MEASURING STABILITY OF THE POLISH FINANCIAL SYSTEM BY MEANS OF A SYNTHETIC INDEX[1]

Krzysztof Maliszewski
Warsaw School of Economics
Collegium of Management and Finance, Chair of Living Standards and Consumption
Al. Niepodleglosci 162
02-554 Warsaw
Poland
krzysztof.maliszewski@doktorant.sgh.waw.pl
telephone: +48 605 601 972

Abstract

The current financial crisis proved again, that financial system stability is crucial for a sound economy. However, there is neither a widely accepted definition of financial system stability, nor a widespread framework for measuring it. Recently some authors tried to develop a financial stability index – a continuous measure of financial system stability, where extreme values signal financial crises.

This paper proposes a new approach for constructing a synthetic stability index by means of taxonomic analysis. Then this new index is compared with a few of the frameworks for developing a financial stability index described in the literature. It is found, that most weighting schemes produce similar results, so the crucial step in the index construction is the choice of variables. Finally, some conclusions are drawn on the stability of the Polish financial system in the period from 1998 till present.

Keywords: *financial stability; index; taxonomic analysis; financial stress*

JEL codes: G20, G21, G28

1. Introduction

The economic researchers' interest in financial system stability has been continuously increasing since the beginning of the nineties. This rising interest was caused by changes in financial systems (mostly, but not only, in developed countries), due to which a potential financial system instability can have a strong adverse effect on GDP growth and on people's living standards. Most important of these changes are ([19], pp. 4-12):

- a rapid expansion financial systems in relation to the real economy,

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- a rising share of non-monetary assets in the financial system (hence: a greater leverage of the monetary base),
- an increasing cross-industry and cross-border integration of financial institutions (transnational financial conglomerates),
- deregulation and liberalization of financial systems,
- the growing complexity of financial instruments which makes the allocation and development of risk difficult to follow.

The significance of financial stability[2] was proved again during the current economic crisis, when the central banks and governments bore considerable costs in order to maintain or restore stability of their financial systems. It is worth remembering that one of original tasks of central banks was to ensure financial stability of the credit creation system (for instance by extending emergency liquidity assistance to commercial banks), and that maintaining price stability came on their task list years later ([4], p. 57). These both tasks are interrelated, since sound financial systems act better as a transmission channel for monetary policy impulses.

The research on financial system stability is still fairly undeveloped, especially in comparison to price stability, and many important issues have not yet been solved. These include a lack of commonly accepted definition of financial stability and widespread framework for measuring it. Particularly, there is no synthetic measure thereof (like price indices for price stability).

This paper presents a financial stability index constructed by means of taxonomic analysis. This new index is then used to analyze the stability of the Polish financial system from 1998 till mid 2009.

The rest of this paper is structured as follows: in the next chapter financial stability definitions and its measurement by means of macroprudential indicators and synthetic indices are described, basing on a literature survey. Construction of a synthetic index for the Polish financial system by means of taxonomic analysis follows in chapter 3, including considerations about the scope of the analysis based on the structure of the system. In the fourth chapter the research results are presented. Chapter 5 concludes.

[2] The terms “financial stability” and “financial system stability” can be used interchangeably.

2. Financial stability – definitions and measurement

2.1 From narrow to wide definitions of financial stability

There are two approaches to defining financial stability in the literature, that could be described as narrow (*sensu stricto*, also referred to as negative) and wide (*sensu largo*, also referred to as positive).

According to negative definitions, all financial systems that are not undergoing a crisis can be treated as stable. Hence, financial stability in a narrow sense is simply lack of financial instability. This approach is quite well established in the literature on financial crises. A variety of statistical and econometric methods can be deployed to measure narrowly defined financial stability, to explain its changes and to find early warning indicators of financial instability. These include for instance: models of qualitative variables (such as logit model), event history analysis or analysis of stochastic processes with a discreet state space (such as Markov chains).

This approach has some serious drawbacks. In developed countries financial crises are rare events. Therefore, it is difficult to apply the framework of qualitative variables analysis to financial systems of these countries due to a heavily unbalanced sample. This framework will very well explain and forecast the presence of non-crisis states; however it might completely fail with crisis states[3]. What is more, it is difficult to precisely specify the starting and ending point of the crisis – this specification is usually based on expert judgement ([1], p. 4). Due to these drawbacks efforts to construct a positive definition of financial system stability have been undertaken.

As mentioned before, no single definition of financial stability is commonly recognized. However, most of positive definitions have much in common[4]. According to Schinasi ([18], p. 6) wide financial stability definitions emphasize the ability of financial system (consisting of institutions, markets and infrastructure) to perform its functions (allocating resources and risks, transferring payments, mobilizing savings, and facilitating wealth accumulation, development, and growth) smoothly and the resilience of financial system to shocks. Hence, financial stability is a complex and multidimensional concept that

[3] If a sample consists of 99 non-crisis periods and 1 crisis period, a naïve prediction model stating that the financial system is always in the non-crisis state, will have a very high goodness of fit, but no practical application.
[4] A survey of financial stability definitions can be found in: [7], p.38.

has no such intuitive measures (and therefore no obvious policy targets) as price indices in case of price stability.

