MEASURING FINANCIAL SYSTEMIC STRESS IN ROMANIA: A COMPOSITE INDICATOR APPROACH[1]

Ágnes NAGY, PhD *
Annamária DÉZSI-BENYOVSZKI, PhD**
Imre SZÉKELY, PhD***

Abstract

The authorities and financial supervisors recognized, following the financial and economic crises, that the process of identification of systemic risks should receive more attention. The aim of this paper is to construct a financial systemic stress indicator which aims to predict which financial stress tends to depress the real economy in Romania. We obtained the composite indicator with the aggregation of five market-specific subindices created from individual financial stress measures (foreign exchange market, bond market, equity market, money market and banking sector). The systemic nature of stress is captured by the time-varying correlations between market segments. This indicator represents a real-time measure of systemic risk and quantify stress in the Romanian financial system. The results show that the financial systemic stress index is able to provide a periodization of crises.

Keywords: financial system, systemic risk, financial crisis, composite indicator, emerging economy

---

[1] *This paper is an extended version of the communication presented at The International Conference "Financial Perspective and Challenges 2016", 16 June, organized by "Victor Slăvescu" Centre for Financial and Monetary Research, Bucharest.*

* *Associate Professor, Babeş-Bolyai University of Cluj-Napoca, Faculty of Economics and Business Administration, e-mail address: agnes.nagy@econ.ubbcluj.ro*

** *Associate Professor, Babeş-Bolyai University of Cluj-Napoca, Faculty of Economics and Business Administration, e-mail address: annamaria.benyovszki@econ.ubbcluj.ro*

*** *Assistant Lecturer Babeş-Bolyai University of Cluj-Napoca, Faculty of Economics and Business Administration, e-mail address: imre.szekely@econ.ubbcluj.ro*

JEL Classification: G01, G10, G20, E44

1. Introduction

The recent financial and economic crisis revealed considerable gaps in the theoretical and empirical frameworks for identifying, analysing, monitoring and controlling systemic risk in the financial system (Holló et al., 2012). The motivation behind studying financial stress is its impact on the real economy and the social costs that it entails (Louzis and Vouldis, 2012).

The European Central Bank defines financial stability as a condition in which the financial system – intermediaries, markets and market infrastructures – can withstand shocks without major disruption in financial intermediation and in the general supply of financial services (ECB, 2015). The definition of National Bank of Romania is quite similar, the financial stability is seen as the financial system's capability to withstand systemic shocks in the long run without triggering major disturbances, to efficiently allocate resources across the economy, and to effectively identify and manage risks (NBR, 2006).

In this paper we construct a composite indicator of financial stress for Romania. This kind of indicator represents a measure of systemic risk and tries to quantify and summarize the stress in the financial system in a single statistic (Cambón and Estévez, 2016). The stress index permits the real time monitoring of the stress level in the whole financial system, also help to delineate historical episodes of financial crises. The composite financial stress indicators can also be used to measure the impact of policy measures directed towards mitigating systemic stress (Holló et al., 2012).

The rest of this paper is organized as follows. Section 2 provides the conceptual framework of financial systemic stress, in Section 3 we explain how to select financial variables as financial stress indicators and how to construct a composite financial stress indicator. Section 4 presents our empirical results. Section 5 summarizes the paper with some concluding remarks.

2. Literature review

The relevance of systemic risk was highlighted by the economic and financial crisis starting in mid-2007 (Cambón and Estévez, 2016). This paper develops a systemic stress indicator for the Romanian financial system. The identification and prediction of

the state of the financial system is an important practical issue for policy design (Louzis and Vouldis, 2012). Systemic risk is the risk of an extensive financial instability that causes the disfunctioning of a financial system to the point where economic growth and welfare suffer materially (ECB, 2009).

Many authors have considered various indicators for measuring uncertainty or stress in financial markets. According to Louzis and Vouldis (2012) financial stress is a situation in which one or more segments of the market show the signs associated with financial stress, namely increasing uncertainty and asymmetry of information. The main concern in constructing financial stress indicators is that the indicators should be able to serve as an early warning indicator for slowdowns in the real economy (Islami and Kurz-Kim, 2013). The development of stress indicators for particular segments of the market and their aggregation into a composite index of systemic stress provides insights into the propagation channels of specific events (Louzis and Vouldis, 2012).

