Int. J. Nonlinear Anal. Appl. In Press, 1–13
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/ijnaa.2023.29952.4300

Evaluating the systemic risk of financial institutions present in the stock market (banks) using the main risk assessment criteria and analyzing the factors affecting it

Hamidreza Hosseinzadeh[a], Mirfeiz Fallah Shams[b,*], Hamidreza Kordlouie[c], Reza Gholami Jamkarani[d]

[a]*Department of Financial Engineering, Qom Branch, Islamic Azad University, Qom, Iran*

[b]*Department of Finance, Central Tehran Branch, Islamic Azad University, Tehran, Iran*

[c]*Department of Finance, Eslamshahr Branch, Islamic Azad University, Tehran, Iran*

[d]*Department of Accounting, Qom Branch, Islamic Azad University, Qom, Iran*

(Communicated by Ehsan Kozegar)

Abstract

Systemic risk is the risk imposed by a financial institution on the entire economy, the importance of which has become clear to many policymakers and economists since the financial crisis of 2008, and its measurement has been put on the agenda of many researchers. The present study deals with the influence of the risk of financial institutions on each other and the need to pay attention to the systemic risk of the banking sector, in which the risk based on three criteria ΔCoVaR, MES and SRISK for current banks in the capital market during the period of 2014-2018 has been investigated. After calculating these indicators, using correlation and regression analysis, the effect of some of the most important intrinsic variables of banks as well as macroeconomic variables was estimated on the mentioned indicators. Based on the obtained results, the value at risk (VAR) of each bank has a positive effect on the MES and ΔCoVaR criteria, and systemic risk is not limited to large banks, and small banks also play a role in the emergence and expansion of systemic risk. It was also found that the concentration of banks only On the ownership ratio and capital adequacy, cannot control systemic risk. And with the increase in the leverage ratio, the systemic risk increases. However, ΔCoVaR has a direct and positive relationship with the increase in the inflation rate, and MES decreases with the improvement of economic growth.

Keywords: systemic risk, conditional value at risk, marginal expected loss, SRISK, $\Delta CoVaR$, MES
2020 MSC: 91B05

1 Introduction

Systemic risk is considered a relatively new concept in the world financial literature, which is similar to systematic risk (which has a well-known concept in the financial world and indicates the probability of a macro-economic, financial or political event and the spread of its effects to companies economic is active in an economy) has a significant difference.

*Corresponding author
Email addresses: hamidrezahosseinzadeh11@gmail.com (Hamidreza Hosseinzadeh), mirfeizfallahshams1@gmail.com (Mirfeiz Fallah Shams), kordlouie@iiau.ac.ir (Hamidreza Kordlouie), gholami@qom-iau.ac.ir (Reza Gholami Jamkarani)

Received: January 2023 *Accepted:* March 2023

Systemic risk indicates the possibility of an inappropriate financial stress in an economic enterprise and its spread to other economic enterprises and finally, the entire economy of a country, which is created and developed simultaneously with the occurrence of financial crises, including the financial crisis of 1999 and The financial crisis was in 2000 [33]. To better understand the deep relationship between systemic risk and the occurrence of some economic crises in the world, the best example is the financial crisis of 2008. In this year, the inappropriate rating of mortgage bonds (assigning credit ratings higher than the real limit to mortgage bonds) by some rating agencies led to significant losses for some financial institutions. This loss was transferred from the aforementioned institutions to other financial institutions and banks and finally spread to the entire American and world economy. For this reason, since then, the identification and measurement of risks arising from an economic enterprise on the whole economy has become very necessary and has been put on the agenda of many financial institutions, research centers and researchers [10]. Despite the fact that each economic enterprise creates a systemic risk for the entire system based on the type of activity, the type of communication with other economic enterprises, and the size, according to the results obtained from most researches, the highest level of systemic risk is related to financial institutions. It is in an economy. One of the reasons for this issue is that financial institutions have a much wider communication network than manufacturing and service companies, and therefore, the liquidity and financial crisis of these institutions, compared to other companies, has a greater speed and scale to the entire financial markets and economy. A country is transferred. In addition, the most important factor causing systemic risk is liquidity risk. Unlike manufacturing, service and commercial companies, which have various operational risks; The most important risk facing financial institutions such as banks, insurances, financial intermediaries and brokerages is liquidity risk. As a result, the potential of creating systemic risk on the part of these institutions is higher than other companies active in different industries [20]. After the 2008 financial crisis and the collapse of the domino banks, it became clear that the one-dimensional view of the systemic risk of financial institutions in the traditional system of banking supervision may ignore the individual systemic risk of financial institutions. The reason for this is that individual indicators, including value at risk, measure the amount of risk of each financial institution by considering it under isolated conditions, while some risks, including contagion risk and systemic risk, alone and without Considering other influencing variables cannot be measured [22]. Thus, with the importance of finding systemic risk among banking regulatory institutions, the scope of studies in the field of measuring the systemic risk of financial institutions has been expanded in such a way that on behalf of various financial institutions, the International Monetary Fund, the Settlement Bank The International Accounts of the Financial Stability Board, together with the Wing Committee and national regulatory institutions, every year publish the list of banks with systemic importance at the global level5 and even banks with systemic risk at the national level and apply stricter regulations to them. In this way, paying attention to the systemic risk of different banks in policy-making will reduce the risks of instability, bankruptcy and collapse of the entire financial market by establishing rules and regulations and applying more controls for these banks. Due to the novelty of the issue of systemic risk in the financial markets of the world, as well as the lack of applied studies in the field of measuring the systemic risk of banks and credit institutions in the country, there are many questions in the field of systemic risk in the country's banking system, which this study tries to address. be answered First, what is the size of the systemic risk among the country's banks and financial institutions? To what extent does Herbank play a role in creating this risk and to what extent is it affected by it? Second, what is the source and main factor of systemic risk in big banks? And things such as low capital, unstable financing, activity in the capital market, large size, value at risk, leverage, what role do they play in creating systemic risk of banks? Thirdly, which of these factors are stable among different banks, and is it basically possible to control the mentioned factors by establishing centralized laws and targeting? The answers to these questions are very important in order to adopt correct and principled policies because based on the type of answer given to these questions, the policies adopted in the management and control of systemic risk of banks will be significantly different from each other and without Paying attention to them, the policies may be imprecise and achieving the desired result, i.e. reducing the probability of financial crisis, is far from expected.

