THE IMPACT OF 2011 EARTHQUAKE AND TSUNAMI ON JAPAN AND ITS MAIN TRADING PARTENERS EVENT STUDY APROACH

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Abstract: On Friday 11 March 2011, a severe earthquake with a magnitude of 8.9 on Richter scale, struck the north-east coast of Japan, being the most powerful earthquakes in Japan since records have begun. This catastrophically event was followed by a devastating tsunami, which hit the East coast of Japan around Sendai causing serious damage to Fukushima nuclear plant. Whilst it is almost impossible to estimate the level of destruction in Japan and the ensuing loss of life, this event study tries to find out the manner to which the companies from Japan and the companies from the main three economic regions to which Japan performs most trading relationships (China, United States of America and European Union) reacted to this natural disaster. Because the stock price is one of the most relevant indicators of how a company performs and how it is affected by certain events, we will consider stock market returns in estimating the effects of the earthquake and tsunami.The results of this paper will be very valuable, not only for the fact that we will find the companies' reaction to this catastrophically event, but further we will be able to see some evidence of globalization and interconnection of the global economy of our days.

Keywords: event study, earthquake, tsunami, stock returns, financial markets.

JEL classification: G14; N20.

1. LITERATURE REVIEW

The purpose of this literature review is to understand the economic and financial implications of a natural disaster. It is focusing on previous studies and articles regarding natural calamities and their effects on local and international markets.

The paper of the Committee on Earthquake Engineering (1992) identifies one of the most important implications of a natural disaster: suspending most activity in the earthquake area will spread beyond that area as customers or suppliers are affected by the shutdown, thus even further businesses have to suffer. This phenomenon is called the ripple effect which means the multiplier effects that will spread from the affected area because of the inability to supply and the inability to sell.

This idea is confirmed by Jonas Elmerraji (2011) who states that besides loss of life, infrastructure destruction is by far the most obvious type of damage that comes to mind when we think about natural disasters. He states that one of the biggest problems for affected areas is business disruption. Blocked roads, interrupted communication infrastructure and building damage, which are common after disasters, all contribute to local businesses shut down for some time until the shock diminishes.

On the other hand, this main disadvantage is broadly considered one of the boosting factors for the prelaunch of the economy. Namely, the infrastructure reconstruction activities are engaging important financial resources, and logistics. This explains why usually companies from constructions sector are outperforming especially after earthquakes. The stock market actually increased after major hurricanes as it was the case for three major storms, Andrew (1992), Hugo (1989), and Camille (1969). Historically, big hurricanes and other natural disasters reduce short term output while boosting economic growth over the long-term through reconstruction. This balance of positives and negatives tends to reduce the overall economic impact of hurricanes (Barton, 2005).

A previous study of Worthington A. and Valadkhani A., (2004), aims to measure the impact of natural disasters on the Australian equity market. The data set analyzed consisted of daily price and accumulation returns over the period 31 December 1982 – 1 January 2002 for the All Ordinaries Index (AOI) and a record of 42 severe storms, floods, cyclones, earthquakes and bushfires (wildfires) during this period.

The results of the study indicate that bushfires, cyclones and earthquakes have a major effect on market returns, unlike severe storms and floods. The net effects can be positive and/or negative with most effects being felt on the day of the event and with some adjustment in the days that follow. The study revealed that major earthquakes in Australia have a mixed impact on market returns. Thus, earthquakes immediately exert a significant negative impact of between 0.38% and 0.47% on the day when these events strike, but after about five days market returns increase by some 0.60%.

Another study done by authors Weiderman, Isaac, Bacon, Frank (2008), identified the Katrina Hurricane's effect on oil companies' stock prices. This event study analyzed 15 firms price's risk adjusted rate of return before and after August 30, 2005. The study tested how quickly the 15 oil firms' stock prices reacted to the Hurricane Katrina event defined as August 30, 2005. Analysis of the hurricane event included 3,376 observations of the 15 oil firms' stock prices and the corresponding Standard & Poor's 500 Index (S&P 500) up to 180 days before the event date, August 30, 2005, and 30 days after.

In order to analyze the effects of the storm on the stock returns, there have been tested the following hypotheses:

H_0: The risk adjusted return of the stock price of the sample of oil firms is not significantly affected by this type of information on the event date;

H_1: The risk adjusted return of the stock price of the sample of oil firms is significantly negatively affected by this type of information on the event date.

