“Force majeure events and stock market reactions in Ukraine”

AUTHORS	Guglielmo Maria Caporale Alex Plastun Inna Makarenko

ARTICLE INFO	Guglielmo Maria Caporale, Alex Plastun and Inna Makarenko (2019). Force majeure events and stock market reactions in Ukraine. *Investment Management and Financial Innovations*, *16*(1), 334-345. doi:10.21511/imfi.16(1).2019.26
DOI	http://dx.doi.org/10.21511/imfi.16(1).2019.26
RELEASED ON	Monday, 01 April 2019
RECEIVED ON	Tuesday, 05 March 2019
ACCEPTED ON	Wednesday, 27 March 2019

JOURNAL	"Investment Management and Financial Innovations"
ISSN PRINT	1810-4967
ISSN ONLINE	1812-9358
PUBLISHER	LLC “Consulting Publishing Company “Business Perspectives”
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
29	**0**	**23**

BUSINESS PERSPECTIVES

LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10, Sumy, 40022, Ukraine
www.businessperspectives.org

Guglielmo Maria Caporale (UK), **Alex Plastun** (Ukraine), **Inna Makarenko** (Ukraine)

FORCE MAJEURE EVENTS AND STOCK MARKET REACTIONS IN UKRAINE

Abstract

This paper examines reactions in the Ukrainian stock market to force majeure events, which are divided into four groups: economic force majeure, social force majeure, terrorist acts, natural and technological disasters. More specifically, using daily data for the main Ukrainian stock market index (namely PFTS) over the period from January 1, to December 31, 2018 this study investigates whether or not force majeure events create (temporary) inefficiencies and there exist profitable trading strategies based on exploiting them. For this purpose, cumulative abnormal returns and trading simulation approaches are used in addition to Student's t-tests. The results suggest that the Ukrainian stock market absorbs new information rather fast. Negative returns in most cases are observed only on the day of the event. The only exception is technological disasters, the market needing up to ten days to react fully in this case. Despite the presence of a detectable pattern in price behavior after force majeure events (namely, a price decrease on the day of the event) no profitable trading strategies based on it are found as their outcomes do not differ from those generated by random trading.

Received on: 5th of March, 2019
Accepted on: 27th of March, 2019

Keywords Ukrainian stock market, force majeure event, event study

JEL Classification C22, G12

Guglielmo Maria Caporale, Professor, Department of Economics and Finance, Brunel University London, UK.

Alex Plastun, Doctor of Economics, Professor, Department of Foreign Economic Relations, Sumy State University, Ukraine.

Inna Makarenko, Doctor of Economics, Associate Professor, Accounting and Tax Department, Sumy State University, Ukraine.

INTRODUCTION

The Efficient Market Hypothesis EMH (see Fama, 1970) is still the dominant theoretical paradigm for understanding the behavior of asset markets. However, the empirical literature has provided plenty of evidence that is inconsistent with market efficiency in the form of various anomalies (including calendar and size ones), over-reactions and under-reactions, persistence, fat tails in the distribution of asset returns, etc. One possible explanation for (temporary) inefficiencies is the arrival of unexpected new information, whilst earnings announcements are normally scheduled and therefore markets are ready to react to them (Foster, 1973; Chambers & Penman, 1984; Falk & Levy, 1989; Lonie et al., 1996; Cready & Gurun, 2010; Syed & Bajwa, 2018, etc.), force majeure events (such as technological and natural disasters, terrorist acts, unexpected economic events, etc.) are by their nature unpredictable and could have a significant impact on stock markets, especially in the case of major shocks such as the 9/11 attacks in the US or the result of the Brexit referendum.

This paper analyzes the specific case of the Ukrainian stock market with the aim of investigating whether or not force majeure events create (temporary) inefficiencies and there exist profitable trading strategies based on exploiting them. For this purpose, cumulative abnormal returns and trading simulation approaches are used in addition to Student's *t*-tests. The analysis is carried out for four different types of force majeure events: economic force majeure, social force majeure, terrorist acts, natural and technological disasters.

http://dx.doi.org/10.21511/imfi.16(1).2019.26

The layout of the paper is the following: section 1 contains a brief literature review, section 2 describes the data and methodology, section 3 presents the empirical results, final section provides some concluding remarks.

1. LITERATURE REVIEW

Event studies are often carried out to examine the impact of some specific events on stock markets (Ball & Brown, 1968; Fama et al., 1969; MacKinlay, 1997; de Jong et al., 1992; Corrado, 2011). A lot of papers focus on earning announcements on market variables (Falk & Levy, 1989; Cready & Gurun, 2010; Syed & Bajwa, 2018). Other studies analyze instead the effects of dividend announcements (Lonie et al., 1996), earnings per share announcements (Foster, 1973), earnings announcements through timeliness of reporting disclosure (Chambers & Penman, 1984).

Force majeure events are unexpected and therefore cannot be incorporated into asset prices in advance. As a result, they could create conditions for obtaining abnormal profits until the new information has been completely absorbed by market participants. In addition to the traditional list of natural disasters (floods, earthquakes, hurricanes), social, military and political events (terrorist attacks, mass riots, protest actions), technological and aviation accidents, some economic events (such as unexpected bankruptcies of companies and financial institutions, cyberattacks to the commercial sector, etc.) can also be considered as force majeure events.

Numerous studies have examined the response of stock markets to terrorist acts: in the SAARC countries (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka) in 2000–2015 (Chaudhry et al., 2018); in Indonesia, Israel, Spain, Thailand, Turkey and the UK in 2002–2006 (Arin et al., 2008); in 22 countries in 1994–2004 (Drakos, 2010); in 25 countries in 1994–2005 (Karolyi & Martell, 2010). Chen and Siems (2004), Karolyi and Martell (2010), Brounen and Derwall (2010) used a common event study methodology to investigate the impact of terrorism on various stock markets.

