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ECONOMETRIC EVALUATION OF RISK AT THE SHANGHAI STOCK EXCHANGE[****]

1. INTRODUCTION

Since the beginning of XXI century two important stock exchanges in Shanghai and in Shenzhen have been participating in international competition becoming an important part of the global capital market. In early 90s of XX century the Chinese capital market was closed to foreign investors. The restructuring process in China began in 1999 with the reform of non-tradable shares. Chinese membership in WTO (since 2001) caused the opening up of the security industry. Foreign securities firms have been allowed to operate directly in B share business and their representative offices in China might have become Special Members of Chinese Stock Exchanges. Further steps of opening up are related with overseas listings of H shares and new regulations concerning public offerings of securities. The Chinese authorities supported eligible companies to list their shares in Hong Kong, Singapore and even in New York or in London.

Nowadays shares of the same enterprise are quoted at domestic market and overseas, however the total number of such cases was only 125 in 2006 (Neftci and Menager-Xu, 2006).The opening-up process exposes stock markets in China on greater price movements. High movements are particularly significant and harmful if they lead to the risk transmission between the financial markets. That risk spillover is vital not only for investors, but also for institutions supervising financial markets. It is crucial for the risk management and for the market participants to understand how the risk spillover mechanism is transmitted between markets. The risk spillover effect may lead to large losses and from that point of view the accurate risk management can incorporate such losses is priceless. To include efficient risk management in financial institutions one should have identified events that cause the risk spillover effect. If one wants to infer about the risk spillover and its effect on markets one should use such methods and tools that can fit properly for catastrophic events. In order to ensure that we used

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Extreme Value Theory (EVT),that was invented particularly for modelling extreme events. The existing literature (Kuester et al.2006; Harmantzis et al.2006; Fałdziński 2011) shows that EVT is more appropriate than other methods for estimating risk measures.

We took into account the process of transferring risk between major indices of Shanghai Stock Exchange and sector indices (sub-indices) representing various segments of the market. To check proposed hypotheses we applied Granger causality in risk concept. Furthermore, we applied different risk measures to take into consideration different risk patterns (small, medium and high risk).The purpose of the paper is to analyse transfer of risk across the financial markets and submarkets in China with the use of the Granger causality in risk test developed by Hong (2001) and Hong et al. (2009). In the original idea of the Granger causality in risk the Value at risk was employed as a risk measure. In this paper we extended the scope of application of the test to Expected Shortfall and Spectral Risk Measure, according to the procedure applied earlier in Fałdziński, Osińska, Zdanowicz (2012).

The rationale for using different risk measures is that they exhibit different risk transmission patterns. Financial markets are affected significantly by the events which occur with various probabilities (smaller and higher) and various frequencies (various time intervals). The three risk measures mentioned above provide a wide range of the risk spillover mechanism.

2. TESTING FOR THE GRANGER CAUSALITY IN RISK

The concept of the Granger causality is widely known and very often applied in practice. Granger's definition is related to predictability of one variable using previous values of another one. Originally (Granger 1969) it was formulated for two stationary time series X_t and Y_t that constituted the whole information set available at time t. As the concept has become more and more popular it was extended to nonstationary (integrated) time series (Toda and Yamammoto 1995), and what was very important in financial econometrics, implemented for conditional variance and for risk measures (Cheung and Ng 1996). Advantages and disadvantages of different definitions of causality in Granger's sense and their applications were the subject of extended discussion in Osińska (2011). In the presented paper one's attention is turned on the causality in risk concept. In short, we can say that using past information the Granger causality in risk concept allows testing whether the history of the occurrence of significant risk in one market has predictive power for the occurrences of large risk in other markets. In the sense of predictability it corresponds to the original idea of the Granger causality. It should be understood in terms of co-dependence between different financial instruments, portfolios or markets that occurred if the risk limits are broken. This means that breaking the VaR (or ES or SRM) in one market results in exceeding maximum risk levels in other markets. Such a situation may correspond with the contagion phenomenon in a negative sense or with positive impulses spreading all over the financial markets.

Formally, the Granger causality in risk is defined as follows (Hong, 2001). Let $\{Y_{1t}, Y_{2t}\}$ is a bivariate not necessarily stationary stochastic time series. Let $A_{lt} = A_{lt}\left(I_{l(t-1)}\right)$ l = 1,2 is the VaR at level $\alpha \in (0;1)$ for Y_{lt} predicted using the information set $I_{l(t-1)} = \{Y_{l(t-1)}, Y_{l(t-2)} \dots, Y_{l1}\}$ available at time t-1. A_{lt} satisfies $P\left(Y_{lt} < A_{lt} \mid I_{l(t-1)}\right) = \alpha$. In the case of the Granger non-causality the null hypothesis is:

$$H_0: \quad P\left(Y_{1t} < A_{1t} \mid I_{1(t-1)}\right) = P\left(Y_{1t} < A_{1t} \mid I_{t-1}\right), \tag{1}$$

almost surely, where $I_{t-1} = \{I_{1(t-1)}, I_{2(t-1)} \dots\}$ with the alternative:

$$H_1: \quad P\left(Y_{1t} < A_{1t} \mid I_{1(t-1)}\right) \neq P\left(Y_{1t} < A_{1t} \mid I_{t-1}\right). \tag{2}$$

The null hypothesis says that the process $\{Y_{2t}\}$ does not Granger-cause the process $\{Y_{1t}\}$ in risk at level α with respect to $I_{(t-1)}$. The alternative hypothesis says that the process $\{Y_{2t}\}$ Granger-causes the process $\{Y_{1t}\}$ in risk at level α with respect to $I_{(t-1)}$. Comparing the above definition with the original one we may state that it concentrates only on the violations of VaR's computed for a given portfolio represented by Y_{1t}. So we interpret it as if information about the second portfolio represented by Y_{2t} could help change the probability of breaking the VaR of the first portfolio Y_{1t}. The definition captures the general characteristics of the Granger causality concept above a certain risk level.

