“Exploring price gap anomaly 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 https://publons.com/researcher/2455969/inna-makarenko/ Lyudmila Khomutenko http://orcid.org/0000-0002-9443-4330 Svitlana Shcherbak http://orcid.org/0000-0002-3969-2062 Olha Tryfonova http://orcid.org/0000-0002-7980-636X

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Alex Plastun (Ukraine), **Inna Makarenko** (Ukraine), **Lyudmila Khomutenko** (Ukraine), **Svitlana Shcherbak** (Ukraine), **Olha Tryfonova** (Ukraine)

EXPLORING PRICE GAP ANOMALY IN THE UKRAINIAN STOCK MARKET

Abstract

This paper analyzes price gaps in the Ukrainian stock market for the case of UX index over the period 2009–2018. Using different statistical tests (Student's *t*-tests, ANOVA, Mann-Whitney test) and regression analysis with dummy variables, as well as modified cumulative approach and trading simulation, the authors test a number of hypotheses searching for price patterns and abnormal market behavior related to price gaps: there is seasonality in price gaps (H1); price gaps generate statistical anomalies in the Ukrainian stock market (H2); upward gaps generate price patterns in the Ukrainian stock market (H3) and downward gaps generate price patterns in the Ukrainian stock market (H4). Overall results are consistent with the Efficient Market Hypothesis: there is no seasonality in price gaps and in most cases there is no evidences of price patterns or abnormal price behavior after the gaps in the Ukrainian stock market. Nevertheless, the authors find very strong and convincing evidences in favor of momentum effect on the days of negative gaps. These observations are confirmed by trading simulations: trading strategy based on detected price pattern generates profits and demonstrates overall efficiency, which is against the market efficiency. These results can be interesting both for academicians (further evidences against market efficiency) and practitioners (real and effective trading strategy to generate profits in the Ukrainian market market).

Keywords market anomaly, price gaps, trading strategy, stock market, seasonality, momentum effect, reversal pattern, Efficient Market Hypothesis

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

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

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

Svitlana Shcherbak, Ph.D., Department of Justice and International Law, Sumy State University, Ukraine.

Olha Tryfonova, Ph.D., Faculty of International Economics, Oles Honchar Dnipro National University, Ukraine.

INTRODUCTION

Efficient Market Hypothesis (EMH) is a theory that, on the one hand, is equated by the theoretical financiers to the meta-theory, and on the other hand, it is perhaps the most criticized hypothesis from practitioners who are actively looking for its discrepancies (so-called anomalies). The probability of anomalies occurrence according to EMH is determined by one chance from many millions.

But study of numerous anomalies has an important theoretical and applied effect both in view of the development of the theory of financial markets and for purely practical reasons – the development of trading practices and profitable trading strategies.

One of these anomalies is the price gap anomaly (the difference between the opening prices of current market day and closing prices in previous day).

Price gaps exploration in empirical literature focuses on two aspects – confirmation of their occurrence and giving the proofs to their statistical significance (Farmer et al., 2004; Bouchaud et al., 2004), as well as the identification of the possibility of its profitable exploitation by

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traders in different developed markets (Wolf & Yu, 2005; Kwok-Wah Fung et al., 2000, 2010; Caporale & Plastun, 2017).

Present paper explores the price gaps occurrence in the Ukrainian stock market as one of the emerging market for the case of UX index over the period 2009–2018. Using different statistical tests and methods including Student's *t*-tests, ANOVA, Mann-Whitney test, regression analysis with dummy variables, modified cumulative approach and trading simulation four hypotheses of interest are tested: there is seasonality in price gaps (H1); price gaps generate statistical anomalies in the Ukrainian stock market (H2); upward gaps generate price patterns in the Ukrainian stock market (H3) and downward gaps generate price patterns in the Ukrainian stock market (H4).

The remainder of the paper is as follows. Section 1 briefly describes the relevant literature. Section 2 contains the data and empirical methodology. Section 3 presents the empirical results. Last section is devoted to concluding remarks.