As for the impact of natural disasters, evidence for Australia is provided by Worthington (2004, 2010), for Canada by Laplante and Lanoie (1994), for Japan and the US by Wang and Kutan (2013).

Unlike natural disasters, which normally affect individual countries, technological disasters are industry related. These include the explosions in chemical plants and refineries worldwide in 1990–2005 (Capelle-Blancard & Laguna, 2009); the nuclear disaster in Fukushima-Daiichi causing abnormal returns for Japanese, French and German nuclear utilities (Ferstl et al., 2012); 209 energy accidents in 1907–2007 without a significant impact on stock markets (Scholtens & Boersen, 2011); aviation disaster announcements causing market losses and higher stock volatility (Kaplanski & Levy, 2008).

Regarding the effects of economic events, Campbell et al. (2003) investigated negative stock market reactions to information security breaches, and Knight and Pretty (1999) the impact of 15 corporate catastrophes on stock prices their volatility, and trading volumes.

Additional studies considered the impact of various force majeure events. Hanabusa (2010) showed that the 9/11 terrorist attacks had a significant effect on the stock prices of Japanese companies, whilst the Iraq War and Hurricane Katrina did not. Baker and Bloom (2013) used a panel including stock prices and volatilities for 60 countries over the period 1970–2012 to investigate the impact of natural disasters, terrorist attacks and unexpected political shocks on economic growth through stock market proxies. Tavor and Teitler-Regev (2019) examined 344 significant effects of natural disasters, artificial disasters and terrorism on the stock market using the Pessimism Index. Karolyi and Martell (2010) compared stock market reactions to 77 terrorist attacks with those to extreme events such as financial crashes (4) and natural catastrophes (19). Below we also consider a variety of unexpected force majeure events to assess their impact on the Ukrainian stock market in particular.

2. DATA AND METHODOLOGY

The Ukrainian stock market index, namely the PFTS, is used for the empirical analysis. The sample period goes from January 1, 1997 to December 31, 2018. The frequency is daily. As already mentioned, force majeure events are divided into four categories: economic, technological and natural disasters, terrorist acts in Ukraine during 1997–2018. A full list of force majeure events and their description is provided in Appendices A-D.

The following hypotheses are then tested:

H1: Force majeure events create temporary inefficiencies in the Ukrainian stock market.

H2: Trading strategies based on force majeure events can generate abnormal profits.

To test them, we use the following methods:

- cumulative abnormal returns approach;
- Student's *t*-tests;
- trading simulation approach.

The cumulative abnormal returns approach is based on MacKinlay (1997) and is standard for event studies. Abnormal returns are defined as follows:

$$AR_t = R_t - E(R_t), \tag{1}$$

where R_t is the daily return of the PFTS index over the period t and $E(R_t)$ is the average return over the sample period.

Returns R_t are computed as follows:

$$R_i = \left(\frac{Close_i}{Close_{i-1}} - 1 \right) \cdot 100\%, \tag{2}$$

where R_i are returns on the i-th day in %, $Close_{i-1}$ is close price on the $i-1$ day, $Close_i$ is close price on the i-th day.

$E(R_t)$ is calculated as follows:

$$E(R_t) = \frac{1}{T} \sum_{i=1}^{N} R_i, \tag{3}$$

where T is the sample size.

The mean abnormal return corresponding to force majeure events on day α denoted as $\overline{AR}_\alpha$ is the sum of the individual abnormal returns on that day divided by the number of force majeure events:

$$\overline{AR}_\alpha = \frac{1}{N \sum_{i=1}^{N} AR_{i,\alpha}}, \tag{4}$$

20

where N is the number of force majeure events.

The cumulative abnormal return for the PFTS index from day to day denoted as $CAR_i(\alpha_1, \alpha_2)$ is simply the sum of the daily abnormal returns from day α_1 to day α_2:

$$CAR_i(\alpha_1, \alpha_2) = \sum_{\alpha=\alpha_1}^{\alpha_2} AR_{i,\alpha}. \tag{5}$$

The sample average cumulative abnormal return for event observations from α_1 to α_2 denoted as $\overline{CAR_i}(\alpha_1, \alpha_2)$ is the sum of the mean abnormal return from day α_1 to day α_2:

$$\overline{CAR_i}(\alpha_1, \alpha_2) = \sum_{t=\alpha_1}^{\alpha_2} AR_t = \\ = \frac{1}{N} \sum_{i=1}^{N} CAR_i(\alpha_1, \alpha_2). \tag{6}$$

These abnormal returns are cumulated over 1, 2, 3, 5, and 10 days following the force majeure event considered by adding them up over these periods. Negative cumulative abnormal returns are evidence in favor of Hypothesis 1.

Parametric *t*-tests are also carried out for Hypothesis 1. The Null Hypothesis (H0) is that the data (returns after force majeure events and over the full sample) belong to the same population, a rejection of the null suggesting the presence of a statistical anomaly in the price behavior after force majeure events. The test is carried out at the 95% confidence level, and the degrees of freedom are $N-1$ (N being equal to $N_1 + N_2$).

To test H2, a trading strategy based on force majeure events is used to establish whether or not it can generate abnormal profits. The trading simulation approach replicates the actions of the trader according to a given algorithm. In this particular

http://dx.doi.org/10.21511/imfi.16(1).2019.26

case, the algorithm is the following: open a short position in the Ukrainian stock market right after the force majeure event and hold it for a specific period of time.