Financial stability *sensu largo* should be analyzed from a systemic perspective and with regard to the real economy. Disturbances in individual institutions or markets are not a threat to financial stability, if they are not expected to strongly influence the real economy or to bring about contagion effect ([18], p. 7). Such turbulences are only manifestation of market forces; they could be positive from the financial stability perspective. This approach is called macroprudential. The differences between macroprudential and microprudential perspectives are presented in table 1.

Table 1 The comparison of macro- and microprudential perspectives

	Macroprudential	***Microprudential***
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	(in part) endogenous	exogenous
Correlations 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: [2], p. 2.

An important drawback of positive financial stability definitions is that, due to their complexity and generality, they are difficult to operationalize. One common trick to evade this problem is to use measures of financial stress instead of measures of financial stability, without explicitly characterizing the relation between financial stability and financial stress.

The analysis in chapters 3 and 4 will be based on the following definition of financial stability:

> Financial stability is a state of the financial system, when the system is resilient to adverse disturbances, that is it can perform its functions even when these disturbances occur.

2.2 Macroprudential indicators of financial stability

Macroprudential indicators (MPIs) are indicators of the health and stability of financial systems ([5], p. 1). On the basis of various sets of MPIs experts' judgements on

financial stability are formed. Examples of analyses deploying MPIs can be found in financial stability reviews(FSRs) published by central banks, supervisory authorities and international organizations[5].

There are two groups of MPIs: aggregated microprudential indicators of individual institutions and macroeconomic variables associated with the soundness of financial system ([5], p. 3). The analysis in this paper is based on the first group of MPIs.

Aggregated microprudential indicators can be divided into groups stemming from the CAMELS framework for assessing individual institutions' soundness. The acronym CAMELS stands for: Capital adequacy, Asset quality, Management, Earnings, Liquidity, Sensitivity to market risk. As MPIs should be quantitative, management assessment is usually not included in macroprudential analysis. The set CAELS is often supplemented by market-based indicators (such as stock indices).

In 2000 the International Monetary Fund (IMF) started a project called "Financial Soundness Indicators" (FSI), which is aimed at assembling a database of MPIs that would allow to assess and (at a later stage) to compare the soundness of financial systems in different countries[6]. The indicators proposed by the IMF were divided into two subsets: core and encouraged. The core set encompasses 12 indicators measuring the areas of deposit takers' soundness described by the acronym CAELS (see table 2). This indicators have to be delivered by all countries taking part in the project. The encouraged set comprises 28 indicators: 13 for deposit takers, 2 for other financial corporations, 5 for nonfinacial corporations, 2 for households, 2 for market liquidity and 4 for real estate markets. Participants of the project are recommended (although not obliged) to deliver indicators from the encouraged set.

It is easy to see that the whole set of FSI is dominated by indicators of deposit takers' health. Many FSRs are also focused on banking sector stability. This is due to the fact, that financial systems in most countries are rather banking-oriented than market-oriented.

[5] Financial stability reviews are the main communication channel of central banks' views on financial stability. An analysis of FSRs content can be found in [3] and [17]. The ESBC framework for MPIs-deploying analysis of the banking sector was described in [13].

[6] The methodology of calculating FSI has been published in: [8]. More information about the project and FSI of countries participating in the project are available on the website of the project: http://fsi.imf.org.

Table 2 Core Financial Soundness Indicators

Capital adequacy	• Regulatory capital to risk-weighted assets (CAR) • Regulatory Tier 1 capital to risk weighted assets (CAR1) • Nonperforming loans net of provisions to capital (NPLnfin)
Asset quality	• Nonperforming loans to total gross loans (NPLall) • Sectoral distribution of loans to total loans (corporates, households)
Earnings	• Return on assets (ROA) • Return on equity (ROE) • Interest margin to gross income (IM) • Noninterest expenses to gross income (NE)
Liquidity	• Liquid assets to total assets (LAR) • Liquid assets to short-term liabilities (LASRL)
Sensitivity to market risk	• Net open position in fx to capital (FX)

Note: in brackets the names of the variables are given that will be used in the analysis in chapters 3 and 4.

Source: [8], p. 2

For aggregated microprudential indicators it is crucial to establish the aggregation/consolidation[7] basis, that is the range of institutions data of which is aggregated/consolidated. The IMF recommends ([8], p. 58) to use the so called "domestic controlled cross-border consolidation basis" (DCCB), that is to consolidate the data of all financial institutions controlled by domestic entities together with foreign branches and subsidiaries of these institutions. However, in the New Member States of the EU and other developing countries it is often the case that most financial corporations are controlled by non-residents. In such countries the application of DCCB consolidation basis would remove the majority of institutions from the scope of analysis. Therefore, for the analysis of financial systems of such countries it would be advisable to aggregate/consolidate data on all domestically incorporated institutions (and maybe also on branches of foreign institutions).

The structure of the Polish financial system will be characterized in chapter 3. On this basis, the scope of further analysis will be defined. The MPIs for the construction of SSI will be chosen from the Core FSI set.

[7] Aggregation means simply adding the data on positions or flows while consolidation means adding the data without positions and flows between entities grouped together ([8], p. 54).

2.3 Synthetic stability indices

A comprehensive review of literature on financial stability indices can be found in [10]. Here, basing on this quoted source, only the information essential for further analysis will be presented.

