Tatiana P. Skufina[1], **Sergey V. Baranov**[2], **Vera P. Samarina**[3]

THE INFLUENCE OF STRONG EARTHQUAKES ON GLOBAL ECONOMY: FACTS, TRENDS, FORECAST *

The article attempts to evaluate and forecast the impact of strong earthquakes on global economy. It is shown that the processes of globalization with each year increase the spread of regional economic losses from earthquakes on the global economy. The authors presents quantitative estimates and their own forecast of the impact of earthquakes on global economy.
Keywords: *earthquakes; global economy; economic assessment; forecast.*
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Тетяна П. Скуф'їна, Сергій В. Баранов, Віра П. Самаріна

ВПЛИВ ПОТУЖНИХ ЗЕМЛЕТРУСІВ НА ГЛОБАЛЬНУ ЕКОНОМІКУ: ФАКТИ, ТРЕНДИ, ПРОГНОЗ

У статті зроблено спробу оцінити та спрогнозувати вплив потужних землетрусів на глобальну економіку. Доведено, що процес глобалізації з кожним роком все більше поширює регіональні економічні збитки від землетрусів на всю глобальну економіку. Надано власні кількісні розрахунки та прогноз впливу землетрусів на глобальну економіку.
Ключові слова: *землетруси; глобальна економіка; економічна оцінка; прогноз.*
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Татьяна П. Скуфьина, Сергей В. Баранов, Вера П. Самарина

ВЛИЯНИЕ СИЛЬНЫХ ЗЕМЛЕТРЯСЕНИЙ НА ГЛОБАЛЬНУЮ ЭКОНОМИКУ: ФАКТЫ, ТРЕНДЫ, ПРОГНОЗ

В статье осуществлена попытка оценить и спрогнозировать влияние сильных землетрясений на глобальную экономику. Доказано, что процесс глобализации с каждым новым годом всё более распространяет региональные экономические убытки от землетрясений на всю глобальную экономику. Предоставлены собственные количественные расчёты, а также прогноз влияния землетрясений на глобальную экономику.
Ключевые слова: *землетрясения; глобальная экономика; экономическая оценка; прогноз.*

Problem setting. The problem of assessing the impact of geological processes on regional economy and the world is one of the most important objectives in science. However, studying this issue is a very difficult task due to a number of facts. Firstly, geological changes in form of catastrophes have a significant impact on economy and regions of the world. Contemporary science is not able to predict such geological events. Consequently, traditional forecasting methods cannot be used to assess how reliable the forecast of their impact is on regional and global economy. Secondly, large-scale geological events which can affect global economy are rare events. Therefore, it is impossible to collect enough data for statistical evaluation of such events, in addition, there is no standard methodology available for estimating the impact of catastrophes exactly on global economy. This also complicates the accuracy of estimates and forecasts of the impact on global economy. At the same time, today's reality shows that geo-

[1] Institute of Economic Problems of the Kola Science Centre of the Russian Academy of Sciences, Apatity, Russia.
[2] Institute of Economic Problems of the Kola Science Centre of the Russian Academy of Sciences, Apatity, Russia.
[3] Staryy Oskol Technological Institute, branch of National Research Technological University "MISIS", Russia.
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logical events may impact not only economies of certain regions, but also the world economy overall. This suggests an increase in practical and theoretical importance of the research aimed at solving the problem of estimating and forecasting the influence of geological processes (events) on the economy of regions and global economy.

Literature review. Scientific achievements in the field of evaluation of the projected changes in geological environment at local and global world economic processes can be reduced to two essential components.

The first component is forecasting geological changes and their consequences. Despite the variety of approaches, the classic formulation of the problem is to determine time and place of future geological changes. Detailed classical formulation of forecasting task specifically for earthquakes was designed in 1976 by the Commission on earthquake prediction of the National Academy of Science in the USA chaired by K. Allen (1976). Solving the problem of building a reliable prediction is moving into 3 overlapping directions: creating theoretically grounded models and mechanisms of earthquakes and geological changes, including the works on experimental forecast (Bufe and Varnes, 1993; Frohlich, 1994; Khain, 2010; Baranov and Chebrov, 2012); detecting consistent patterns that do not have explanations, at least, at the present level of scientific development (or having incomplete explanation), also including the works on experimental forecast (Molchan, 1991; Baranov, 2013); searching and classifying a reliable "prognostic" geological changes and earthquakes, including the tasks of their formalization (Helmstetter and Sornette, 2002; Sobolev and Ponomarev, 2003; Baranov and Shebalin, 2016). Analysis of these research results allows us conclude that despite significant progress, methods of forecasting geological changes (events) on technological level are not developed enough.

