THE ANALYSIS OF PREDICTABILITY OF SHARE PRICE CHANGES USING THE MOMENTUM MODEL

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Abstract

Within the context of behavioral finance, there is increasing evidence on predicting the stock returns based on several variables specific for each company. One of these anomalies also identified as the one which is most difficult to explain within the context of traditional price paradigms, is the effect of price momentum.

It is demonstrated that the shares that have generated the highest (or lowest) returns in the period from 3 to 12 months have the tendency of increase (or decrease) in the following 3 to 12 months. The findings are contrary to the Efficient Market Hypothesis (EMH). The investment industry professionals are aware of the momentum effect, and it seems that the stock evaluation is performed based on the price momentum.

This paper presents empirical evidence on existence of price momentum in the stock market. The anomalies continue to persist.

Key words: *price momentum, shares, proof of anomaly, stock market*

1. INTRODUCTION

Within the context of behavioural finance, increasing number of research results contain evidence on partial predictability of future price movements based on the data on past price movements or corporate indicators. Momentum is one of the most familiar anomalies present in the capital market, and is difficult to explain using the context of traditional price paradigms. It is specifically manifested in the case of shares that earn high returns over a period between 3 and 12 months, and earn higher than average returns in the following period. The same applies in the opposite case, shares that have earned lowest returns in the same period continue to earn lower than average returns in the next period. This is contradictory to the Efficient Market Hypothesis (EMH), implying that prices change as a reflection of all market information, and that price movements are not predictable (or are predictable only at a small scale, making it impossible to earn profits after operational costs), i.e. there is no auto-correlation of the share price changes.

2. MOMENTUM MODEL

Professionals in the money management industry are aware of the momentum effect and it appears that they evaluate stocks based on price momentum. For example, Grinblatt, Titman, and Wermers (1995) and Chan, Jegadeesh, and Wermers (2000) find that mutual funds tend to buy past winners and sell past losers. Also, Womack (1996) and Jegadeesh, Kim, Krische, and Lee (2003), among others, report that analysts generally recommend and prefer high-momentum stocks to low-momentum stocks. However, despite the popularity of momentum strategies in the investment community and its visibility in the academic community, there is no evidence of the effect disappearing. Jegadeesh and Titman (2001) show that momentum strategies are profitable in the nineties as well, which is a period subsequent to the sample period in Jegadeesh and Titman (1993).

The momentum strategies are also profitable outside the United States. For example, Rouwenhorst (1998) reports that the momentum strategies examined by Jegadeesh and Titman (1993) for the U.S. market are also profitable in the European markets. Indeed, Japan is the only large developed stock market that does not exhibit momentum (Chui, Titman and Wei, 2000). Momentum strategies implemented on samples consisting of stocks from a number of less developed stock markets also exhibit momentum (Rouwenhorst, 1999 , Chui, Titman and Wei, 2000), although the momentum strategies are not always profitable within individual countries. In addition, recent papers by Chan, Hameed, and Tong (2000), and Bhojraj and Swaminathan (2003) find that international stock market indexes also exhibit momentum.

2.1. The Momentum Evidence

If stock prices either overreact or underreact to specific information, then profitable trading strategies that select stocks based on their past returns will exist. In an influential paper, DeBondt and Thaler

(1985) examine the returns earned by contrarian strategies. The strategy is based on buying past losers and selling past winners. Specifically, they consider strategies with formation periods (the period over which the past returns are measured) and holding periods of between one and five years and find that in most cases, contrarian portfolios earned significantly positive returns.[1] Jegadeesh (1990) and Lehmann (1990) examine the performance of trading strategies based on one-week to one-month returns and find that these short horizon strategies yield contrarian profits over the next one week to one month. These studies of very long-term and very short-term reversals generally lead to the general conclusion that stock prices overreact to information.