1. LITERATURE REVIEW

EMH is a basis for many discussions in investigation stock market behavior. The EMH describes stock markets as such unpredictable markets, where prices fully reflect all existing information and their efficiency degree can be characterized as weak, semi-strong and strong (Fama, 1965; Samuelson, 1965; Fama, 1970).

EMH has become a methodological basis for numerous models for evaluating financial assets and creating investment strategies (Sharpe, 1965; Lintner, 1965; Mossin, 1966; Treynor, 1962).

At the same time, the EMH discussion points (information asymmetry and moral hazards, transaction costs in stock markets (Grossman & Stiglitz, 1980), investor spirits, the herd instinct, mass investor panic (Shiller, 2000; Akerlof & Shiller, 2009) gave impetus to the development of alternative concepts and hypotheses (behavioral finance, adaptive market hypothesis, fractal market hypothesis, etc.).

The basis of these alternative approaches is the understanding that existing EMH anomalies (term proposed by Kuhn (1970)) can be used by investors to create profitable strategies (Schwert, 2003).

The study of EMH anomalies (calendar (time), price, size effects, M&A effect, the IPO effect etc. is widely presented in the academia (Thaler, 1987; Dimson, 1988) both from the standpoint of the theoretical justification for their existence and their statistical evaluation (Jensen, 1978) and classification (Raghubir & Das, 1999; Jacobsen et al., 2005).

The largest number of anomalies is so-called calendar anomalies that have an effect on price fluctuations, taking into account time components and factors (Plastun et al., 2019). Among such anomalies, intraday patterns (time of the day anomaly) have an empirical confirmation (Harris, 1986; Levy, 2002). However, the development of trading strategies using this anomaly and taking into account transaction costs did not confirm the obtaining of extra profits and EMH inconsistencies (Caporale et al., 2016).

Another anomaly, which, however, relates to price effects, is a price gaps anomaly (trading, opening, common, stock, morning gaps). It realizes when the opening prices for certain assets in the stock market on the current day are different from the closing prices of the previous day.

The visual interpretation of the anomaly can be used to confirm the price movements, and the gap itself may indicate significant changes in investors' expectations and behavior due to unexpected events and announcements, time breaks, technical changes, or changes in terms of trade (Caporale & Plastun, 2017).

The study of price gaps anomaly in empirical literature focuses on two aspects – the confir-

mation of the occurrence of an anomaly, the proving of its statistical significance, as well as the identification of the possibility of its profitable exploitation by traders in different markets. Using London Stock Exchange as an example, price gaps and fluctuations are investigated by Farmer et al. (2004). Bouchaud et al. (2004) analyzed Paris stock market and confirmed the existence of price gaps anomaly.

Grant, Wolf, and Yu (2005) confirm presence of intraday price reversals in the US stock index futures market at the market open in 1987–2002. At the same time, according to the authors, the constant exploitation of intraday anomalies by traders for profit is questionable because of transaction costs.

The study of Kwok-Wah Fung et al. (2000), conducted on the example of intraday price reversals after large price changes at the opening for the case of S&P500 futures market and the HSI futures market, also focuses on the possibility of profitable exploitation of this phenomenon in the irrational behavior of investors after deducting transaction costs.

Later Kwok-Wah Fung et al. (2010) also give an example of cross-market price gaps and reversals between the Asian index futures and the US market.

At the same time, price gaps in the Ukrainian stock market, which is quite interesting for the study of market anomalies due to its high riskiness and volatility, have never been discussed. However, emerging nature of the market justifies its opportunities to generate anomalies, in particular price gaps, and hence opportunities for its profitable exploitation.

2. DATA AND METHODOLOGY

We analyze daily data from the major Ukrainian stock market index (UX index) over the period from 2009 to 2019. The data were sourced from the Ukrainian Exchange (www.ux.ua). Descriptive statistics for data is presented in Table 1.

