“Exploring frequency of price overreactions in the Ukrainian stock market”

AUTHORS	Alex Plastun https://orcid.org/0000-0001-8208-7135 https://publons.com/researcher/1449372/alex-plastun/ Inna Makarenko https://orcid.org/0000-0001-7326-5374 http://www.researcherid.com/rid/AAE-8453-2020 Lyudmila Khomutenko http://orcid.org/0000-0002-9443-4330 http://www.researcherid.com/rid/P-6162-2014 Yanina Belinska Maryna Domashenko

ARTICLE INFO	Alex Plastun, Inna Makarenko, Lyudmila Khomutenko, Yanina Belinska and Maryna Domashenko (2018). Exploring frequency of price overreactions in the Ukrainian stock market. *Investment Management and Financial Innovations*, *15*(3), 157-168. doi:10.21511/imfi.15(3).2018.13
DOI	http://dx.doi.org/10.21511/imfi.15(3).2018.13
RELEASED ON	Friday, 17 August 2018
RECEIVED ON	Saturday, 30 June 2018
ACCEPTED ON	Friday, 10 August 2018

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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
21	10	8

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BUSINESS PERSPECTIVES

LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10, Sumy, 40022, Ukraine

www.businessperspectives.org

Alex Plastun (Ukraine), **Inna Makarenko** (Ukraine), **Lyudmila Khomutenko** (Ukraine), **Yanina Belinska** (Ukraine), **Maryna Domashenko** (Ukraine)

EXPLORING FREQUENCY OF PRICE OVERREACTIONS IN THE UKRAINIAN STOCK MARKET

Abstract

This paper explores the frequency of price overreactions in the Ukrainian stock market by focusing on the PFTS Index over the period 2006–2017 and UX index over the period 2008–2017, as well as some "blue chips" (BAVL, UNAF, MSICH, CEEN) for the period of 2013–2015. Using static approach to detect overreactions, a number of hypotheses are tested: the frequency of price overreactions is informative about crisis events in the economy (H1), can be used for price prediction purposes (H2), and exhibits seasonality (H3). To do this, various statistical tests (both parametric and non-parametric), including correlation analysis, augmented Dickey-Fuller tests (ADF), Granger causality tests, and regression analysis with dummy variables, are carried out. Hypotheses H1 and H2 are confirmed: frequency of price overreactions can be used as a crisis predictor (a sharp increase in the number of overreactions is associated with a crisis period) and could be used to predict stock returns. No seasonality in the overreactions frequency is found. Implications of this research include crisis prediction and stock market prices forecasting and can be used for designing trading strategies.

Keywords stock market, crisis, frequency analysis, overreactions, frequency of overreactions

JEL Classification G12, G17, C63

Received on: 30th of June, 2018
Accepted on: 10th of August, 2018

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Alex Plastun, Ph.D., Sumy State University, Ukraine.

Inna Makarenko, Ph.D., Sumy State University, Ukraine.

Lyudmila Khomutenko, Ph.D., Sumy State University, Ukraine.

Yanina Belinska, Ph.D., University of the State Fiscal Service of Ukraine, Ukraine.

Maryna Domashenko, Ph.D., Sumy State University, Ukraine.

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INTRODUCTION

The world economy under globalization is characterized by a significant level of turbulence. Different kinds of macroeconomic shocks and crises occur more and more often, and their consequences become more and more painful. The Asian crisis and the default of Russia in the late 90's, dot-come bubble in the early 2000's, the global financial crisis of 2007–2009 evidence in favor of this.

Traditional macroeconomic indicators like GDP, industrial production, inflation, unemployment rate, etc. are characterized by significant time lags of their disclosure and low predictive properties for the purposes of economic crises prediction. At the same time, there are indicators deprived of these shortcomings. Among them are stock market prices, volatility, trade volumes, correlation between assets, current trends, market persistence, etc. For example, the downward nature of the asset prices dynamics in the stock market signals about the accumulation of negative phenomena in financial and economic systems; a growing trend indicates a restoration of a favorable economic situation (Grech & Pamula, 2008). Sharp growth of volatility signals about increase of the panic moods in the stock market and allows to detect crisis phases (Crato & Ray, 2000; Kazemi, 2013). The growth of correlations between various assets in the stock market signals about the emergence of crisis phenomena in financial and economic systems (Sandoval & Franca, 2012), the same is true for the market persistence (Caporale et al., 2016).

Despite the variety of signals from stock markets, search for new ones continues. For example, price overreactions can be used for the purposes of early forecasting of crisis phenomena in economic systems, their detection and periodization (Savor, 2012; Feldman et al., 2012; Angelovska, 2016). Sharp increase or fall of the overreactions frequency may indicate changes in the current economic situation and create the basis for its forecasting in the future.

The present study provides a systematic analysis of the overreactions frequency in the Ukrainian stock market to examine issues such as their predicative abilities for the cases of crises prediction as well as price prediction in the stock market, seasonal patterns and information content by testing the following hypotheses: the frequency of overreactions is informative about crisis event in economy (H1), the frequency of overreactions can be used for price prediction purposes (H2), and price overreactions exhibit seasonality (H3). For this purpose, a number of statistical tests (both parametric and non-parametric) are carried out. The analysis is based on data from two leading Ukrainian stock indices (PFTS and UX).