Based on this, in this research, it has been tried in the first part by using the most important criteria for measuring systemic risk, including "marginal expected loss", MES, "conditional value at risk", CoVaR and "Srisk", which are all three of the most famous criteria. are measuring systemic risk, the systemic risk of the country's banking system is measured and then, using regression models, the effect of some of the most important intrinsic variables of banks as well as macroeconomic variables, is examined and analyzed. In the second part of the theoretical foundations, an overview the literature and the background of the research are presented, in the third part, the research methodology and systemic risk measurement based on the three criteria $\Delta CoVaR$, MES and Srisk are stated. In the fourth part, the experimental results from the analysis are presented. And finally, in the fifth part Summary, discussion and conclusion are expressed.

2 Research literature

2.1 Theoretical

The existence of systemic risk between financial and credit institutions has been proven by various researches in different time frames and different geographical areas. Systemic risk is known as the focus of the expansion of the recent financial crisis, but there is no single definition and consensus for it [8]. But this risk is completely different from systematic risk (meaning the simultaneous effect of general factors on the total price of securities in the financial market). Based on an initial definition, a set of conditions that threaten the stability and stability and public trust in the financial system is known as systemic risk. It defines that with its release, the performance of the financial system is destroyed and the result is significant damage to economic growth and the level of welfare of the society. The European Systemic Risk Board has also defined systemic risk as the risk of a breakdown in the financial system that has potentially negative consequences for the internal market and the real sector of the economy. However, other definitions such as risks focus on imbalances [11], exposure to correlated risks [2], spillovers to the real sector of the economy [19], information destructions [27], feedback behavior [15], asset bubble [30], contagion [28] and negative external effects [14] have also been introduced as systemic risk [8]. Nevertheless, the recent financial crisis is a perfect case example for understanding systemic risk, which shows how the creation of a crisis in one of the financial sectors causes widespread financial instability, and by expanding its scope outside the financial markets, the activities of the real sector disrupts the economy [16]. Economic indicators during the global financial crisis show the depth of systemic risk effects on the financial and real sectors of the economy. During this crisis, the stock markets of the United States, England, and Europe fell by more than 39%, the W.T.O. also experienced a 12% decline, and many countries experienced negative economic growth and deep recession. These crashes show well the effects and scale of systemic risk at the local, regional and global levels. The placement of banks in the center of the recent financial crisis has caused the attention of regulatory bodies to become much stricter, as evidenced by the strict Wing 3 rules, the Volcker and Dodd-Frank rules in the United States, the Vickers and Benkelly rules in England, and Likanen's proposals for Europe. . But why does systemic risk arise in financial institutions, what are its main drivers? And to control it, what should be considered? Considerations show that the reason for creating systemic risk in financial institutions can be found in two factors that reinforce each other. The first factor is the inherent deviation of the credit reserves of financial institutions from the pro-cyclical movement that shows itself in the group exposed to risk [16]. This excessive risk taking is a factor that, along with weak regulations, causes such deviations to appear [6]. The second factor of systemic risk, which is also called network risk, is caused by the high integration and intertwined connections of financial systems in contracts, information and behavior [16]. Various researches have shown that in addition to the above reasons, other variables such as the size of the bank, the amount of capital, market value, sources of financing, degree of leverage, the volume of non-current claims and other such factors can also play a role in the level of systemic risk. For example, López Espinosa et al. [25], have concluded that the response of the financial system to positive and negative market value shocks of individual banks is asymmetric. Laeven et al. [23] also concluded that there is a negative relationship between the bank's capital and systemic risk, and banks with sufficient capital are less exposed to systemic risk.

Therefore, in order to control systemic risk, some policies, including the Ball rules, advocate the use of capital-based tools, such as increasing capital adequacy by 2.5% for large banks. Some like the Volcker and Dodd-Frank laws of America, the Vickers laws of England and Likanen's proposals for the European Union are advocates for restricting the risky activities of banks. Others, like the laws of the Bank of England, advocate limiting the size of the bank. The Financial Stability Board has decided to identify financial institutions with significant systemic risk. Based on this, each of the financial institutions in the country whose size is larger than a certain limit; They take a systemic risk balance. Institutions with higher leverage must maintain more safety reserves with the Federal Reserve. For example, JPMorgan is placed in basket 4 and maintains 2.5% of reserves more than the minimum safety reserve; While HSBC Bank is placed in basket 3 and they are required to maintain 2% safety reserve higher than the minimum safety reserve [14]. However, some believe that the imposition of such restrictive regulations may cause deviations in the allocation of banks' resources, damage the efficiency of capital allocation and impose significant costs on the real sector of the economy, and suggest that by emphasizing more transparency of banks and capital requirements Conditionally, reduce costs caused by the too-big-to-fail theory [24].

2.2 Research background

In a research, Bhattacharya et al. [7] investigated the communication network of commercial banks in 39 countries between 1988 and 2014 and concluded that with the increase in credit risk and liquidity risk, the possibility of a financial crisis and its transmission to other banks, increase. Andris and Galasan [5] measured the size and direction

of the crisis transfer between European commercial banks in the years 2006 to 2016, and using a value-at-risk model based on conditional risk, systemic risk using parameters such as size, geographic location and the position in the communication network between financial institutions have been calculated. Acharya et al. [1, 2] presented a simple model of systemic risk and showed that the contribution of a financial institution to systemic risk can be measured by the expected systemic loss (SES) of that institution. SES actually measures the tendency of a single financial institution to suffer capital loss when the entire financial system suffers from capital loss. The result of Acharya et al.'s study, in addition to measuring systemic risk, showed that SES increases with leverage ratio. The institution as well as the increase in the expected loss of the financial institution increases on the tail of the financial system's loss distribution. After that, Adrian and Brunnermeier [3] introduced a new method to measure systemic risk, which became known as COVAR. For this purpose, by introducing COVAR Δ as the difference between COVAR conditional on the criticality of individual financial institution conditions and COVAR conditional on the normality of individual financial institution conditions and calculating the contribution of each financial institution in creating systemic risk, they found that in the time series dimension, a very strong relationship between the value At the risk of each financial institution, there is a COVAR Δ related to that institution, while in the cross-sectional dimension, the relationship between these two variables is estimated to be weak. Girardi and Ergun [18] presented a new way of measuring systemic risk in a study by modifying the COVAR criterion introduced by Ardian and Brunnermeier and changing the definition of financial chaos to the financial institution being placed in a yield lower than its VAR. The results of this study show that depository financial institutions have contributed the most to systemic risk. The result of examining the relationship between COVAR Δ and VAR of the financial institution in this research also shows that this relationship is weakly established in both time series and cross-sectional dimensions. In a study, Yun and Moon [32] have measured the systemic risk of the Korean banking sector with two criteria, MES and COVAR. Their empirical analysis shows that both criteria reach similar results in explaining the differences in systemic risk share between banks. The results of their research show that each bank's share of systemic risk is closely related to some variables specific to the same bank, such as the value at risk, size and leverage ratio of that bank, although the extent of their influence in the time dimension is different from the cross-sectional dimension.