A financial stability index (also called financial stress index), from now on referred to as SSI (synthetic stability index[8]), is an aggregate of MPIs measuring stability (or stress) in various segments of the financial system. It is usually calculated as a linear combination (weighted sum) of MPIs. SSI is based on a positive definition of financial stability, hence it is continuous (not binary or discreet). It is somewhat similar to monetary conditions indices. SSI usually describes the current situation and is not forward-looking (although some authors combine forward-looking and backward-looking MPIs in the index).

In contrast to price indices, SSI is an ordinal measure[9], in a sense that its levels have no meaning attached – they only describe the stability of the given period relatively to other periods in the sample. Hence, it is impossible to tell whether a given index level can be assessed as good or bad – one can only tell, whether it is better or worse than in an other period. The SSI is often presented as deviation from its mean value.

It is worth remembering, that SSI is not the ultimate financial stability measure. It should be rather treated as a starting point of the study. Usually, when describing financial stability by means of MPIs, one begins with an analysis of individual MPIs and on this basis tries to make general conclusions about financial stability. This approach could be described as "bottom-up". SSI is a tool that allows to start the analysis with a general statement and then to follow with a decomposition of the index into individual MPIs (a "top-down" approach). In other words, SSI does not replace individual MPIs, it supplements them.

The following construction stages of a SSI can be distinguished:

1. choosing the aspects of financial system stability to cover, MPIs that cover them and the frequency of calculating an SSI;
2. attaching weights to the chosen MPIs – combining the MPIs into an index;
3. evaluating the quality of a SSI.

[8] I do not use the customary terms "financial stability index" or "financial stress index", since they have the same acronym as the above-described Financial Soundness Indicators, which could blur the logic of the reasoning.
[9] "Ordinal" here does not strictly refer to measurement scales known in statistics.

In the first stage it is crucial to determine the structure of the analyzed financial system. As mentioned before, in most countries the banking sector is the major part of the financial system (such systems are called banking-oriented or continental, in contrast to marked-oriented or Anglo-Saxon financial systems). Therefore, the range covered by the MPIs used in the SSI is often constrained to the banking sector. As the choice of MPIs depends strictly on the structure of financial system, the SSI is unsuitable for international comparisons.

The choice of MPIs determines the frequency of a SSI. If only variables stemming from financial markets are deployed, SSI can be calculated on a daily basis. If information from financial reports or macroeconomic variables are used, quarterly or annual frequency is possible.

In the literature there are multiple ways of assigning weights to MPIs, including the following:

- expert judgement,
- standardization (variance-equal weights),
- the size of the market segment,
- coefficients of the first factor from factor analysis,
- transformation of variables using the sample cumulative distribution function,
- estimation of a backward-looking IS curve,
- estimation of a VAR model,
- estimation of a logit model (the dependent variable is based on expert judgement).

Once the weights have been attached, the evaluation of the SSI is performed. If the weighting method can be classified as supervised learning, usual evaluation procedures apply. For unsupervised learning methods evaluation based on heuristics is commonly used[10]. The best-performing SSIs are usually constructed with variance-equal weights or market size weights.

[10] Supervised learning methods make use of a reference variable (dependent variable) to "teach" the model. In unsupervised learning there is no reference variable.

In chapter 3, a SSI for Poland will be constructed. It will be evaluated in chapter 4 through comparison with other SSIs.

3. Synthetic stability index for the Polish financial system

3.1 Structure of the Polish financial system

The Polish financial system can be classified as banking-oriented. Banks always have been by far the largest subset of financial institutions (see table 3). Even during the recent stock market boom, when the values of assets of pension funds and investment funds reached their historic peaks, banks still controlled two thirds of financial institutions' total assets. After the stock indices collapsed in 2007 and 2008, a flow of funds withdrawn from investment funds to bank deposits was registered, which reinforced the dominant role of the banking sector. The importance of the banking system can also be derived from the analysis of households' stocks of financial assets (see table 4).Polish households keep almost 40% of their assets in banks, twice as much as US households. During the current crisis no wealth effects on consumption resulting from the decreasing value of savings held directly in stock or in investment funds were registered ([11]). Adding to that the insignificance of debt securities issuance as a source of funds for Polish companies ([15]), it is easy to arrive at a conclusion, that even serious disturbances in financial markets have a limited adverse effect on the real economy. Hence, the scope of macroprudential analysis may be narrowed to the banking sector.

Table 3 The institutional structure of the Polish financial system by assets (in percent)

	1997	***2000***	***2003***	***2006***	***2008***
Banks	93,05	87,72	76,44	66,87	73,74
Insurers	4,96	7,76	10,27	10,63	9,91
Investment funds	0,71	1,45	5,19	9,70	5,22
Open pension funds	0,00	2,03	7,00	11,44	9,79
Other	1,28	1,04	1,09	1,36	1,34

Source: [14].

