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EMPIRICAL TEST OF THE STRONG FORM EFFICIENCY OF THE WARSAW STOCK EXCHANGE: THE ANALYSIS OF WIG 20 INDEX SHARES

TOMASZ POTOCKI, PhD[a*]
TOMASZ ŚWIST, PhD[b]
[a]University of Rzeszow
[b]University of Warsaw

Abstract
There are three forms of information efficiency of a market that may be verified. Testing weak form efficiency provides information on reflection of the historical values of share prices. Most research on the subject proves the validity of the hypothesis that the technical analysis does not allow the achievement of abnormal rates of return. In the case of the semi-strong form the empirical research does not provide explicit answers; however, most research weighs in favour of the hypothesis of the semi-strong form of market informational efficiency. According to the hypothesis, it is impossible to achieve above-average profits in the long run, based on technical and fundamental analysis. The strong form efficiency represents another type of market informational efficiency, which is most difficult to verify, as it requires the use of non-public information. The purpose of the following article is to verify the strong form of market informational efficiency, based on the assumption that the institutions issuing recommendations have access to information inaccessible to the community of investors. The research sample consists of 3,270 recommendations produced between 1 January 2005 and 31 March 2010 by 63 financial entities with reference to companies making up the WIG 20 index. In most cases the obtained results provide evidence for the hypothesis that the strong form efficiency is characteristic of the WIG 20 index shares listed on the Warsaw Stock Exchange.

JEL Classification: C1, G1, G14, G23
Keywords: Capital Market, Strong Form Informational Efficiency, Abnormal Rate of Return, WIG 20 Index

[*]*Corresponding Author:* Tomasz Potocki, University of Rzeszow, Faculty of Economics, M. Cwiklinskiej Street 2, 35-601 Rzeszow, Poland. e-mail: tpotocki@gmail.com

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Research problem

The efficient and effective operation of financial markets, particularly capital markets, constitutes the foundation of the development of the modern economy. The stock markets play a crucial role in capital allocation and its transformation from savings to financing new investment initiatives, consequently creating more wealth. The financial investments on capital markets refer to the flow of all streams of funds managed by banks and financial institutions, mainly the stock exchange and institutions investing in it, i.e. investment funds, pension funds and insurance companies. The main objective of stock markets is to provide capital inflow for entities issuing stocks, thereby allowing them to grow and to create wealth for investors, who invest their free capital in stocks, which they perceive as attractive investments. Moreover, the capital market is a place, where the current market value of a company is determined by the supply and demand of its shares. Reliability of the stock valuation process is substantially correlated with results obtained in the verification of the hypothesis of the stock market efficiency. The subject of market efficiency is very often brought into question by practitioners and theoreticians from the financial sector, who build and verify investment strategies. They try to find an answer to the question: Is it possible to develop a long-term investment strategy, which will enable investors to achieve abnormal rates of return?. The presence of strong form efficiency on the market implies that it is impossible to achieve above-average profits when having access to a full set of information. Therefore, access to fundamental information, information about the stock price as well as knowledge of non-public information does not guarantee the development of a long-term, profit-making investment strategy. One can talk about the strong-form efficiency market when all the information, both public and non-public, is immediately reflected in the stock market prices. The overall approval of this form of efficiency indicates that the investors with access to general information, as well as those having access to non-public information, are not able to "beat the market" and achieve abnormal rates of return. The authors of this publication make a presumption that the recommending institutions have access to non-public information. This article attempts to verify the strong-form efficiency on the basis of recommendations issued by 63 financial institutions. The analysis was carried out on the basis of a simplified assumption that financial institutions issuing recommendations could also use information not available to the average market participant (for instance non-public and confidential information). This assumption does not imply that having such information is a necessary condition for developing stock recommendations. Moreover, it is important to mention that Polish law prohibits exploiting non-public (inside information) or confidential information in conducting transactions on the capital market.

Concept of market efficiency

The concept of market informational efficiency is one of the fundamental terms in finance. In most papers it is used in reference to a market, on which relevant information is reflected in the price of financial assets. Sometimes economists use the term in reference to the operational efficiency of a market, emphasizing the way resources are employed to facilitate its operation.