The remainder of the paper is organized as follows. Section 1 reviews the existing literature on the price overreactions. Section 2 describes the methodology used in this study. Section 3 discusses the empirical results. The last section provides some concluding remarks.

1. LITERATURE REVIEW

Over- and underreactions are defined as significant deviations in asset prices from their average values over a period of time (Stefanescu et al., 2012). The theoretical basis for the study of overreactions in stock markets and the corresponding overreaction hypothesis is proposed by De Bondt and Thaler (1985): overreactions are evidence of the irrational behavior of investors that overestimate the recent arrivals of information, which causes significant deviation of asset prices from their fundamental value, and in the future leads to price corrections. If investors demonstrate the signs of overreaction during a specified period, in the next period they tend to act in the opposite direction (Bremer & Sweeney, 1991; Caporale et al., 2018). Among the key factors that cause appearance of overreactions in the stock market are psychological, technical and fundamental reasons.

Stock market is the most commonly used object of overreactions analysis. The US stock market was analyzed by Brown, Harlow, and Tinic (1988), Atkins and Dyl (1990), Ferri and Min (1996), and many others. As the objects of analysis, stock markets of Spain (Alonso & Rubio, 1990), Canada (Kryzanowsky & Zhang, 1992), Japan (Chang et al., 1995), and others were acted.

However, a question of the frequency of overreactions is mostly unexplored. Some aspects of this issue were considered by Sandoval and Franca (2012), Govindaraj et al. (2014), and Angelovska (2016). Still Ukrainian stock market was never an object of analysis for the case of frequency of overreactions. The present study is the first to conduct a systematic analysis of the frequency of overreactions examining issues such as their predicative abilities for the cases of crises prediction as well as price prediction in the stock market, seasonal patterns and information content, etc.

2. DATA AND METHODOLOGY

Data sample includes daily data from the Ukrainian stock market: PFTS Index over the period 2006–2017 and UX index for the period 2008–2017 (this selection is due both to the data availability and the research objectives, which include analysis of two crisis situations in the Ukrainian economy: 2007–2009 and 2013–2015). Also as additional data sets, e the data of the "blue chips" of the Ukrainian Exchange (BAVL, UNAF, MSICH, CEEN) are used for the period of 2013–2015. The data sources are the official sites of the PFTS Exchange and the Ukrainian Stock Exchange.

To detect overreactions, methodology developed by Caporale and Plastun (2018b) is used.

The first step is to create a number of data necessary for the analysis. For this, the daily closing

price parameters are used. In order to equalize and compare the primary data, their logarithm is used. Thus, the formula for calculating the analyzed series of data is as follows:

$$S_t = \ln(P_t) - \ln(P_{t-1}), \quad (1)$$

where S_t – an appropriate element of a series of data that will be used for the analysis, P_t and P_{t-1} – closing price of a current and a previous day.

The next step is to conduct a frequency analysis. The first step is to form data plots (frequency intervals). The second step is to calculate the frequency of data hits in a specific plot. The next step is to define the abnormality threshold and identify abnormal data. The final stage of the analysis is forming a histogram of the distribution of abnormal price fluctuations.

Then the following hypotheses are tested:

(H1): The increase in the frequency of overreactions is informative about crisis processes in the economy and the phases of crisis correlate with the changes in the frequency of overreactions.

(H2): The frequency of overreactions is informative about price movements in the Ukrainian stock market.

(H3): The frequency of overreactions in the Ukrainian stock market exhibits seasonality.

To test these hypotheses, parametric (ANOVA analysis) and non-parametric (Kruskal-Wallis test) test statistics are used as well as visual inspection of patterns in the frequency of overreactions.

Augmented Dickey-Fuller tests (ADF) and Granger causality tests, as well as regression analysis are used to analyze the relationship between the frequency of overreactions and the dynamics of the Ukrainian stock market.

A regression analysis includes the models with and without the use of dummy variables (see equations 2 and 3):

$$Y_t = b_0 + b_1 Monday_t + b_2 Tuesday_t + \\ + b_3 Wednesday_t + b_4 Friday_t + \varepsilon_t, \quad (2)$$

where Y_t – stock market returns log differences on day *t*; b_n stock market returns mean log differences; a_1^+ (a_1^-) – slopes for the positive and negative overreactions, respectively; $Monday_t$ (D_{1n}^-) – a dummy variable equal to 1 on positive (negative) overreaction days, and equal to 0 otherwise; ε_t – random error term at time *t*.

The size, sign and statistical significance of the slope coefficients provide information about the possible influence of the frequency of overreactions on the stock market log returns.

$$Y_t = b_0 + b_1 Monday_t + b_2 Tuesday_t + \\ + b_3 Wednesday_t + b_4 Friday_t + \varepsilon_t, \quad (3)$$

where Y_t – stock market returns log differences on day *t*; b_n – stock market returns mean log differences; $a_1 \cdot (a_2)$ – slopes for the positive and negative overreactions, respectively; $Monday_t$ (O_t^-) – the number of positive (negative) overreaction days during a period *t*; ε_t – random error term at time *t*.