Jegadeesh and Titman (1993) (JT) examine the performance of trading strategies with formation and holding periods between three and twelve months. Their strategy selects stocks on the basis of returns over the past J months and holds them for K months, where J and K vary from three to twelve months. JT construct their *J-month/K-month* strategy as follows: At the beginning of each month *t*, they rank securities in ascending order on the basis of their returns in the past J months. Based on these rankings, they form ten portfolios that equally weight the stocks in each decile. The portfolios formed with the stocks in the highest and lowest return deciles are the “winner” and “loser” portfolios, respectively. The momentum strategies buy the winner portfolios and sell the loser portfolios.

Jegadeesh and Titman examine the performance of momentum strategies using stocks traded on the NYSE and AMEX during the 1965 to 1989 period. Table 1[2] reports the average returns earned by different buy and sell portfolios as well as the zero-cost, winners minus losers portfolios. All zero-cost portfolios here earn positive returns. The table also presents the returns for a second set of strategies that skip a week between the portfolio formation period and holding period. By skipping a week, these strategies avoid some of the bid-ask spread, price pressure, and lagged reaction effects that underlie the evidence of short horizon return reversals in Jegadeesh (1990) and Lehmann (1990).

Total returns on the zero-cost portfolios are statistically significant except for the three-month/three-month strategy that does not skip a week. The most successful zero-cost strategy selects stocks based on their returns over the previous twelve months and then holds the portfolio for three months. This strategy yields 1.31% per month when there is no time lag between the portfolio formation period and

[1]The evidence in DeBondt and Thaler (1985) indicates that for a one-year formation period and a one-year holding period, past winners earn higher returns than past losers. Since DeBondt and Thaler primarily focus on longer-term contrarian strategies, they provide no further discussion or analysis of the momentum effect that is apparent over the one-year horizon.

[2] This table forms momentum portfolios based on past J-month returns and holds them for K months. The stocks are ranked in ascending order on the basis of J-month lagged returns, and an equally weighted portfolio of stocks in the highest past return decile is the buy portfolio, and an equally weighted portfolio of stocks in the lowest past return decile is the sell portfolio. This table presents the average monthly returns (in percentages) of these portfolios. The momentum portfolios in panel A are formed immediately after the lagged returns are measured for the purpose of portfolio formation. The momentum portfolios in panel B are formed one week after the lagged returns used for forming these portfolios are measured. The t-statistics are reported in parentheses. The sample period is January 1965 to December 1989.

the holding period (see Table 1 Panel A). The six-month formation period produces returns of about 1% per month regardless of the holding period.

Table 1: Momentum portfolio returns.

		Panel A				Panel B			
J	*K=*	3	6	9	12	3	6	9	12
3	Sell	1.08	0.91	0.92	0.87	0.83	0.79	0.84	0.83
		(2.16)	(1.87)	(1.92)	(1.87)	(1.67)	(1.64)	(1.77)	(1.79)
3	Buy	1.40	1.49	1.52	1.56	1.56	1.58	1.58	1.60
		(3.57)	(3.78)	(3.83)	(3.89)	(3.95)	(3.98)	(3.96)	(3.98)
3	Buy-Sell	0.32	0.58	0.61	0.69	0.73	0.78	0.74	0.77
		(1.10)	(2.29)	(2.69)	(3.53)	(2.61)	(3.16)	(3.36)	(4.00)
6	Sell	0.87	0.79	0.72	0.80	0.66	0.68	0.67	0.76
		(1.67)	(1.56)	(1.48)	(1.66)	(1.28)	(1.35)	(1.38)	(1.58)
6	Buy	1.71	1.74	1.74	1.66	1.79	1.78	1.75	1.66
		(4.28)	(4.33)	(4.31)	(4.13)	(4.47)	(4.41)	(4.32)	(4.13)
6	Buy-Sell	0.84	0.95	1.02	0.86	1.14	1.10	1.08	0.90
		(2.44)	(3.07)	(3.76)	(3.36)	(3.37)	(3.61)	(4.01)	(3.54)
9	Sell	0.77	0.65	0.71	0.82	0.58	0.58	0.66	0.78
		(1.47)	(1.29)	(1.43)	(1.66)	(1.13)	(1.15)	(1.34)	(1.59)
9	Buy	1.86	1.86	1.76	1.64	1.93	1.88	1.76	1.64
		(4.56)	(4.53)	(4.30)	(4.03)	(4.72)	(4.56)	(4.30)	(4.04)
9	Buy-Sell	1.09	1.21	1.05	0.82	1.35	1.30	1.09	0.85
		(3.03)	(3.78)	(3.47)	(2.89)	(3.85)	(4.09)	(3.67)	(3.04)
12	Sell	0.60	0.65	0.75	0.87	0.48	0.58	0.70	0.85
		(1.17)	(1.29)	(1.48)	(1.74)	(0.93)	(1.15)	(1.40)	(1.71)
12	Buy	1.92	1.79	1.68	1.55	1.96	1.79	1.67	1.54
		(4.63)	(4.36)	(4.10)	(3.81)	(4.73)	(4.36)	(4.09)	(3.79)
12	Buy-Sell	1.31	1.14	0.93	0.68	1.49	1.21	0.96	0.69
		(3.74)	(3.40)	(2.95)	(2.25)	(4.28)	(3.65)	(3.09)	(2.31)