The second component – assessment of economic impact of changes in the geological environment. In this area, the activity of the world scientific thought focuses on "pointed" regional research of statistical economic losses defined by the amplitude of surface waves, probability of tsunamis, volcanic eruptions, etc. Estimation of economic consequences for countries and regions usually has narrow practical character, generally, only direct damage is determined (Bernknopf et al., 1990; Volynets et al., 2000; IPRC Climate, 2011; Cooper et al., 2011; Komatsu, 2014). However, direct economic costs, which are, the price expression of what has been damaged or lost as a result of geological change, is not sufficient for estimating potential danger. Several studies have shown that natural disasters can actually lead to negative consequences for countries and regions. Besides, the greatest danger comes not from direct but rather indirect losses determined by the size of a shock, scale and pace of investments into recovery (Hochrainer, 2009; Raddatz, 2009; Henriet et al., 2012; Cavallo, 2013). Our analysis of damage assessment results shows that functional complexity of large and redistributive effects of catastrophic events lead to difficult quantitative estimations not only of direct, but especially indirect economic losses (Baranov and Skufina, 2011). Therefore, a significant problem is the development of reliable methods for assessing total economic losses for countries and regions (Hallegatte and Przyluski, 2010; Morita and Nagai, 2011; Nanto, 2011).

Studies with evaluation and forecast of economic impact of geological events on the world economic system level almost do not exist. We believe this is due to a lack in modern (before the earthquake and tsunami in Japan, 11.03.2011) of geological

events that could affect the entire world economic system so much that it would be reflected in specific world economic indicators.

The problem overview allows us emphasize the need for better understanding of economic impacts of geological changes (events) and offer a new research direction, specific methodological solutions and estimates presented in this article.

Problem statement and research objective. In this study we focus specifically on the impact of earthquakes on global economy. This is due to the fact that earthquakes bring the greatest losses for the economies of countries and regions among economic losses from all natural geological events. In addition, specifically the earthquake in Japan of 11.03.2011, called Tahoku, clearly showed that geological events are a factor of influence on the global economic system.

The purpose of the study – to assess the impact of strong earthquakes on global economy. *Research objectives:* 1) to present facts and trends of seismic risks for economic systems of the subduction zone and global economy; 2) to present the authors' assessment of economic impact of the earthquake Tahoku for the regions of the world and global economy; 3) to forecast losses of global economy from strong earthquakes occurred in economically developed countries of the world.

Key results. Strong earthquakes should be analyzed for the purpose of determining facts and trends of seismic risks by regions. For our analysis we used the data on strong earthquakes (with the magnitude of 8.5 and higher) and strongest earthquakes (magnitude of 9 and higher), as well as their consequences, occurred in the period since 1900, which confirmed the increased risk of seismic activity for natural and technological systems (Baranov and Skufina, 2011; 2014).

In this paper, we propose a simple but clear method of confirming the strengthening impact of strong earthquakes on regions global economy. From 17 strong earthquakes with the magnitude of 8.5 and higher, occurred during the period since 1900, 6 occurred since 2004 to present day. That is, in the recent 12 – year period (which accounts for 10.4% of the total period of 115 years) occurred 35% of all strong earthquakes. A similar pattern is observed for the strongest earthquakes with the magnitude of 9 and above (Figure 1). Since 1700 until our times there have been 7 such earthquakes, 5 of which happened after 1952. Thus, the time interval of 20% has 71% of the strongest earthquakes.

Therefore, the analysis of data tells us about the increasing quantity of strong and strongest earthquakes in the recent years.

Recall, the classic formulation of the problem of earthquake forecasting is to determine location and time of a future event. Science today can confidently name the location of the expected seismic event, but the time factor is unknown. It is known that a strong earthquake centered in the subduction zone (zone along which there is an immersion of one crustal blocks under the other). This zone extends, in particular, along the most developed regions of the world – US, Japan, Canada.

Data on strong and strongest earthquakes allows us state that risks of natural and technological systems are increasing in subduction zones and territories covered by possible consequences of geological changes. Given that subduction zones are located mostly in the economically developed regions of the world we have a reason to talk about increased risks for these regions and the global economy overall.