In order to measure systemic risk across the Romanian financial system, we consider the foreign exchange market, bond market, money market, equity market and banking sector as good representations of different segments of the financial system.

Currency risk is an important component of financial stress for transition economies. The large movements in foreign exchange markets are particularly relevant for those institutions heavily dependent on non-domestic liabilities and also for those with a high exposure to non-domestic assets (Cambón and Estévez, 2016). On the other hand, foreign exchange rates can move driven by investors' expectations related to increased sovereign yield spreads or wider interest rate spreads (Eichler et al., 2009).

Movements in the government bond market are related to sovereign risk and concern about solvency and liquidity conditions in the corporate bond market. They can also be a consequence of an increase in the uncertainty or the risk aversion of investors (Cambón and Estévez, 2016). The CDS spread is an indicator for default risk and can be transformed into market implied probabilities of default, given the recovery rate and time to maturity and under the assumption of risk neutrality of the investor (Islami and Kurz-Kim, 2013). The interaction between the financial and fiscal stress has intensified during and after the Global Financial Crisis (Magkonis and Tsopanakis, 2016).

The money market is a primary source of liquidity for the financial sector. Inclusion of money market variables enhances the index's ability to identify the financial stress (Louzis and Vouldis, 2012).

The contribution of stock market volatility to the real economy has become negligible (Beetsma and Giuliodori, 2012). Stock market crashes constitute one of the primary forms of financial crises (Reinhart and Rogoff, 2009). The inclusion of equity market data is needed in order to capture the stress related to the stock market. The conditional variance of stock market returns is essential for calculating measures of risk (Cevik et al., 2013). A large number of studies employ GARCH models to forecast volatility in the stock market.

The soundness of banking system is important for financial stability and a large number of studies consider riskiness of the banking sector in measuring financial stress (Cevik et al., 2013). Financial intermediaries play a major role in the correct functioning of the financial system. High increases in stress conditions for these institutions can be spread across the financial system and potentially have a strong negative impact on the real economy (Cambón and Estévez, 2016).

In the literature related to the development of stress indicators have emphasized on the selection of variables which is driven primarily by the need to reflect stress conditions in all dimensions related to the functioning of the financial system (Louzis and Vouldis, 2012). The studies have used market data (e.g. Cardarelli et al., 2011; Hollo et al., 2012; Zigraiova and Jakubik, 2015), balance sheet data (e.g. Morales and Estrada, 2010) or mixed market and balance sheet data (e.g. Hanschel and Monnin, 2005; Louzis and Vouldis, 2012). Most of the studies have utilized market data.

The adopted methodology in this paper is to construct composite indices for sets of variables and then aggregate them into a systemic stress indicator. The aggregation schemes vary in the literature. According to Louzis and Vouldis (2012) it can be classified into variance-equal weight method and portfolio theory based aggregation schemes. The mostly used variance-equal weight methods are: the average of standardized variables (e.g. Bordo et al., 2001; Cardarelli et al., 2011), principal component analysis (e.g. Hakkio and Keeton, 2009; Cevik et al., 2013), logit models (e.g. Nelson and Perli, 2007). The portfolio theory based aggregation takes

into account the correlation structure of stress indicators (e.g. Holló et al., 2012; Louzis and Vouldis, 2012; Cambón and Estévez, 2016).

The validation approach, followed most frequently in the literature, has been used to compare the derived index with known events of intensified financial stress (e.g. Hanschel and Monnin, 2005; Hakkio and Keeton, 2009; Cardarelli et al., 2011; Louzis and Vouldis, 2012).

3. Methodology and data

The composite indicator comprises the five most important segments of an economy's financial system: foreign exchange market, bond market, money market, equities market and the banking sector. Each of these segments will be presented as a subindex of the composite indicator. The systemic nature of stress is captured by the correlations between stress components. The systemic risk is higher when the correlation between the stress indicators increases.