Source: Jegadeesh and Titman (1993)

2.2. Potential Sources of Momentum Profits

A logical interpretation of the fact that past winners and losers continue the trend is that stock prices underreact to information. In that case, it is the only possible source of momentum profits. However, this is not the only possible reason why past winners outperform past losers. Another possible reason is that past winners may be riskier than past losers, and the difference between winner and loser portfolio returns could simply be compensation for risk. Also, if the premiums for bearing certain types of risk vary across time in a serially correlated fashion, momentum strategies will be profitable. We can use the following single-factor model to formally examine the contribution of these sources of momentum profits:[3]

$$\begin{aligned} & r_{it} = \mu_i + b_i f_t + e_{it}\,, \\ & E\left(f_t\right) = 0 \\ & E\left(e_{it}\right) = 0 \\ & Cov\left(e_{it}, f_t\right) = 0,\ \forall i \\ & Cov\left(e_{it}, e_{jt-1}\right) = 0,\ \forall i \neq j \end{aligned} \tag{1}$$

where μ_i is the unconditional expected return on security i, r_{it} is the return on security i, f_t is the unexpected return on a factor-mimicking portfolio, e_{it} is the firm-specific component of return at time t, and b_i is the factor sensitivity of security i.

The superior performance of momentum strategies implies that stocks that generate higher than average returns in one period also generate higher than average returns in the period that follows. In other words, these results imply that:

$$\begin{aligned} & E\left(r_{it} - \overline{r_t} \,\middle|\, r_{it-1} - \overline{r_{t-1}} > 0\right) > 0 \\ & i \\ & E\left(r_{it} - \overline{r_t} \,\middle|\, r_{it-1} - \overline{r_{t-1}} < 0\right) < 0, \end{aligned} \tag{2}$$

where a bar above a variable denotes its cross-sectional average.

Therefore,

$$E\left\{\left(r_{it} - \overline{r_t}\right)\left(r_{it-1} - \overline{r_{t-1}}\right)\right\} > 0. \tag{3}$$

The cross-sectional covariance in (3) turns out to equal the expected profits to a trading strategy that weights stocks by the difference between the past returns of the respective stocks and the equally weighted index. Specifically, the portfolio weight for stock i in month t for this strategy is:

[3] The model we discuss here is from JT. Similar models have also been used by Lo and MacKinlay (1990) and Jegadeesh (1990) to understand the sources of short-horizon contrarian profits.

$$w_i = r_{i,t-1} - \overline{r_{t-1}}. \tag{4}$$

This weighted relative strength strategy (WRSS) is closely related to the strategy in *Table 1* and it has a correlation of .95 with the returns on *P1–P10*. [4] While the equally weighted decile portfolios are used in most empirical tests, the closely related WRSS provides a tractable framework for examining analytically the sources of momentum profits and evaluating the relative importance of each of these sources.