The testing idea derived by Hong (2001) and modified by Hong et al. (2009) is based on the cross-spectral density of a bivariate covariance stationary process V_{1t} and V_{2t}, where $V_{lt} = I\left(Y_{lt} > A_{lt}\right)$, l = 1,2 denotes the VaR break indicator. The break indicator takes on the value 1 when VaR is exceeded by loss and takes on the value 0 otherwise.

The hypotheses corresponding to (1) and (2) can be transformed into the expected value level:

$$H_0: \quad E\left(V_{1t} \mid I_{1(t-1)}\right) = E\left(V_{1t} \mid I_{t-1}\right). \tag{3}$$

$$H_1: \quad E\left(V_{1t} \mid I_{1(t-1)}\right) \neq E\left(V_{1t} \mid I_{t-1}\right). \tag{4}$$

For unidirectional causality the test statistic takes the form:

$$Q_1(M) = \left[T \sum_{j=1}^{T-1} k^2(j/M)\,\hat{\rho}(j)^2 - C_{1T}(M)\right] / D_{1T}(M)^{1/2}. \tag{5}$$

$C_{1T}(M)$ and $D_{1T}(M)$ are the mean and the variance, $k(j/M)$ is the kernel function, $\hat{\rho}(j)$ is the sample cross-correlation function between V_{1t} and V_{2t}. As it was emphasized by Hong et al. 2009 the test statistic does not check exactly the null but it is a necessary condition that allows capturing the most important information on the average. There exists an analogue of (5) for bidirectional causality concept denoted $Q_2(M)$ (see for more details Hong et al. (2009)). It should be stressed that in Hong (2001) the Granger causality in risk has been considered only in the case on simple model GARCH(1,1) with normal conditional distribution. It is also important to emphasize that in Hong et al. (2009) formal results have been provided only under:

$$V_{lt}(\theta_l) = V_l(I_{l(t-1),\theta_l}), \quad (l = 1,2).$$

To verify the pair of hypotheses (1)–(2), we propose to use the expected shortfall and the spectral risk measures. It is expected that the results obtained for the ES should be stronger than those computed for the VaR because the ES denoted the situation when VaR was already exceeded. The same relation is valid for ES and SRM. It is based on ability to satisfy the coherence axioms (Artzner et al. (1997)) and taking into account risk-aversion parameter. Then hypotheses are modified as follows.

Let $B_{lt} = B_{lt}(I_{l(t-1)})$ $l = 1,2$ is the Expected Shortfall at confidence level $\alpha \in (0;1)$ for Y_{lt} predicted using the information set $I_{l(t-1)} = \{Y_{l(t-1)}, Y_{l(t-2)} \ldots, Y_{l1}\}$ available at time *t-1*. Then $ES_{lt} = I(Y_{lt} \mid Y_{lt} > B_{lt})$, $l = 1,2$ is the ES break indicator (constructed similarly to the VaR break indicator).The break indicator takes the value 1 when ES is exceeded by loss and takes the value 0 otherwise. In the case of ES hypotheses to be tested are

$$H_0: \quad E\left(ES_{1t} \mid I_{1(t-1)}\right) = E\left(ES_{1t} \mid I_{t-1}\right). \tag{6}$$

$$H_1: \quad E\left(ES_{1t} \mid I_{1(t-1)}\right) \neq E\left(ES_{1t} \mid I_{t-1}\right). \tag{7}$$

The test statistics as well as its characteristics remain the same because the expected shortfall does not remain in contradiction with the VaR. Spectral Risk Measure (SRM) as the most general quantile based risk measure can also be used in testing for the Granger-causality in risk. Let $C_{lt} = C_{lt}(I_{l(t-1)})$ $l = 1,2$ is the Spectral Risk Measure with parameter R for Y_{lt} predicted using the information set $I_{l(t-1)} = \{Y_{l(t-1)}, Y_{l(t-2)} \ldots, Y_{l1}\}$ available at time *t*-1. Then $SRM_{lt} = I(Y_{lt} \mid Y_{lt} > C_{lt})$ $l = 1,2$ is the SRM break indicator (constructed similarly to the VaR and ES break indicator). Hypotheses corresponding to the Granger causality in risk in case of SRM are considered to take the forms:

$$H_0 : E(SRM_{1t} \mid I_{1(t-1)}) = E(SRM_{1t} \mid I_{t-1}), \tag{8}$$

almost surely

$$H_1 : E(SRM_{1t} \mid I_{1(t-1)}) \neq E(SRM_{1t} \mid I_{t-1}), \tag{9}$$

When testing for causality in risk we take into account the number of violations of the respective risk measure. It does not occur very often, however its consequences are very strong. We tested for the Granger causality in risk for the three risk measures: VaR, ES and SRM, respectively. The conditional mean was defined by the autoregressive model with GARCH type error:

$$Y_{lt} = \psi_{l0} + \psi_l (L) Y_{lt} + \sqrt{h_{Y_{lt}}} \zeta_{lt}, \quad \text{for } l = 1, 2, \tag{10}$$

where: ζ_{lt}, l = *1,2* are normally distributed white noises, $\psi_l(L) = \sum_{i=1}^{q} \psi_{li} L^i$, l = 1,2 are polynomial autoregressive operators, $h_{Y_{lt}}$, l = 1,2 denote conditional variances of the corresponding time series. The conditional variance is modelled using GARCH(1,1) representation with t-Student error distribution:

$$h_{Y_{lt}} = \gamma_{l0} + \gamma_{l1} \xi_{l,t-1}^2 + \delta_{l1} h_{Y_{l,t-1}}, \quad \text{for } l = 1, 2, \tag{11}$$

where: $\xi_{lt} = \sqrt{h_{Y_{lt}}} \zeta_{lt}$, $l = 1, 2$.

In the case of analysis of events with huge size that break the limits determined by the mentioned risk measures, the Extreme Value Theory (EVT) is applicable. For further analysis the Peaks over Threshold (POT) method (see for details Embrechts et al. 2003) is applied in this paper. According to the Peaks over Threshold method we used standardised residuals from GARCH(1,1) model with t-disturbances to estimate parameters of Generalized Pareto Distribution with assumed threshold u . The choice of threshold is the weak spot of POT theory: it is arbitrary and therefore judgmental (Dowd (2005)).We set u as a value corresponding to a 10% level for all observations in time series which is the standard level. It is often seen that 10% level is a proper compromise between bias and variance.

In the next step all the three risk measures were estimated in accordance with formulas:

$$VaR_q^t = \mu_{t+1} + \sigma_{t+1} VaR(Z)_q, \tag{12}$$

$$ES_q^t = \mu_{t+1} + \sigma_{t+1} ES(Z)_q, \tag{13}$$

where $VaR_q^t(Z)$ is the q-th quantile of Z_t and $ES_q^t(Z)$ is the corresponding expected shortfall.

We assume that X_t is a time series that represents daily observations of log return on a financial asset price, which are given by $X_t = \mu_t + \sigma_t Z_t$, where Z_t is a white noise process with zero mean, unit variance and the marginal distribution function $F_Z(z)$ McNeil and Frey (2000). We assume that μ_t is the expected return and σ_t is the volatility of the return. Furthermore in this paper we implemented analogical formula for the conditional spectral risk measure in the form:

$$SRM_q^t = \mu_{t+1} + \sigma_{t+1} SRM(Z)_q, \tag{14}$$

In the POT method VaRat the confidence level p is given by:

$$VaR_p = u + \frac{\hat{\sigma}}{\hat{\gamma}}\left(\left(\frac{n}{N_u}p\right)^{-\hat{\gamma}} - 1\right), \tag{15}$$

and the ES is given by:

$$ES_p = \frac{q_p}{1-\gamma} + \frac{\sigma - \gamma u}{1-\gamma}, \tag{16}$$

where N_u denotes the number of exceeding observations. The spectral risk measure with exponential risk-aversion function is given by:

$$M_\phi = \int_0^1 \frac{R\,\mathrm{e}^{-R(1-p)}}{1-e^{-R}}\left[u + \frac{\hat{\sigma}}{\hat{\gamma}}\left(\left(\frac{n}{N_u}p\right)^{-\hat{\gamma}} - 1\right)\right]dp, \tag{17}$$

when POT method is applied. They were compared with original series to obtain a sequence of violations. In the last step we tested for the Granger causality in risk for VaR, ES and SRM, respectively. In the case of the GARCH model and generalized Pareto distribution parameters were estimated with the maximum likelihood method. We calculated the integral (17) using numerical integration, and in this case we applied one-third Simpson's method (see: for details Miranda and Fackler 2002).

3. EMPIRICAL ANALYSIS

The subject of the research concentrated on dependencies between time series of 12 sub-indices from SSE, Chinese yuan against the U.S. dollar, Hang Seng Index (HSI) and Shanghai Stock Exchange Composite Index (SSE).These 12 subindices are: SSE A, SSE B, SSE 50 (selects 50 largest stocks of good liquidity), SSE 180 (serving as a performance benchmark for investment and a basis for financial innovation), SSE Commercial, SSE Industrial, SSE Conglomerates, SSE Real Estate, SSE Utilities (all listed stocks (both A and B shares) of that specific sector), SSE Dividend (reflect high dividend-paying companies), SSE Fund (all security investment funds listed) and SSE Government Bond (all fixed-rate government bonds).Daily observations from Feb. 1, 2006 till Feb. 18, 2011 were taken into account (sample: 2–1326, i.e. 1325 observations). They were divided into two groups: before the financial crisis from Feb. 1, 2006 till Jul. 31, 2008 (sample: 2–658) and during and after the crisis from Aug. 1, 2008 till Feb. 18, 2011 (sample: 659–1326). All the data were transformed into logarithmic rates of return according to the formula: $r_t = 100 * \left(\ln(P_t) - \ln(P_{t-1})\right)$. In the case of short position the data were transformed according to $r_t = -100 * \left(\ln(P_t) - \ln(P_{t-1})\right)$.