The percentage result of the individual deal is computed as follows:

$$\%\text{result} = \frac{100\% \cdot P_{close}}{P_{open}}, \tag{7}$$

where P_{open} – opening price, P_{close} – closing price.

The sum of the results from each deal is the total financial result of trading. A strategy producing positive total profits implies that there exists an exploitable market anomaly.

Another important indicator of trading strategy efficiency is the percentage of successful trades:

$$\%\text{successful trades} = \\ = \frac{100\% \cdot \text{number of successful trades}}{\text{overall number of trades}}, \tag{8}$$

To check the statistical difference of the results from random ones, *t*-tests are used. They compare the means from two samples to establish whether or not they come from the same population. The first sample consists of the trading results based on Hypothesis 2, and the second one of random trading results.

If there are statistically significant differences, it is concluded that trading strategy really generate abnormal profits. Otherwise there are no advantages from exploiting this strategy.

It should be mentioned that the trading simulation approach used in this paper does not incorporate transaction costs (spread, fees to the broker or bank, swaps, etc.).

3. EMPIRICAL RESULTS

Descriptive statistics for the PFST returns over the period of analysis are provided in Table 1. The series is rather volatile, as indicated by the size of standard deviation and minimum/maximum values; its mean return is consistent with random walk behavior.

Table 1. Descriptive statistics for the PFST returns over the period 1997–2018

Number of observations	5,226
Mean	0.000519
Median	0.000552
Sum	2.710888
Minimum	–0.159017
Maximum	0.276746
Variance	0.000385
Std. dev.	0.019609
Standard error	0.000271
Skewness	0.569882
Kurtosis	19.28168

First we calculate the cumulative abnormal returns in the case of economic force majeure events; the results are reported in Table 2.

Table 2. Cumulative abnormal returns for the PFST index over the period 1997–2018: economic force majeure events

Parameter/period	1	2	3	5	10
Mean abnormal return across force majeure event on day α	–0.59%	1.24%	–0.08%	0.15%	0.01%
Cumulative abnormal return across event observations from α_1 to day α_2	–4.73%	5.15%	4.50%	8.52%	12.49%
Average cumulative abnormal return across event observations from α_1 to day α_2	–0.59%	0.64%	0.56%	1.07%	1.56%

As can be seen, there appears to be a negative reaction of the stock market only on the day of the event, when cumulative abnormal returns, as well as mean abnormal returns, are negative. Over longer time horizons (2, 5 and 10 days after force majeure event), there is no evidence of a market drop.

To establish whether the effect of economic force majeure events is statistically significant, *t*-tests are carried out (see Table 3).

Table 3. *T*-test for the PFST returns over the period 1997–2018: economic force majeure events

Parameter/ period α	1	2	3	5	10
Mean return across force majeure event on day α	–0.54%	0.37%	0.24%	0.26%	0.21%
Standard deviation of returns across force majeure event on day α	1.34%	2.39%	1.97%	1.70%	1.30%
Mean return for the whole data set	0.05%	0.05%	0.05%	0.05%	0.05%
Standard deviation of returns for the whole data set	1.96%	1.96%	1.96%	1.96%	1.96%
The size of the data set across force majeure event on day α	8	16	24	40	80
The size of the whole data set	5,226	5,226	5,226	5,226	5,226
t-criterion	–1.25	0.38	0.27	0.35	0.34
t-critical (0.95)	1.89	1.75	1.71	1.68	1.66
Null Hypothesis	Not rejected	Not rejected	Not rejected	Not rejected	Not rejected

The Null Hypothesis is not rejected, which implies that the behavior of returns after economic force majeure events does not statistically differ from their usual one.

As for Hypothesis 2, Table 2 indicates a market drop only on the day of the event, but the size of returns is not statistically different from the average returns over the whole sample period. Nevertheless, we simulate the action of a trader for this case and obtain the results reported in Table 4.

Table 4. Trading simulation results for the PFST returns over the period 1997–2018: economic force majeure events, $\alpha = 1$

Number of trades, units	Number of successful trades, unit	Number of successful trades, %	Profit, %	Profit % per trade
8	4	50.0%	4.3%	0.5%

As can be seen, the percentage of successful trades is 50% and profit per trade are close to the average return for the full sample, which suggests that these results do not differ from the random ones. As a further check a *t*-test is carried out (see Table 5), which again leads to the same conclusion. Therefore, there is no evidence of abnormal profits based on exploiting the occurrence of economic force majeure events.

Table 5. *T*-test for evaluating the success of the trading strategy: PFST returns over the period 1997–2018, economic force majeure, $\alpha = 1$

Parameter	Value
Number of the trades	8
Total profit	4.32%
Average profit per trade	0.54%
Standard deviation	1.25%
t-test	1.22
t-critical (0.95)	1.78
Null Hypothesis	Not rejected

The results of the cumulative abnormal returns approach for the case of social force majeure and terrorist acts in Ukraine during the period 1991–2018 are presented in Table 6.