Given the one-factor model defined in (1), the WRSS profits given in (3) can be decomposed into the following three terms, defined by the following equation:

$$E\left(\sum_{i=1}^{N} w_i r_{it}\right) = \sigma_\mu^2 + \sigma_b^2 Cov\left(f_t, f_{t-1}\right) + \frac{1}{N}\sum_{i=1}^{N} Cov\left(e_{it}, e_{it-1}\right), \tag{5}$$

where N is the number of stocks, σ_μ^2 and σ_b^2 are cross-sectional variances of expected returns and factor sensitivities, respectively.

In this decomposition, the three terms on the right-hand side correspond to the three potential sources of momentum profits that we discussed earlier. The first term here is the cross-sectional dispersion in expected returns. Since realized returns contain a component related to expected returns, securities that experience relatively high returns in one period can be expected to earn higher than average returns in the following period. The second term is related to the potential to time the factor. If factor portfolio returns are positively serially correlated, large factor realizations in one period will be followed by higher than average factor realizations in the next period. The momentum strategy tends to pick stocks with high factor sensitivities following periods of large factor realizations, and hence it will benefit from the higher expected future factor realizations. The last term in the above expression is the average serial covariance of the idiosyncratic components of security returns. This term would be positive if stock prices underreact to firm-specific information.

To assess whether the existence of momentum profits imply market inefficiency, it is important to identify the sources of the profits. If the profits are due to either the first or the second term in Eq. (5), they may be attributed to compensation for bearing systematic risk and need not be an indication of market inefficiency. However, if the profitability of the momentum strategies were due to the third term, then the results would suggest market inefficiency.

[4] The momentum portfolios are formed based on past six-month returns and held for six months. *P1* is the equal-weighted portfolio of ten percent of the stocks with the highest past six-month returns and *P10* is the equal-weighted portfolio of the ten percent of the stocks with the lowest past six-month returns.

3. STUDY CASE AND RESULTS

3.1. Methodological Background

The methodology used in this scientific paper is based on the strategy implemented by Jegadeesh and Titman, 1993 (Table 1).

By using the linear regression model (CAPM Alpha) and the Fama-French three-factor model (FF Alpha), Jegadeesh and Titman demonstrate that the momentum effect, i.e. higher than average returns of the highest decile cannot be explained by increased risk. In other words, it is not possible to explain the momentum effect by using the efficient market hypothesis. Therefore, the explanation of the phenomenon is to be found in behavioural models.

There are two underlying ideas, i.e. underreaction and delayed overreaction. In the first case, the market underreacts to exceptionally positive information about a company, and the stock price rises. However, it does not reach its intrinsic value in the formation period (*J*). During the holding period (*K*) the price keeps rising and reaches its intrinsic value. To clarify: if the efficient market hypothesis worked, the prices would momentarily rise to their new intrinsic value, and there would be no option of yielding higher than average returns. It is possible that the investors underreact to good news, i.e. do not realise all the benefits of the information, causing the price to rise slowly, and then continues to rise during the longer period, in order to reach its intrinsic value. In the second case, in the formation period (*J*) the market overreacts to positive information on a company, the stock price rises and quickly reaches its intrinsic value. However, the investors tend to disregard the influence of coincidence and extrapolate past growth rates and business results into the future, thus creating unrealistic expectations. Due to this, in the holding period (*K*), the stock prices continue to rise above their intrinsic value.

There is no consensus on which of the two explanations is correct. However, findings of several studies support the second theory or explanation.

3.2. Momentum Model Assumptions

The developed momentum model was tested on data provided by Bloomberg. Stock price data was provided by the company Aureus Invest. Data are taken for 384 shares in the S&P 500 index (highly representative U.S. index), but only for the shares with available data for the complete sample period (shares that have been subsequently listed are not included).