3.1. THE RESULTS OF TESTING FOR CAUSALITY IN RISK

On the basis of the GARCH models with t-Student error distribution we estimated Value at Risk as well as Expected Shortfall at 5 per cent and 95 per cent confidence level. To apply the spectral risk measure we needed to choose a suitable value for the coefficient of the absolute risk aversion R. The higher R is, the more we care about the higher losses relative to the others. It therefore makes sense to apply an EVT approach in the first place if we care a great deal about the very high losses (i.e. extremes) related to the non-extreme observations, and this requires that R takes a high value. In principle, this can be any positive value, so we decided to follow Cotter and Dowd (2006) and set $R = \{100\}$.

We decided to focus on China as one of the fastest growing economies in the last decade. The Chinese stock market as a significant part of economy experienced huge gain and – to some extend – integrated with other financial markets. It was interesting to examine whether and how much particular segments of Chinese stock market have become a part of the global financial system with its entire positive and negative effects such as the risk spillover or contagion. It should be emphasized that violations (breaks) of the spectral risk measure (cases when SRM is exceeded by loss) are less frequent than the expected short fall as well as the VaR breaks. So the results obtained for the SRM are significantly more important for forecasting the risk transfers than the results obtained for the ES and/or VaR. It is connected with the idea behind these three risk measures. The SRM breaks down only in cases when really extreme events (catastrophic) occur. When they occur it is more probable that these events will bring spillover effect because of its magnitude and rarity.

Table 1and Table 2 reports representative test statistics for the Granger causality in risk at α=5% confidence level (with *p*-values) when Value-at-Risk is applied. For short position (profits)SSE does Granger cause in almost all cases. There are two exceptions: SSE Government Bond Index and SSE Real Estate. The former comprises all fixed-rate government bonds listed at SSE.

It reflects the changes in the government bond market. The latter comprises all listed stocks regarding real estate market.

Generally we can say that in case of the Granger causality in risk from subindices to SSE results are almost the same (with the same two exceptions). On the other hand, for Value-at-Risk for long position (losses) we can observe (Table 2) that there is risk spillover effect between some specific subindices (SSE 50, SSE 180, SSE Conglomerates, SSE Dividend, SSE Real Estate, SSE Utilities) and SSE, but only after 40 days. As we could see losses on SSE cause risk spillover effect, but specific subindices alone do not possess such power. In other words some subindex is not strong enough to bring about Granger causality in risk. Of course SSE as the composite index does Granger cause in risk in almost all cases with one exception like before (SSE Government Bond Index). It could indicate that bond market which evaluates the potential of the Chinese economy isin some way detached from stock exchange or invulnerable to losses/gains on stock market.

For Expected Shortfall at 5% confidence level results (Table 3 and Table 4) are similar to these for VaR. We find extremely significant two-way Granger causality in risk between SSE 50, SSE Fund and SSE for long position. In case of ES more subindices do cause risk spillover effect. We believe it means that SSE 30 is an ‘exclusive’ index and SSE 180 comprises to many companies which clearly indicate that they not behave like SSE in terms of risk transmission patterns. It boils down to the conclusion that companies which are included in SSE 50 are strong enough to influence SSE and bring existence to risk spillover. SSE Fund as the bearer of all security investment funds listed at SSE is enough influential to bring about Granger causality in risk.

For Spectral Risk Measure which fails only when extreme events occurs, we find (Table 5 and Table 6) that Granger causality in risk from subindices to SSE in more frequent that for ES and VaR.It clearly indicates that huge losses on some specific part of the stock market influence the whole stock market (in that case SSE) and there is no simple escape from it.

4. CONCLUSIONS

The results of the Granger-causality in risk can be considered in terms of market contagion analysis. They answer the questions put at the beginning of the analysis about the source of risk and the speed of its diffusion. The results of testing the Granger-causality in risk show that in the whole sample period non-expected but positive signals (short position) were weaker than the corresponding negative signals (long position) for all risk measures VaR, ES and SRM considered in the paper. Positive signals were spread slower than the negative ones taking into account the time lags. We believe that there are different risk transmission patterns on Chinese stock market and it is important to separate them due to the fact that it is absolutely crucial to recognize them in context of risk management or/and market supervision. We find that Chinese stock market is partially segmented and it will be challenging to authorities to maintain it.

Table 1. The results of testing for Granger-causality in risk at 5% confidence level from Feb. 1, 2006 till Feb. 18, 2011 when Value-at-Risk is applied in case of short position