3. EMPIRICAL RESULTS

Following the logarithmization of the primary data and their distribution in the pockets of frequencies, the following results were obtained (Table 1).

Table 1. Frequency analysis of daily price fluctuations of the PFTS and UX indices

Pocket	Frequency PFTS	Frequency UX
Less than –0,10	2	10
–0,10 – –0,08	4	9
–0,06 – –0,04	18	17
–0,04 – –0,02	37	45
–0,02 – 0,00	159	186
0,00 – 0,02	989	973
0,02 – 0,04	1053	959
0,04 – 0,06	164	204
0,06 – 0,08	27	40
0,08 – 0,10	7	15
More than 0,10	9	11

The visual interpretation of these data is shown in Figures 1 and 2.

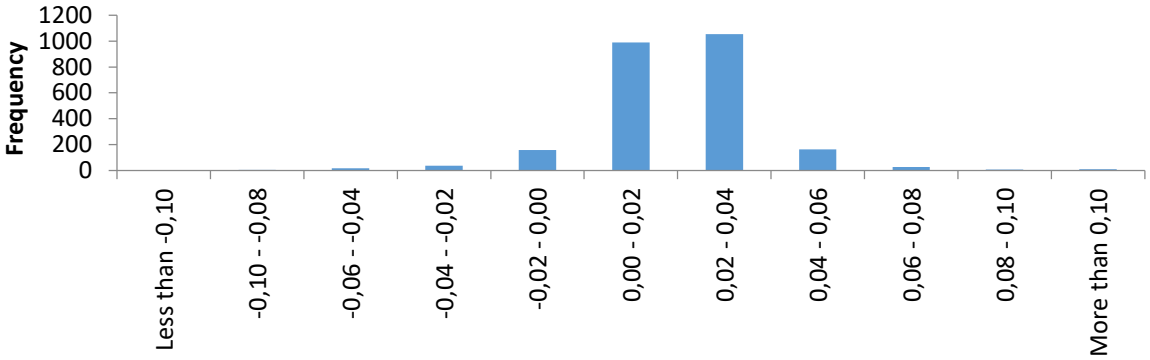

Figure 1. Frequency distribution for the PFTS index

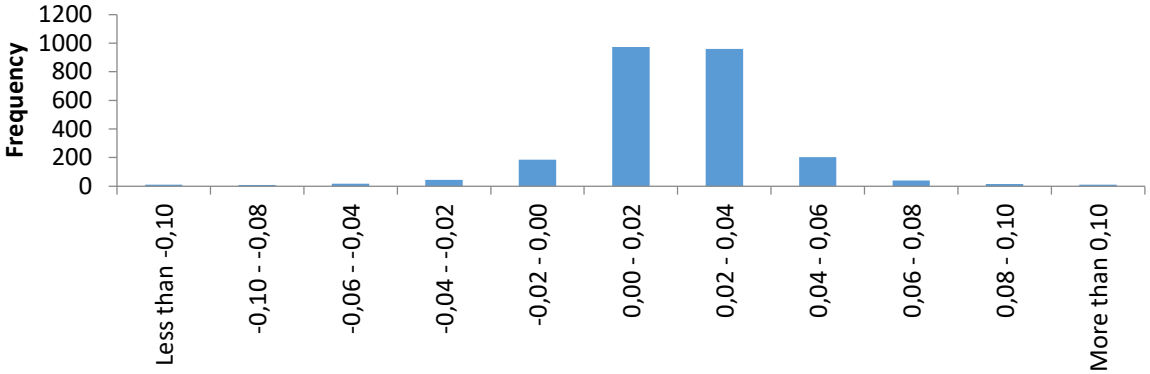

Figure 2. Frequency distribution for the UX index

In order to deal only with abnormal cases in price dynamics as a threshold point for the identification of abnormal returns, a point – +/–0.04 has been chosen. Accordingly, all values below/above this threshold are considered as abnormal (this is approximately 2-3% of the total data set which meets the criterion of anomaly).

As a result, a sample of abnormal values is obtained, which is displayed as a histogram (see Figures 3 and 4).

As can be seen, 2008 was the period when abnormal price fluctuations on both indices appeared extremely often. This coincides with the peak of the global crisis in September 2008: during this period the key events have occurred.

The next step in the analysis is to study the behavior of the overreactions frequency in the Ukrainian stock market over the period of 2007–2009. The results for PFTS and UX indices are presented in Figures 5 and 6.