Table 6. Cumulative abnormal returns for the PFST returns over the period 1991–2018: social force majeure and terrorist acts

Parameter/ period α	1	2	3	5	10
Mean abnormal return across force majeure event on day α	–0.78%	0.78%	2.34%	1.22%	0.71%
Cumulative abnormal return across event observations from α_1 to day α_2	–6.27%	–0.07%	18.62%	26.44%	43.21%
Average cumulative abnormal return across event observations from α_1 to day α_2	–0.78%	–0.01%	2.33%	3.30%	5.40%

The results are very similar to those for the economic force majeure events: negative returns are observed only on the day of event (not for any other time horizon). The *t*-test results are presented in Table 7.

http://dx.doi.org/10.21511/imfi.16(1).2019.26

Table 7. *T*-test for the PFST returns over the period 1991–2018: social force majeure and terrorist acts

Parameter/ period α	1	2	3	5	10
Mean return across force majeure event on day α	–0.73%	0.05%	0.83%	0.71%	0.59%
Standard deviation of returns across force majeure event on day α	1.99%	2.49%	3.49%	3.04%	2.93%
Mean return for the whole data set	0.05%	0.05%	0.05%	0.05%	0.05%
Standard deviation of returns for the whole data set	1.96%	1.96%	1.96%	1.96%	1.96%
The size of the data set across force majeure event on day α	8	16	24	40	80
The size of the whole data set	5,226	5,226	5,226	5,226	5,226
t-criterion	–1.11	0.00	0.63	0.61	0.52
t-critical (0.95)	1.89	1.75	1.71	1.68	1.66
Null Hypothesis	Not rejected	Not rejected	Not rejected	Not rejected	Not rejected

The Null Hypothesis is not rejected in any case, i.e. the behavior of returns after social force majeure and terrorist acts does not statistically differ from the usual one.

To test Hypothesis 2, the time horizon $\alpha = 1$ is used (this is the only case when a negative reaction was observed). The results are presented in Table 8.

Table 8. Trading simulation results for the PFST returns over the period 1991–2018: social force majeure and terrorist acts, $\alpha = 1$

Number of trades units	Number of successful trades unit	Number of successful trades %	Profit, %	Profit % per trade
8	6	75.0%	5.9%	0.7%

There is a high percentage of successful trades, namely 75%, but profit per trade is close to the mean return, which is evidence in favor of the randomness of the results. A *t*-test confirms that there are no statistical differences between these trading results and those from random trading, i.e. Hypothesis 2 is rejected.

Table 9. *T*-test for evaluating the success of the trading strategy: PFST returns over the period 1991–2018, social force majeure and terrorist acts, period $\alpha = 1$

Parameter	Value
Number of the trades	8
Total profit	5.86%
Average profit per trade	0.73%
Standard deviation	1.87%
t-test	1.11
t-critical (0.95)	1.78
Null Hypothesis	Not rejected

The results of the cumulative abnormal returns approach for the case of natural disasters are presented in Table 10.

Table 10. Cumulative abnormal returns for the PFST returns over the period 1991–2018: natural disasters

Parameter/ period α	1	2	3	5	10
Mean abnormal return across force majeure event on day α	–0.57%	2.94%	14.20%	8.09%	24.10%
Cumulative abnormal return across event observations from α_1 to day α_2	–0.14%	0.74%	3.55%	2.02%	6.02%
Average cumulative abnormal return across event observations from α_1 to day α_2	–0.14%	0.88%	2.81%	–0.10%	1.00%

As in the previous cases (economic force majeure and social force majors/terrorist acts), Hypothesis 1 is not rejected only for the day of the force majeure event, whilst there is no evidence of negative returns for any other time horizons. A *t*-test indicates that H1 is rejected even for $\alpha = 1$ (see Table 11).

Table 11. *T*-test for the PFST returns over the period 1991–2018: case of natural disasters

Parameter/ period α	1	2	3	5	10
Mean return across force majeure event on day α	–0.09%	0.42%	1.24%	0.46%	0.65%
Standard deviation of returns across force majeure event on day α	1.27%	1.57%	2.74%	2.51%	2.53%
Mean return for the whole data set	0.05%	0.05%	0.05%	0.05%	0.05%
Standard deviation of returns for the whole data set	1.96%	1.96%	1.96%	1.96%	1.96%
The size of the data set across force majeure event on day α	4	8	12	20	40
The size of the whole data set	5,226	5,226	5,226	5,226	5,226
t-criterion	–0.23	0.47	0.86	0.32	0.48
t-critical (0.95)	2.13	1.89	1.75	1.71	1.68
Null Hypothesis	Not rejected	Not rejected	Not rejected	Not rejected	Not rejected

The results of the trading strategy for $\alpha = 1$ are presented in Table 12.

Table 12. Trading simulation results for the PFST returns over the period 1991–2018: natural disasters, $\alpha = 1$

Number of trades, units	Number of successful trades, unit	Number of successful trades, %	Profit, %	Profit % per trade
4	1	25.0%	0.4%	0.1%

Only 25% of the trades are successful, and profit per trade is less than the mean return. The *t*-test statistics implies that these results are not statistically different from the random ones (see Table 13).

Table 13. *T*-test for evaluating the success of the trading strategy: PFST returns over the period 1991–2018, natural disasters, $\alpha = 1$

Parameter	Value
Number of the trades	4
Total profit	0.36%
Average profit per trade	0.09%
Standard deviation	1.10%
t-test	0.17
t-critical (0.95)	1.78
Null Hypothesis	Not rejected

Finally, the results of the cumulative abnormal returns approach in the case of technological disasters are displayed in Table 14.

Table 14. Cumulative abnormal returns for the PFST returns over the period 1991–2018: technological disasters

Parameter/ period α	1	2	3	5	10
Mean abnormal return across force majeure event on day α	0.00%	–0.33%	0.19%	–0.14%	–0.11%
Cumulative abnormal return across event observations from α_1 to day α_2	–0.01%	–6.88%	–2.82%	–22.60%	–44.04%
Average cumulative abnormal return across event observations from α_1 to day α_2	0.00%	–0.33%	–0.13%	–1.08%	–2.10%

In this case, unlike the previous ones, there is no pattern in price behavior on the day of the event, and the longer the time horizon the higher cumulative abnormal returns are. To see whether the detected differences in returns are statistically significant a *t*-test is again performed (see Table 15). The null hypothesis is rejected only for the case of $\alpha = 10$.