The statistical tests applied in this study showed that Katrina Hurricane had a significant and negative impact on the risk adjusted rate of return on selected oil company stock prices over the event study period. Results showed stock returns dropping significantly just before Hurricane Katrina reached the land. More exactly, results reflected that oil company stock price returns started to go down up to 25 day prior to the hurricane event on August 30, 2005.

These results confirm semi-strong market efficiency, showing that the market rapidly anticipated the possible consequences of the hurricane.

To bring us closer to the Japanese earthquake event there have been analyzed several articles regarding Japanese market. One relevant article is of Asset Management Dexia (2011). The article states that the earthquake most similar to the current one was Kobe earthquake in 1995. Economic losses have been estimated to around €88 billion and indirect economic losses (reduced employment, production and logistic interruptions) have amounted to around €263 billion. Then, the industrial production declined but reaccelerated quickly because companies had relocated production in plants located elsewhere in Japan. Only after about four months after the earthquake, the full-scale recovery emerged, as public investments added to private investments and consumption in the rebuilding phase. This phase continued for a couple of quarters.

In another article, Stokowski, A., (2011), catches the main short term consequences of the 2011 earthquake and tsunami. According to the article, Japanese automakers, electronics firms and oil refiners saw their share prices drop by double digit percentages at one point after having to close key factories. The benchmark Nikkei index N225 fell 6.2 percent to 9,620.49, and slumped to a four-month intraday low at one point, with technology companies such as Kyocera Corp and Canon Inc among the biggest drags on the market. The broader TOPIX index closed down 7.5 percent, the largest daily decline since October 2008 in the wake of the

Lehman Brothers failure. Shares of Tokyo Electric Power, Japan's biggest utility that owns a nuclear plant that may be close to meltdown, were a big focus for the market, immediately after the event. TEPCO ended ask-only at 1,621 yen, down 23.6 percent.

On the other hand, construction-related businesses rallied on the back of expectations for demand from rebuilding efforts, with Kajima Corp jumping 22.2 percent to 259 yen and Taiheiyo Cement climbing 21.2 percent to 137 yen.

The conclusion of the literature study is that previous studies confirmed that natural disasters have a significant negative impact on companies from the affected region, immediately after the event. Moreover, we found out that the trend of the stock market changes some days or even months after the event due to the production relocation of affected companies and reconstruction efforts.

2. DATA COLLECTION

The event we are analyzing is the earthquake and tsunami that affected Japan on March 11th 2011. A massive 8.9 magnitude quake hit northeast Japan followed by a tsunami which seriously damaged Fukushima nuclear power plant. More precisely, we want to estimate the impact of this natural disaster on Japanese companies and companies from the main three countries to which Japan has trading relationships. In the analysis we must consider that this kind of event is hard to anticipate (although it is known that Japan is a seismic area we cannot anticipate the moment and the severity of these events).

It is assumed that the companies' stock prices are the most relevant indicators to measure the impact of certain events on companies, industries or even economies.

As it is a difficult task to analyze each stock separately in order to evaluate the impact of the event, there will be used the data provided by the market index from each analyzed countries, namely: Nikkei 225 index for companies from Japan, Shanghai Stock Exchange (SSE) Composite Index for companies from China, New York Stock Exchange (NYSE) composite index for companies from United States of America and EURO STOXX 50 for companies from European Union, more specifically Eurozone.

We chose these countries based on the exports values recorded for 2010, which can be seen in the table 1, from where we selected the first 3 of them.

Table 1. *Exports values for Japan in 2010, per countries (thousands of US dollars)*

COUNTRIES	EXPORT VALUES	MARKET INDEX
China	**149,086,369**	**SSE composite**
United States of America	**118,199,405**	**NYSE composite**
European Union	**79,071,812**	**EURO STOXX 50**
Korea	62,053,705	KOSPI composite
Taiwan	52,206,626	TAIEX index
….	…	….

Source: based on information from http://www.jetro.go.jp/en/reports/statistics/ accessed on 27 April 2014.

For global market index we will use as a proxy the S&P Global 1200 index, which is a real time index that includes the largest and the most liquid stocks from around the world. All of them are market capitalization weighted indices. The components of S&P Global 1200 are: S&P 500 (US), S&P Europe 350 (Europe), S&P/TSX 60 (Canada), S&P/TOPIX 150 (Japan), S&P/ASX All Australian 50 (Australia), S&P Asia 50 (Hong Kong, Korea, Singapore and

Taiwan), S&P Latin America 40 (Brazil, Chile, Mexico and Peru), S&P 700, S&P Global 100 and S&P ADR.