As can be seen, extreme values of the frequency of overreactions for both of the analyzed indices were observed in September–October 2008. Thus, the authors have obtained additional confirma-

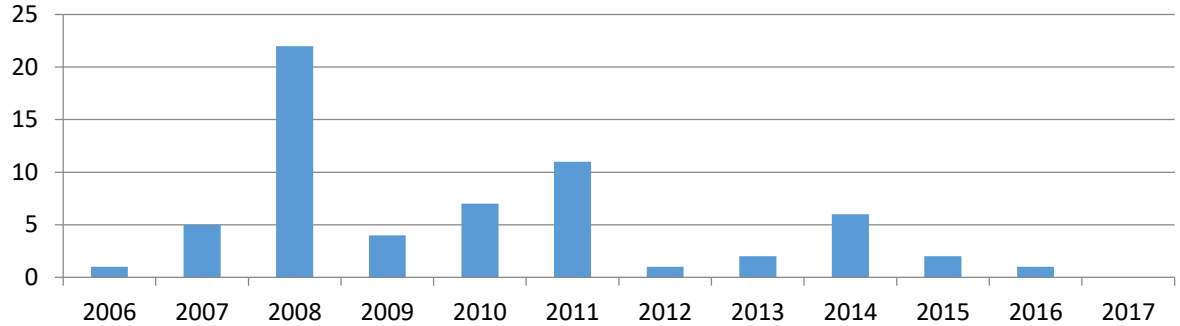

Figure 3. Frequency of overreactions: case of the PFTS index for the period 2006–2017 (annual data)

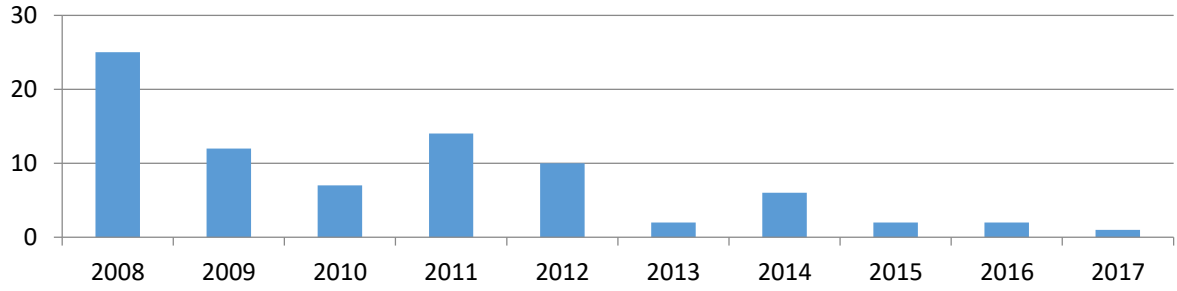

Figure 4. Frequency of overreactions: case of the UX index for the period 2008–2017 (annual data)

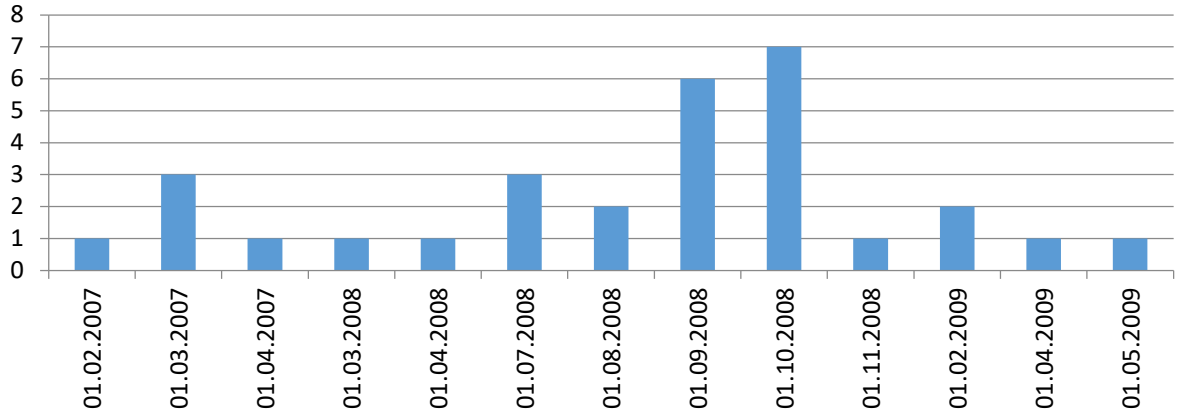

Figure 5. Frequency of overreactions in the PFTS index over the period 2007–2009 (monthly data)

tion of the adequacy of this approach use to assess the current state of the economic system and the identification of the crisis phases: the increase in overreactions frequency indicates the emergence of crisis in the economy, and its extreme values indicate that it is the peak phase of the crisis.

To confirm the results and demonstrate that this approach works not only in the context of the global crisis, but can also be used to analyze local crises, a frequency analysis of overreactions in the Ukrainian stock market over the period 2013–2015 (local crisis in Ukraine) is conducted. To do this, data from the PFTS index are used, as well as the "blue chips" of the Ukrainian Stock Exchange (BAVL, UNAF, MSICH, CEEN). The results are shown in Figures 7 and 8, respectively.