Table 15. *T*-test for the PFST returns over the period 1991–2018: technological disasters

Parameter/ period α	1	2	3	5	10
Mean return across force majeure event on day α	0.05%	–0.11%	0.01%	–0.16%	–0.16%
Standard deviation of returns across force majeure event on day α	1.88%	1.73%	1.76%	1.73%	1.70%
Mean return for the whole data set	0.05%	0.05%	0.05%	0.05%	0.05%
Standard deviation of returns for the whole data set	1.96%	1.96%	1.96%	1.96%	1.96%
The size of the data set across force majeure event on day α	21	42	63	105	210
The size of the whole data set	5,226	5,226	5,226	5,226	5,226
t-criterion	0.00	–0.61	–0.20	–1.25	–1.74
t-critical (0.95)	1.73	1.68	1.67	1.66	1.65
Null Hypothesis	Not rejected	Not rejected	Not rejected	Not rejected	Rejected

http://dx.doi.org/10.21511/imfi.16(1).2019.26

To find out whether this abnormal behavior provides opportunities to "beat the market" a trading simulation approach is used once more. The results for the time horizon $\alpha = 10$ are shown in Table 16.

Table 16. Trading simulation results for the PFST returns over the period 1991–2018: natural disasters, $\alpha = 10$

Number of trades, units	Number of successful trades, unit	Number of successful trades, %	Profit, %	Profit % per trade
21	12	57.1%	33.2%	1.6%

The number of successful trades is close to the 60% and profit per trade is three times higher than the average return. However, the *t*-test statistic (see Table 17) implies that these results are not statistically different from the random ones.

Table 17. *T*-test for the trading strategy effectiveness evaluation: PFST returns over the period 1991–2018, natural disasters, $\alpha = 1$

Parameter	Value
Number of the trades	21
Total profit	33.15%
Average profit per trade	1.58%
Standard deviation	5.68%
t-test	1.27
t-critical (0.95)	1.78
Null Hypothesis	Not rejected

The results of the tests for the Hypothesis 1 and 2 are summarized in Tables 18 and 19, respectively.

Table 18. Overall results for Hypothesis 1*

Group of force majeure/ period α	1	2	3	5	10
Economic force majeure	+/–	–	–	–	–
Social force majeure and terrorist acts	+/–	–	–	–	–
Natural disasters	+/–	–	–	–	–
Technological disasters	–	+/–	+/–	+/–	+

Note: * "+" – Hypothesis 1 is confirmed and differences are statistically significant; "+/–" – Hypothesis 1 is not rejected but differences are not statistically significant; "–" – Hypothesis 1 is rejected.

Table 19. Overall results for Hypothesis 2*

Group of force majeure/ period α	1	2	3	5	10
Economic force majeure	+/–	–	–	–	–
Social force majeure and terrorist acts	+/–	–	–	–	–
Natural disasters	–	–	–	–	–
Technological disasters	–	–	–	–	+/–

Note: * "+" – Hypothesis 2 is not rejected and results differ from random ones; "+/–" – Hypothesis 2 is not rejected but results do not differ from random ones; "–" – Hypothesis 2 is rejected.

CONCLUSION

This paper examines price behavior in the Ukrainian stock market after four types of force majeure events (economic force majeure, social force majeure, terrorist acts, natural and technological disasters. Using daily data for the PFTS index (the main index of the Ukrainian stock market) for the period from January 1, 1997 to December 31, 2018 two different hypotheses are tested: force majeure events create temporary inefficiencies in the Ukrainian stock market (H1), and trading strategies based on force majeure events can generate abnormal profits (H2). For this purpose, a variety of methods are used, including cumulative abnormal returns and trading simulation approaches, as well as Student's *t*-tests.

On the whole, it appears that the Ukrainian stock market absorbs new information rather fast. Negative returns in most cases are observed only on the day of the event. The behavior of returns on other days shows no sign of abnormality. The only exception is technological disasters, possibly because it is harder for agents to evaluate their consequences and incorporate them into stock prices.

Further, the trading simulation analysis implies that, despite the presence of a specific pattern in price behavior after force majeure events (namely a decrease on the day of the event), it is not possible to devise trading strategies exploiting it that generate abnormal profits: the results from apparently successful strategies are not statistically different from the random trading ones.

ACKNOWLEDGMENT

Alex Plastun gratefully acknowledges financial support from the Ministry of Education and Science of Ukraine (0117U003936).