The period over which the prices will be examined include an estimation period of 250 days, an event window of 21 days and a post-event window of 47 days, as it can be seen on figure 1. The estimation period of 250 trading days has been chosen in order to include a complete annual cycle in the study. Even if the event is unpredictable and thus the market has not been influenced before it struck, we selected an event window of 10 days before event and 10 days after the event in order to highlight the market evolution just before it and after it.

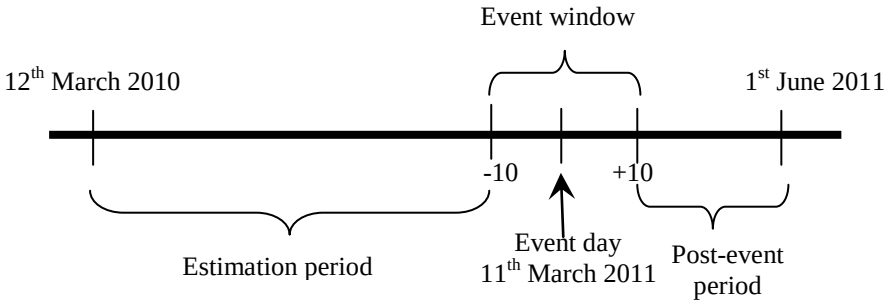

Figure 1: The pre-event and post-event period

The event period starts on February 25th 2011 and lasts until March 28th 2011. The tsunami caused a severe damage to Fukushima nuclear plant, and the crisis extended due to nuclear radiation for a months.

After about one month things came under control and we considered another two months to analyze how the stock market performed in the post-event period. By studying the literature review, we have found out that after a certain period, the market changes its trend and increases due to production relocation and reconstruction activities. Thus, the post-event window starts on March 28th 2011 and lasts until June 1st 2011.

Table 2. *Descriptive statistics for the markets' returns*

INDEX	MEAN	MEDIAN	MAX.	MIN.	STD. DEV.
NIKKEI 225	-0.0003	0.0000	0.0552	0.0145	
SSE Composite	-0.0002	0.0000	0.0342	0.0130	
NYSE Composite	0.0004	0.0006	0.0481	0.0112	
EURO STOXX 50	-0.0001	-0.0001	0.0984	0.0138	
Global 1200	0.0004	0.0008	0.0464	0.0100	

Source: authors' calculation

In table 2 we present some descriptive statistics for the data used in the analysis for period between March 12th 2010 and June 1st 2011. As we can see, the most profitable index for this period is represented by NYSE composite. In the same time, if someone invested in a portfolio which replicates the Nikkei 225 cash flows, that person recorded a loss due to the fact that for the analyzed period Nikkei 225 recorded an average decrease of 0.03%. The highest value for standard deviation for this index, reveals the high risk which it is associated to it, so the events from March 11th 2014 seem to significantly influence the return from Japanese Financial Market.

3. METHODOLOGY

The same methodology will be used to compute the returns and abnormal returns for all indices analysed. The first step of the analysis is to measure the stock performance for the window period, using the formula:

$$R_t = \log(\frac{P_t}{P_{t-1}})$$

where R_t is the return at time *t*, P_t is the price at moment *t* and P_{t-1} is the price at time *t-1*.

The next step is to measure the expected return which means the return that would have accrued to the shareholders in the absence of this or any other unusual event. In order to do so we chose to compute the expected return using the market model:

$$R_t = \alpha + \beta \times R_{Mt}$$

where α and β are firm-specific parameters, and R_{Mt} is the return of the market at moment t – in the case of this paper, we will consider Global 1200 index. The parameters for this equation will be estimated based on the values recorded during the estimation period, the interval of time between March 12th 2010 and 10 days before the event.

With the values for the expected return and the real values, we can compute the abnormal return which is the estimated impact of the event on the share value:

$$Ab_t = R_t - E(R_t)$$

where Ab_t is the abnormal return, R_t is the observed return and $E(R_t)$ is the predicted return, for time period *t*. In our case, it will show the impact of the earthquake and tsunami on the companies from Japan and also on companies from China, United States of America and European Union.