Table 4 Financial assets of Polish and US households (end of 2008)

	Poland			*USA*		
	billion PLN	***thousand PLN per capita***	***%***	***billion PLN***	***thousand PLN per capita***	***%***
Sum, of which	950,22	24,92	100,00	120 883,50	394,28	100,00
- Cash	83,42	2,19	8,79	462,63	1,51	0,38
- Deposits	358,65	9,40	37,72	22 299,98	72,73	18,45
- Debt securities and receivables	17,16	0,45	1,81	11 481,12	37,45	9,50
- Quoted stock	23,58	0,62	2,49	16 297,01	53,16	13,48
- Unquoted equity shares	170,16	4,46	17,90	22 325,16	72,82	18,47
- Mutual funds	50,69	1,33	5,34	9 637,99	31,44	7,97
- Life insurance companies	66,36	1,74	6,98	3 425,03	11,17	2,83
- Pension funds	143,27	3,76	15,09	30 447,30	99,31	25,19
- Other	36,92	0,97	3,89	4 507,27	14,70	3,73

Source: Author's calculations based on data from [6], [15], http://www.nbp.pl, http://www.stat.gov.pl, http://www.census.gov

Nonresidents (most of them from other EU countries) control about 70% of the Polish banking sector (see table 5). However, their business is mainly conducted in the form of domestically incorporated entities. Branches of EU banks, whose activity began to develop in 2004, are still of little systemic importance[11]. Domestic-owned commercial banks constitute the bigger part of the remaining 30% of the banking sector. It is worth noticing though, that the share of nonfinancial sector deposits placed in cooperative banks is quite large.

Table 5 Structure of the Polish banking sector (end of 2008, in percent)

	Assets	***Loans to nonfinancial sector***	***Deposits of nonfinancial sector***
Domestic-owned commercial banks	22,2	23,2	24,0
Foreign-owned commercial banks	67,0	66,4	64,9
Branches of foreign banks	5,4	5,0	2,7
Cooperative banks	5,4	5,4	8,4

Source: http://www.knf.gov.pl

As indicated in subchapter 2.2, applying the DCCB consolidation basis to the Polish banking sector would leave most of it out of scope of macroprudential analysis. Therefore, further analysis will be based on aggregated data for domestically incorporated banks (in some cases intra-sector positions and flows will be eliminated, if the necessary data is

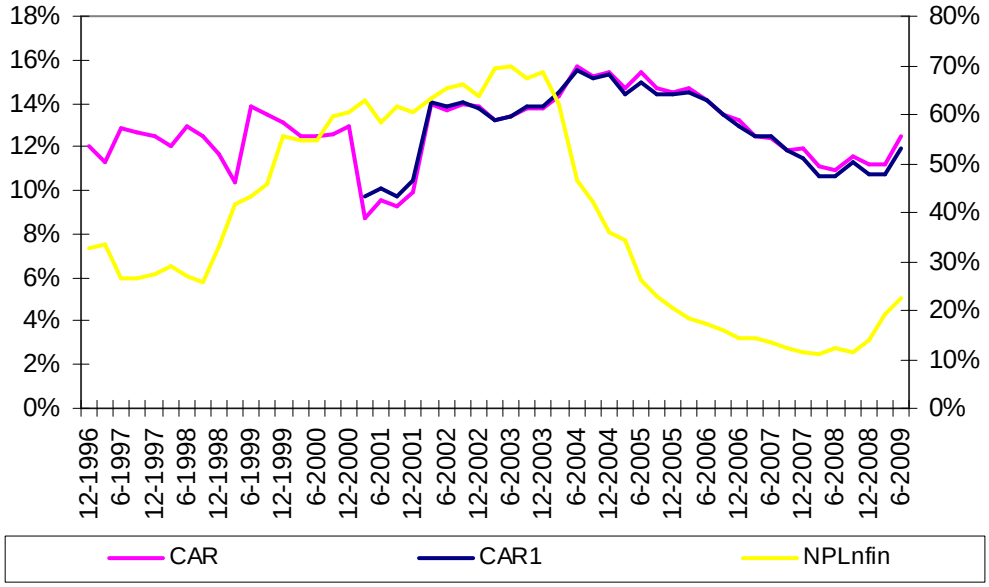
[11] There is one exception from this rule – the Polish branch of the Greek EFG Eurobank Ergasias. However, the rumor has it that due to pressure from the Polish Financial Supervisory Authority the bank is going to apply fir the Polish banking license soon.

available). In order to maintain consistency of ratios containing regulatory funds or equity series, branches of foreign banks will not be taken into consideration[12].

3.2 Data

MPIs belonging to the Core FSI set were calculated for the period from December 1997 to June 2009 with quarterly frequency. Data from the National Bank of Poland databases containing financial reports of Polish banks were used. The ratios are in general consistent with the IMF methodology described in [8] if all the required information is available. However, some changes were introduced in order to maintain the coherence of the data series throughout the sample period (if there were changes in reporting forms). Net open position in fx was measured as the absolute value of difference between aggregated long and short positions. Ratios containing data on flows were annualized. The calculated MPIs are presented in figures 1-4.