The frequency of overreactions is extremely unstable. The peak was in March 2014, which completely correlates with the events that took place in Ukraine at that time (change of state authori-

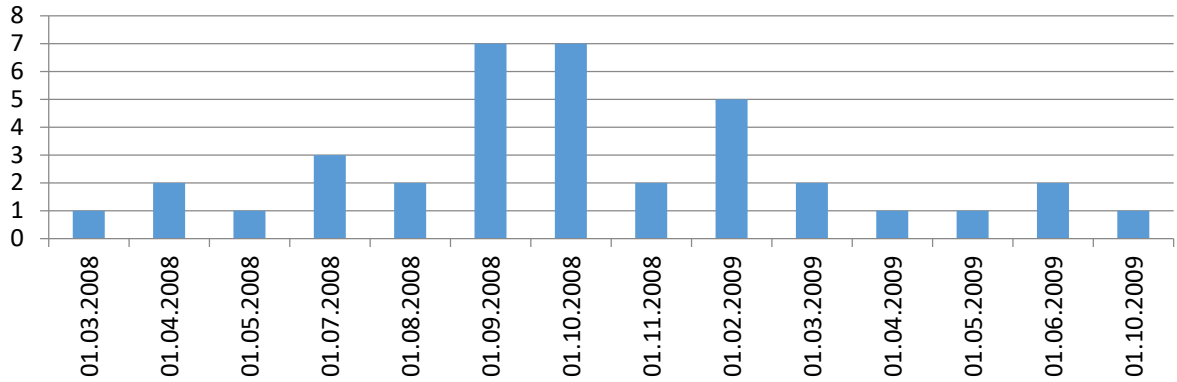

Figure 6. Frequency of overreactions in the UX index over the period 2008–2009 (monthly data)

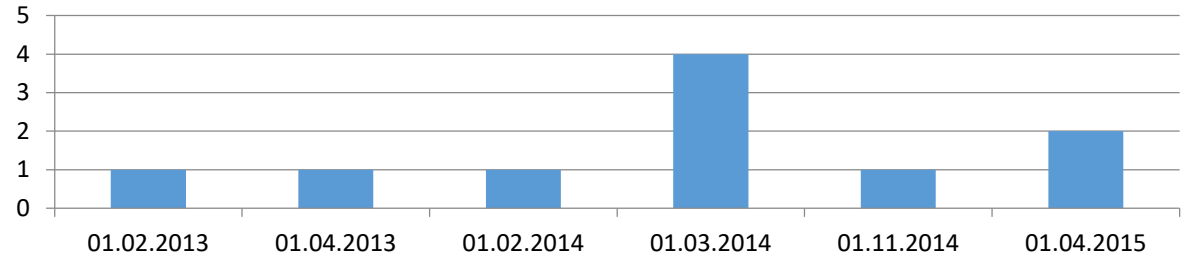

Figure 7. Frequency of overreactions, case of the PFTS index over the period 2013–2015 (monthly data)

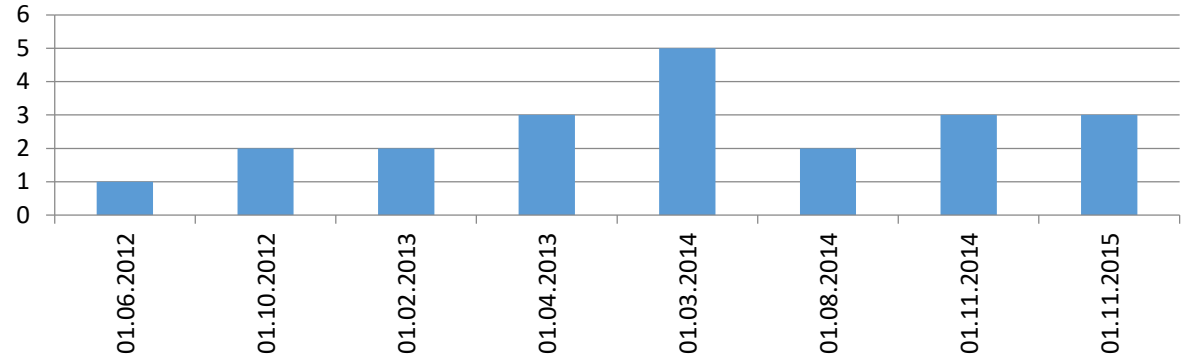

Figure 8. Frequency of overreactions, case of the "blue chips" of the Ukrainian Stock Exchange over the period 2012–2015 (monthly data)

ties, annexation of Crimea by Russia). Thus, stock market signals about negative changes in the economic system, indicating the start of the crisis, in fact, even before it has begun.

Overall visual inspection provides clear evidences in favor of Hypothesis 1 (*H1*): The increase in the frequency of overreactions is informative about crisis processes in the economy and the phases of crisis correlate with the changes in the frequency of overreactions.

To provide additional evidences in favor of instability of overreactions frequency, ANOVA analysis and Kruskal-Wallis tests (Table 2) are carried out. Results are mixed: parametric ANOVA analysis cannot reject the hypothesis of the absence of statistical differences in the frequency of overreactions between different years, but non-parametric Kruskal-Wallis test confirms that the differences between years are statistically significant, i.e. that the frequency of overreactions varies over time.