Laeven et al. [23] have analyzed the role of bank size, capital, financing and bank activities at the same time by using COVAR and SRISK indices in order to investigate the separate effects of each of these key variables on systemic risk. The results of their study on 412 banks from 56 countries of the world show that systemic risk has a direct relationship with the size of the bank, but it has an inverse relationship with the amount of capital, although this relationship is also established with the individual risks of banks. Giglio et al. [17], By testing the predictability of each of the systemic risk indicators in predicting macroeconomic shocks, they came to the conclusion that although systemic risk is influential in macro variables, each of these criteria alone does not have the ability to predict future shocks. Therefore, they proposed an index that is obtained from combining these criteria and has the ability to predict economic recessions within the sample and outside the sample. Hosseini and Razavi [21] estimated the expected loss of 31 financial institutions and the amount of capital that these institutions need in the condition of lack of capital as systemic risk. Based on the results of this research, market value fluctuations have a positive and significant relationship with the expected loss and the final expected loss, but it has no significant relationship with the risk of non-payment of obligations. Also, unlike the study of [2], there is a negative and significant relationship between debt volatility and final expected loss, and there is no significant relationship between debt volatility and non-payment risk. In a research, [4] investigated the systemic risk of 20 companies using two criteria, MES and COVAR, and using the COVAR capability, they measured the effect of the crisis of the companies on each other and ranked these companies. Rostgar and Karimi [31] estimated the systemic risk among 7 banks with the COVAR Δ measure and with the help of the dynamic conditional correlation model and then examined its relationship with value at risk, leverage ratio and capital. Based on the results of this study, The aforementioned measure has a positive and significant relationship with the leverage ratio, capital and value at risk. Mahdavi et al. [26] also measured the systemic risk of a number of banks in the country using COVAR Δ and ranked them. Based on their results, Middle East Bank has the highest amount of risk and Capital Bank has the lowest amount.

3 Research methodology

So far, a lot of research has been done about risk assessment and stock market. In the calculation of systemic risk criteria, the use of financial market variables such as stock price and credit default swap gap is one of the most important common tools. However, the use of each of these variables depends on the specific conditions of the country and the degree of validity of these variables. For example, [29] concluded that although systematic risk based on credit default swap gap data have better performance, Due to its absence in developing countries, the variable of stock returns is used in these countries. In this research, bank stock price information is used for all three criteria COVAR,

MES and SRISK. The two systemic risk measures MES and COVAR are different from each other in the way they look at the systemic risk caused by individual financial institutions. The MES criterion defines systemic risk as the expected return on the stock of an individual financial institution when the financial market is in critical conditions. The critical conditions of the financial market are also different depending on the characteristics of each economy. In developed countries where the stock market has more volatility in the day, a drop of more than 2% in the financial market is considered as a critical condition. exposed to the risk of the market return (for example, the value at risk of the market return with a probability of 95 percent) provided that the individual financial institution is in a critical situation (for example, when the stock return of this individual financial institution is equivalent to the value at risk of one day itself with a probability of 95%) is defined. In total, these two criteria are different from each other in the two aspects of cause and effect of systemic risk. On the cause side, the MES criterion measures the crisis conditions for the financial market and the CoVaR criterion measures the crisis conditions for the financial institution. On the effect side, MES measures the financial institution's impact on financial market crisis conditions by means of the average return under these conditions, while the CoVaR measure measures the financial market's impact when each of the financial institutions is in a crisis. The means of value are exposed to market risk He complains. The SRISK index, which measures the lack of capital of a bank or financial institution under the conditions of a severe decline in financial markets, was introduced (by [1, 9]). This index is based on MES and some other variables, such as the ratio of capital to assets, value Debt book as well as stock market value is used to measure systemic risk. In this study, dynamic conditional correlation (DCC) models introduced by Engel [13] as one of the multivariate GARCH types are used to calculate MES, COVAR and SRISK criteria. Multivariate models have the advantage that they can consider the level of exposure to systemic risk of the variable over time for the financial institution or the market, an advantage that quantile regression - one of the methods of measuring systemic risk - has [32].

3.1 MES

Based on the study of Brownlees and Engle [9], the MES criterion on day t is defined as follows;

$$MES_i(C) = E_{t-1}[R_{i.t}|R_{m.t} < C] \tag{3.1}$$

where $R_{m.t}$ and $R_{i.t}$ are the daily returns of the financial market (such as the daily return of the stock index) and the daily return of the bank's stock on day t. Also, C is a threshold value that indicates the occurrence of a systemic event. This value in This study is considered equivalent to -1%. As stated earlier, in this study, the DCC model introduced by Engel [13] is used to estimate MES. Therefore, the conditional average for both returns of the market stock index and The return on shares of individual financial institutions is considered as relation (3.2).

$$\begin{aligned} R_{m.t} &= \mu_{m.t} + \sigma_{m.t}\epsilon_{m.t} \\ R_{i.t} &= \mu_{i.t} + \sigma_{i.t}\rho_{i.t}\epsilon_{m.t} + \sigma_{i.t}\sqrt{1-\rho_{i.t}^2}\eta_{i.t} \end{aligned} \tag{3.2}$$

where $\epsilon_{m.t}$ and $\eta_{i.t}$ are disturbance components that are assumed independently. Note that $\epsilon_{m.t}$ and $\eta_{i.t}$ are simply obtained from the Cholsky decomposition. Relationship (3.2) shows the pricing model of conditional capital assets with variable beta coefficients over time. Therefore, the conditional average efficiency of the individual institution in relation (3.2) can be rewritten as follows;

$$\begin{aligned} R_{i.t} &= \mu_{m.t} + \frac{cov_{t-1}(R_{m.t}.R_{i.t})}{\sigma_{m,t}^2}(R_{m.t} - R_{i.t}) + \sigma_{i.t}\sqrt{1-\rho_{i.t}^2}\eta_{i.t} \\ &= \mu_{i.t} + \beta_{i.t}(R_{m.t} - \mu_{m.t}) + \sigma_{i.t}\sqrt{1-\rho_{i.t}^2}\eta_{i.t} \end{aligned} \tag{3.3}$$

where $\beta_{i.t}$ is the variable beta coefficient over time. Considering the above relationships and conditional volatility modeling using conditional correlations by DCC model, multivariate GARCH models of MES are calculated as shown below.