The last statistic to be calculated is the cumulative abnormal return:

$$CAR_t = \sum_{k=-10}^{t} Ab_k$$

The main hypothesis that is going to be tested in this event study refers to the impact that the earthquake and tsunami from Japan had on selected indices for Japan (Nikkei 225), China (SSE Composite), S.U.A. (NYSE Composite) and Eurozone (EURO STOXX 50). Thus, we will test if the average cumulative abnormal return for each of them has been significantly influenced by this event.

$H_0 : \overline{CAR}_{0-10} = 0;$

$H_1 : \overline{CAR}_{0-10} \neq 0.$

We expect that H_0 will be rejected for Nikkei 225 and thus, the event will prove to have significant impact to Japanese market. Moreover, we expect that significant impact has been recorded for other indices, especially in the first days after the event. The second hypothesis refers to the post event period. By testing it, we would like to find out if significant changes happened after the one month event period.

$H_0 : \overline{CAR}_{11-57} = 0;$

$H_1 : \overline{CAR}_{11-57} \neq 0.$

The reason for considering this hypothesis consists in the fact that, as stated in the literature review, the negative impact of a natural disaster on the stock market is temporary and frequently followed by a positive trend because of the efforts to reconstruct affected areas and to fulfill the demand that was not honored during the event (because of closed plants, affected labor etc). We expect that H_0 will again be rejected because of the opposite evolution of the market that should take place.

4. RESULTS

In order to be sure that our results will be reliable, we checked the series' stationarity based on Augmented Dickey-Fuller test. The test showed us that all series are stationary at 1% significance level. Further on, we start applying the event study methodology.

The first step is represented by the estimation of the regression equations between each index's return and Global 1200 return, based on which we computed the expected return during the event window and post event window. Using the abnormal return, which is the difference between the real return and expected return for each index, we compute the average cumulative abnormal returns.

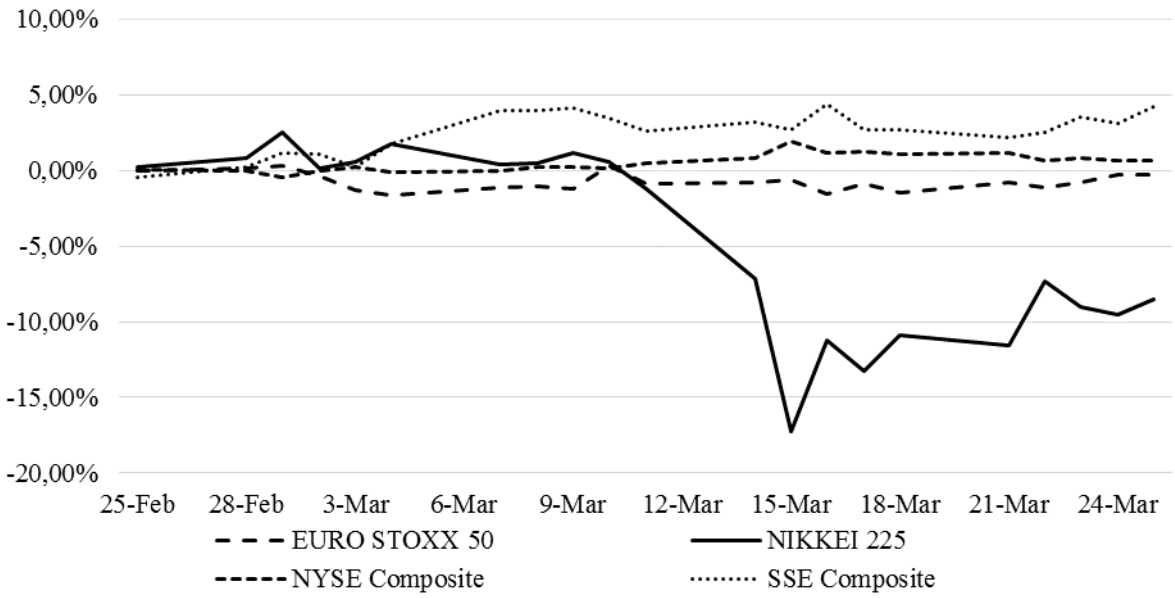

Figure 2. Cumulative abnormal returns for analyzed indices or event period

In order to make a general point of view regarding the impact of the earthquake and tsunami from March 11th 2011 on selected indices, we present the evolution of cumulative abnormal returns for the four selected indices for period February 25th 2011 - March 28th 2011. This evolution can be seen in figure 2.