The concept of market efficiency was comprehensively described for the first time in Fama's doctoral dissertation in 1964 and further developed in his later publications from the years 1965 and 1970 for the *Journal of Business* and *Journal of Finance*. The last publication was a monograph reviewing the existing literature, the taxonomy of research evolution and also formalization of the concept of market efficiency. The idea of market efficiency was formalized on the basis of conditional expected value relative to relevant information. This theory assumes that conditions of market stability may be expressed by the value of the expected returns achieved on an effective market, which may be presented in the following form:

$$E(\tilde{p}_{n,t+1} \mid \Phi_t) = [1 + E(\tilde{r}_{n,t+1} \mid \Phi_t)]p_{n,t} \tag{1}$$

where:

$\tilde{p}_{n,t+1}$ - random variable representing the price of the *n*–th asset in period $t+1$,

$p_{n,t}$ - price of *n* –th asset in period *t*,

$\tilde{r}_{n,t+1}$ - random variable representing the return from the *n*-th asset in period $(t, t+1)$,

Φ_t - set of information reflected in the asset's price in period *t*.

In this case, when the market proves effective in relation to the set of information Φ_t, developing an investment strategy based only on the following set does not guarantee superior returns from investment. From the perspective of the above considerations the possible superior return in period $(t, t+1)$ from *n*-th asset may be expressed as:

$$e_{n,t+1} = p_{n,t+1} - E(\tilde{p}_{n,t+1} \mid \Phi_t) \tag{2}$$

then, if the market is effective we receive:

$$E(\tilde{e}_{n,t+1} \mid \Phi_t) = 0 \tag{3}$$

By analogy the above formula may be expressed in terminology of the abnormal return:

$$E(\widetilde{\varepsilon}_{n,t+1} \mid \Phi_t) = 0 \tag{4}$$

where:

$\widetilde{\varepsilon}_{n,t+1}$ – random variable presenting the abnormal return from *n*-th asset in period $t+1$.

The way of formalizing the market efficiency described by equations (1)-(4) is criticized by LeRoy (1976), who maintains that the conclusions drawn by Fama (1964) are methodologically and intuitively coherent, but in reality they present tautology. When the conditional expected value function is used for the equation (2) in relation to set of information Φ_t, as a result we receive:

$$E[\widetilde{e}_{n,t+1} \mid \Phi_t] = E[\widetilde{p}_{n,t+1} \mid \Phi_t] - E[E(\widetilde{p}_{n,t+1} \mid \Phi_t) \mid \Phi_t] = 0 \tag{5}$$

which proves the equation (3). A similar line of reasoning may be applied for the abnormal return, and in consequence it is equivalent to the equation (4).

In response to the above accusation, Fama (1964) suggested an alternative approach to the mathematical concept of the market efficiency theory. The fundamental part of the modified approach was the distinction of two forms of the conditional expected value – the market value $E_m(\widetilde{p}_{n,t+1} \mid \Phi_t^m)$, which considers information used by the market, and the theoretical value $E(\widetilde{p}_{n,t+1} \mid \Phi_t)$, focused on all relevant information. According to the theory, the market is efficient, when the distribution of asset prices within a given set of information used by a market is identical to the potential distribution of prices when all relevant information was presented by the price distribution. As a result we obtain the following equation:

$$f(\widetilde{p}_{n,t+1} \mid \Phi_t) = f_m(\widetilde{p}_{n,t+1} \mid \Phi_t^m), \tag{6}$$

which implies that there is no difference between information sets Φ_t and Φ_t^m in terms of their economic usefulness. In such case, referring to equation (1), the prices are shaped in the following way:

$$p_{n,t} = \frac{E_m(\widetilde{p}_{n,t+1} \mid \Phi_t^m)}{1 + E_m(\widetilde{r}_{n,t+1} \mid \Phi_t^m)} \tag{7}$$

where:

$E_m(\widetilde{p}_{n,t+1} \mid \Phi_t^m)$ – the expected price of the *n*-th asset in period $t+1$ in the moment of market equilibrium, which results from the distribution $f_m(\widetilde{p}_{n,t+1} \mid \Phi_t^m)$,