$$\begin{aligned} MES_{i,t}(C) &= \mu_{i.t} + \sigma_{i.t}E_{t-1}\left[\rho_{i.t}\epsilon_{m.t} + \sqrt{1-\rho_{i.t}^2}\eta_{i.t}|\epsilon_{m.t} < \frac{C-\mu_{m.t}}{\sigma_{m.t}}\right] \\ &= \mu_{i.t} + \sigma_{i.t}\rho_{i.t}E_{t-1}\left[\epsilon_{m.t}|\epsilon_{m.t} < \frac{C-\mu_{m.t}}{\sigma_{m.t}}\right] + \sigma_{i.t}\sqrt{1-\rho_{i.t}^2}E_{t-1}\left[\eta_{i.t}|\epsilon_{m.t} < \frac{C-\mu_{m.t}}{\sigma_{m.t}}\right] \\ &= \mu_{i.t} + \sigma_{i.t}\rho_{i.t}E_{t-1}\left[\epsilon_{m.t}|\epsilon_{m.t} < \frac{C-\mu_{m.t}}{\sigma_{m.t}}\right] \end{aligned} \tag{3.4}$$

3.2 CoVaR conditional value at risk

The COVAR criterion in this study is based on the study of [18]. Based on this, the conditional value at risk is considered as follows.

$$pr(R_{m.t} \leq CoVaR^{m|i}_{q.t} \leq VaR^{i}_{q.t}) = q \tag{3.5}$$

The condition considered is that the yield of bank i is smaller than the amount of value at risk of that bank. The difference between this definition and the definition of Adrian and Brunnermeier [3] is that in their definition, the condition value was defined in such a way that the bank is exactly in its VAR value, but in this definition, with the definition of the financial institution being in a lower return value. From its VAR, it is possible to consider more extreme events and disturbances for Banki. With this definition, $CoVaR\Delta$ as the contribution of institution i to systemic risk is as follows.

$$\Delta CoVaR^{m|i}_{q.t} = 100 \times (CoVaR^{m|i}_{q.t} - CoVaR^{m|b^i}_{q.t})/CoVaR^{m|b^i}_{q.t} \tag{3.6}$$

$$\text{Standard:} \mu_{i.t} - \sigma_{i.t} \leq R_{i.t} \leq \mu_{i.t} + \sigma_{i.t}$$

The $COVAR\Delta$ measure obtained here is the percentage difference between the value at risk of the market under critical conditions of institution i and the value at risk of the market under normal conditions (the standard of institution i), which is $\mu_{i.t} - \sigma_{i.t} \leq R_{i.t} \leq \mu_{i.t} + \sigma_{i.t}$. The standard mode b^i represents the mode where the efficiency of institution i is around its average with a difference of at least one standard deviation. Then, like the MES standard calculations, the parasitic DCC model is also used in the COVAR standard calculations to model systemic risk. However, unlike MES, the direction of agency is from the bank to the market.

3.3 SRISK

SRISK, which was introduced by Brownlees and Engle [9] and Acharya et al. [1], is calculated as follows.

$$SRISK_{i.t} = kD_{i.t} - (1-k).t(1 - LRMES_{i.t} + h|(Ct+h|t)) \tag{3.7}$$

where K is the minimum capital deficit in relation to total assets that every bank must maintain, and in this part, K can be considered as the minimum capital adequacy rate, i.e. 8%. $D_{i,t}$ and $W_{i,t}$ respectively Book of debts (total debts) and market value of shares. Also, according to the study of Acharya et al. [1], h is equal to 180 days and $Ct + h|t$ is also considered -40%. To calculate the long-term MES from the one-day MES - which was explained in the previous part - the following relationship can be used.

$$LRMES_{i.t} + 180|(Ct + 180|t) = 1 - \exp(-18 \times MES_{i.t} + 1|(Ct + 1|t)) \tag{3.8}$$

$$MES_{i.t} + 1|(Ct + 1|t) = -Et(R_{i.t} + 1|t|R_{m.t} + 1|t < C) \tag{3.9}$$

3.4 Research variables, statistical population and sampling

According to the considerations of [12, 29], the method based on bank stock prices is used to measure systemic risk, which is more appropriate and compatible with the reality of the country's economy. In this case, the use of the method based on banks' stock prices also faces limitations, such as the fact that some banks are state-owned and lack of market shares, delays in providing financial information, and differences in the history of activity in the capital market. Therefore, the selection of the examined sample has been made with these considerations in mind. Based on this, the number of fifteen banks (Ekhtaznovin, Ansar, Parsian, Pasargad, Post Bank, Tejarat, Day, Capital, Sina, Shahr, Saderat, Qavamin, Entrepreneur, Tourism and Mellat) whose information was available from 2014 to 2018 have been selected as the final sample, in addition to their stock price information, some information specific to each bank (including financial statement information) has also been used in order to estimate and determine the effects of these variables on the systemic risk of banks. These data are from financial information. The seasons of each of these banks have been extracted from the Kodal system.

4 Research findings

Trend analysis and correlation of the calculated indicators In this study, using MATLAB software codes to calculate systemic risk based on the DCC model and according to the methods introduced in the methodology section, the systemic risk criteria of MES, COVAR and SRISK have been measured for fifteen banks in the country in the period 2014-2018. Also, in order to maintain confidentiality, a number has been assigned to each bank and these numbers are used instead of the bank name. The left side of the graph 1 shows the homogeneity of the systemic risk of all three criteria among banks, for simplicity, only the seasonal average of each of the criteria is depicted in the respective graphs. On the left side of graph 1, graph 1(a) homogeneity of systemic risk based on the MES criterion, graph 1(b) homogeneity of systemic risk based on the COVAR Δ criterion, and graph 1(c) homogeneity of systemic risk based on the SRISK criterion among banks. As can be seen from the average systemic risk measures in each chart, the systemic risk of different banks has a significant difference. In the meantime, according to the MES criteria, four banks with numbers 6, 7, 10, and 11 have a systemic risk lower than 0.5%, and two banks 6 and 7 belong to the category of private banks and two banks 10 and 11 belong to the category of banks affiliated to are public institutions. Considering that these four banks are in the category of medium banks in terms of size, the lowness of the MES index cannot be attributed to the size of these banks. Based on COVAR Δ criteria, the same banks 6, 7, 10 and 11 that have the lowest risk based on MES also have the lowest amount of risk based on ΔCOVAR. Based on the SRISK index, there is intuitively a strong relationship between systemic risk and bank size, in such a way that larger banks have greater systemic risk, and as banks shrink, their systemic risk decreases. Bank No. 10 is an exception. Even though this bank had the lowest risk level among other banks in MES and ΔCoVaR indices and it is in the category of small banks in terms of size, it is considered one of the most risky banks in the SRISK index.