We can see that only the Nikkei 225 was significantly affected by the events from March 11th 2011, while the other three countries were not affected. But to be sure from the statistical point of view, we will further test if the average cumulative abnormal returns are different to zero. In order to do this, we will use the following four periods: 10 days before the event to the event day; 5 days before the event to the event day; from the event day to the fifth day after the event; and from event day to the tenth day after the event. The next step is to test if these values are statistically significant different to 0 and further if these values are less than 0. The results for two side t-test are presented in Table 3.

Table 3. *Statistical significance testing for cumulative abnormal returns for event period*

Days $i-j$	Average cumulative abnormal return	$H_0 : \overline{CAR}_{i-j} = 0;$ $H_1 : \overline{CAR}_{i-j} \neq 0.$	
		t-statistic	p-value
NIKKEI 225			

-10 → 0	0.0087	3.6738***	0.0051
-5 → 0	0.0086	3.3965**	0.0274
0 → 5	**-0.1017**	**-4.5390*** **	**0.0062**
0 → 10	**-0.0972**	**-7.9875*** **	**0.0000**
EURO STOXX 50			
-10 → 0	**-0.0058**	**-2.5106** **	**0.0333**
-5 → 0	**-0.0093**	**-2.9078** **	**0.0438**
0 → 5	**-0.0104**	**-6.8688*** **	**0.0010**
0 → 10	**-0.0086**	**-9.7988*** **	**0.0000**
NYSE Composite			
-10 → 0	0.0003	0.5090	0.6230
-5 → 0	0.0009	1.2999	0.2635
0 → 5	0.0112	5.5928***	0.0025
0 → 10	0.0097	7.6989***	0.0000
SSE Composite			
-10 → 0	0.0195	3.5013***	0.0067
-5 → 0	0.0345	7.7726***	0.0015
0 → 5	0.0304	10.8256***	0.0001
0 → 10	0.0308	14.5984***	0.0000

***,**,* - the null hypothesis is rejected at 1%, 5%, respectively 10% significance level

Based on values from table 3, we can see that the Nikkei 225 was significantly affected by the earthquake, because after the event it is recorded a significant negative cumulative abnormal return. Even if for EURO STOXX 50 it is recorded the same tendency, we see that before the event there is also recorded negative cumulative abnormal returns, so maybe these values are not necessary the impact of the event from March 11th 2011. On the other side, for SSE composite and NYSE we see that there is recorded a significant positive cumulative abnormal return, which means that this event is influencing positively the evolution of financial markets from these countries. This may indicate the fact that the investors have shifted their investments from the Japanese financial market to US and Chinese markets.

Table 4. *Statistical significance testing for cumulative abnormal returns for post-event period*

Days after event $i-j$	Average cumulative abnormal return	$H_0 : \overline{CAR}_{i-j} = 0;$ $H_1 : \overline{CAR}_{i-j} \neq 0.$	
		t-statistic	p-value
NIKKEI 225			
11 → 30	**-0.0782**	**-44.8413*** **	**0.0000**
11 → 57	**-0.0713**	**-39.7926*** **	**0.0000**
EURO STOXX 50			
11 → 30	**-0.0061**	**-4.1649*** **	**0.0005**

11 → 57	**-0.0111**	**-9.7138*****	**0.0000**
NYSE Composite			
11 → 30	0.0039	5.2864***	0.0000
11 → 57	0.0012	1.7809*	0.0815
SSE Composite			
11 → 30	0.0484	15.7081***	0.0000
11 → 57	0.0212	5.0095***	0.0000

***,**,* - the null hypothesis is rejected at 1%, 5%, respectively 10% significance level

Further we tested if the cumulative abnormal return is significantly different to 0 for the period March 29th 2011 – June 1st 2011. These results are presented in table 4, where we can see that there is still present the effect of the earthquake and tsunami on Financial Market from Japan, while for other markets, the things are less obvious, and the returns seem to return to their normal values. The same evolution can be seen in the figure 3.