M (lags)	5	10	20	40	M (lags)	5	10	20	40
SSE → SSE A	19.260	14.150	10.040	8.440	SSE A → SSE	0.562	2.596	2.492	1.892
	0.000	0.000	0.000	0.000		– 0.286	– 0.004	– 0.006	– 0.029
SSE → SSE B	256.900	198.000	146.700	106.300	SSE B → SSE	2.557	11.950	13.890	11.860
	0.000	0.000	0.000	0.000		– 0.005	0.000	0.000	0.000
SSE → SSE 50	105.400	83.360	62.510	44.530	SSE 50 → SSE	2.920	9.249	11.220	9.931
	0.000	0.000	0.000	0.000		– 0.001	0.000	0.000	0.000
SSE → SSE 180	55.210	45.310	34.950	24.800	SSE 180 → SSE	3.581	10.480	12.430	10.910
	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000
SSE → SSE Commercial	25.990	19.310	13.180	9.567	SSE Commercial → SSE	6.454	20.210	30.050	30.860
	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000
SSE → SSEComposite	351.500	272.500	202.800	147.300	SSE Composite → SSE	2.557	11.950	13.890	11.860
	0.000	0.000	0.000	0.000		– 0.005	0.000	0.000	0.000
SSE → SSE Conglomerates	160.400	125.200	94.470	70.440	SSE Conglomerates → SSE	0.941	3.725	7.400	9.476
	0.000	0.000	0.000	0.000		– 0.173	0.000	0.000	0.000
SSE → SSE Dividend	111.900	87.120	68.160	54.750	SSE Dividend→ SSE	1.170	4.359	5.436	10.160
	0.000	0.000	0.000	0.000		– 0.120	0.000	0.000	0.000
SSE → SSE Fund	134.900	103.100	75.360	53.910	SSE Fund → SSE	5.049	7.038	7.345	7.802
	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000
SSE → SSE Govern. Bond	– 0.267	0.132	0.337	0.564	SSE Govern. Bond → SSE	– 0.382	– 0.436	– 0.674	– 0.557
	– 0.605	– 0.447	– 0.367	– 0.286		– 0.648	– 0.668	– 0.749	– 0.711
SSE → SSE Industrial	222.700	172.800	128.500	93.290	SSE Industrial → SSE	1.724	5.655	6.557	5.756
	0.000	0.000	0.000	0.000		– 0.042	0.000	0.000	0.000
SSE → SSE Real Estate	– 1.108	– 1.600	– 2.288	– 2.401	SSE Real Estate → SSE	– 1.108	– 1.600	– 2.289	– 1.561
	– 0.866	– 0.945	– 0.988	– 0.991		– 0.866	– 0.945	– 0.988	– 0.940
SSE → SSE Utilities	351.500	276.900	208.300	151.400	SSE Utilities → SSE	8.326	22.690	24.630	21.480
	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000

→” represents the direction in test for Granger causality in risk. The numbers in parentheses are the *p*-values.

Source: author’s own.

Table 2. The results of testing for Granger-causality in risk at 5% confidence level from Feb. 1, 2006 till Feb. 18, 2011 when Value-at-Risk is applied in case of long position

M (lags)	5	10	20	40	M (lags)	5	10	20	40
SSE → SSE A	154.600	118.300	86.210	61.130	SSE A → SSE	−0.764	−0.273	−0.270	−0.442
	0.000	0.000	0.000	0.000		−0.777	−0.607	−0.606	−0.670
SSE → SSE B	539.100	414.800	305.500	221.500	SSE B → SSE	−0.774	−0.713	−0.176	0.447
	0.000	0.000	0.000	0.000		−0.780	−0.762	−0.569	−0.327
SSE → SSE 50	335.800	257.800	190.200	139.000	SSE 50 → SSE	0.486	1.154	2.118	3.289
	0.000	0.000	0.000	0.000		−0.313	−0.124	−0.017	0.000
SSE → SSE 180	364.600	280.000	206.500	151.000	SSE 180 → SSE	0.651	1.063	1.778	2.645
	0.000	0.000	0.000	0.000		−0.257	−0.143	−0.037	−0.004
SSE → SSE Commercial	175.500	134.500	98.140	69.720	SSE Commercial → SSE	−0.779	−0.483	0.483	1.391
	0.000	0.000	0.000	0.000		−0.782	−0.685	−0.314	−0.082
SSE → SSE Composite	539.000	414.200	304.800	220.800	SSE Composite → SSE	−0.774	−0.713	−0.176	0.447
	0.000	0.000	0.000	0.000		−0.780	−0.762	−0.569	−0.327
SSE → SSE Conglomerates	212.700	163.700	120.600	87.160	SSE Conglomerates → SSE	0.486	1.154	2.118	3.282
	0.000	0.000	0.000	0.000		−0.313	−0.124	−0.017	0.000
SSE → SSE Dividend	236.900	182.800	134.500	97.320	SSE Dividend→ SSE	−0.749	−0.124	1.438	3.259
	0.000	0.000	0.000	0.000		−0.773	−0.549	−0.075	0.000
SSE → SSE Fund	292.800	225.400	166.400	120.900	SSE Fund → SSE	−0.036	0.010	0.283	0.611
	0.000	0.000	0.000	0.000		−0.514	−0.495	−0.388	−0.270
SSE → SSE Govern. Bond	−0.774	−0.645	−0.297	−0.031	SSE Govern. Bond → SSE	−0.417	−0.512	−0.394	−0.355
	−0.780	−0.740	−0.617	−0.512		−0.661	−0.695	−0.653	−0.638
SSE → SSE Industrial	253.000	194.900	143.200	103.300	SSE Industrial → SSE	−0.774	−0.390	0.737	1.945
	0.000	0.000	0.000	0.000		−0.780	−0.651	−0.230	−0.025
SSE → SSE Real Estate	42.180	34.700	25.990	18.620	SSE Real Estate → SSE	−0.437	1.897	3.064	4.161
	0.000	0.000	0.000	0.000		−0.669	−0.028	−0.001	0.000
SSE → SSE Utilities	272.000	209.100	153.400	110.300	SSE Utilities → SSE	−0.782	−0.217	0.970	2.156
	0.000	0.000	0.000	0.000		−0.782	−0.586	−0.166	−0.015

Indication as described in Table 1 above.