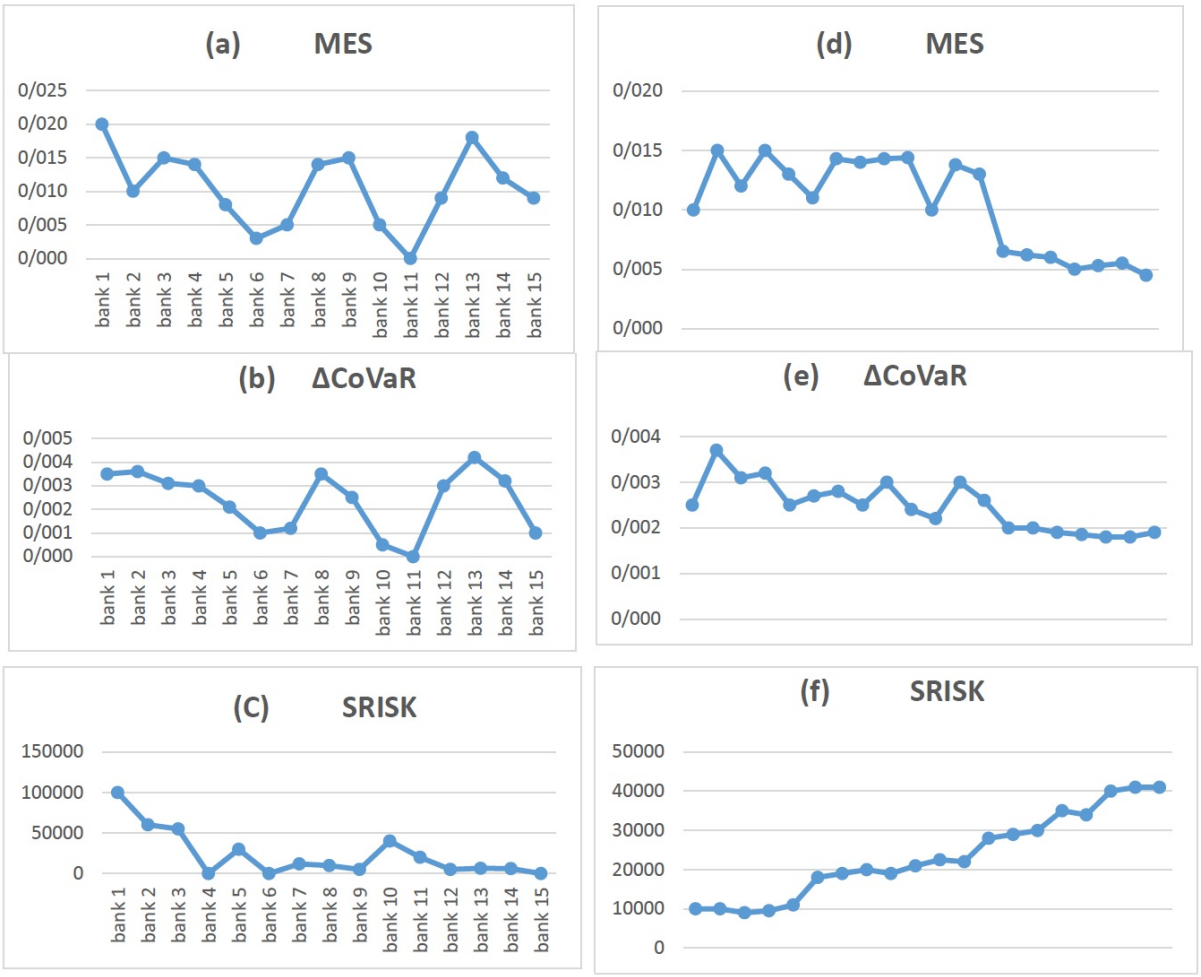

Figure 1: Systemic risk based on the three criteria of MES, ΔCoVaR and SRISK in cross-sectional dimension and time series

The right side of the graph 1 shows the systemic risk trend of all three measures over time, which is also depicted here for the sake of simplicity, only the average of the banks in each quarter. On the right side of diagram 1, diagram

1(d) shows the trend of systemic risk based on the MES criterion, diagram 1(e) shows the trend of systemic risk based on the ΔCoVaR criterion, and finally, diagram 1(f) shows the trend of systemic risk based on the SRISK criterion over time. According to the obtained results, it is clear that the general trend of MES and ΔCOVAR criteria has been downward for banks during the period under review. Unlike the previous two criteria, during the period under review, the general trend of SRISK criteria for banks has been upward. The rise of the risk index A system based on the SRISK criterion over time, which means that the capital shortage of banks has grown over time, due to the nominal growth of the book value of debts and the decline in the market value of bank shares in recent years.

Table 1: The amount of long-term systemic risk of banks and their ranking in each of the criteria

rank	**SRISK**	**Bank name**	**rank**	**ΔCOVAR**	**Bank name**	**rank**	**MES**	**Bank name**
1	98.184	Bank 1	3	0.004	Bank 1	1	0.019	Bank 1
2	70.641	Bank 2	6	0.004	Bank 2	8	0.011	Bank 2
3	59.222	Bank 3	2	0.003	Bank 3	4	0.014	Bank 3
12	5.195	Bank 4	7	0.003	Bank 4	7	0.012	Bank 4
5	28.219	Bank 5	10	0.002	Bank 5	10	0.008	Bank 5
15	267	Bank 6	13	0.001	Bank 6	14	0.003	Bank 6
7	12.858	Bank 7	11	0.001	Bank 7	12	0.005	Bank 7
8	10.443	Bank 8	4	0.003	Bank 8	5	0.013	Bank 8
11	6.137	Bank 9	9	0.003	Bank 9	3	0.014	Bank 9
4	36.998	Bank 10	14	0.001	Bank 10	13	0.005	Bank 10
6	15.861	Bank 11	18	0.000	Bank 11	15	0.001	Bank 11
13	3.008	Bank 12	8	0.003	Bank 12	11	0.008	Bank 12
9	9.266	Bank 13	1	0.004	Bank 13	2	0.017	Bank 13
10	6.589	Bank 14	5	0.003	Bank 14	6	0.012	Bank 14
14	1997	Bank 15	12	0.001	Bank 15	9	0.009	Bank 15

In order to compare the systemic risk of banks, Table 1 shows the long-term average of all three measures of MES, COVAR Δ and SRISK for banks and the ranking of each of them. As can be seen from table 1, the order of systemic risk of banks is different based on different criteria. However, the two indices MES and COVAR Δ have a high correlation with each other and banks that have high risk based on one index are also classified as high risk banks based on another index. In addition, Table 2 shows that the group of privatized banks, which includes the country's largest banks based on size, has the highest level of systemic risk in all three criteria. The ranking of other groups in systemic risk is different based on each criterion.

