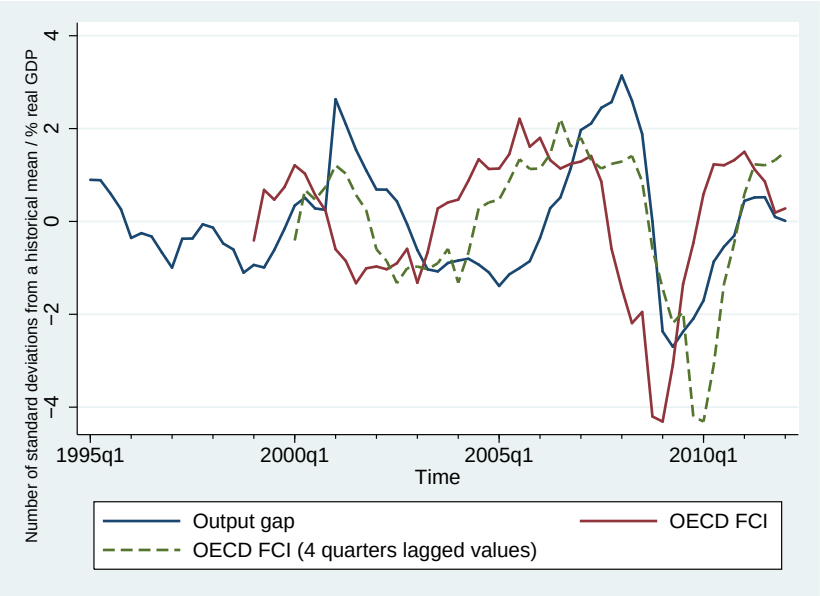
Continued on Next Page...

Table A.2 – Continued

| | **Euro area** | **United States** | **Japan** |
|---|---|---|---|
| OECD FCI 6Q lagged values | 0.5526 | 0.3711 | -0.0929 |

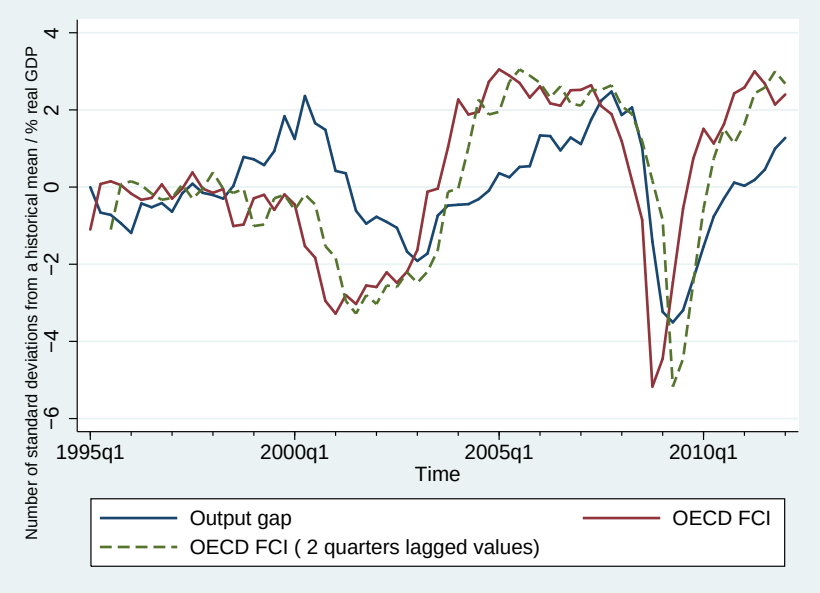
*Source:* Data provided by Stephan Danninger from IMF, Eurostat, author's computation