To make sure that there could be some predicative abilities in the overreaction frequency data, a correlation analysis is provided. Results for different parameters (number of negative overreactions, number of positive overreactions, and over-

Table 2. Results of ANOVA and non-parametric Kruskal-Wallis tests for statistical differences in the frequency of overreactions between different years

ANOVA test			
F	**p-value**	**F critical**	**Null hypothesis**
1.73	0.07	1.86	Not rejected
Kruskal-Wallis test			
Adjusted H	**p-value**	**Critical value**	**Null hypothesis**
21.77	0.02	19.68	Rejected

Table 3. Results of the correlation analysis between the frequency of overreactions and different PFST index variables

Parameter	Over_negative	Over_positive	All_over
PFST index close prices	–0,02	0,00	–0,01
PFST index returns	–0,41	0,43	–0,10
PFST index log returns	–0,48	0,36	–0,18

all number of overreactions) and indicators (PFST index close prices, PFST index returns, PFST index log returns) are presented in Table 3.

As can be seen, the most convincing correlation is observed for the cases of returns and log returns. The results are rather rational: increase of negative/positive overreactions leads to decrease/increase in PFST index returns (log returns). Overall number of overreactions (as it should be) has rather weak correlation and therefore cannot be used as a predictor.

To make sure that zero lag is the best proxy and there is no need to shift data in any direction one can provide a cross-correlation analysis of these indicators at time interval t and the other at time interval $t+i$, where $I \in \{-10, \ldots, 10\}$. Figure 9 reports the cross-correlation between PFST index log returns and frequency of overreactions over the total sample period for different lead and lag intervals.

The extreme values of correlation coefficient are observed for the 0 lags. Thus it is the best proxy for the analysis of relationship between these variables. Any other lead and lag intervals cannot improve the results.

Next, further analysis of the relationship between the PFST index log returns and the frequency of overreactions is provided. First, ADF tests are carried out to make sure that data are stationary and Granger Causality tests can be performed (see Table 4).

Data have no unit roots in all cases and Granger Causality tests can be performed (see Table 5).

Granger Causality tests for the lags 1 and 2 provide no evidence of the existence of linkages between the PFST index log returns and the frequency of overreactions. Nevertheless, results of correlation analysis give sufficient reasons in favor of informative abilities of the frequency of overreactions about price movements in the Ukrainian stock market.

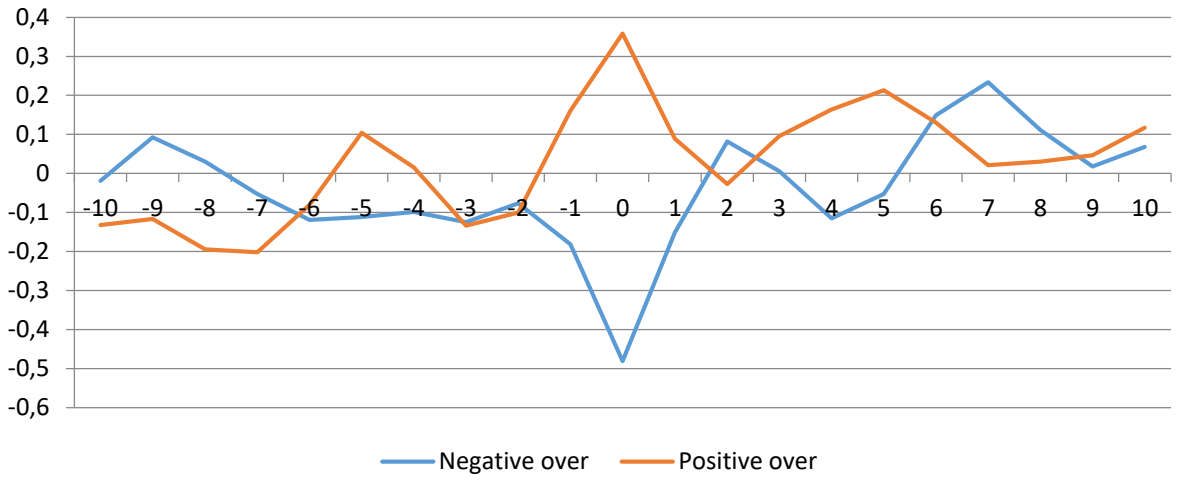

Figure 9. The cross-correlation between PFTS index log returns and frequency of overreactions over the total sample period for different lead and lag intervals

Table 4. Augmented Dickey-Fuller test: PFST index log returns and overreactions frequency data*

Parameter	Log returns	Over_all	Over_negative	Over_positive
Augmented Dickey-Fuller test (Intercept)				
Augmented Dickey-Fuller test statistic	–8.46	–8.14	–8.21	–8.90
Probability	0.0000	0.0000	0.0000	0.0000
Test critical values (1% level):	–3.48	–3.48	–3.48	–3.48
Null hypothesis	Rejected	Rejected	Rejected	Rejected
Augmented Dickey-Fuller Test (Trend and intercept)				
Augmented Dickey-Fuller test statistic	–8.43	–8.38	–8.36	–9.11
Probability	0.0000	0.0000	0.0000	0.0000
Test critical values (1% level):	–4.02	–4.02	–4.02	–4.02
Null hypothesis	Rejected	Rejected	Rejected	Rejected
Augmented Dickey-Fuller Test (Intercept, 1st difference)				
Augmented Dickey-Fuller test statistic	–11.33	–11.73	–12.29	–10.68
Probability	0.0000	0.0000	0.0000	0.0000
Test critical values (1% level):	–3.48	–3.48	–3.48	–3.48
Null hypothesis	Rejected	Rejected	Rejected	Rejected

Note: * Lag Length: 0 (Automatic – based on Schwarz information criterion, maxlag = 10).