Table 2: The level of long-term systemic risk of the banks' group and their ranking in each of the criteria

SRISK Criterion		**ΔCOVAR Criterion**		**Criterion MES**		**← Criterion**
rank	SRISK	rank	ΔCOVAR	rank	MES	group ↓
1	76.016	1	0.00367	1	0.0147	Privatized banks
3	10.520	3	0.00217	2	0.0092	Private banks
2	14.344	2	0.00220	4	0.0086	Banks affiliated to public institutions
4	1.997	4	0.00100	3	0.0090	State-affiliated banks

4.1 Correlation analysis

In the banking literature, value at risk, market value and leverage ratio of each bank are considered as the most important factors affecting the risks of a bank. Here, the value at risk is considered as a representative of the bank's individual risk, the market value as a representative of the bank's size, and the leverage ratio as a representative of the bank's asset and liability structure, and then their correlation with systemic risk measures is measured. Considering that the long-term averages of each of the indicators for banks were used for the correlation analysis, therefore, the analysis of the results can only be used in the cross-sectional dimension of the banks, and claims such as direct or indirect relationship between the systemic risk criteria and the specifics of the bank In this part, it can be interpreted only in the cross-sectional dimension and between the banks. Chart 1 shows the correlation of each of the systemic risk criteria with the most important variables specific to each bank. The interesting point of these analyzes is the direct connection of systemic risk indicators with most of the intrinsic indicators of banks. Based on the calculated correlation, banks that had a larger value at risk or had a larger market value had a higher systemic risk in the long

term based on all three criteria. However, the relationship between systemic risk indicators and banks' leverage ratio is not the same for the three criteria. The SRISK criterion has a high and direct correlation with the banks' leverage ratio, and with the increase of the leverage ratio, the systemic risk increases based on this criterion. Also, the MES criterion has a weak direct correlation with the banks' leverage ratio. In contrast to these two, the correlation of systemic risk based on the COVAR Δ criterion with the banks' leverage ratio is negative, and with the increase of the leverage ratio among banks, the systemic risk decreases based on this criterion. Of course, the correlation rate is −0.16, which is not considered a strong correlation. These results are different from the results of the studies of Adrian and Brunnermeier [3] and Girardi and Ergun [18] for advanced countries, including the United States, which did not find any relationship with the MES and COVAR Δ criteria for some variables such as the value at risk of the bank. Table 3 also shows the correlation of long-term values of systemic risk indicators with each other, it also shows the correlation of these indicators with the intrinsic variables of the bank. The correlation of 0.87 between MES and COVAR Δ indicates that the policies that are made to control the systemic risk through each of these indicators will largely lead to the control of the other index.

Table 3: Correlation of systemic risk indicators with value at risk, market value and leverage ratio

leverage ratio	**Value a market**	**Value at risk**	**Criterion SRISK**	**Criterion ΔCOVAR**	**Criterion MES**	**Correlation**
0.04	0.40	0.48	0.39	0.87	1.00	Criterion MES
−0.16	0.43	0.25	0.31	1.00	0.87	Criterion ΔCOVAR
0.27	0.70	0.11	1.00	0.31	0.39	SRISK Criterion
0.56	−0.36	1.00	0.11	0.25	0.48	Value at risk
−0.26	1.00	−0.36	0.70	0.43	0.40	market value
1.00	−0.26	0.56	0.27	−0.16	0.04	leverage ratio

4.2 Estimating factors affecting systemic risk indicators

Panel econometric models have been used for more detailed analysis of factors affecting systemic risk criteria. It should be kept in mind that in these models, in addition to bank size, value at risk and market value, there is a possibility of influencing some other intrinsic characteristics of the bank, including the ownership ratio. Therefore, in panel modeling, these characteristics are also included as explanatory variables in the model to determine the most important factors affecting the systemic risk of banks. In this regard, using quarterly data from financial institutions, separate models have been estimated for each of the three systemic risk criteria. To avoid possible endogeneity problem, explanatory variables with a seasonal break have been used. For the dependent variable, the seasonal average of each of the MES, COVAR Δ and SRISK criteria has been used. In order to investigate the effects of changes in systemic risk criteria over time and among banks, in addition to the fact that the intrinsic variables of banks have been entered into the model as explanatory variables, in order to control other effects, instead of using a fictitious variable (dummy) among the variables Explanation, macroeconomic variables have been used to consider potential time effects in the models. Based on the tests conducted by Lemer and Hausman to select the appropriate model for estimating factors affecting systemic risk indicators, it was determined that for the two criteria MES and SRISK, the fixed effects method is a more appropriate model and provides more accurate results. On the other hand, for the COVAR Δ measure, the random effects model of panel data is a more suitable model. Accordingly, in this section, only the outputs of the best estimated models are presented. Table 4 contains the results of the best models obtained from the estimation of factors affecting system risk indicators, which summarizes their coefficients and their significance.

Table 4: Estimation of the effect of effective factors on systemic risk indicators

Fixed effects method		**Random effects method**		**Fixed effects method**		
SRISK		**ΔCOVAR**		**MES**		
Possibility	Coefficient	Possibility	Coefficient	Possibility	Coefficient	Variable
0.00	433313.8	0.00	−0.015266	0.61	−0.017942	C
0.11	214148	0.00	0.084794	0.00	0.368903	Value at risk
0.00	12605.82	0.45	0.000128	0.00	−0.003725	Logarithm of asset value
0.00	−21528.78	0.02	0.00041	0.01	0.002957	Logarithm of stock market value
0.00	201.7744	0.18	0.00000444	0.31	0.0000179	leverage ratio

0.34	9892.31	0.63	−0.000335	0.00	0.013005	Proprietary ratio
0.00	−51990.77	0.00	0.003359	0.30	0.003537	swelling
0.96	−122.2745	0.54	0.000115	0.01	−0.002506	Economic Growth
	0.89		0.41		0.72	R^2
	0.88		0.40		0.71	R^2 **justified**
	113.7479		30.87976		36.526	**F-statistics**
	0.000		0.000		0.000	**Possibility**