Figure 1 Capital adequacy indicators of domestically incorporated banks

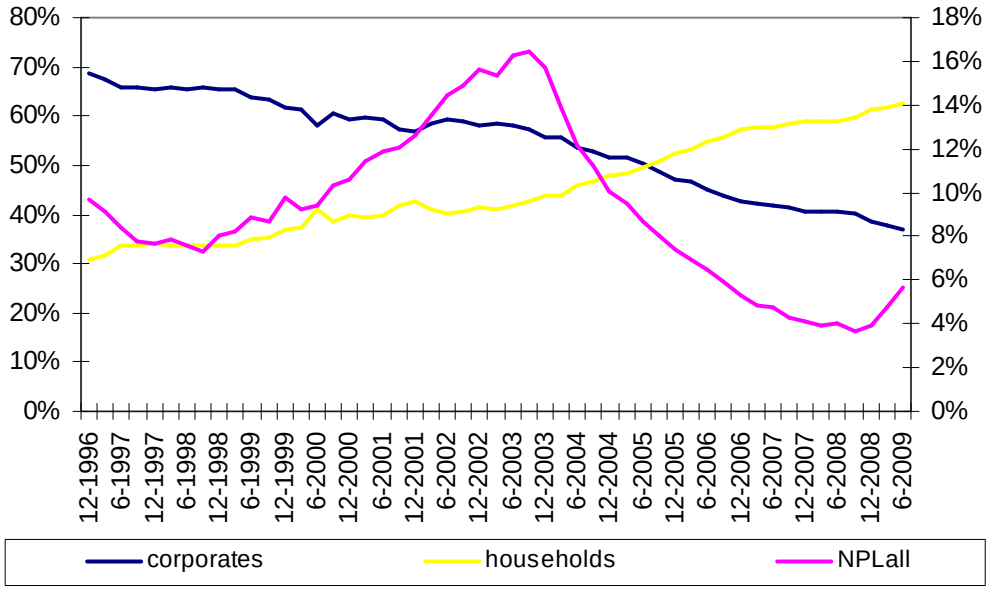


Note: NPLnfin on the right axis, remaining indicators on the left.

Source: Author's calculations based on National Bank of Poland data.

[12] Branches of foreign banks are not obliged to report their capital adequacy to the supervisory agency of the hosting country. Their activities are accounted for in the calculation of capital adequacy reported to the supervisory agency in their home country. Moreover, in banks' financial reports there is no equity assigned to branches.

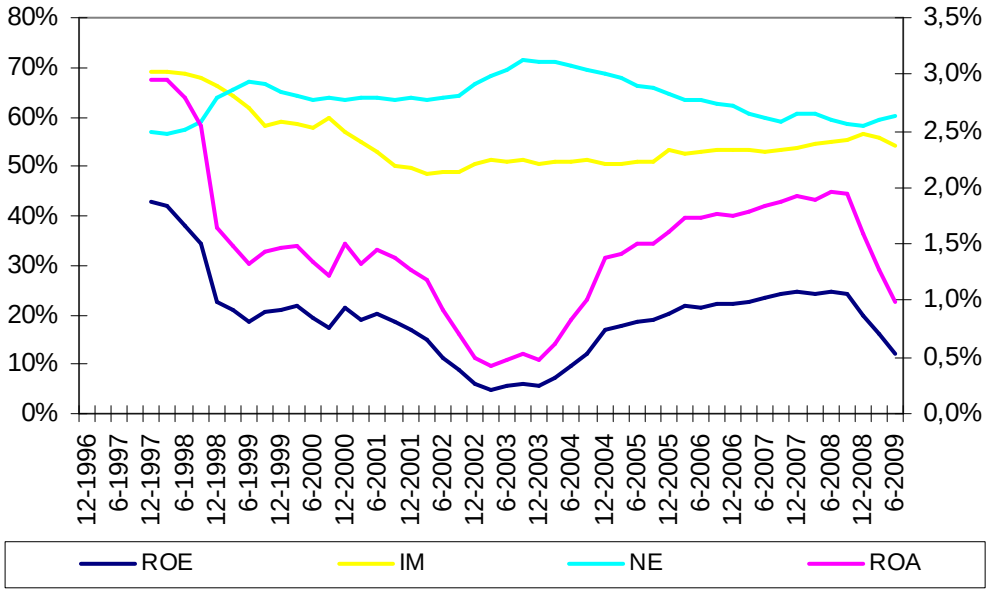
Figure 2 Asset quality and structure indicators of domestically incorporated banks



Note: NPLall on the right axis, remaining indicators on the left.

Source: Author's calculations based on National Bank of Poland data.

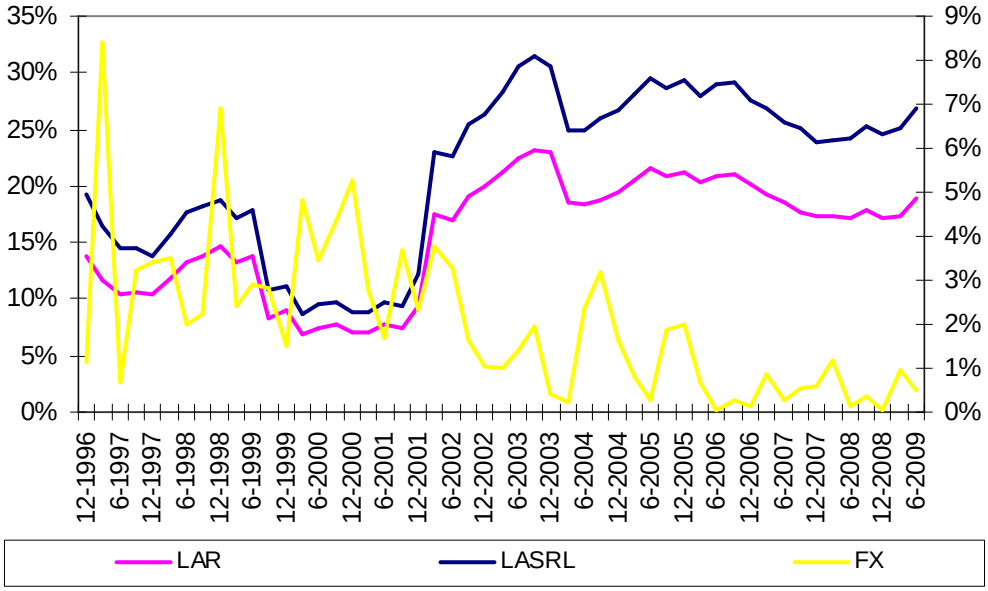
Figure 3 Earnings ratios of domestically incorporated banks



Note: ROA on the right axis, remaining indicators on the left.