REFERENCES

1. Arin, K., Ciferri, D., & Spagnolo, N. (2008). The price of terror: The effects of terrorism on stock market returns and volatility. *Economics Letters, 101*(3), 164-167. https://doi.org/10.1016/j.econlet.2008.07.007
2. Baker, S., & Bloom, N. (2013). *Does Uncertainty Reduce Growth? Using Disasters as Natural Experiments* (NBER Working Paper No. 19475). Retrieved from https://www.nber.org/papers/w19475
3. Ball, R., & Brown, P. (1968). An Empirical Evaluation of Accounting Income Numbers. *Journal of Accounting Research, 6*(2), 159-178.
4. Brounen, D., & Derwall, J. (2010). The Impact of Terrorist Attacks on International Stock Markets. *European Financial Management, 16*(4), 585-598. http://dx.doi.org/10.1111/j.1468-036X.2009.00502.x
5. Campbell, K., Gordon, L. A., Loeb, M. P., & Zhou, L. (2003). The Economic Cost of Publicly Announced Information Security Breaches: Empirical Evidence from the Stock Market. *Journal of Computer Security, 11,* 431-448.
6. Capelle-Blancard, G., & Laguna, M.-A. (2009). How Does the Stock Market Respond to Chemical Disasters? *Journal of Environmental Economics and Management, 59*(2), 192-205.
7. Chambers, A., & Penman, S. (1984). Timeliness of Reporting and the Stock Price Reaction to Earnings Announcements. *Journal of Accounting Research, 22*(1), 21-47. https://doi.org/10.2307/2490700
8. Chaudhry, N., Roubaud, D., Akhter, W., & Shahbaz, M. (2018). Impact of terrorism on stock markets: Empirical evidence from the SAARC region. *Finance Research Letters, 26,* 230-234. https://doi.org/10.1016/j.frl.2018.02.024
9. Chen, A. H., & Siems, T. F. (2004). The effects of terrorism on global capital markets. *European Journal of Political Economy, 20*(2), 349-366.
10. Cready, W., & Gurun, U. (2010). Aggregate Market Reaction to Earnings Announcements. *Journal of Accounting Research, 48*(2), 289-334. Retrieved from http://www.jstor.org/stable/40784950
11. Drakos, K. (2010). Terrorism activity, investor sentiment, and stock returns. *Review of Financial Economics, 19*(3), 128-135.
12. Falk, H., & Levy, H. (1989). Market Reaction to Quarterly Earnings' Announcements: A Stochastic Dominance Based Test of Market Efficiency. *Management Science, 35*(4), 425-446. Retrieved from http://www.jstor.org/stable/2631890
13. Fama, E. F., Fisher, L., Jensen, V. C., & Roll, R. (1969) The Adjustment of Stock Prices to New Information. *International Economy Review, 10*(1), 1-21. Retrieved from http://www.e-m-h.org/FFJR69.pdf
14. Fama, E .F. (1970). Efficient markets: A review of theory and empirical work. *Journal of Finance, 25*(2), 383-417.
15. Ferstl, R., Utz, S., & Wimmer, M. (2012). The Effect of the Japan 2011 Disaster on Nuclear and Alternative Energy Stocks Worldwide: An Event Study. *Business Research, 5*(1), 25-41. Retrieved from https://link.springer.com/article/10.1007/BF03342730
16. Foster, G. (1973). Stock Market Reaction to Estimates of Earnings per Share by Company Officials. *Journal of Accounting Research, 11*(1), 25-37. https://doi.org/10.2307/2490279
17. Hanabusa, K. (2010). Effects of foreign disasters on the petroleum industry in Japan: A financial market perspective. *Energy, 35*(12), 5455-5463.
18. Kaplanski, G., & Levy, H. (2008). Sentiment and Stock Prices: The Case of Aviation Disasters. *Journal of Financial Economics, 95*(2), 174-201. https://doi.org/10.1016/j.jfineco.2009.10.002
19. Karolyi, A., & Martell, R. (2010). Terrorism and the Stock Market. *International Review of Applied Financial Issues and Economics, 2,* 285-314.
20. Knight, R. F., & Pretty, J. F. (1999). Corporate Catastrophes, Stock Returns, and Trading Volume. *Corporate Reputation Review, 2*(4), 363-378. https://doi.org/10.1057/palgrave.crr.1540092
21. Laplante, B., & Lanoie, P. (1994). The Market Response to Environmental Incidents in Canada: A Theoretical and Empirical Analysis. *Southern Economic Journal, 60*(3), 657-672. https://doi.org/10.2307/1060574
22. Lonie, A. A., Abeyratna, G., Power, D. M., & Sinclair, C. D. (1996). The stock market reaction to dividend announcements: A UK study of complex market signals. *Journal of Economic Studies, 23*(1), 32-52. https://doi.org/10.1108/01443589610106534
23. MacKinlay, A. C. (1997). Event Studies in Economics and Finance. *Journal of Economic Literature, 35,* 13-39.
24. Scholtens, B., & Boersen, A. (2011). Stocks and energy shocks: The impact of energy accidents on stock market value. *Energy, 36*(3), 1698-1702.

http://dx.doi.org/10.21511/imfi.16(1).2019.26

25. Syed, A. M., & Bajwa, I. A. (2018). Earnings announcements, stock price reaction and market efficiency – the case of Saudi Arabia. *International Journal of Islamic and Middle Eastern Finance and Management, 11*(3), 416-431. https://doi.org/10.1108/IMEFM-02-2017-0044

26. Tavor, T., & Teitler-Regev, Sh. (2019). The impact of disasters and terrorism on the stock market. *Journal of Disaster Risk Studies, 11*(1), 1-8. https://doi.org/10.4102/jamba.v11i1.534

27. Wang, L., & Kutan, A. (2013). The Impact of Natural Disasters on Stock Markets: Evidence from Japan and the US. *Comparative Economic Studies, 55*(4), 672-686. https://doi.org/10.1057/ces.2013.16

28. Worthington, A. (2010). The impact of natural events and disasters on the Australian stock market: A GARCH-M analysis of storms, floods, cyclones, earthquakes and bushfires. *Global Business and Economics Review, 10*(1), 1-10.