Value at risk, which had a significant direct relationship with MES and COVAR Δ and a weaker relationship with SRISK in the cross-sectional analysis among banks, has a direct and significant effect on MES and COVAR Δ here as well. As mentioned above, this result is different from the findings of Adrian and Brunnermeier [3] and Girardi and Ergun [18], who did not find a relationship between value at risk and systemic risk indicators. obtained, it is not possible to confidently comment on the effect of the value at risk on the SRISK index. However, based on the two criteria MES and ΔCOVAR, it is concluded that although the value at risk acts as a measure of the individual risk of each bank, but due to its direct effect on these two systemic risk indicators among the investigated banks, It can be said that the control of the individual risk of the country's banks, which is possible through the control of the value at risk, can lead to the control of the systemic risk. To measure the effect of bank size on the systemic risk index, two variables, the logarithm of the assets value and the logarithm of the market value, are included as explanatory variables in the model. Considering that the nominal variables are growing over time and the value of the banks' assets increases in proportion to the growth of the nominal variables, therefore, it alone cannot indicate the effect of bank size on systemic risk. Based on this, the market value of bank shares, which shows the size of the bank from the point of view of shareholders' equity, is included in the model as a corresponding explanatory variable. Based on the estimation results, the logarithm of bank assets has a negative effect on MES index and a positive effect on SRISK. The negative effect on the MES index indicates that banks with larger assets do not necessarily have a larger systemic risk, and perhaps banks with smaller assets have a larger systemic risk. These results were also evident in the initial part of the systemic risk calculations, so that the four banks whose sizes are categorized as small banks had a greater systemic risk. Also, according to the obtained results, the effect of the logarithm of banks' assets on the COVAR Δ index is not significant. The positive effect of the logarithm index of banks' assets on the SRISK index indicates that, based on this index, larger banks have a greater systemic risk. This result is similar to the result obtained by Laeven et al. [23] regarding the effect of bank size on the SRISK index. Despite the fact that the market value of bank shares has had a significant effect on all three indices, the direction of these effects is not the same. Based on the obtained results, the effect of this variable on the MES and COVAR Δ indices is positive and significant. This means that banks with a larger market value have a larger systemic risk. This is while the effect of market value on the SRISK index is negative and significant. In other words, according to this index, banks with a larger market value do not necessarily have a larger systemic risk. The difference in the effect of bank size on three systemic risk indicators shows that the policymaker's attention to the size of banks to control the effects of systemic risk may cause it to neglect other banks that can lead to the creation and expansion of systemic risk. As in the correlation analysis, the leverage ratio among the banks did not have a significant effect on the systemic risk, here it also did not have a significant effect on the MES and ΔCoVaR index. Therefore, it can be claimed that both in the cross-sectional dimension and in the time series dimension, the leverage ratio as a representative of the banks' debt structure does not have a significant effect on the MES and COVAR Δ indices. However, the effect of the leverage ratio on the SRISK index is positive and significant, and more leveraged banks have a higher systemic risk.

Based on the obtained results, the effect coefficient of the ownership ratio on the MES index of systemic risk is positive and significant, but it is not significant on the other two indices. Although it is expected that the improvement of ownership ratio as well as capital adequacy will reduce systemic risk and the relationship of this ownership ratio with systemic risk indicators is inverse, but it is argued that the role of such ratios due to the pro-cyclical nature and arbitrage of laws, in this The field is limited and sometimes even a direct relationship between these ratios and risks may be established. Therefore, based on the MES index, banks with a larger ownership ratio have a higher systemic risk. In the estimated models, to control the effects of macroeconomic conditions, two variables of economic growth and inflation rate as the most important macroeconomic variables affecting the systemic risk of banks are included in the models. Based on the obtained results, the inflation rate has a significant effect on the MES index, but its effect is positive on COVAR Δ and negative on SRISK. Due to the different effects of this variable on systemic risk indicators, a single result cannot be deduced from it. However, the direct relationship between inflation and COVAR Δ indicates an increase in systemic risk following an increase in inflation. In other words, an increase in inflation causes an increase in speculative activities and the entry of banks into the investment markets in fixed assets, which

results in the riskiness of the investment portfolio. It becomes banks. Under these conditions, changes in the price of capital goods also cause changes in the value of banks' shares, which can increase systemic risk due to the coordinated direction of banks in this field. Economic growth rate has no significant effect on COVAR Δ and SRISK indices, but its effect on MES index is negative and significant. Based on this, with the increase and improvement of economic growth, the systemic risk of banks decreases.

5 Conclusion and suggestion

In this research, the amount of this risk was calculated and measured based on the three criteria of MES, ΔCoVaR and SRISK for fifteen banks active in the capital market, considering the impact of the risk of banks and financial institutions on each other and the need to pay attention to the systemic risk of the banking sector. It is a daily time for the level of systemic risk of each bank. Calculations show that based on the two criteria MES and COVAR Δ, systemic risk has gone through a downward trend in the investigated period, while considering the nature of the SRISK index and its influence on the book value of some financial variables, this index has always been upward. Therefore, in order to investigate the influencing factors on these trends, after calculating the indices, using correlation and regression analysis, the effect of some of the most important intrinsic variables of banks as well as macroeconomic variables was estimated on these indices. The results indicate that the value at risk of each bank has a positive effect on the MES and ΔCoVaR criteria, but contrary to what is suggested in the banking literature for large banks, systemic risk is not only focused on large banks and small banks also play a role in the emergence and expansion of this risk. have. It was also found that banks' attention only on ownership ratio and capital adequacy cannot control systemic risk. Also, with the improvement of economic growth, MES decreases and with the increase of inflation, ΔCoVaR increases. Based on the obtained results and the widespread use of MES and COVAR Δ indices in the calculation of systemic risk, the higher the value at risk of banks, the higher their systemic risk. Considering that in many countries, including Iran, systemic risk is still not used seriously by regulatory institutions and attention and focus is only on value at risk, this direct relationship between value at risk and systemic risk can To some extent, it covers the neglect of policy-making institutions from systemic risk. Considering which of the systemic risk criteria the regulatory body chooses as the systemic risk measurement index, their control tools will be different. For example, if the regulatory body considers the MES index as a systemic risk measurement index, the logarithm of the value of bank assets has a negative effect on this index, and this means that the regulatory body cannot prevent asset growth through the establishment of control regulations. prevent the occurrence of severe systemic risk. But in this situation, due to the positive effect of the value at risk on this index, it can prevent the aggravation of systemic risk through the establishment of control regulations on this index. Therefore, choosing the appropriate index to measure systemic risk in order to be able to use control tools is one of the issues that the bank's supervisory body should focus on. In the end, it is suggested to investigate the impact of the real sector of the economy on systemic risk in the next studies.