The choice of the variables is of crucial importance for the construction of financial stress indices. We select the financial variables used for constructing financial stability indices in the literature, such as in Holló et al. (2012), Louzis and Vouldis (2012), Islami and Kurz-Kim (2013), Babecký et al. (2013), Zigraiova and Jakubik (2015), Cambón and Estévez (2016).

The financial variables are daily time series covering the period between 1st March 2008 and 25th August 2015 (1,897 observations). High frequency stress indices depict in a more precise way the level of stress.

Each subindex include a few stress indicators, which capture one or more of the typical symptoms of financial stress. The set of variables used in the construction of the financial systemic stress index include market data. In what follows, the stress indicators and the data source is presented, organized by the representative market segment.

Foreign exchange market:

- daily close bid-ask spread calculated from firm quotations (EUR/RON spot foreign exchange market). Source: Reuters.
- daily change in mid close price calculated from firm quotations (EUR/RON spot foreign exchange market). Source: NBR interactive database.
- daily volatility of average daily EUR/RON spot exchange rates: we estimated the daily volatility of the EUR/RON spot

exchange rates with generalized autoregressive conditional heteroscedasticity (GARCH) model.

Government securities market:

- 5Y Romanian CDS spread. Source: Bloomberg.
- Transactions in government securities in the interbank secondary market (number and turnover): leu and euro denominated debt securities. Source: NBR interactive database.

Money market:

- daily volatility of the overnight ROBOR rate: we estimated the daily volatility of the overnight ROBOR rate with generalized autoregressive conditional heteroscedasticity (GARCH) model. Source: NBR interactive database.
- daily change of the overnight ROBOR rate. Source: NBR interactive database.

Equity market:

- BET index (source: Bloomberg): We use the CMAX transformation of the Bucharest Stock Exchange Trading Index (BET) to identify periods of sharp declines in Romanian stock market. The CMAX in defined as:

$$CMAX_t = \frac{BET_t}{\max\left[BET \in \left(BET_{t-j} \middle| j = \overline{1,90}\right)\right]}, \quad (1)$$

where BET_t is the Bucharest Stock Exchange Trading Index at day *t*.

- Volatility of the returns from the BET index: we estimated the daily volatility of the returns from the BET index with generalized autoregressive conditional heteroscedasticity (GARCH) model. Source: Bloomberg.

Banking sector:

- conditional value at risk (CoVaR) for the financial institutions listed in the BSE: time series estimated with quantile regression. For more details see Adrian and Brunnermeier (2008). CoVaR measures the Value at Risk (VaR) of the financial system conditional on an institution being in distress.

The first step towards the computation of the financial systemic stress index is the construction of subindices that correspond to each of the five sets of variables. The aggregation starts with putting the individual stress indicators on a common scale. The standardized indicators are then usually aggregated into a

composite indicator. Similar to Holló et al. (2012), we transform the stress indicators based on their empirical cumulative distribution function (CDF).

A particular data set of a stress indicator x_t is denoted as $x = (x_1, x_2, \ldots, x_n)$ with *n* the total number of observations in the sample. The ordered sample is denoted $(x_{[1]}, x_{[2]}, \ldots, x_{[n]})$, where $x_{[1]} \leq x_{[2]} \leq \cdots \leq x_{[n]}$ and $[r]$ referred to as the ranking number assigned to a particular realisation of x_t. The transformed stress indicators z_t are computed from the stress indicators x_t on the basis of the empirical cumulative distribution function $(F_n(x_t))$ as follows:

$$z_t = F_n(x_t) = \begin{cases} \frac{r}{n} \; for \; x_{[r]} \leq x_t < x_{[r+1]}, \quad r = \overline{1, n-1} \\ 1 \; for \; x_t \geq x_{[n]} \end{cases} \quad \text{for } t = \overline{1, n}. \tag{2}$$

The transformation thus projects stress indicators into variables which are unit-free and measured on an ordinal scale with range (0, 1].

The stress factors of each market category (i = 1, 2, … 5) are finally aggregated into their respective subindex by taking their arithmetic average:

$$s_{i,t} = \frac{\sum_{j=1}^{n_i} z_{i,j,t}}{n_i}, \tag{3}$$

where n_i is the number of stress indicators of subindex *i*. This implies that each of the stress factors is given equal weight in the subindex.