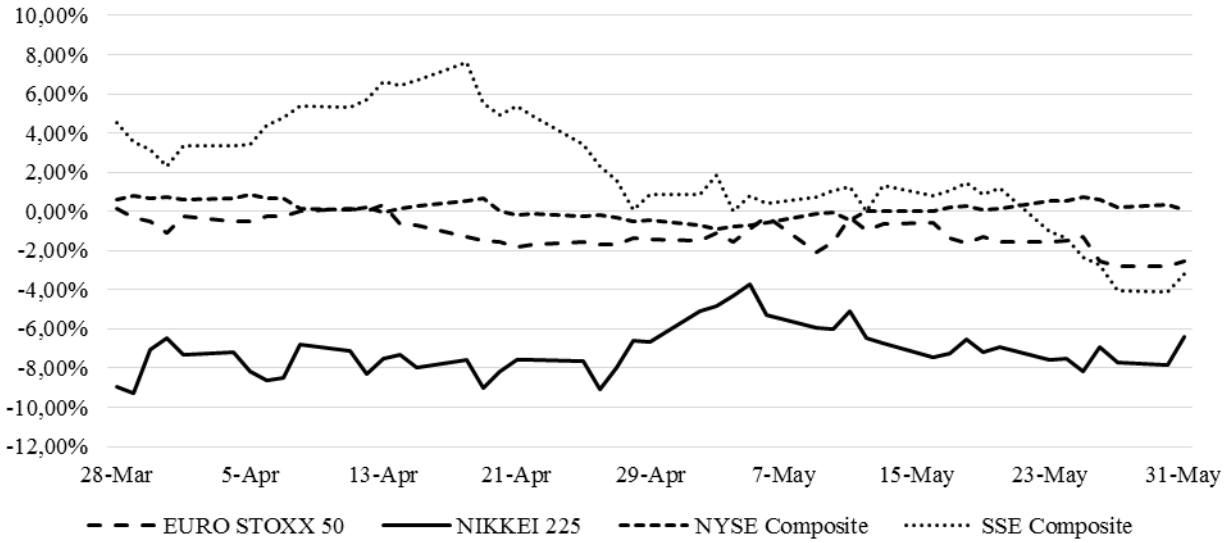

Figure 3. Cumulative abnormal returns for analyzed indices for post-event period

4. CONCLUSIONS

This event study identified in the literature review part the implications of a natural disaster on the evolution of stock markets, with suggestive examples like Katrina hurricane or Kobe earthquake. Then, there have been identified the methodological aspects in order to measure the impact of the March 2011 earthquake and tsunami from Japan, on the companies from Japan, China, U.S.A. and European Union. We tested 2 hypotheses: if each index has been significantly influenced by the natural disaster during the month when several earthquakes and tsunami happened and if the same index had important fluctuations the month after the event.

The results of the study proved that in the first month the Nikkei 225 index has been significantly influenced by the natural disasters from March 2011. Also, the index have significant fluctuations in the post-event window period. In the same time for others indices, we obtained that the NYSE composite and SSE Composite index were affected by this event in a positive way, that it is why we can conclude that the investors from Japanese Financial

Markets redirected their investments on other markets, especially these two markets (USA and China).

REFERENCES

1. Asset Management Dexia (2011), Special Report March 2011
2. Barton Jr., D.R. (2005), How is the stock market affected by natural disasters?
3. Brooks, C., (2008), Introductory Econometrics for Finance, Cambridge University Press
4. Committee on Earthquake Engineering, National Research Council, 1992, The Economic Consequences of a Catastrophic Earthquake: Proceedings of a Forum, pp. 144-150
5. Elmerraji, J. (2011), The Financial Effects Of A Natural Disaster, Financial Edge
6. Fama, E. F. (1970), Efficient Capital Markets: A Review of Theory and Empirical Work. Journal of Finance 25, pp. 383-417
7. Japan External Trade Organization (2011), Japan's International Trade in Goods for 2011, available at: http://www.jetro.go.jp/en/reports/statistics/
8. S&P Indices (2011), S&P 1200 Global 1200 Index Methodology
9. Slodkowski, A. (2011), After quake, TOPIX suffers biggest drop in 2 years, Reuters
10. Weiderman I., Bacon F., 2008, Hurricane Katrina's Effect on Oil Companies Stock Prices, Academy of Strategic Management Journal
11. Worthington A., Valadkhani A. (2004), Measuring the impact of natural disasters on capital markets: an empirical application using intervention analysis, Applied Economics 36, pp. 2177–2186
12. Yahoo Finance, official web site: http://finance.yahoo.com/