References

[1] V. Acharya, R. Engle and M. Richardson, *Capital shortfall: a new approach to ranking and regulating systemic risks*, Amer. Econ. Rev. **102** (2012), no. 3, 59–64.

[2] V. Acharya, L. Pedersen, T. Philippon and M. Richardson, *Measuring systemic risk*, working paper, New York University, 2010.

[3] T. Adrian and M.K. Brunnermeier, *CoVaR*, Working Paper, Princeton University and Federal Reserve Bank of New York, 2011.

[4] Z. Ahmadi and S.M.J. Farhanian, *Comprehensive risk measurement with CoVaR and MES approach in Tehran stock exchange*, Stock Exchange Quart. **7** (2013), no. 26.

[5] A.M. Andries and E. Galasan, *Measuring financial contagion and spillover effects with a state-dependent sensitivity value-at-risk model*, Risks **8** (2020), no. 1, p. 5.

[6] B. Arnold, C. Borio, L. Ellis and F. Moshirian, *Systemic risk, Basel III, global financial stability and regulation*, J. Bank. Financ. **12** (2012), no. 36, 3123–3124.

[7] M. Bhattacharya, J.N. Inekwe and M.R. Valenzuela, *Credit risk and financial integration: An application of network analysis*, Int. Rev. Financ. Anal. **72** (2020), p. 1015.

[8] D. Bisias, M.D. Flood, A.W. Lo and S. Valavanis, *A survey of systemic risk analytics*, U.S. Department of Treasury, Office of Financial Research, 2012.

[9] C. Brownlees and R. Engle, *Volatility, correlation and tails for systemic risk measurement*, Available at SSRN, 2012.

[10] M.K. Brunnermeier and L.H. Pedersen, *Market liquidity and funding liquidity*, Rev. Financ. Stud. **22** (2009), no. 6.

[11] R.J. Caballero, *The" other" imbalance and the financial crisis*, Nat. Bureau Econ. Res. (2010), no. w15636.

[12] G. Choi, *Identification of N-SIFI and directions for macroprudential supervision*, Financ. Stability Stud. **12** (2012), no. 1, 89–135.

[13] R. Engle, *New frontiers for ARCH models*, J. Appl. Econ. **17** (2002), no. 5, 425–446.

[14] F.S.B., *Report to G20 finance ministers and governors guidance to assess the systemic importance of financial institutions, markets and instruments: Initial considerations*, Wayamba J. Manag. **15** (2009), no. 1.

[15] P. Gai and S. Kapadia, *Contagion in financial networks*, Proc. Royal Soc. A: Math. Phys. Eng. Sci. **466** (2010), no. 2120, 2401–2423.

[16] P. Gasper, S. Ge, A. Loomis and S. Miller, *Prospects of ecotourism in Hong Kong: a case study on Tung Ping Chau*, Excerpt from https://web.wpi.edu/Pubs/E-project/Available/E-project-022912-111516/unrestricted/Ecotourism_in_Hong_Kong_Final_Report.pdf, 8 (2012), p. 16.

[17] S. Giglio, B. Kelly, S. Pruitt and X. Qiao, *Systemic risk and the macroeconomy: an empirical evaluation*, J. Financ. Econ. **119** (2016), no. 3, 457–471.

[18] G. Girardi and A.T. Ergun, *Systemic risk measurement: multivariate GARCH estimation of CoVaR*, J. Bank. Financ. **37** (2013), no. 8, 3169–3180.

[19] Group of Ten, *Report on consolidation in the financial sector: Chapter III. Effects of consolidation on financial risk*, International Monetary Fund Working Paper, 2001.

[20] X. Jin, *How much does book value data tell us about systemic risk and its interactions with the macroeconomy? A Luxembourg empirical evaluation*, Central Bank of Luxembourg, 2018.

[21] S.A. Hosseini and S.S. Razavi, *The role of capital in the systemic risk of financial institutions*, Experiment. Account. Res. **4** (2013), no. 1, 127–147.

[22] P. Kent and P. Kjaer, *The efficacy of targeted interventions for modifiable psychosocial risk factors of persistent nonspecific low back pain–a systematic review*, Manual Therapy **17** (2012), no. 5, 385–401.

[23] L. Laeven, L. Ratnovski and H. Tong, *Bank size, capital, and systemic risk: some international evidence*, J. Bank. Financ. **69** (2016), S25–S34.

[24] T. Laun and J. Wallenius, *Social insurance and retirement: a cross-country perspective*, Rev. Econ. Dyn. **22** (2016), 72–92.

[25] G. López-Espinosa, A. Moreno, A. Rubia and L. Valderrama, *Systemic risk and asymmetric responses in the financial industry*, J. Bank. Financ. **58** (2015), no. C, 471–485.

[26] G. Mahdavi Klishmi, N. Elahi, E. Farzinosh and J. Gilanipour, *Systemic risk assessment in Iran's banking network by the criteria of value changes at conditional risk*, Financ. Eng. Secur. Manag. Quart. **8** (2016), no. 33, 265–281.

[27] F.S. Mishkin, *Systemic risk and the international lender of last resort*, working paper, Board of Governors of the Federal Reserve, Speech delivered at the Tenth Annual International Banking Conference, Federal Reserve Bank of Chicago, 2007.

[28] A. Moussa, *Contagion and systemic risk in financial networks*, Columbia University, 2011.

[29] M. Rodriguez-Moreno and J.I. Pena, *Systemic risk measures: the simpler the better?*, J. Bank. Financ. **37** (2013), 1817–1831.

[30] E.S. Rosengren, *Asset bubbles and systemic risk*, Glob. Interdepend. Center's Conf. Financ. Interdepend. World's Post-Crisis Capital Markets, Speech, 2010, no. 32.

[31] M.A. Rostgar and N. Karimi, *Systemic risk in the banking sector*, Risk Model. Financ. Eng. Quart. **1** (2015), no. 1, 1–19.

[32] J. Yun and H. Moon, *Measuring systemic risk in the Korean banking sector via dynamic conditional correlation models*, Pacific-Basin Finance J. **27** (2014), 94–114.

[33] N.A. Tarashev, C.E. Borio and K. Tsatsaronis, *Attributing systemic risk to individual institutions*, BIS Working Paper No. 308, Available at SSRN: https://ssrn.com/abstract=1631761, (2010).