The formation period (*J*) referenced in different studies is usually 3, 6, 9 and 12 months. Specifically, the formation period (*J*) is a period based on which the portfolio is created (selecting shares that have entered the highest percentile based on the returns in the formation period). In the empirical research, the 6 month period is used, more specifically the period covering 126 working days. The decision for selecting the 6 month period was based on previous research, indicating that this is the most favourable time period for sampling. The results have confirmed this choice.

The holding period (*K*) is the time period during which the shares are held in the portfolio and their results are measured. The time periods for the holding period are 10, 30 and 60 working days.

For each day in the 12-year time period, at least one test was done for each J / K combination, with percentile variations 1%, 2%, 3%, 5% i 10%. In this manner, it was presented which changes occur by varying this parameter, i.e. the parameter indicating the size of the winner portfolio (the one earning higher than average returns). Another important point is that the market index is weighted; i.e. weighted by market capitalization. The methodology used when selecting the winner portfolio in this research was always selecting the equally weighted shares.

Compared to all previous studies, changes are introduced concerning the manner of forming the winner portfolios. All previous studies have formed the portfolios in the same manner (“winner” and “loser”), i.e. the portfolios were created based on returns in the period *J*. In this paper, in addition to standard portfolio formation, so called double formation is also used. The formation period (J = 126 working days) is divided into two equal segments, 63 days each (J = 63+63). Returns (r_1) in segment 1 and returns (r_2) in segment 2 were observed. Returns yielded by a specific share in each of the segments are consolidated with the market returns, i.e. the S&P 500 index returns in the time period. In this way, we avoid the possibility of market circumstances determining which period would be chosen, which is of utmost importance. Subsequently, we determine a value lower than consolidated returns (r_1' and r_2'), and rank the shares based on the defined returns. Short formulation:

$$\begin{aligned} r_1' &= (1+r_1)/(1+r_{1,S\&P500})-1 \\ r_2' &= (1+r_2)/(1+r_{2,S\&P500})-1 \\ r &= \min(r_1', r_2') \end{aligned} \tag{6}$$

r_1 – share returns in period t_1

r_2 – share returns in period t_2

$r_{1,S\&P500}$ – S&P 500 index returns in period t_1

$r_{2,S\&P500}$ – S&P 500 index returns in period t_2

To clarify; when we consolidate the returns, percentages cannot be subtracted, since we need to consider the relative change. Therefore, if the share grew by 32%, and the index increased by 20%, the share exceeded the index by 12 percent points, not by 12%, but by 10% (132 / 120 - 1 = 10%). The GDP growth is a similar case. If nominal GDP growth rate is 5%, and the inflation is 2%, real GDP growth is not 3%, but 2.94. Following this clarification, another issue arises: “For what reason do we divide the period into two segments?". This is an original approach in implementation of the momentum model. The idea occurred due to specific shares that form a portfolio. These are shares with highest returns. However, these could be shares with continuous growth, but also shares with high growth in a short period, that subsequently stopped growing. For example, it is possible that a company receives a takeover bid with a significant premium in relation to the market price, and complete growth occurs in only one day. It can be assumed that the momentum effect would not be manifested on these shares, unlike other shares that had balanced growth (continuous increase of returns). It is important to eliminate such shares with rapid short-term growth.

3.3. Results and Testing Analysis

Sample period: 12 years (from 1st January 1997 to 31st December 2008); Number of shares in the sample: 384 shares in the S&P 500 index, with available data for the complete sample period (subsequently listed shares have been eliminated); Formation period (J): 6 months (126 working days). Table 2 presents the results obtained by testing the momentum effect in a standard manner (for the entire period), and the results obtained by using double formation (dividing the period into two segments).