Table 1. Descriptive statistics for data, UX index over the period from 2009 to 2019

Parameter	UX
Mean	1,301.12
Median	1,114.55
Maximum	2,893.81
Minimum	509.86
Std. dev.	522.18
Skewness	1.02
Kurtosis	0.47
Sum	32,37,201
Sum Sq. Dev.	272,669.2
Observations	2,488

To see whether price gaps generate price patterns and abnormal market behavior the following hypotheses are tested:

H1: *There is seasonality in price gaps.*

H2: *Price gaps generate statistical anomalies in the Ukrainian stock market.*

H3: *Upward gaps generate price patterns in the Ukrainian stock market.*

H4: *Downward gaps generate price patterns in the Ukrainian stock market.*

To test H1, we find the distribution of price gaps by days. The presence of significant differences evidences in favor of seasonality in price gaps.

To test H2, we analyze and divide the number of days with positive or negative returns after gaps (positive or negative respectively) by the total number of gaps. If it is much higher than 50% this may indicate in favor of abnormal price behavior and as the results confirm the hypothesis.

To test H3 and H4 we compare returns related to gaps and returns on "usual" days.

To do this, we use the following techniques: Student's *t*-tests, ANOVA analysis, Mann-Whitney test, regression analysis with dummy variables, modified cumulative abnormal returns approach, and trading simulation approach.

In order to avoid incorporation, the gap size into returns is calculated them as follows:

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$$R_i = \left(\frac{Open_i}{Close_i} - 1 \right) \cdot 100\%, \quad (1)$$

where R_i – returns on the *i*-th day in %, $Open_i$ – open price on the *i*-th day, $Close_i$ – close price on the *i*-th day.

The statistical tests are performed to find whether or not returns during "normal" and "abnormal" periods belong to the same data set (null hypothesis). A rejection of the null hypothesis suggests the presence of an anomaly.

To find additional evidences pro/contra anomalies, we use regression analysis with dummy variables. This method allows to identify statistically significant differences between "usual" days and periods related to price gaps:

$$Y_t = a_0 + a_1 D_t + \varepsilon_t, \quad (2)$$

where Y_t – return in period t; a_0 – average return in a "usual" day, a_1 – average return in related to price gaps period, D_t – dummy variable. It is equal 1 in case of "abnormal" periods and is equal 0 in case of "usual" periods, ε_t – random error term for period t.

The sign and statistical significance of the dummy coefficients evidence about possible anomalies.

In order to avoid methodological bias, an alternative method of anomalies detection is used. Plastun et al. (2019) developed modified cumulative abnormal returns approach (MCAR) to detect market anomalies. It is based on classical event studies methodologies proposed by MacKinlay (1997). The algorithm of the MCAR is as follows. First, abnormal returns are defined:

$$AR_t = R_t - E\left(R_t\right), \quad (3)$$

where R_t is the return at time t and $E\left(R_t\right)$ is corresponding average return computed over the whole sample period as follows:

$$E\left(R_t\right) = \left(\frac{1}{T} \right) \sum_{i=1}^{T} R_i, \quad (4)$$

where T is the size of data set.

The cumulative abnormal return CAR_i is total sum of the abnormal returns:

$$CAR_i = \sum_{i=1}^{T} AR_i. \quad (5)$$

Next, we check CAR_i data for the presence of trend (evidences in favor of abnormal behavior of data). To do this, a linear time regression model is built. High overall quality of the model (multiple *R*) and statistical significance of the model (*F*-test and *p*-value), as well as slope coefficients and their statistical significance (their signs and *p*-values), confirm/reject tested hypotheses.

In case of anomalies detection, we check whether or not they generate profits from trading. To do this a trading simulation approach is used. According to this approach, a trading strategy based on detected anomaly is developed. Next, we replicate the actions of the trader according to this trading strategy.