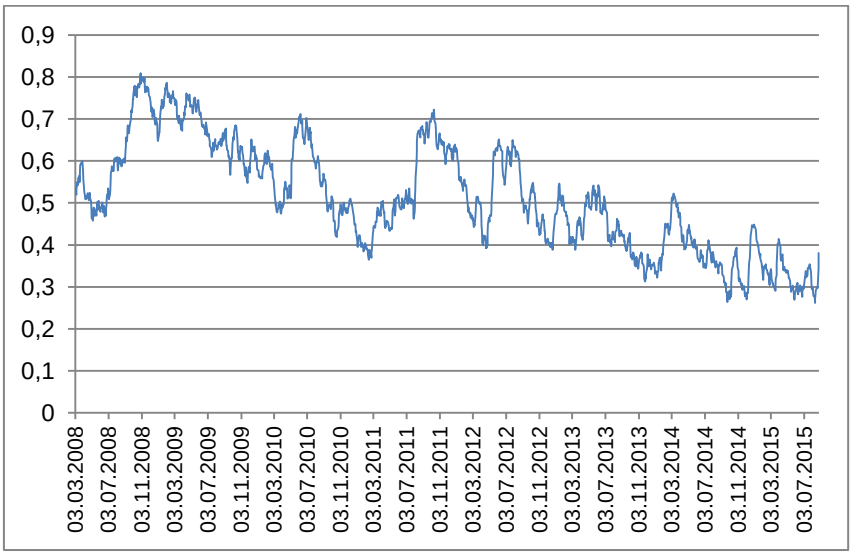
The next step is the aggregation of the five subindices into a simple indicator to measure the systemic stress. The subindices are aggregated into the composite indicator using Exponential Weighted Moving Average (EWMA) method, modelling time-varying cross-correlations with lambda=0,94.

4. Results

The quantile transformations of stress indicators are presented in appendix. In Fig. 1 we present the composite stress indicator estimated with exponential weighted moving average (EWMA) model.

Figure 1

Composite stress indicator for Romania



Source: Own estimations in R.

Based on calculated composite stress indicator in case of Romania we have identified the following stressful periods:

- September 2008 – May 2009 (with a maximum value in October 2008): Romania was affected by the global financial turmoil took place after the bankruptcy of Lehman Brothers (in September 2008). This external effect was intensified by internal vulnerabilities coming from previous fiscal indiscipline. The IMF Stand-By Arrangement (in May 2009), and the Vienna Agreement (in March 2009 enforced in May 2009) has played a significant role in moderating the utmost financial stress that we have identified.
- May 2010 – July 2010: Overlaps external and internal factors. In this period peaked the first round of the Greek sovereign debt crises increasing financial risks in emerging Eastern European

countries. In this context, the postponement of Romanian fiscal adjustment that had been during 2009 and on the beginning of 2010 was untenable. In July 2010 the implementation in a suitable extent of fiscal correction measures grounded a lower financial systemic risk.

- August 2011 – November 2011: The increased values of the indicator are due to increased financial instability in the euro area associated with sovereign risk crisis, worsen banking sector prospects and weaken macroeconomic activities. The launching of the Two-pack in the end of November 2011 and the entering in force of the Six-pack in the beginning of December 2011 have started to restore the confidence in Europe with favourable effect on Romanian financial stability.
- May 2012 – August 2012: Financial stability was affected by the renewed European pressures associated with a significant deterioration of internal political conditions. The political instability started with the interruption of the governance installed three month before and continued with the presidential impeachment attempt. This process was ended up in the end of August when the European financial conditions improved.

During 2013-2015, the composite indicator decreased signalling the improvement of the financial stability conditions. We have not identified any major stressful period. The indicator's slight and sporadic increase is not persistent, its value is not so high like formerly and quickly jumps back to the lower values.

5. Conclusions

The global financial crisis of 2007–2009 highlighted the importance of financial stress and their implications for real economic activity. There are few studies in the literature focused on former socialist economies in Eastern Europe. In this study we constructed a financial systemic stress index for Romania. Romania is an emerging market economy with relatively less experience dealing with (managing) financial crises. Accurate recognition of the systematic nature of stress is important in order to provide proper policy guidance with respect to financial crises identification.