Source: Author's calculations based on National Bank of Poland data.

Figure 4 Liquidity and sensitivity to market risk indicators of domestically incorporated banks



Note: FX on the right axis, remaining indicators on the left.

Source: Author's calculations based on National Bank of Poland data.

Since the data on Tier 1 capital is only available from 2001, this indicator was not included in the further research steps. This should however have little impact on the results, because the difference between the value of regulatory funds and Tier 1 capital is very small in the Polish banking sector. Hence, variables CAR and CAR1 contain virtually the same information, which is evidenced by their high correlation ratio (99%).

There were two significant changes in the definitions of variables within the sample period. The rapid drop in the value of the CAR ratio in the beginning of 2001 was caused by the inclusion of market risk in the total capital requirement[13]. The jump in the value of liquidity ratios resulted from a change in accounting regulation on financial instruments classification: a new category of available for sale instruments was added[14] and the banks were allowed to reclassify their portfolios of financial instruments.

The relation between most of the FSI and financial stability as defined in subchapter 2.1 is quite obvious. Higher levels of CAR, ROA, ROE, LAR and LASRL facilitate financial stability, while higher levels of NPLnfin, NPLall, NE and FX hinder financial stability[15].

[13] The inclusion of operational risk in the total capital requirements in the beginning of 2008 did not have such a strong effect on the capital adequacy ratios.
[14] Debt securities from this category issued by the state or the central bank should be treated as liquidity reserve, because the market for them is liquid.
[15] It can be argued that too high capital adequacy or liquidity may be undesirable, since the banks would not take advantage of all good investment opportunities, which in the long run would have a negative effect on their

There is a growing literature proving that interest margin is the most stable component of banking income (see for instance [9] or [20]), so it can also be assumed that high levels of the IM ratio are positive from the point of view of financial stability (even though riskier activities, like trading, may be more profitable). It is not that clear how the share of loans to households or corporations in the total loans to the nonfinancial sector would influence financial system stability. Historically, in Poland corporate loans were always of lower quality than household loans, so it might be expected that granting loans to households would be favourable from the financial stability perspective. However, this is rather an empirical suggestion than an established theory.

3.3 Index construction

MPIs that would be incorporated in the index, were chosen out of the Core FSI set on the basis of two criterions: their variability and correlation with other variables in the set . Coefficients of variation and correlation are presented in table 6. The median-based variation coefficient is calculated with the following formula:

$$V^{P}(x_j) = \frac{MAD(x_j)}{M(x_j)} \tag{1}$$

where M is the median of the respective variable and MAD is its median absolute deviation. No variables were rejected on the basis of the variability criterion. As for correlation, the framework of identifying central, satellite and isolated variables was deployed ([16], p. 21), with the threshold of correlation coefficient for satellite variables at 0,65. The classification of variables resulting from this procedure is shown in table 7. This classification seems plausible, since each of the CAELS areas has its representative FSI. However, due to strong correlation between the FSI, a slightly other threshold would result in a different classification. Variables identified as central and isolated were used for the construction of stability indices.

stability. However, in this research it is assumed, that within the range of values of capital adequacy and liquidity ratios observed in the sample their high levels facilitate financial system stability.

Table 6 Correlation matrix and variation coefficients

	CAR	***NPL nfin***	***NPL all***	***corpo rates***	***house holds***	***ROA***	***ROE***	***IM***	***NE***	***LAR***	***LASRL***	***FX***
CAR	1,00	0,03	0,24	0,00	0,01	-0,27	-0,30	-0,27	0,51	0,57	0,55	-0,13
NPLnfin	0,03	1,00	0,94	0,68	-0,68	-0,67	-0,58	-0,24	0,63	-0,29	-0,34	0,43
NPLall	0,24	0,94	1,00	0,60	-0,59	-0,71	-0,65	-0,36	0,73	0,02	-0,04	0,27
corporates	0,00	0,68	0,60	1,00	-1,00	-0,03	0,08	0,45	0,28	-0,52	-0,58	0,69
households	0,01	-0,68	-0,59	-1,00	1,00	0,03	-0,09	-0,46	-0,27	0,53	0,59	-0,69
ROA	-0,27	-0,67	-0,71	-0,03	0,03	1,00	0,99	0,69	-0,80	-0,30	-0,27	0,06
ROE	-0,30	-0,58	-0,65	0,08	-0,09	0,99	1,00	0,75	-0,78	-0,40	-0,37	0,16
IM	-0,27	-0,24	-0,36	0,45	-0,46	0,69	0,75	1,00	-0,50	-0,49	-0,49	0,41
NE	0,51	0,63	0,73	0,28	-0,27	-0,80	-0,78	-0,50	1,00	0,28	0,23	0,05
LAR	0,57	-0,29	0,02	-0,52	0,53	-0,30	-0,40	-0,49	0,28	1,00	1,00	-0,63
LASRL	0,55	-0,34	-0,04	-0,58	0,59	-0,27	-0,37	-0,49	0,23	1,00	1,00	-0,66
FX	-0,13	0,43	0,27	0,69	-0,69	0,06	0,16	0,41	0,05	-0,63	-0,66	1,00
Variation coefficient	0,13	0,53	0,41	0,17	0,20	0,41	0,44	0,10	0,06	0,32	0,34	0,81
Median-based variation coefficient	0,08	0,60	0,35	0,12	0,16	0,19	0,15	0,05	0,05	0,20	0,16	0,69

Source: Author's calculations based on National Bank of Poland data.