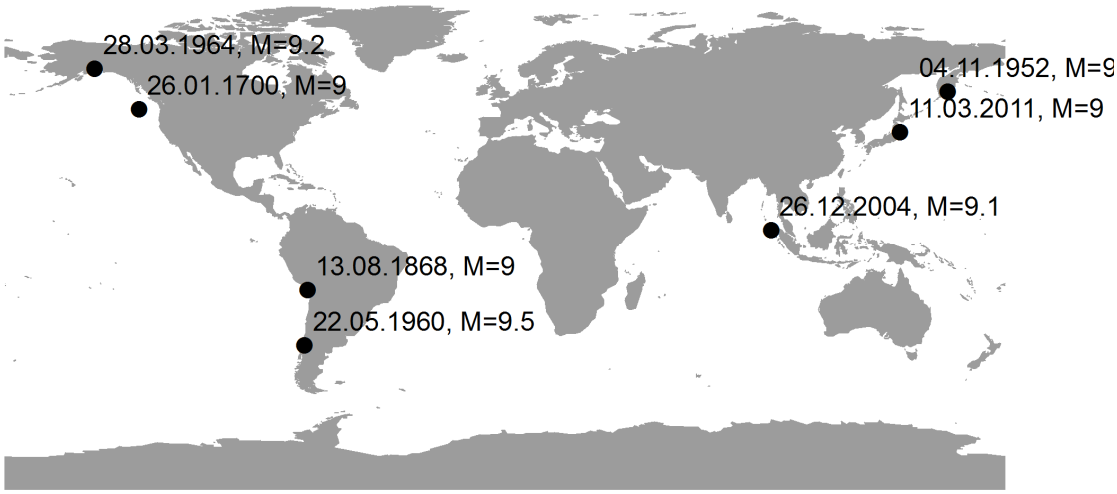

Figure 1. **Earthquakes with the magnitude of 9 and higher, occurred since 1700,** *selected from* USGS (Search Earthquakes Archives, 2016)

Analysis of economic impact of the earthquake with the magnitude of 9 near the Eastern coast of Japan in March 2011 (Tahoku earthquake) shows the strengthening of globalization which increases the effect of strong earthquakes on the world economy.

Relative rarity of this event in Japan and uniqueness of it on the scale of influence on the world processes indicate the need to develop specific methods for economic evaluation of its impact on global economy. The authors have already developed and tested such a methodology based on the data as of end of August 2011 (Baranov and Skufina, 2011; 2014). In this paper we present the revised methodology and the results of its testing based on the revised statistical data.

The methodology consists of the analysis of 3 blocks of information: 1st block – reaction of Japanese economy overall; 2nd block – reaction of the world stock exchanges; 3rd block – reaction by sectors within global economy.

1st block – the considering reaction of Japanese economy. At this stage the authors analyze the dynamics of the Japanese national currency against USD during the period after the catastrophe, export and import dynamics, as well as GDP dynamics.

We noted significant fluctuations of yen against USD, however, our research shows that regulatory efforts of Japanese government managed hold the exchange rate within the optimal preservation of profitability.

Analysis of Japanese export and import dynamics shows: 1) significant drop in these two indicators in the first 2 months after the catastrophe compared to the fall caused by the global financial crisis of 2008; 2) it took almost a year to stabilize the situation to its pre-catastrophe level. The analysis of the dynamics of Japan's GDP (Figure 2) shows that the earthquake and the following tsunami caused the drop in Japan's GDP by 3% in the period from the 4th quarter of 2010 to the 2nd quarter of 2011, but already in the 3rd quarter of 2011 GDP almost reached the pre-catastrophe level. Thus, Tahoku earthquake delayed the recovery of Japanese economy from the global crises of 2008 by almost a year.

2nd block – reviewing the reaction of the world stock exchanges. Analysis is done in two stages: 1) behaviour of indices that reflects the condition of Japanese

stock exchange (S&P Japan 500), the global stock market (S&P 1200), European markets (S&P Europe 350), the US (S&P 500) and Asia (S&P Asia 50); 2) dynamics of the cost of shares of the largest companies – USA (General Electric), Japan (Hitachi, Mitsubishi), Europe (Siemens) (selection of the companies was based on the criteria of compliance with the basic structure of the main articles of Japanese exports). The analysis shows significant and synchronous changes of all stock indicators. The greatest fall and the longest recovery period is typical for the indices of Japan (S&P Japan 500) and Asia overall (S&P Asia 50). Reaction of the largest companies in the USA, Europe, and Japan on the consequences of the earthquake are also rather synchronised, the only difference is in the scale of drop, the speed and the level of situation stabilization.