The financial stress index developed in this paper incorporates foreign exchange market, government bond market, equity market, money market and banking sector. Each subindex include a few stress indicators, which capture one or more of the typical symptoms of financial stress. The variables used for the

construction of the composite stress indicator include market data. The aggregation starts with putting the individual stress indicators on a common scale. Similar to Holló et al. (2012), we transform the stress indicators based on their empirical cumulative distribution function (CDF). Lastly, the subindices are aggregated into the composite indicator using Exponential Weighted Moving Average (EWMA) method. It was found that the stress index is sensible to the financial crisis events.

Further research could be conducted to develop financial stress index for Romania using portfolio theory for the aggregation of the subindices, as well as to estimate the impact of financial stress on the real economy. The range of analysed countries could be extended to other Eastern European countries, which provides an opportunity to identify common stressful periods, in particular case the same source of these stresses.

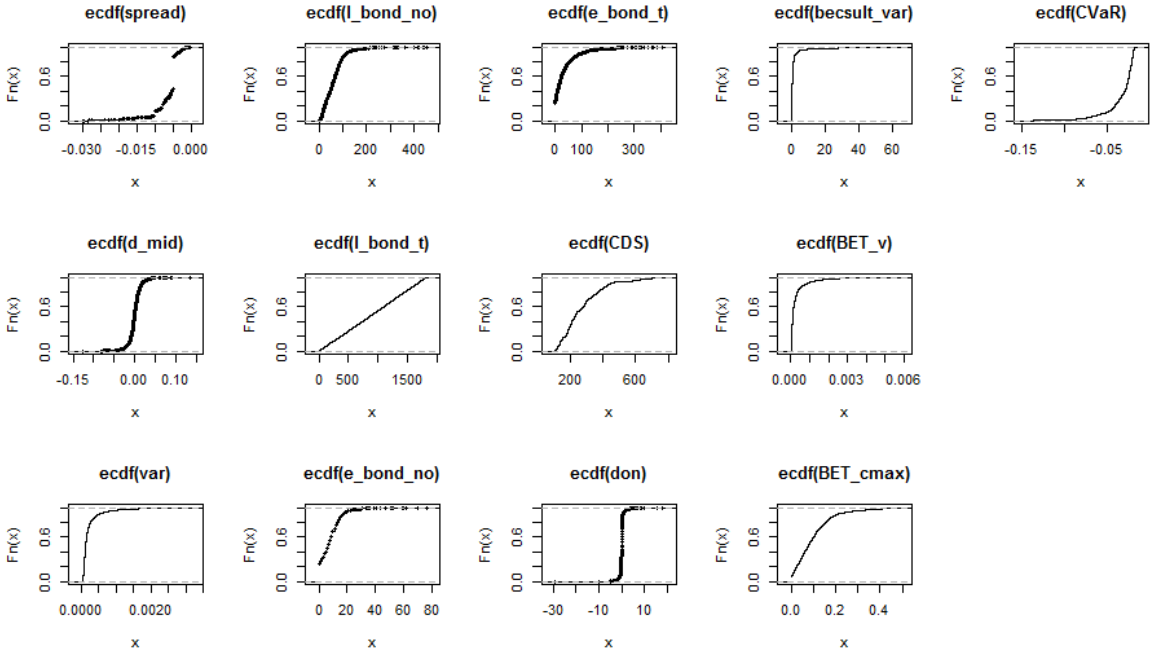
References

1. Adrian, T., Brunnermeier, M. K. (2008). "CoVaR". *Federal Reserve Bank of New York Staff Reports,* 348.
2. Babecký, J., Havránek, T., Matěju, J., Rusnák, M., Šmídková, K., Vašíček, B. (2013). “Leading Indicators of Crisis Incidence: Evidence from Developed Countries”. *Journal of International Money and Finance*, 35, pp. 1–19.
3. Beetsma, R., Giuliodori, M. (2012). “The changing macroeconomic response to stock market volatility shocks”. *Journal of Macroeconomics*, 34, pp. 281–293.
4. Bordo, M., Dueker, M., Wheelock, D. (2001). “Aggregate price shocks and financial stability: a historical analysis”. *Federal Reserve Bank of St. Louis Working Paper*, 2000-005B.
5. Cambón, I., Estévez, L. (2016). “A Spanish Financial Market Stress Index (FMSI)”. *The Spanish Review of Financial Economics,* 14, pp. 23-41.
6. Caldarelli, R., Elekdag, S. A., Lall, S. (2011). “Financial Stress and Economic Contractions”. *Journal of Financial Stability*, 7, pp. 78-97.
7. Cevik, E. I., Dibooglu, S., Kutan, A. M. (2013), “Measuring financial stress in transition economies”. *Journal of Financial Stability,* 9, pp. 597– 611.

8. ECB (2009). “The concept of systemic risk”. *ECB Financial Stability Review*, December 2009.
9. ECB (2015). “ECB Financial Stability Review”. November 2015.
10. Eichler, S., Karmann, A., Maltritz, D. (2009). “The ADR shadow exchange rate as an early warning indicator for currency crises”. *Journal of Banking and Finance*, 33, pp. 1983–1995.