Table 7 Central, satellite and isolated variables

Central or isolated variables	***Satellite variables***
NPLnfin	NPLall, corporates, households, ROA
LAR	LASRL
ROE	IM, NE
CAR	-
FX	-

Source: Author's calculations based on National Bank of Poland data.

MPIs NPLnfin and FX, which have a negative impact on financial stability, were transformed using the formula:

$$x_j^{\ T} = \max_j\{x_j) - x_j \tag{2}$$

Two frameworks for calculating an SSI were applied:

- Measuring the Euclidean distance between a given point and an optimum point ([12], p. 123). The optimum point is defined as an artificial point where all the variables are at the maximum value from the sample. The variables are standardized. The index was multipled by –1, so that its higher values would represent better financial system stability.
- A procedure described in [12] p. 131, using normalization of the variables deploying the Weber geometric median.

Additionally, three weighting patterns of those described in subchapter 2.3 were deployed in order to have series for comparison. These were: simple standardization, weighting with coefficients of the first factor from factor analysis and transformation of

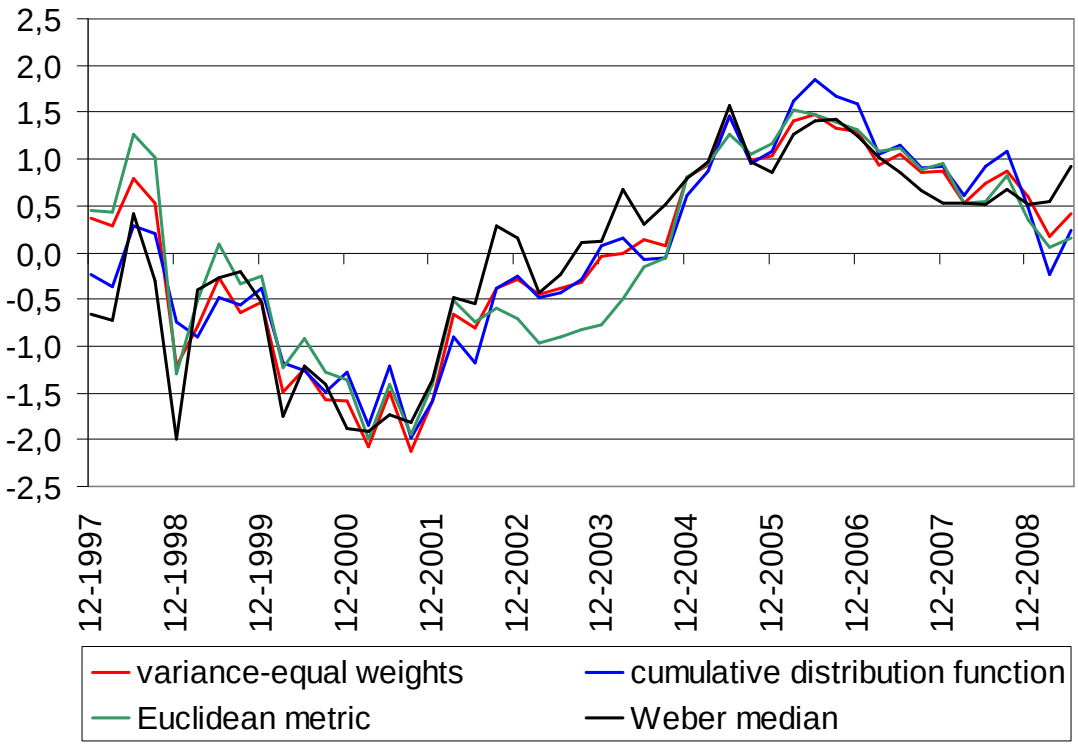
variables using the sample cumulative distribution function. The results are presented in the next chapter.

4. Results

4.1 Comparison of the synthetic stability indices

The synthetic stability indices calculated in a way described in subchapter 3.3 are presented in figure 5. The factor analysis based index was omitted, since it is incompatible with the other indices, as evidence by correlation ratios in tables 8 and 9. This is probably due to the fact that the part of variability if the data set explained by the first factor amounted to only 43%. This low number in turn was partly caused by the framework of eliminating satellite variables from the sample.

Figure 5 Synthetic stability indices (as standard deviations from the sample mean)



Source: Author's calculations based on National Bank of Poland data.

Table 8 Correlation coefficients – levels of indices

	variance-equal weights	***cumulative distribution function***	***factor analysis***	***Euclidean metric***	***Weber median***
variance-equal weights	1,00	0,97	-0,11	0,96	0,93
cumulative distribution function	0,97	1,00	-0,10	0,93	0,91
factor analysis	-0,11	-0,10	1,00	0,04	-0,26
Euclidean metric	0,96	0,93	0,04	1,00	0,85
Weber median	0,93	0,91	-0,26	0,85	1,00

Source: Author's calculations based on National Bank of Poland data.