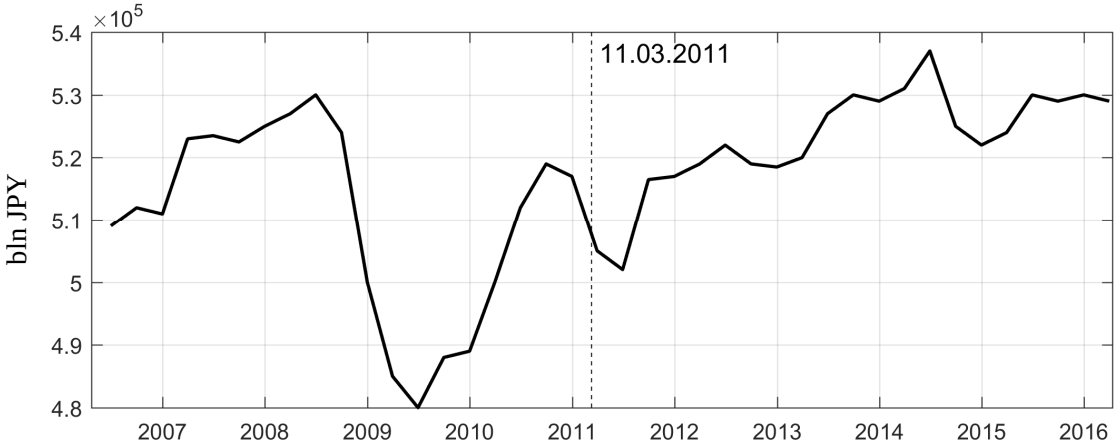

Figure 2. **Japan's GDP at constant prices,** *bln JPY, calculated on the data from* (Trading Economics, 2016)

3rd block – considering the reaction by sectors of global economy. Analysis of the behaviour of the composite index of industrial activity in the sectors of Japan, American and European economies has been completed. The authors found that sharp decline in Japanese production significantly affected the production index of the USA (this is due to the failure to supply the equipment for mechanical engineering from Japan to the USA), but had almost no effect on the European production.

The completed analysis of this information allowed stating that Tahoku earthquake significantly influenced not only regional but also overall global economic system. Prior to this event there has been no evidence suggesting the influence of any earthquake or other geological event on the whole global economy.

Globalization somehow increases seismic risks for the whole world economic processes and thus economic losses too. The globalization level of a regional economy increases the influence of geological changes on global economy, with simultaneous exponential growth of loss.

To understand the risks for global economy from strong earthquakes in developed countries we offer a forecast of economic losses. Our approach to forecast is based on evaluating the possible influence of strong earthquakes on global economy and regional economic systems based on transferring the analogues of strong earthquakes into the modern reality, as well as the factor of strengthened likelihood of seismic events and their consequences.

It is important to realize the expected scale of changes in global economy if such an event happens near USA. Such event already happened back in 1970 in the northwest coast of the United States.

For our calculations the strong Tahoku earthquake will be taken as an analogue. It is logical to assume that the impact of the earthquake on global economy will be stronger as the USA's GDP is greater that Japan's.

US GDP was at 15.52 trln USD in 2011, GDP of Japan – 5.91 trln USD. Thus, the losses of global economy from a similar earthquake near the USA would be 2.6 times higher.

Our calculations show that the fall in the global index – S&P Global 1200 – as a result of strong earthquake and tsunami near Japan was 5.7% (1500.04 before the event, and 1413.86 after). Therefore, if a similar event takes place near the US, the drop in S&P Global 1200 would have amounted to about 15%. The longer the time of an earthquake would be as compared to Tahoku, the higher would be the losses.

As globalization continues to strengthen, simultaneously, the impact of geological changes on global economy grows exponentially.

When the strongest earthquakes happen in low globalized natural and technological systems, the global economy practically does not notice them, despite huge human losses. Some of the examples are the earthquake with the magnitude of 9.1 and tsunami in 2004 in Sumatra or the strongest earthquake in the history of instrumental observations – Chilean earthquake with the magnitude of 9.5 back in 1960 (Figure 1).

Conclusions and directions for further investigation. Based on the analysis of instrumental observations it is established that seismicity has intensified in the recent decades. Therefore, increased are also the risks of natural and technological systems of subduction zones and territories covered by possible consequences of geological changes. It is determined that seismic risks for global economy are increasing because subduction zones are located mostly in highly developed regions of the world.

The results of authors' estimates of the economic impact of the 2011 earthquake near the eastern coast of Japan for regional and global economies are presented. It is shown that the process of globalization with each year increase the spread of regional economic losses from the earthquake onto the global economy.

To understand the scale of expected economic costs for global economy from strong earthquakes in developed countries we have performed a quantitative forecast of global economic losses from an earthquake in the United States which similar in strength to the earthquake in Japan of 2011. At the same time it is stated that further away this hypothetical event is from the analog (the earthquake in Japan) – the more globalization will increase losses for global economy.

These facts determine the increased relevance of this research within the framework of the problem of estimating the impacts of projected changes in geological environment on regional and global economies. This actuality includes two important components. First, practical significance which is defined by the prognostic nature of the information. There is a perception among economists that if exact time and place of an earthquake is unknown, then it is not interesting for big regions and global economy, especially from the standpoint of the world financial flows. Moreover, knowledge about a possible major event allows preparation for it, and thus,

would minimize potential losses. Second, the scientific component which includes integration of knowledge about interaction of geological environment and society. This will allow connecting known and new natural and human life knowledge under a new aspect, thus minimizing potential regional and global risks.

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