Source: author's own.

Table 3. The results of testing for Granger-causality in risk at 5% confidence level from Feb. 1, 2006 till Feb. 18, 2011 when Expected Shortfall is applied in case of short position

M (lags)	5	10	20	40	M (lags)	5	10	20	40
SSE → SSE A	47.070	35.770	26.700	20.280	SSE A → SSE	– 0.124	1.587	1.485	0.835
	0.000	0.000	0.000	0.000		– 0.549	– 0.056	– 0.068	– 0.201
SSE → SSE B	458.900	354.100	261.300	188.700	SSE B → SSE	1.477	6.219	6.856	5.701
	0.000	0.000	0.000	0.000		– 0.069	0.000	0.000	0.000
SSE → SSE 50	312.800	240.600	176.900	127.200	SSE 50 → SSE	0.670	5.905	7.091	6.191
	0.000	0.000	0.000	0.000		– 0.251	0.000	0.000	0.000
SSE → SSE 180	331.000	255.400	188.800	136.400	SSE 180 → SSE	0.434	4.688	5.552	4.741
	0.000	0.000	0.000	0.000		– 0.331	0.000	0.000	0.000
SSE → SSE Commercial	78.370	59.880	43.690	31.470	SSE Commercial → SSE	0.576	2.778	4.740	6.228
	0.000	0.000	0.000	0.000		– 0.282	– 0.002	0.000	0.000
SSE → SSE Composite	533.500	411.800	304.100	219.900	SSE Composite → SSE	1.904	7.662	8.431	7.124
	0.000	0.000	0.000	0.000		– 0.028	0.000	0.000	0.000
SSE → SSE Conglomerates	273.800	210.500	154.700	111.300	SSE Conglomerates → SSE	1.303	5.892	8.714	9.502
	0.000	0.000	0.000	0.000		– 0.096	0.000	0.000	0.000
SSE → SSE Dividend	174.000	133.700	98.200	70.370	SSE Dividend→ SSE	0.425	1.833	1.967	3.288
	0.000	0.000	0.000	0.000		– 0.335	– 0.033	– 0.024	0.000
SSE → SSE Fund	242.700	187.600	138.400	99.590	SSE Fund → SSE	0.808	4.284	4.745	4.835
	0.000	0.000	0.000	0.000		– 0.209	0.000	0.000	0.000
SSE → SSE Govern. Bond	2.596	1.932	3.666	4.845	SSE Govern. Bond → SSE	0.372	0.983	0.687	0.690
	– 0.004	– 0.026	0.000	0.000		– 0.354	– 0.162	– 0.245	– 0.244
SSE → SSE Industrial	242.700	187.500	138.500	100.600	SSE Industrial → SSE	– 0.249	0.969	0.816	0.600
	0.000	0.000	0.000	0.000		– 0.598	– 0.166	– 0.207	– 0.274
SSE → SSE Real Estate	15.990	11.760	7.958	5.142	SSE Real Estate → SSE	5.830	4.108	3.985	6.939
	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000
SSE → SSE Utilities	222.700	172.300	127.600	92.650	SSE Utilities → SSE	1.604	6.644	7.048	5.605
	0.000	0.000	0.000	0.000		– 0.054	0.000	0.000	0.000

Indication as described in Table 1 above.

Source: author’s own.

Table 4. The results of testing for Granger-causality in risk at 5% confidence level from Feb. 1, 2006 till Feb. 18, 2011 when Expected Shortfall is applied in case of long position