The next step is testing of Hypothesis 2 (*H2*): The frequency of overreactions is informative about price movements in the Ukrainian stock market. To that end, two linear regression models are run: a simple linear regression and regression with dummy variables model (see methodology section for details). Results for the case of PFST index log returns are presented in Table 6.

As can be seen6 the best results are obtained for the case of negative and positive overreactions as separate independent variables and PFST index

Table 5. Granger Causality Test: Log returns vs overreactions frequency

	F	p-value
Log returns vs Over_all (lag = 1)		
Granger Causality Test: Y(log returns) = f (Over_all)	0.01	0.9216
Granger Causality Test: Y(Over_all) = f (log returns)	0.01	0.9195
Log returns vs Over_all (lag = 2)		
Granger Causality Test: Y(Log returns) = f (Over_all)	0.28	0.7527
Granger Causality Test: Y(Over_all) = f (log returns)	0.56	0.5688
Log returns vs Over_negative (lag = 1)		
Granger Causality Test: Y(Log returns) = f (Over_negative)	0.01	0.9112
Granger Causality Test: Y(Over_negative) = f (log returns)	0.02	0.8495
Log returns vs Over_negative (lag = 2)		
Granger Causality Test: Y(Log returns) = f (Over_negative)	0.79	0.4536
Granger Causality Test: Y(Over_negative) = f (log returns)	0.02	0.9816
Log returns vs Over_positive (lag = 1)		
Granger Causality Test: Y(Log returns) = f (Over_positive)	0.16	0.6897
Granger Causality Test: Y(Over_positive) = f (log returns)	0.65	0.4229
Log returns vs Over_positive (lag = 2)		
Granger Causality Test: Y(Log returns) = f (Over_positive)	0.09	0.9121
Granger Causality Test: Y(Over_positive) = f (log returns)	2.80	0.0641
Over_negative vs Over_positive (lag = 1)		
Granger Causality Test: Y(Over_negative) = f (Over_positive)	0.70	0.4045
Granger Causality Test: Y(Over_positive) = f (Over_negative)	0.26	0.6089
Over_negative vs Over_positive (lag = 2)		
Granger Causality Test: Y(Over_negative) = f (Over_positive)	0.63	0.5307
Granger Causality Test: Y(Over_positive) = f (Over_negative)	3.34	0.0384

Table 6. Regression analysis results: case of PFST index log returns as a dependent variable

Parameter	All overreactions	Negative and positive overreactions as separate variables	Regression with dummy variables
a_0	0.008 (0.43)	–0.002 (0.77)	0.001 (0.92)
Slope for the overreactions ()	–0.01 (0.03)	–	–
Slope for the overreactions ()	–	–0.07 (0.00)	–0.04 (0.00)
Slope for the overreactions ()	–	0.10 (0.00)	0.04 (0.00)
F-test	4.87 (0.03)	108.12 (0.00)	26.63 (0.00)
Multiple R	0.18	0.78	0.40

Note: P-values are in parentheses.

log returns both for the simple linear regression model and model with dummy variables. The best model is observed for the simple linear regression model. To show that the use of two separate models where negative and positive overreactions act as independent variables additional analysis is provided. Results are presented in Table 7. The behavior of positive overreaction as a function of negative overreactions is also modelled there (Granger Causality test provides evidences of the existence of linkages between these parameters).

Despite the fact that slopes in both cases (model with negative and positive overreactions) are statistically significant, overall quality of these models are much lower than general model. Also one can show that the frequency of positive overreactions can be predicted based on the frequency of negative overreactions. Summarizing these results the best model can be described by the following equation:

$$\text{PFTS Index log return}_i = \\ = -0.02 - 0.07 \times \text{OF}_i^- + 0.10 \times \text{OF}_i^+, \quad (4)$$

i.e., there is a strong relationship between the PFTS Index log returns and the frequency of overreactions. Negative overreactions provide negative impact and positive overreactions – positive.

On the whole, the above evidence supports *H2*.

The practical implications of these results are price prediction in the Ukrainian stock market and search for divergences in current stock market prices. Counting the number of overreaction (both positive and negative) predicted values of the PFTS Index can be calculated. A comparison between the current value of the PFTS Index and that implied by the estimated regression could be useful to investors to infer its likely future movements. For example, if current log returns are much lower than calculated values, it can be concluded that PFTS Index is underestimated and its prices should grow. And vice versa, if current log returns are much higher than calculated values, it can be concluded that PFTS Index is overestimated and its prices should decline. Accordingly, in case of undervaluation, PFTS Index should be bought and in case of overvaluation – sold. When the diver-

Table 7. Additional regression analysis results

Parameter	Negative overreactions	Positive overreactions	Positive overreactions = =f (negative overreactions)
a_0	0.017 (0.04)	–0.017 (0.07)	0.197 (0.00)
Slope for the overreactions (a_1)	–0.04 (0.00)	0.05 (0.00)	0.26 (0.00)
F-test	42.27 (0.00)	20.71 (0.00)	29.54 (0.00)
Multiple R	0.48	0.36	0.42

Note: P-values are in parentheses.