Table 9 Correlation coefficients – changes of indices

	variance-equal weights	***cumulative distribution function***	***factor analysis***	***Euclidean metric***	***Weber median***
variance-equal weights	1,00	0,88	0,12	0,95	0,77
cumulative distribution function	0,88	1,00	0,03	0,77	0,62
factor analysis	0,12	0,03	1,00	0,16	0,29
Euclidean metric	0,95	0,77	0,16	1,00	0,79
Weber median	0,77	0,62	0,29	0,79	1,00

Source: Author's calculations based on National Bank of Poland data.

All the other indices show relatively high consistency with one another. This is especially true for the indices based on variance-equal weights and on Euclidean metric. Hence, it can be assumed, that for indices based on the same variables most of the weighting frameworks would deliver similar results.

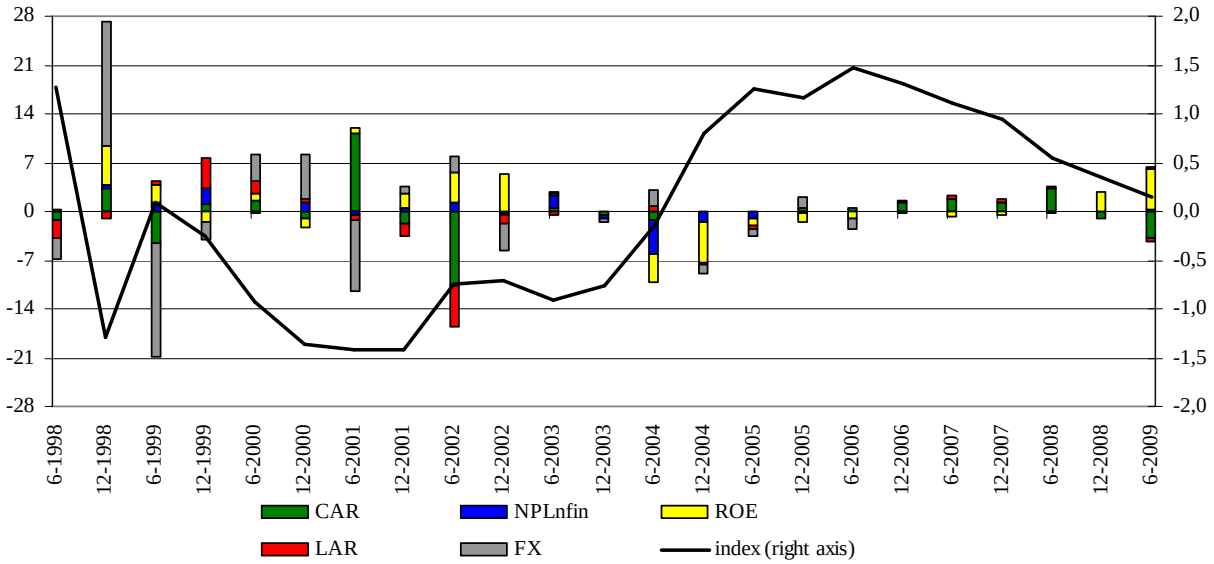
4.2 Stability of the Polish financial system

According to all the four SSI, in the sample there was one period of distinctively lower financial system stability. This period began in the end of 1998 and ended towards the end of 2003. Also a period of exceptionally sound stability situation can be identified, beginning in 2004 and ending around the end of 2007. It is interesting to see, that during the current crisis the stability of the Polish financial sector remained at higher levels than during the 1998-2003 period.

A decomposition of the SSI based on Euclidean distance is presented in figure 6. It is stunning that in the second half of the sample period the variability of the index ingredients was much smaller than in the first half, especially for the FX variable. On the basis of this decomposition the following conclusions can be drawn:

- Until 1999 the index exhibits high volatility due to strong changes in the exposition to fx risk.
- Declining liquidity and rising exposition to fx risk were the main reasons behind the slide of the index observed in 2000.
- Low index value in 2001 was caused by the change of regulations regarding the calculation of total capital requirement, so it shouldn't be interpreted.
- The upswing of the index in the year 2004 resulted from improving quality of the loan portfolio and a rise of profitability.
- The main factor behind the fall of the index beginning in 2006 was sinking capital adequacy. This changed towards the end of 2008, when, despite improving capital adequacy, the index value continued to decrease due to declining profitability.

Figure 6 Euclidean distance based index and semiannual changes in its ingredients*



** Ingredients of the index are expressed as squared distances of the respective standardized MPIs from their optimum level.*

Source: Author's calculations based on National Bank of Poland data.

5. Conclusion

To sum up, synthetic stability indices seem to be an interesting tool, that would supplement the analysis of financial sector stability based on macroprudential indicators and help to structure it. However, the interpretation of these indices should be cautious, as it is based on the sample mean, hence it strongly depends on the choice of the sample period. The crucial step in the construction of these indices is the choice of their ingredients, while the weighting scheme is less of importance (as long as it produces reasonable results).

This research could be in the future supplemented polling a group of experts on their judgement of financial stability in order to obtain a reference series for the indices. It would be also interesting to formally group the sample periods into subsets exhibiting similar financial stability levels[16].

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