- It is evident that the results of the momentum effect improve with decreasing portfolio size. For example, with 60 day holding period and 10% percentile, in standard formation the annualized returns will be 15.97%, while in the same conditions, for percentile 1% annualised returns will be 20.14%. The same occurs with double formation. Namely, under same conditions, i.e. 60 day holding period and 10% percentile, annualised returns will be 19.75%, whereas for the smaller portfolio, i.e. percentile 1%, annualised returns will be 42.47%. This confirms the momentum effect and proves that it yields better results with smaller samples. Moreover, the findings significantly contribute to proving the momentum effect, since we test its performance for the same period, the same shares, only by varying the percentile, i.e. the parameter that indicates the size of the winner portfolio.
- It is evident that the returns in double formation exceed the returns in standard formation, with identical holding period and percentile. For example, with 10 day holding period and 10% percentile, the annualised returns in double formation will be 17.77%, whereas in standard formation the returns will be 15.82%, creating nearly 2 percentage point better results in double formation than in standard formation. Considering the returns in view of the total sample, in this case in double formation the returns will be 7.70% above average (10.07%), whereas in standard formation the returns will be 5.75% above average. The momentum strategy in testing returns with percentile variations 1%, 2%, 3%, 5% and 10% yields highest

returns for the smallest percentile, i.e. 1% percentile, which is particularly evident in double formation period. For example, with 30 day holding period and 1% percentile, in double formation the annualised returns will be 45.31%, whereas in standard formation the returns will be 20.60%, giving a nearly 25% point better results in double formation than in standard formation. In addition, considering the returns in view of the total sample, in this case in double formation the returns will be 36.05% above average (9.26%), whereas in standard formation the returns will be 11.34% above average. Examining the table shows that all results indicated considerably higher momentum effect in double formation, than in standard formation. Specifically, the last column shows positive realised difference of the momentum effect in favour of double formation, when compared to standard formation.

Variation of the percentile parameter (1%, 2%, 3%, 5% i 10%) i.e. the parameter indicating the size of the winner portfolio (the one showing higher than average returns) for different holding periods (10, 30 and 60 working days) in standard and double formation is optimally presented in the Table 3 (Stanivuk, 2012).

Table 2: Overview of the test results.

PARAMETERS		STANDARD FORMATION		DOUBLE FORMATION		DIFFERENCE
holding (K)	percentile	annualised returns	higher than average returns	annualised returns	higher than average returns	double-standard formation
10	all shares	10,07%	-	10,07%	-	-
10	10%	15,82%	5,75%	17,77%	7,70%	1,95%
10	5%	18,71%	8,64%	23,30%	13,23%	4,59%
10	3%	20,21%	10,14%	26,08%	16,01%	5,87%
10	2%	18,78%	8,71%	29,75%	19,68%	10,97%
10	1%	21,21%	11,14%	43,28%	33,21%	22,07%
30	all shares	9,26%	-	9,26%	-	-
30	10%	15,40%	6,14%	18,62%	9,36%	3,22%
30	5%	18,25%	8,99%	25,49%	16,23%	7,24%
30	3%	18,78%	9,52%	30,02%	20,76%	11,24%
30	2%	18,26%	9,00%	33,71%	24,45%	15,45%
30	1%	20,60%	11,34%	45,31%	36,05%	24,71%
60	all shares	9,64%	-	9,64%	-	-
60	10%	15,97%	6,33%	19,75%	10,11%	3,78%
60	5%	17,96%	8,32%	25,68%	16,04%	7,72%
60	3%	18,47%	8,83%	29,96%	20,32%	11,49%
60	2%	19,41%	9,77%	33,83%	24,19%	14,42%
60	1%	20,14%	10,50%	42,47%	32,83%	22,33%

Source: According to authors analysis

Table 3: Overview of testing results.

percentile	10%	5%	3%	2%	1%
J=126 K=10	15,8%	18,7%	20,2%	18,8%	21,2%
J=63+63 K=10	17,8%	23,3%	26,1%	29,8%	43,3%
J=126 K=30	15,4%	18,3%	18,8%	18,3%	20,6%
J=63+63 K=30	18,6%	25,5%	30,0%	33,7%	45,3%
J=126 K=60	16,0%	18,0%	18,5%	19,4%	20,1%
J=63+63 K=60	19,8%	25,7%	30,0%	33,8%	42,5%