$E_m(\tilde{r}_{n,t+1} \mid \Phi_t^m)$ – the expected rate of return from the *n*-th asset in period $t+1$ in the moment of market equilibrium, which results from the distribution $f_m(\tilde{r}_{n,t+1} \mid \Phi_t^m)$. Moreover, assuming equation (6) is true, the expected return (price) from the *n*-th share price on an efficient market equals the actual return (price) expected on the basis of the set of information Φ_t, therefore we obtain:

$$E(\tilde{p}_{n,t+1} \mid \Phi_t) = E_m(\tilde{p}_{n,t+1} \mid \Phi_t^m), \tag{8}$$

$$E(\tilde{r}_{n,t+1} \mid \Phi_t) = E_m(\tilde{r}_{n,t+1} \mid \Phi_t^m) \tag{9}$$

Buczek (2005) suggested a modification to the formula describing the market informational efficiency. He substituted the dependency from Fama's theory (8) with an asymptotic criterion of the conditional expected values. He depicted it in the following way:

$$E(\tilde{p}_{n,t+1} \mid \Phi_t) \to E_m(\tilde{p}_{n,t+1} \mid \Phi_t^m) \tag{10}$$

Nevertheless, the presented asymptotic convergence is inaccurate, because it does not take into account the convergence variable and the limit of convergence. In the light of inaccuracy the authors made an attempt to specify more precisely the dependencies (10). Their reasoning is based on two key assumptions:

- in period $(t, t+1)$ whole set of information Φ_t becomes accessible for the market,
- in period $(t, t+1)$ there will be no new set of information influencing the price.

Investors evaluate the share price in period *t* on the basis of an incomplete set of information available to the market in period *t.* At their disposal they have only some elements of information and in conducting the evaluation they use only subset . The complete information set Φ_t is therefore not available to the market in period *t* and it will take period to present the information to the market, including moment *t'*, where . Therefore, to be more precise, information set Φ_t should be described as $\Phi_{(t,t')}$, and its subset of information unavailable to the market diminishes in the course of time. Let's define the information set unavailable to the market in period *t* as:

$$\Phi_{(t,t')}^d = \Phi_{(t,t')} \setminus \Phi_{(t,t')}^m, \tag{11}$$

then:

$$\Phi_{(t,t')}^d \xrightarrow{t \to t'} \varnothing \tag{12}$$

or equivalently:

$$\Phi_{(t,t')} \xrightarrow{t \to t'} \Phi_{t'}^{m} . \tag{13}$$

Hence the final expression (10) considering equation (13) takes the following form:

$$E(\tilde{p}_{n,t+1} \mid \Phi_{(t,t')}) \xrightarrow{\Phi_{(t,t')} \to \Phi_{t'}^{m}} E_m(\tilde{p}_{n,t+1} \mid \Phi_{t'}^{m}), \tag{14}$$

where:

$$\Phi_{(t,t')} = \Phi_{t}^{m} \cup \Phi_{(t,t')}^{m}$$

The similar reasoning may be applied for any $t' \in (t, \infty)$, considering in periods t, t+1, t+2..., the part of information available on the market and reflected in the price.

To sum up this section of the article, one can conclude that the market efficiency hypothesis is simple by assumption; however, it shows some kind of elusiveness when it is applied in the research. From the paper by Bachelier (1900), through the monograph of Fama (1970), it has become the fundamental paradigm in finance theory. In the times of its greatest interest it was the subject of study for the most important research centers in the United States. Nevertheless, already at that time one could encounter some papers presenting its anomalies, which from the beginning ought to have been seen as incoherent with the hypothesis. Ball (1978) pointed out that such anomalies should be interpreted only as defects of models applied in the research. Fama (1998) supported his view by claiming, that behavioural finance, which is a foundation of market anomalies, constitutes no evidence for the absence of market informational efficiency, but is just a *sine qua non* condition of the more precise validation of models applied in the research on capital market efficiency. Behavioural finance gained in significance and recognition in the nineties, because treating it as a source of information about anomalies and deviations was no longer justified when it became clear that it facilitated achieving superior profits. The above mentioned approach, however does not undermine or weaken the capital market efficiency hypothesis, which still remains one of the most fundamental theories in modern finance.