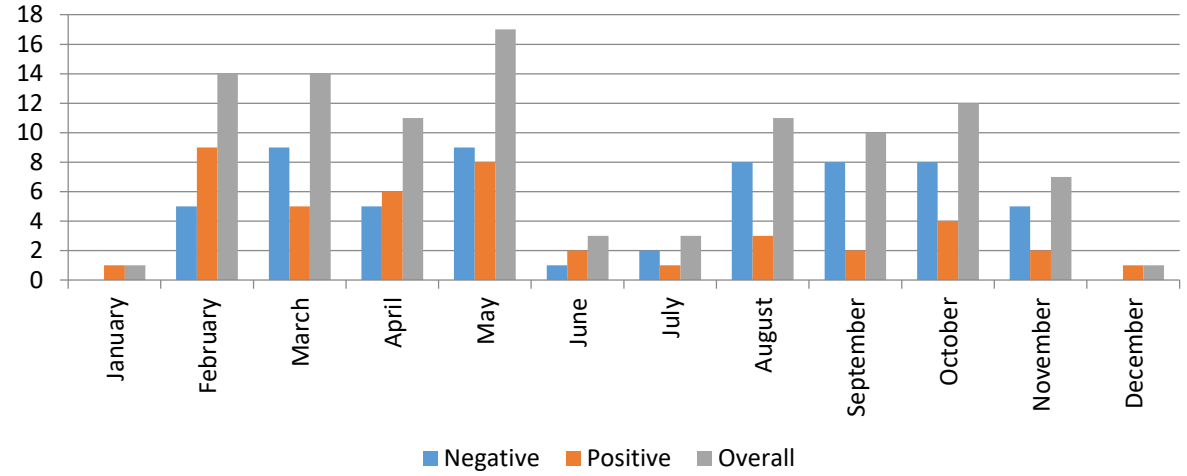

Figure 10. Monthly seasonality in overreactions frequency: case of PFTS Index

gence disappears (actual PFTS Index price is close to the calculated/predicted value), positions should be closed.

Finally, Hypothesis 3 (*H3*) is tested: The frequency of overreactions in the Ukrainian stock market exhibits seasonality. Figure 10 provides some evidence on cyclical nature of the overreactions frequency: it tends to be higher in spring and autumn and decreases in other seasons. In general, the frequency of the overreactions looks like a "reverse W" seasonality pattern.

To confirm/reject this observation parametric (ANOVA) and non-parametric (Kruskal-Wallis), tests are performed; the results are presented in Tables 8 and 9.

As can be seen, there are no statistically significant differences between the frequency of overreactions in different months of the year (i.e., no evidence of seasonality), therefore H3 can be rejected and the previous conclusions from the visual inspection are statistically insignificant.

Table 8. Parametric ANOVA of monthly seasonality in overreactions frequency

Parameter	Frequency of negative overreactions	Frequency of positive overreactions	Frequency of overreactions (overall)
F	0.67	1.09	0.88
p-value	0.7642	0.3722	0.5587
F critical	1.86	1.86	1.86
Null hypothesis	Not rejected	Not rejected	Not rejected

Table 9. Non-parametric Kruskal-Wallis test of monthly seasonality in overreactions frequency

Parameter	Frequency of negative overreactions	Frequency of positive overreactions	Frequency of overreactions (overall)
Adjusted H	12.34	11.41	11.93
d.f.	11	11	11
P value	0.34	0.41	0.37
Critical value	19.675	19.675	19.675
Null hypothesis	Not rejected	Not rejected	Not rejected

CONCLUSION

This paper explores the frequency of price overreactions in the Ukrainian stock market by focusing on the PFTS Index over the period 2006–2017 and UX index over the period 2008–2017. It uses different methods (both parametric and non-parametric) including correlation analysis, augmented Dickey-Fuller tests (ADF), Granger causality tests, and regression analysis with dummy variables to test a number of hypotheses of interest. Among them are: the frequency of overreactions is informative about crisis events in economy (*H1*), can be used for price prediction purposes (*H2*), and exhibits seasonality (*H3*).

Visual inspection as well as statistical tests provides evidence that the frequency of overreactions is related to crises and their phases. During crisis periods, frequency of overreactions tends to increase and vice versa. So, *H1* is confirmed.

Another important conclusion is the fact that analysis of overreactions frequency can help to predict prices in the Ukrainian stock market. Appropriate linear regression model is developed and *H2* is confirmed.

Visual inspection of overreactions frequency provides some evidence on cyclical nature of the overreactions frequency and presence of "reverse W" seasonality pattern. Nevertheless, statistical tests show no statistically significant differences between the frequency of overreactions in different months of the year (i.e., no evidence of seasonality). So, *H3* is rejected.

The findings obtained have a number of important implications. First, they can be used to predict crises (which is extremely important in the context of globalization): a sharp increase in the number of overreactions is associated with a crisis period. Further, they could be used to predict stock market prices. On the whole, it can provide useful information about market developments and for designing trading strategies.

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