Figure A.4: OECD Financial Conditions Index and output gap for Euro area



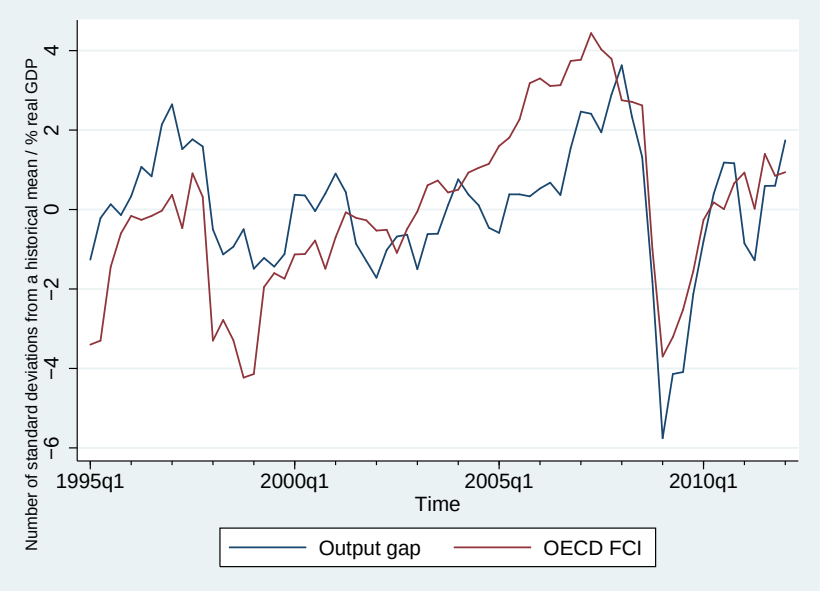

*Source:* Data provided by Stephan Danninger from IMF, Eurostat, author's computation

Figure A.5: OECD Financial Conditions Index and output gap for the United States




*Source:* Data provided by Stephan Danninger from IMF, Eurostat, author's computation

Figure A.6: OECD Financial Conditions Index and output gap for Japan




*Source:* Data provided by Stephan Danninger from IMF, Eurostat, author's computation

Table A.3: Data description [1]

| **Data** | **Source** | **Frequency** | |
|---|---|---|---|
| OECD Financial Cinditions Index for the United States and Japan | Data provided by Stéphanie Guichard, OECD | Quarterly, q1 1995 - q2 2012 | |
| OECD Financial Cinditions Index for Euro area | Data provided by Stéphanie Guichard, OECD | Quarterly, q1 1999 - q2 2012 | |
| CITI Financial Conditions Index for the United States | Data provided by Peter D'Antonio, Citigroup Global Markets Inc. | Monthly, m1 1983 - m5 2012 | Monthly data were transformed into quarterly frequency by averaging respective values if needed |
| Kansas City Financial Stress Index for the United States | www.kc.frb.org | Monthly, m2 1990 - m5 2012 | Monthly data were transformed into quarterly frequency by averaging respective values if needed |
| Federal Reserve Bank St. Louise Financial Stress Index | research.stlouisfed.org | Monthly, m1 1994 - m5 2012 | Monthly data were transformed into quarterly frequency by averaging respective values if needed |
| Cleveland Financial Stress Index | www.clevelandfed.org | Daily, 25.9.1991 - 14.6.2012 | Daily data were transformed into quarterly frequency by averaging respective values |
| IMF Financial Stress Index for Belgium, Germany and the United States | Data provided by Stephan Danninger, IMF | Monthly, m12 1980 - m2 2012 | Monthly data were transformed into quarterly frequency by averaging respective values if needed |
| IMF Financial Stress Index for Italy, Japan and Spain | Data provided by Stephan Danninger, IMF | Monthly, m12 1980 - m1 2012 | |

Continued on Next Page...

Table A.3 – Continued

| **Data** | **Source** | **Frequency** | |
|---|---|---|---|
| IMF Financial Stress Index for the United Kingdom | Data provided by Stephan Danninger, IMF | Monthly, m12 1980 - m10 2011 | |
| IMF Financial Stress Index for Switzerland | Data provided by Stephan Danninger, IMF | Monthly, m1 1982 - m1 2012 | |
| Real GDP for the United States, reference year 2005 | Eurostat, www.epp.eurostat.ec.europa.eu | Quarterly, q1 1970 - q1 2012 | Output gap was calculated using H-P filter with lambda 1600 over period q1 1970 - q1 2012 |
| Real GDP for Euro area, reference year 2005 | Eurostat, www.epp.eurostat.ec.europa.eu | Quarterly, q1 1995 - q1 2012 | Output gap was calculated using H-P filter with lambda 1600 over period q1 1995 - q1 2012 |
| Real GDP for Japan, reference year 2005 | Eurostat, www.epp.eurostat.ec.europa.eu | Quarterly, q1 1980 - q1 2012 | Output gap was calculated using H-P filter with lambda 1600 over period q1 1980 - q1 2012 |

[1]The data are available on request.