29. Worthington, A., & Valadkhani, A. (2004). Measuring the Impact of Natural Disasters on Capital Markets: An Empirical Application Using Intervention Analysis. *Applied Economics, 36*(19), 2177-2186. https://doi.org/10.1080/0003684042000282489

APPENDIX A

Table A1. The main economic force majeure events in Ukraine during 1991–2018

Force majeure	Description	Date
Bankruptcy of the bank "Nadra"	Because of insolvency of the bank, the amount of payments from the Guarantee Fund for Individuals' Deposits is UAH 3.6 billion	February 6, 2015
Bankruptcy of DeltaBank	Because of insolvency of the bank, the amount of payments from the Guarantee Fund for Individuals' Deposits and state loses is UAH 24 billion	March 3, 2015
Nationalization of Privatbank	According to the decision of the government and the National Security and Defense Council, PrivatBank became the property of the state for UAH 1; the capital requirement at the time of nationalization amounted to UAH 148 billion, the amount of issued Eurobonds was USD 595 million	December 18, 2016
Hacker attack on government sites in Ukraine	Due to the mass hacking attack on government sites (the State Treasury of Ukraine and others) and the network of state authorities there were mass delays in payments. To protect against hackers, the Government of Ukraine allocated UAH 80 million	December 6, 2016
Bankruptcy of "PlatinumBank"	Due to insufficient level of capital, the bank is declared as bankrupt, the amount of losses of state-owned enterprises – clients of the bank is 500 million UAH	January 11, 2017
"Petya" virus attack	Due to the large-scale virus cyberattacking through the software of M.E.Doc. installed on 1 million computers, the estimated losses for the Ukrainian economy are 0.5% of GDP. The largest enterprises and institutions of Ukraine were the Boryspil airport, Ukrtelecom, Ukrposhta, Oschadbank, Ukrzaliznytsya and others	June 27, 2017
Bankruptcy of insurance company "Dominanta"	Due to the insolvency of the company included in the 10 largest insurance companies of Ukraine, outstanding obligations to customers remain at the amount of UAH 98 million, 300 thousand of civil liability laws remained unprotected	August 12, 2018
Bankruptcy of PJSC "Black Sea Shipbuilding Plant"	According to the court decision PJSC "Black Sea Shipbuilding Plant", the largest enterprise in Ukraine and Europe, which was founded in 1897, was declared bankrupt after unsuccessful and lengthy sanation procedures	July 4, 2018

APPENDIX B

Table B1. The main social, military and political force majeure events and terrorist acts in Ukraine during 1991–2018

Force majeure	Description	Date
"Orange Revolution", Kyiv, etc. regional centers	Because of numerous falsifications in the second round of elections, an all-Ukrainian protest rally began, which resulted in a significant change in the political vector in the country	November 22, 2004
"Revolution of dignity", Kyiv, etc. regional centers	As a result of the failure of signing the Association Agreement with the EU, the rejection of the policy of the government began mass protests	November 21, 2013
Power breaking of EuroMaydan, Kyiv	Because of illegal actions of power units, in particular, "Berkut" on cleaning the Independence Square from protesters, 79 people were injured	November 30, 2013

Table B1 (cont). The main social, military and political force majeure events and terrorist acts in Ukraine during 1991–2018

Force majeure	Description	Date
"Bloody Thursday", Kyiv	As a result of the confrontation of power units and protesters, 105 people were killed (as of April 10, 2014), 1,500 people were injured, hundreds were declared as missing	February 20, 2014
Crimean annexation	Because of the pseudo-referendum, the Autonomous Republic of Crimea was included in the RF and secured an illegal annexation of the Crimea. The date of the beginning of occupation of Crimea by the RF Verkhovna Rada of Ukraine was recognized on February 22, 2014	March 16, 2014
The beginning of the Russian military aggression against Ukraine	Terrorists captured Kramatorsk and Sloviansk. As a result of attempts to capture a military unit in Mariupol (April 16, 2014) and fighting in Sloviansk (April 17, 2014), 7 people were killed and 16 were injured	April 12, 2014
Malaysia Airlines Boeing 777 aircraft shot down	Because of the terrorist attack, carried out with the help of an anti-aircraft missile complex "Beech" of Russian production, 298 people from the 16 countries died, primarily the Netherlands and Malaysia. The terrorist attack is qualified as the largest in Ukraine and the most deadly for civil aviation. After the terrorist attack, a wave of sanctions against the Russian Federation began in 41 countries of the world	July 17, 2014
"Ilovaisky pocket"	As a result of the insidious actions of the pro-Russian military forces during the exit from the boiler on the march, 366 soldiers of the Armed Forces of Ukraine died, 429 people were wounded, 300 people – were captured. The amount of losses exceeded 70 million UAH (according to the data of the General Prosecutor's Office of Ukraine from August 14, 2017)	August 29, 2014

APPENDIX C

Table C1. The main natural disasters in Ukraine during 1991–2018

Force majeure	Description	Date
Flood in Transcarpathian region in 1998	Due to the heavy rains of the Tisza, Borzhava, Latoritsa and others, rivers came out of the coast and flooded 120 settlements. 350 thousand people were recognized as flood victims, 17 people died, 20 thousand people were resettled, 40793 were flooded, the amount of losses exceeded 820 million UAH. On November 7, 1998 the territory of the oblast was declared a zone of emergency ecological situation	November 3-5, 1998
Flood in the Precarpathians, Carpathians, Transcarpathia	Due to heavy rains on July 31, 2008, territories of 6 western regions were declared as zones of emergency ecological situation, rivers Prut, Dniester and others left the banks. 30 people died, 40,601 dwelling houses flooded, the amount of losses is more than 4 billion UAH	July 28, 2008
Flood in Transcarpathian region in 2017	Due to heavy rains and snow, the level of water on the rivers of Transcarpathia exceeded the level during the 1998 flood, 1023 households were flooded, 1 person died, 146 people evacuated	December 13-18, 2017
Anomalous heat in Ukraine	As a result of the action of the anticyclone, the climatic indicators of a number of areas of the West and the Center of Ukraine exceeded the norm by 5-10 degrees Celsius, 3 people died	August 3-6, 2017