11. Hakkio, S.C., Keeton, W.R. (2009). “Financial stress: what is it, how can it be measured, and why does it matter?”. *Federal Reserve Bank of Kansas City Economic Review*, *Second Quarter*, pp. 5–50.
12. Hanschel, E., Monnin, P. (2005). “Measuring and forecasting stress in the banking sector: evidence from Switzerland”. *BIS Working Paper,* No 22.
13. Holló, D., Kremer, M., Lo Duca, M. (2012). “CISS – A Composit Indicator of Systemic Stress in the Financial System”. *European Central Bank Working Paper Series, p.* 1426.
14. Islami, M., Kurz-Kim, J.-R. (2013). ”A single composite financial stress indicator and its real impact in the euro area”. *Bundesbank Discussion Paper*, p. 31.
15. Louzis, D. P., Vouldis, A. T. (2012). “A methodology for constructing a financial systemic stress index: An application to Greece”. *Economic Modelling,* 29, pp. 1228–1241.
16. Magkonis, G., Tsopanakis, A. (2016). “The financial and fiscal stress interconnectedness: The case of G5 economies”. *International Review of Financial Analysis*, 46, pp. 62–69.
17. Morales, M.A., Estrada, D. (2010). “A Financial Stability Index for Columbia”. *Annals of Finance*, 6, pp. 555–581.
18. NBR (2006). “*Financial Stability Report*”
19. Nelson, W.R., Perli, R. (2007). “Selected indicators of financial stability”. *Irving Fisher Committee's Bulletin on Central Bank Statistics*, 23, pp. 92–105.
20. Reinhart, C.M., Rogoff, K.S. (2009). “This Time is Different”. Princeton University Press, Oxford.
21. Zigraiova, D., Jakubik, P. (2015). “Systemic event prediction by an aggregate early warning system: An application to the Czech Republi”. *Economic Systems,* 39, pp. 553–576.

APPENDIX

Quantile transformation of stress indicators



Note: ecdf denotes the empirical cumulative distribution calculated from the entire sample of available data. spread – daily close bid-ask spread calculated from firm quotations (EUR/RON spot foreign exchange market); d_mid - daily change in mid close price calculated from firm quotations (EUR/RON spot foreign exchange market); var - daily volatility of average daily EUR/RON spot exchange rates; l_bond_no – number of transaction in leu denominated government securities in the interbank secondary market; l_bond_t - turnover of transaction in leu denominated government securities in the interbank secondary market; e_bond_no – number of transaction in euro denominated government securities in the interbank secondary market; e_bond_t - turnover of transaction in euro denominated government securities in the interbank secondary market; CDS – 5Y Romanian CDS spread; don - daily change of the overnight ROBOR rate; becsult_var - daily volatility of the overnight ROBOR rate; BET_v - volatility of the returns from the BET index; BET_cmax - CMAX transformation of the BET index; CVaR - conditional value at risk (CoVaR) for the financial institutions listed in the BSE.

Source: Own estimations in R.