Source: According to authors analysis

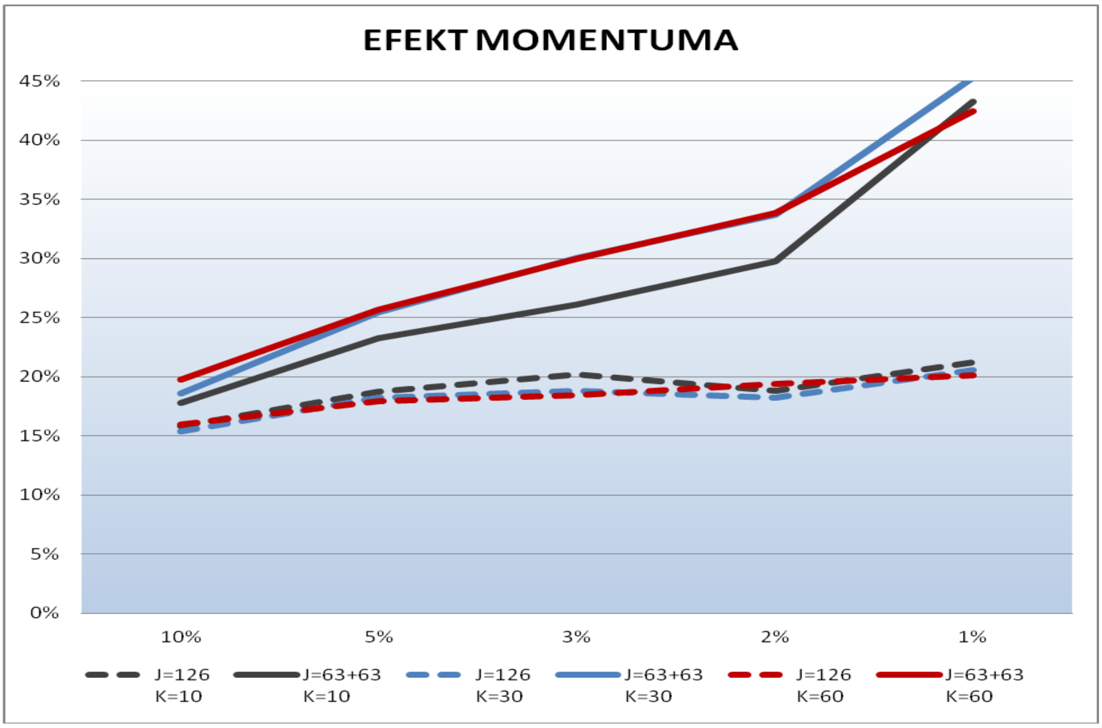

Figure 2: Graphical display of momentum effect test results.

5. CONCLUSIONS

The test results confirm the findings of Jegadeesh and Titman in relation to the existence of momentum effect in the capital market. In all 36 completed tests and all combinations of holding period K, percentile size and formation method, the returns of our portfolio exceeded the returns of the total sample of 384 shares. The essential point is confirming the anomaly that occurred several years ago. Generally, an anomaly may exist in the market for a period of time, and later it ceases to exist. However, the anomaly still exists and thereby it can be proved that the market is extremely inefficient, i.e. the investors behave irrationally.

Furthermore, evidence shows that returns increase with smaller percentile (parameter indicating the size of the winner portfolio), regardless of the holding period or portfolio formation method. Therefore, the test results indicate that the momentum effect obtains better results with the decrease in portfolio size, i.e. the smaller the sample, the better the results. This may come as s surprise, since the classic Markowitz modern portfolio theory assumes that the investors are rational and the market is efficient. Therefore, the sole fact that the momentum effect exists in any form is contradictory to the assumptions of the Markowitz theory. Finally, the test results show that in double formation the momentum effect is significantly higher than in standard formation, yielding considerably higher returns of the highest percentile. Double formation shows consistently better results, the returns exceeding those of standard formation in all 15 test pairs. One possible explanation is that double formation eliminates certain situations occurring in standard formation, in which investors tended to behave rationally. For example, following the announcement of the takeover bid, the share prices increase momentarily and high growth occurs.

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