If a strategy generates more than 50% of profitable trades and shows total financial result above 0, this can be an evidence in favor of its efficiency.

Still, this efficiency may be the result of occasion. To make sure that results of a trading strategy differ from random ones, we run additional statistical tests. To find differences between random trading and trading strategy results in this paper, *z*-test is used. The null hypothesis (H0) is that the mean trading result is the same in both cases. Rejection of H0 evidences in favor of statistical difference presence, which suggests that analyzed trading strategy results are not random.

3. EMPIRICAL RESULTS

According to Caporale and Plastun (2017), the size of the gap is one of the most crucial parameters for such type of research. They show that a small gap size could generate too many gaps to consider them as anomalies. But big gap size may lead to very small number of detected cases. As a result, it is unable to perform statistical tests and explore anomaly as it is.

Though for the purposes of this paper we will use gap size that equals 0.6%, this will generate 100+

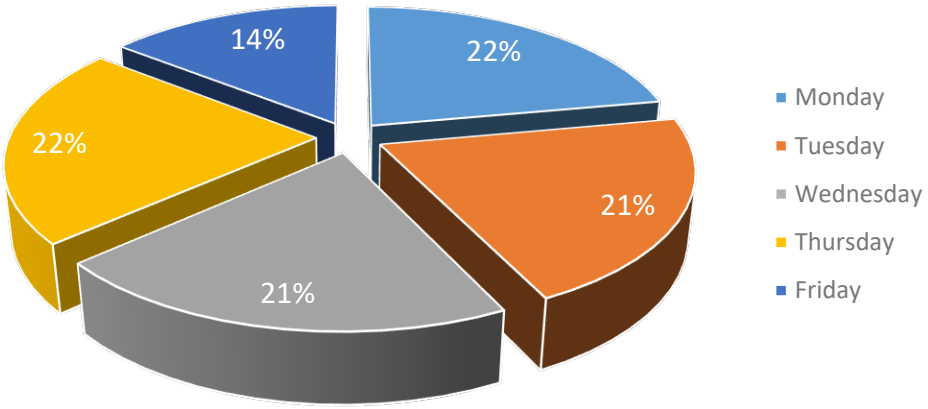

Figure 1. Day of the week and gaps in the Ukrainian stock market

observations both for the upward and downward gaps. At the same time, the number of the gaps will be less than 10% of the population and hence can be considered anomalies.

First, we test Hypothesis 1: Price gaps exhibit seasonality. For example, according to Caporale and Plastun (2017), 95% of gaps in the FOREX appeared on Mondays. The motivation for this is as follows: markets are closed on weekends.

Results of the analysis for the case of Ukrainian stock market are presented in Figure 1.

As can be seen, the distribution of price gaps during a week is rather equal. So Hypothesis 1 is rejected. There is no seasonality in price gaps in the Ukrainian stock market.

Next, we test Hypothesis 2: price gaps generate statistical anomalies in the Ukrainian stock market. To do this, we divide the number of days with positive or negative returns after gaps (positive or negative, respectively) by the total number of gaps.

Table 2. Price patterns in the Ukrainian stock market before and after gaps

Before/ after the gap	Parameter	Number of days after the gap, %		
		1	2	3
Before the gap	Positive gaps	54	51	49
	Negative gaps	58	56	55
	All gaps	56	54	52
After the gap	Positive gaps	56	56	51
	Negative gaps	63	53	46
	All gaps	60	54	48

Table 2 clearly shows that there are no any stable price patterns in price behavior after the gaps. Momentum effect from the point of probability is very weak. There is certain advantage of days with positive/negative returns after positive/negative gaps. But their number in general is less than 60%.

One more possible price pattern in case of gaps is as follows: "gaps tend to get filled". We have analyzed price behavior during 5 days after the gap (Table 3) and find no evidences in favor of this pattern. At least, in case of short-term price reaction.