Review of empirical research on the strong form efficiency of stock markets

One can talk about the strong form efficiency of a market when the prices reflect all relevant information, public as well as non-public. The approval of this form of efficiency indicates, that neither investors relying on generally available information, nor those having access to non-public information, can "beat the market" and achieve abnormal rates of return. The strong form efficiency hypothesis seems to be intuitively false. The public and non-public information cannot be reflected in the price of a stock

seeing that it has not reached the market yet and has not been discounted in the current price. The available assessment methodology of the strong form efficiency of a market was usually limited to conducting an analysis of the achievements of institutional investors, as they were subjects with privileged access to non-public information and sophisticated investment tools, and then comparing these achievements (usually) to the weighted-capitalization market index. Until the sixties one could observe a severe shortage of research works showing the results of professional investment portfolios managers. Along with the elaboration of Markowitz's theory, the CAPM model became a *benchmark* for comparing profitability of investment fund performance. One of the first publications evaluating returns achieved by investment funds was the analysis of 115 investment funds covering the years 1945-1964, conducted by Jensen (1969). The results of the analysis showed that investment funds achieve abnormal rates of return; however, taking into account the payment of fees and expenses, the researcher concluded that *"on average the funds apparently were not successful enough in their trading activities to recoup even their brokerage expenses"*. This indicates that activities undertaken with the use of relevant information do not guarantee generating profits exceeding the average rate of return. The above mentioned conclusions are meant to be treated as supporting evidence for the hypothesis of the strong form efficiency of a market. Other research, conducted by Jaffe (1974), produced contrary results to Jensen's as presented above. This research showed the possibility of achieving profits superior to the market average by using non-public information, and therefore rejected the hypothesis of the strong form efficiency of a market. In respect to the research on the strong form efficiency one can come across the above mentioned analysis of investment fund results and another analysis of profitability of recommendations prepared by professional analysts. The issue provides both arguments for a discussion on the semi-strong and the strong form efficiency theory, due to the inconsistencies in assigning recommendations to the set of public or non-public information. Moreover, it is difficult to determine which subset of information available to an analyst has more significant influence on assets evaluation. The presented research results were obtained in the course of an *ex post* analysis of non-public information. The significant part of the research conducted in the initial development stage of the subject provides evidence for the statistical and economic relevance of recommendations and reports prepared by professional analysts in the process of achieving abnormal rates of return. The results of the research conducted on the American market by Ambachtsheer (1972, 1974) and on the British market by Fitzgerald (1975), provide reasons to reject the strong form efficiency market hypothesis of a given capital market and to admit the possibility of "beating the market". Nevertheless, the reliability of the above mentioned papers was challenged by Elton and Gruber (1998), who criticized the selection of data used in the research. There was a suspicion that the process of providing access to the reports by the recommending institutions may have been linked with manipulating some *ex*

post data. The aforementioned accusation was refuted by Dimson and Marsh (1984), who based their research on a large set of information produced by the investment fund operating on the British market. The data used for the analysis was gathered from 35 brokerage houses and they referred to 200 companies listed on the British capital market. The authors, on the basis of a set of almost 4000 forecasts, proved poor dependency between the forecast returns and those actually realized. It shows that professional analysts are not able to forecast movement of asset prices. Nevertheless, transactions completed on the basis of such recommendations allowed investors to achieve better results in a given period than one would achieve in the case of a reference interest rate. Up to this point one can draw the conclusion that non-public recommendation and forecasts prepared by analysts allow investors to "beat the market", which in turn contradicts the existence of the strong form efficiency of a market. Research conducted by Keown and Pinkerton (1981), however provided evidence for achieving abnormal rates of return by insiders before the public announcement of planned mergers. The research refers to the years 1975-1978 and covers 194 companies. The analysed rates of return allow us to make an assumption that trade and use of non-public information is a common practice. According to the authors, making use of non-public information within a period of 12 days before its announcement, enables investors to achieve abnormal rates of return. These results obviously contradict the hypothesis on the existence of the strong form efficiency of a market. The results obtained by Morse (1980) and Penman (1982) proved the inefficiency of the American stock market. Morse has shown significant increase of sales volume and possibility of achieving abnormal rates of return one day before publishing the report of a merger or the financial statements of a company. At the same time Penman made use of data collected by U.S. SEC (Security and Exchange Commission), which gathers and analyses data on almost 8000 stocks, 15000 investment funds and many other financial instruments and institutions.[1] He proved that insiders may achieve premium profits by buying assets just before the public announcement of the information and selling them straight after it takes place. This means that insiders possessing non-public information, which is not reflected in the share price, can "beat the market" in the short run. It would support the hypothesis previously brought forward by other researchers. Evidence for the possibility of achieving abnormal rates of return through the use of non-public information was presented and there were a number of research works rejecting the hypothesis of the strong form efficiency of capital markets.