M (lags)	5	10	20	40	M (lags)	5	10	20	40
SSE → SSE A	382.400	294.100	216.200	155.600	SSE A → SSE	−0.561	−0.690	−0.642	−0.712
	0.000	0.000	0.000	0.000		−0.712	−0.755	−0.739	−0.761
SSE → SSE B	726.700	559.200	411.900	297.700	SSE B → SSE	−0.297	−0.284	−0.148	−0.182
	0.000	0.000	0.000	0.000		−0.617	−0.611	−0.559	−0.572
SSE → SSE 50	390.000	299.900	222.000	161.400	SSE 50 → SSE	4.437	5.115	4.768	4.023
	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000
SSE → SSE 180	567.200	436.500	321.900	233.000	SSE 180 → SSE	−0.341	−0.368	−0.267	−0.288
	0.000	0.000	0.000	0.000		−0.633	−0.643	−0.605	−0.613
SSE → SSE Commercial	457.900	352.200	259.000	186.300	SSE Commercial → SSE	−0.232	−0.396	−0.418	−0.386
	0.000	0.000	0.000	0.000		−0.592	−0.653	−0.662	−0.650
SSE → SSE Composite	760.300	585.200	431.100	311.600	SSE Composite → SSE	−0.249	−0.189	−0.012	−0.015
	0.000	0.000	0.000	0.000		−0.598	−0.575	−0.505	−0.506
SSE → SSE Conglomerates	353.200	271.700	200.800	145.200	SSE Conglomerates → SSE	1.316	1.327	1.644	1.839
	0.000	0.000	0.000	0.000		−0.094	−0.092	−0.050	−0.032
SSE → SSE Dividend	544.000	418.500	308.100	222.400	SSE Dividend→ SSE	−0.379	−0.444	−0.376	−0.430
	0.000	0.000	0.000	0.000		−0.647	−0.671	−0.646	−0.666
SSE → SSE Fund	494.200	380.300	280.600	203.300	SSE Fund → SSE	2.060	2.307	2.847	3.175
	0.000	0.000	0.000	0.000		−0.019	−0.010	−0.002	0.000
SSE → SSE Govern. Bond	3.156	3.028	3.086	2.199	SSE Govern. Bond → SSE	−0.460	−0.583	−0.787	−0.649
	0.000	−0.001	−0.001	−0.013		−0.677	−0.720	−0.784	−0.741
SSE → SSE Industrial	641.200	493.300	363.200	262.200	SSE Industrial → SSE	−0.413	−0.512	−0.473	−0.548
	0.000	0.000	0.000	0.000		−0.660	−0.695	−0.682	−0.708
SSE → SSE Real Estate	192.600	148.300	109.700	79.210	SSE Real Estate → SSE	−0.124	−0.314	−0.156	0.005
	0.000	0.000	0.000	0.000		−0.549	−0.623	−0.562	−0.497
SSE → SSE Utilities	481.500	370.700	272.900	196.500	SSE Utilities → SSE	−0.131	−0.079	−0.043	−0.033
	0.000	0.000	0.000	0.000		−0.552	−0.531	−0.517	−0.513

Indication as described in Table 1 above.

Source: author's own.

Table 5. The results of testing for Granger-causality in risk at 5% confidence level from Feb. 1, 2006 till Feb. 18, 2011 when Spectral Risk Measure is applied in case of short position

M (lags)	**5**	**10**	**20**	**40**	**M (lags)**	**5**	**10**	**20**	**40**
SSE → SSE A	11.160	7.868	4.721	2.707	SSE A → SSE	– 1.075	– 1.552	– 2.218	– 3.150
	0.000	0.000	0.000	– 0.003		– 0.858	– 0.939	– 0.986	– 0.999
SSE → SSE B	245.500	188.300	137.600	98.650	SSE B → SSE	1.163	2.610	1.851	1.101
	0.000	0.000	0.000	0.000		– 0.122	– 0.004	– 0.032	– 0.135
SSE → SSE 50	256.900	197.000	144.100	103.800	SSE 50 → SSE	0.503	1.371	0.660	– 0.117
	0.000	0.000	0.000	0.000		– 0.307	– 0.085	– 0.254	– 0.546
SSE → SSE 180	256.900	197.000	144.100	103.800	SSE 180 → SSE	0.503	1.371	0.660	– 0.117
	0.000	0.000	0.000	0.000		– 0.307	– 0.085	– 0.254	– 0.546
SSE → SSE Commercial	76.220	57.960	41.640	30.350	SSE Commercial → SSE	0.892	4.686	8.631	8.455
	0.000	0.000	0.000	0.000		– 0.186	0.000	0.000	0.000
SSE → SSE Composite	460.800	355.400	261.900	188.700	SSE Composite → SSE	0.503	1.371	0.660	– 0.117
	0.000	0.000	0.000	0.000		– 0.307	– 0.085	– 0.254	– 0.546
SSE → SSE Conglomerates	36.930	27.710	20.490	14.500	SSE Conglomerates → SSE	– 1.058	– 1.526	– 2.182	– 2.235
	0.000	0.000	0.000	0.000		– 0.855	– 0.936	– 0.985	– 0.987
SSE → SSE Dividend	76.220	57.960	41.660	30.110	SSE Dividend→ SSE	0.892	2.099	1.351	– 0.168
	0.000	0.000	0.000	0.000		– 0.186	– 0.017	– 0.088	– 0.566
SSE → SSE Fund	137.900	105.400	76.640	54.480	SSE Fund → SSE	– 0.564	2.323	3.350	2.864
	0.000	0.000	0.000	0.000		– 0.713	– 0.010	0.000	– 0.002
SSE → SSE Govern. Bond	– 1.075	– 1.087	0.548	1.541	SSE Govern. Bond → SSE	5.808	5.890	4.009	1.623
	– 0.858	– 0.861	– 0.291	– 0.061		0.000	0.000	0.000	– 0.052
SSE → SSE Industrial	351.500	271.300	199.900	143.900	SSE Industrial → SSE	0.503	1.371	0.660	– 0.713
	0.000	0.000	0.000	0.000		– 0.307	– 0.085	– 0.254	– 0.762
SSE → SSE Real Estate	7.829	5.314	2.857	1.258	SSE Real Estate → SSE	– 1.058	– 1.526	– 1.833	– 1.448
	0.000	0.000	– 0.002	– 0.104		– 0.855	– 0.936	– 0.966	– 0.926
SE → SSE Utilities	155.800	119.200	86.760	61.890	SSE Utilities → SSE	1.718	5.650	5.423	3.340
	0.000	0.000	0.000	0.000		– 0.042	0.000	0.000	0.000

Indication as described in Table 1 above. Risk measure is applied in case of short position.