APPENDIX D

Table D1. The main technological disasters in Ukraine during 1991–2018

Force majeure	Description	Date
Accident during the celebration of the 60th anniversary of 14 AK in Sknyliv airfield, Lviv region	Because of the fall of the Su-27UB fighter aircraft, 77 people (28 of them – children) were killed in a crowd of spectators, more than 250 people were injured. The accident is qualified as the largest catastrophe in the airshow of the number of dead	July 27, 2002
Explosions of artillery shells at the warehouses of the 52nd mechanized brigade of the 6th Army Corps of the Southern Operational Command of the Army Land Forces in Artemivsk, Donetsk region	Because of the explosions of shells, 10 warehouses from 17 were destroyed, 66 apartment buildings and 120 private houses, five schools and three hospitals were damaged, two people were injured	October 10, 2003
Explosions of artillery shells in the warehouses of the military unit A-2985 with Novobohdanivka, Zaporizhzhia region	As a result of the explosions of shells, 90 thousand tons of munitions ("Grad", "Smerch" and "Hurricane") were destroyed and 1.5 thousand people were evacuated, 5 people died, 81 persons were traumatized by various degrees of severity, 22 houses were destroyed	May 6, 2004

http://dx.doi.org/10.21511/imfi.16(1).2019.26

Table D1 (cont.). The main technological disasters in Ukraine during 1991–2018

Force majeure	Description	Date
Explosions of artillery shells at the warehouses of the 275th ammunition storage base in Novobohdanivka, Zaporizhzhia region	Due to the high temperature of the air, detonation of the shells of one of the warehouses took place, and 5 persons were injured	July 23, 2005
The accident at the housing and communal services facilities in the city of Alchevsk, Luhansk region	As a result of the accident and false actions of communal services, 60 thousand people were left without heating, an emergency situation at the state level was announced	January 22, 2006
Explosions of artillery shells at the warehouses of the 275th ammunition storage base in Novobohdanivka, Zaporizhzhia region	As a result of the explosions, the fire captured more than 3 hectares of the territory of the compound, 1,5 thousand people were evacuated, 4 thousand people were displaced, 4 were injured	August 9, 2006
Explosions of artillery shells at the warehouses of the 275th ammunition storage base in Novobohdanivka, Zaporizhzhia region	As a result of mine clearance of warehouses and explosions already injured by preliminary fires of shells, 1 person was wounded, 2 people were killed	May 18, 2007
The leakage of phosphorus and fire on the railway under Ozhid village, Lviv region	The accident at the freight train № 2005 on the Reds-Ozhidov run, which resulted in the transfer of 15 tanks with yellow phosphorus, spontaneous combustion of 6 tanks and injured 152 people (including 42 children)	July 16, 2007
The explosion of gas in a residential building in Dnipropetrovsk	Because of the explosion, the entrance of the dwelling house was completely destroyed, and three neighboring ones were damaged. 23 people were killed, 20 were injured	October 13, 2007
Accident at the mine named after Zasiadko, Donetsk	As a result of the explosion of air-methane mixture on the horizon of 1078, 100 people died	November 18, 2007
Explosions of shells in the warehouses of the military part of 0829, 61st Arsenal of the Southern Operational Command of the Army, and fire at the gas distribution station of Lozova, Kharkiv region	Because of explosions evacuated people in the 3-km zone, 1 person was injured.	August 27, 2008
Fire at the station "Otradnoe", Dzhankoy district (ARC Crimea) at the station for storage of pesticides	Because of the fire, an area of 600 m2 burned about 160 tons of pesticides.	October 17, 2009
The explosion at the hospital № 7 in the city of Luhansk	As a result of the explosion of an oxygen cylinder in the intensive care unit, 16 people were killed	January 18, 2010
Explosion of the gas pipeline in Uzhhorod, Transcarpathian region	As a result of the explosion, 1 person was killed, 2 were injured	August 29, 2011
Fire at Vuglegirsk eneggy station (PJSC "Tsentrenergo"), Svitlodarsk, Donetsk region	As a result of the fire, 4 power units of TPP were destroyed by 1 person, 5 people were injured, 12 thousand residents of Svitlodarsk city were left without water and heating	March 29, 2013
Accident at the chemical plant of PJSC "Stirol", city of Horlivka, Donetsk region	The largest accident at chemical plants during the years of independence, which resulted in the release of ammonia, 6 people killed injured 26.	August 6, 2013
Accident at the mine named after Zasiadko, Donetsk	As a result of the explosion of the methane mixture on the eastern slope No. 2, 100 people were killed	March 4, 2015
Explosions of shells at the depots of the Ministry of Defense of Ukraine in the Svatov, Luhansk region	Because of explosions, 59 multistory buildings, 581 private houses and 21 social facilities were damaged, and four people were killed. The Ministry of Defense qualifies as a terrorist act	October 29, 2015
Accident at the Steppe mine, Glukhiv village, Lviv region	As a result of the explosion of methane mixture on the horizon of 550 m, 119 conveyor bombers killed 8 people and injured 23 people	March 2, 2017
Explosions of shells at the depots of the Ministry of Defense of Ukraine in the city of Balakliia, Kharkiv region	Because of explosions, 2 people died, 5 people were injured, 300 houses were damaged, 5 were destroyed. The Ministry of Defense qualifies as a terrorist act	March 23, 2017
Explosions of shells in the warehouses 48 of the arsenal of military unit A1119 in the Kalynivka village, Vinnytsia region	Because of the bombings, 2 people were injured, 24 people were evacuated 5 people, 300 buildings were damaged, 5 were destroyed. Qualifies as a sabotage of the Russian Federation.	September 26, 2017