1. See: http://www.sec.gov.

Other researchers dealing with the subject were Kara and Denning (1998). They analysed 370,000 transactions carried out by insiders in the years 1979-1980, with help of the U.S. SEC. The hypothesis of the strong form efficiency of the financial instruments' market (N.Y.S.E. and Amex) was rejected on the basis of the collected data on purchases and sale transactions of financial instruments by insiders. It was established that the average return from the analysed funds was on average 3% higher than the reference rate of return, even though *circa* 40% of the completed transactions were deemed unprofitable.

Brown, Richardson and Trzcinka (2003) verified the strong form efficiency of the Canadian stock market. In their work they analysed forecasts of stock prices made by brokerage companies' analysts and proved that the analysts operating on the Canadian market had access to non-public information. The article demonstrated that the choice between CAPM and ATP models has no impact on the results of the analysis, which confirms the fact that the analysts have access to relevant non-public information enabling them accurately to forecast movements of prices. These findings imply that forecasts made by analysts are an accurate estimator of the future situation on the market and they contradict the strong form efficiency of the stock market in Toronto. Therefore, numerous publications indicate that early identification of new information may bring considerable profits. Insiders who trade with the use of non-public information may achieve abnormal rates of return, which contradicts the hypothesis of the strong form efficiency.

In comparison to the extensive literature on the strong form efficiency published in other countries, research regarding the Polish capital market seems to be very limited. The only example of such research are papers analysing results obtained by investment funds operating on the Polish market. The estimation of the strong form efficiency of the Warsaw Stock Exchange in different development phases: hibernation, manipulation and speculation was carried out by Czekaj, Woś and Żarnowski (2001). They assessed the skills of selection and market timing of investment fund managers. According to the authors, the selectivity skill ought to be understood as "increasing the portfolio efficiency by a wise choice of stocks based on public as well as non-public information" and the timing skills as "choosing the right time for changing the proportion of risky assets in a portfolio" (Czekaj, Woś, Żarnowski, 2001, p. 133). The latter skill is closely correlated with the anticipation of the future situation on the market. The presented results (based on the ratios of portfolio analysis) show that information available to investment fund managers does not allow them to achieve abnormal rates of return, both in case of a wise selection of assets in the portfolio and making accurate forecasts of the economic situation on the market. In consequence, this supports the hypothesis of the existence of a strong form efficiency on the Warsaw Stock Exchange. Another Polish author conducting research in this area is Buczek (2005), who verified results of 12 existing investment funds, which operated in the period 2001-2004 and 6 funds,

which were set up during that time. The research hypothesis presented referred to the possibility of achieving abnormal rates of return from investment funds, which changed their managers or were newly created. His results confirmed the thesis of achieving abnormal rate of return in both cases, which could indicate that the Warsaw Stock Exchange was inefficient in its consolidation phase. Nevertheless, according to Buczek (2005, p.163), the obtained results do not present the evidence in the discussion on the strong form efficiency. According to his conclusions it is impossible to verify in practice the strong form efficiency. Therefore the above mentioned research results relating to the Polish capital market provide no clear answers. This indicates the need to conduct further research on the topic, aiming to verify the strong form efficiency hypothesis using a different approach.

Research hypotheses and methodology

The following methodology devised by the authors aims to verify two research hypothesis:

RH I: Having access to information set Φ_{t-1} allows the institution issuing recommendations to achieve positive capital flow in the period between receiving the information and the moment of its publication in the form of a recommendation in period *t*.

RH II: Having access to information set Φ_{t-1} allows the institution issuing recommendations to achieve abnormal rates of return in period (t–1, t) in reference to the market index rate of return, i.e. WIG index (if and only if the **RH I** is true).