Source: author's own.

Table 6. The results of testing for Granger-causality in risk at 5% confidence level from Feb. 1, 2006 till Feb. 18, 2011 when Spectral Risk Measure is applied in case of long position

M (lags)	5	10	20	40	M (lags)	5	10	20	40
SSE → SSE A	110.600	84.430	61.110	42.610	SSE A → SSE	– 1.073	– 1.548	– 2.213	– 3.130
	0.000	0.000	0.000	0.000		– 0.858	– 0.939	– 0.986	– 0.999
SSE → SSE B	565.200	436.600	321.700	231.700	SSE B → SSE	3.321	3.211	1.789	– 0.041
	0.000	0.000	0.000	0.000		0.000	0.000	– 0.036	– 0.516
SSE → SSE 50	396.300	307.200	227.300	165.100	SSE 50 → SSE	4.561	4.546	2.893	0.782
	0.000	0.000	0.000	0.000		0.000	0.000	– 0.001	– 0.216
SSE → SSE 180	565.200	436.600	321.700	231.700	SSE 180 → SSE	3.321	3.211	1.789	– 0.041
	0.000	0.000	0.000	0.000		0.000	0.000	– 0.036	– 0.516
SSE → SSE Commercial	351.600	272.500	200.900	144.500	SSE Commercial → SSE	3.871	3.803	2.278	0.322
	0.000	0.000	0.000	0.000		0.000	0.000	– 0.011	– 0.373
SSE → SSE Composite	628.700	485.800	358.100	258.100	SSE Composite → SSE	3.871	3.803	2.278	0.322
	0.000	0.000	0.000	0.000		0.000	0.000	– 0.011	– 0.373
SSE → SSE Conglomerates	243.000	188.900	139.400	100.000	SSE Conglomerates → SSE	3.871	3.803	2.278	0.852
	0.000	0.000	0.000	0.000		0.000	0.000	– 0.011	– 0.197
SSE → SSE Dividend	314.000	244.300	180.600	130.100	SSE Dividend→ SSE	5.450	5.504	3.688	1.381
	0.000	0.000	0.000	0.000		0.000	0.000	0.000	– 0.083
SSE → SSE Fund	479.600	368.400	270.300	194.100	SSE Fund → SSE	3.871	3.803	2.278	0.322
	0.000	0.000	0.000	0.000		0.000	0.000	– 0.011	– 0.373
SSE → SSE Govern. Bond	– 1.057	0.555	0.915	– 0.181	SSE Govern. Bond → SSE	– 1.057	– 1.525	– 2.180	– 2.321
	– 0.854	– 0.289	– 0.180	– 0.571		– 0.854	– 0.936	– 0.985	– 0.989
SSE → SSE Industrial	314.000	244.300	180.600	129.800	SSE Industrial → SSE	– 1.073	– 1.548	– 2.213	– 3.130
	0.000	0.000	0.000	0.000		– 0.858	– 0.939	– 0.986	– 0.999
SSE → SSE Real Estate	441.800	344.200	255.000	183.900	SSE Real Estate → SSE	– 1.088	– 1.570	– 2.245	– 2.178
	0.000	0.000	0.000	0.000		– 0.861	– 0.941	– 0.987	– 0.985
SSE → SSE Utilities	480.200	371.400	273.900	197.200	SSE Utilities → SSE	3.871	3.803	2.278	0.322
	0.000	0.000	0.000	0.000		0.000	0.000	– 0.011	– 0.373

Indication as described in Table 1 above.

Source: author's own.

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ECONOMETRIC EVALUATION OF RISK AT SHANGHAI STOCK EXCHANGE

The problem of risk transferring is well known in empirical finance. Agents often try to transmit their risk from one market to another when the limit values of their potential losses are being approached or exceeded. When financial markets are completely segmented, risk cannot be transmitted across markets, but on the other hand when markets are integrated and suffer from the same shock, then risk is expected to transmit across markets. Chinese financial market was segmented during Asian crisis 1997–1998 (Lardy (1998)), but during last financial crisis was more vulnerable to risk spillover. The aim of the paper is to analyze the segmentation of the Chinese

financial market. We took into account the process of transferring risk between major indices of Shanghai Stock Exchange and sector indices (sub-indices) representing various segments of the market. To check proposed hypotheses we applied Granger causality in risk concept. We applied different risk measures to take into consideration different risk patterns (small, medium and high risk generated locally and/or globally).

EKONOMETRYCZNA OCENA RYZYKA NA GIEŁDZIE PAPIERÓW WARTOŚCIOWYCH W SZANGHAJU

Rynek kapitałowy w Chinach przez wiele lat nie był włączony do globalnego rynku finansowego. Dlatego tez cechowały go wyższe wartości średnie zwrotów i mniejsze ryzyko. Dopiero kryzys finansowy z roku 2007–2009 spowodował większe zainteresowanie chińskim rynkiem kapitałowym a w konsekwencji wzrost ryzyka. Celem artykułu jest analiza procesów zachodzących wewnątrz rynku, ze szczególnym uwzględnieniem relacji między indeksami głównymi giełdy w Szanghaju a subindeksami reprezentującymi różne segmenty rynku. Zastosowana metodologia obejmuje: modele zmienności, analizę przyczynowości w ryzyku oraz teorie wartości ekstremalnych.