Table 3. Fill the gap effect in the Ukrainian stock market

Parameter	Number of days to fill the gap, %				
	1	2	3	4	5
Positive gaps	24	30	31	34	35
Negative gaps	19	28	37	41	41
All gaps	22	29	34	37	38

As a result, Hypothesis 2 is rejected.

Next, we test Hypothesis 3: upward gaps generate price patterns in the Ukrainian stock market and Hypothesis 4: downward gaps generate price patterns in the Ukrainian stock market.

To do this, we perform average analysis (results are presented in Table A1), *t*-tests (Table A2), ANOVA analysis (Table A3), Mann-Whitney tests (Table A4), regression analysis with dummy variables (Table A5) and modified CAR approach (Table A6).

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Results are summarized in Table 4.

Table 4. Overall results for the Ukrainian stock market: case of H3 and H4

Method	Gap day (positive gaps)	Gap day (negative gaps)	Day after gap (positive gaps)	Day after gap (negative gaps)
Average analysis	+	+	–	+
t-test	–	+	–	–
ANOVA analysis	–	+	–	–
Mann-Whitney test	–	+	–	–
Regression analysis with dummy variables	–	+	–	–
Modified CAR approach	+	+	–	+
Overall	2	6	0	2

Note: * "+" – anomaly is confirmed, "–" anomaly is not confirmed.

We find very strong evidences in favor of abnormal price behavior on the days of negative gaps: prices tend to decrease on the day of negative gap. Still, this momentum effect is short-lived. On the day after the negative gap, no statistically significant momentum effects are observed. In case of positive gaps, no abnormal price behavior or price patterns are detected. Looks like investors and traders in the Ukrainian stock market lose their rationality only in the case of negative events.

The presence of momentum effect after negative gaps evidences against the Efficient Market Hypothesis and market efficiency. As a result, there could be profit opportunities in the Ukrainian stock market. To test this hypothesis, we create very simple trading strategy: sell on the day of negative gap and close this position at the end of this day. Profitability of this strategy will be additional evidence in favor of the abnormal market behavior. Results are presented in Table 5.

Table 5. Efficiency of the trading strategy based on price gap anomaly: the case of the Ukrainian stock market over the period 2009–2018

Number of trades, units	Number of successful trades, unit	Number of successful trades, %	Profit, %	Profit, % per year
116	73	62.9%	74.8%	7.5%

As can be seen, trading strategy based on momentum effect after negative price gaps is profitable with more than 60% of successful trades. To show that these results differ from random trading, we perform *z*-test. Results are presented in Table 6.

Table 6. *Z*-test of the trading strategy based on price gap anomaly: the case of the Ukrainian stock market over the period 2009–2018

Parameter	Value
Number of trades	116
Total profit	0.7479
Average profit per trade	0.0064
Standard deviation	0.0250
z-test	2.77
critical (0.95)	1.78
Null hypothesis	Rejected

The computed value of the z-test is higher than the critical one. This suggests that the created trading strategy can generate abnormal profits.

Overall, obtained results clearly show that Ukrainian stock market loses its efficiency after negative price gaps. This effect is temporarily and lasts only for 1 day. Still even this time is enough to exploit the "hole" in the market efficiency and generate abnormal profits from trading.

CONCLUSION

In this paper, we analyze price gap anomaly in the Ukrainian stock market by using UX index data over the period 2009–2018. We test 4 different hypotheses: H1: there is seasonality in price gaps; H2: price gaps generate statistical anomalies in the Ukrainian stock market; H3: upward gaps generate price patterns in the Ukrainian stock market and H4: downward gaps generate price patterns in the Ukrainian stock market. To do this, a number of statistical methods are used: Student's *t*-tests, ANOVA analysis, Mann-Whitney tests, regression analysis with dummy variables, modified cumulative abnormal returns approach and trading simulation approach.

Calculations show that there is no seasonality in price gaps: the number of gaps is distributed mostly equal among different days of the week. So Hypothesis 1 is rejected.

According to our results, in most cases there is no significant evidence of price patterns or abnormal price behavior after the gaps (Hypothesis 2 and Hypothesis 3 are rejected). Nevertheless, we find very strong and convincing evidences in favor of momentum effect on the days of negative gaps (Hypothesis 4 is confirmed). These observations were confirmed by trading simulations: trading strategy based on detected price pattern (the algorithm is as follows: sell on the start of the day of negative gap and close position at the end of this day) generates profits and demonstrates overall efficiency (the number of successful trades exceeds 60%, and these results differ from the random trading). This is inconsistent with the Efficient Market Hypothesis and indicates that there are holes in the efficiency of the Ukrainian stock market and they can be exploited. These results can be interesting both for academicians (further evidences against market efficiency) and practitioners (real and effective trading strategy to generate profits in the Ukrainian market market).

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APPENDIX A

STATISTICAL TESTS RESULTS

Average analysis

Table A1. Average analysis, the case of the UX index over the period 2009–2018

Parameter	Positive gap day	Negative gap day	Day after positive gaps	Day after negative gaps
Average return (gap day)	0.42%	–0.64%	0.03%	–0.15%
Average return (non-gap day)	0.08%	0.08%	0.08%	0.08%
Anomaly status	Confirmed	Confirmed	Not confirmed	Confirmed

Student's t-test

Table A2. *T*-test, the case of the UX index over the period 2009–2018

Parameter	Positive gap day	Negative gap day	Day after positive gaps	Day after negative gaps
t-criterion value	1.08	3.04	0.24	0.82
t-critical value (p = 0.95)	1.96	1.96	1.96	1.96
Null hypothesis status	Not rejected	Rejected	Not rejected	Not rejected

ANOVA analysis

Table A3. ANOVA, the case of the UX index over the period 2009–2018

Parameter	Positive gap day	Negative gap day	Day after positive gaps	Day after negative gaps
F	3.78	19.27	0.76	1.82
p-value	0.05	0.00	0.08	0.18
F critical value	3.84	3.84	3.84	3.84
Null hypothesis status	Not rejected	Rejected	Not rejected	Not rejected

Mann-Whitney test

Table A4. Mann-Whitney test, the case of the UX index over the period 2009–2018

Parameter	Positive gap day	Negative gap day	Day after positive gaps	Day after negative gaps
Adjusted *H* value	1.20	10.18	0.01	0.55
d.f.	1	1	1	1
p-value	0.27	0.00	0.91	0.46
Critical value	3.84	3.84	3.84	3.84
Null hypothesis status	Not rejected	Rejected	Not rejected	Not rejected

Regression analysis with dummy variables

Table A5. Regression analysis with dummy variables, the case of the UX index over the period 2009–2018

Parameter	Positive gap day	Negative gap day	Day after positive gaps	Day after negative gaps
a_0	0.0008 (0.05)	0.0008 (0.04)	0.0008 (0.04)	0.0008 (0.04)
a_1	0.0034 (0.05)	–0.0072 (0.00)	–0.0005 (0.77)	–0.0023 (0.18)
Anomaly status	Not confirmed	Confirmed	Not confirmed	Not confirmed

Note: * *p*-values are in parentheses.

Modified CAR approach

Table A6. Modified CAR approach, the case of the UX index over the period 2009–2018

Parameter	Positive gap day	Negative gap day	Day after positive gaps	Day after negative gaps
Multiple R value	0.79	0.97	0.47	0.82
F-test value	177.23 (0.00)	1669.74 (0.00)	30.31 (0.00)	234.18 (0.00)
a_0	–0.1629(0.00)	0.0215 (0.00)	–0.0025 (0.82)	0.0612 (0.00)
a_1	0.0046 (0.00)	–0.0064 (0.00)	–0.0010 (0.00)	–0.0032 (0.00)
Anomaly status	Confirmed	Confirmed	Not confirmed	Confirmed

Note: * *p*-values are in parentheses.

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