The lack of evidence to reject **RH I** and **RH II** will allow formulation of a thesis that there is no strong form of market informational efficiency of selected stocks quoted on the Warsaw Stock Exchange.

The strong form efficiency hypothesis of the Polish capital market was verified with the use of statistical and econometric methods. The analysis of correlations and one of the regression methods (depending on the properties of the analysed empirical data) was to provide information on the potential relationships between the analysed random variables. The analysis of the efficiency of the part of the Polish capital market included three random variables:

X - random variable "recommendation" with values of "buy", "neutral" or "sell",

Y - return from a financial instrument, which is an element of the WIG 20 index between the moment of receiving access to information set Φ_{t-1} and the moment of its publication (assuming a 5 working day period length between them),

Z - return from the WIG index – as a measure corresponding to the possibility of achieving superior profits to a stock recommended in the period of the analysis (t–1, t) (assuming a 5 working day period length between them).

For the purpose of the analysis the 'recommendation' random variable has been presented in the following way:

$$X_{nt} = \begin{cases} 1 & \text{for the recommendation value } buy \text{ for } n\text{ - th company in period } t \\ 0 & \text{for the recommendation value } neutral \text{ for } n\text{ - th company in period } t \\ -1 & \text{for the recommendation value } sell \text{for } n\text{ - th company in period } t. \end{cases},$$

Due to the wide and differentiated (in terms of nomenclature used by the recommending institutions) set of recommendations used in the research, it was necessary to classify each kind of recommendation into one of the recommendation values. Table 1 shows the distinction established after conducting a thorough analysis of contents of the available recommendations.

Table 1. Classification of recommendation values

Positive (buy)	Negative (sell)
above the market	sell
over the market	avoid
better than the market	reduce
capitalize	take profit
buy	below the market
definitely buy	limit
buy speculative	worse than the market
overweight	underweight
hold	

Source: Own analysis

Moreover, the realization of random variables Y and Z were defined in the following way:

- rate of return from n – th instrument at moment t:

$$y_{nt} = \frac{p_{nt+1} - p_{nt}}{p_{nt}}; \quad t = 1,2,\ldots,T-1; \quad n = 1,2,\ldots,N, \tag{15}$$

where:

p_{nt} - price of n - th asset at moment t,

p_{nt+1} - price of n - th asset at moment $t+1$.

- rate of return from the WIG index in period *t*:

$$z_{Mt} = \frac{p_{Mt+1} - p_{Mt}}{p_{Mt}}; \quad t = 1,2,\ldots,T-1, \tag{16}$$

where:

p_{Mt} - value of the WIG index at moment *t*,
p_{Mt+1} - value of the WIG index at moment $t+1$.

Scope and assumptions of the empirical research

- The research on the strong form efficiency of the Warsaw Stock Exchange covers the period between 01.01.2005 - 31.03.2010. The reason for choosing the presented start date is that most authors specializing in the analysis of the life cycle of the stock market refer to year 2005 as the beginning of the maturity phase of the Warsaw Stock Exchange. This choice may also be supported by the fact that Poland joined the European Union a few months earlier.
- The entities covered by the research are companies comprising the WIG 20 index at the time of conducting the analysis. Therefore, the research also covered companies which on the 31.03.2010 were not a part of the WIG 20 index. The companies of the WIG 20 index were collected from the website: *www.gpw.pl/zrodla/gpw/spws/portfele*,
- Table 2 shows the number of recommendations available between 01.01.2005 and 31.03.2010 (the elements of the index are revised every quarter), whereas in most cases the recommendations were of "buy" and "sell" values.
- The recommending institutions (63 entities) are: ABN AMRO, DM BOS, Erste Bank, ING, Pioneer PDM, Fortis Securities Polska, DI BRE Banku, Nomura, Wood & Company, IDSMA, Morgan Stanley, BNP Paribas, CSFB, Societe General, J.P. Morgan, Lehman Brothers[2], PBK AM, DM Penetrator[3], Suprema[4], Millennium DM, KBC Securities, UniCredit CAIB, CDM PEKAO, DM BZ WBK, ING Securities, Merrill Lynch, SSSB, Citigroup, Elimar, AmerBrokers, DM BH, Deutsche Bank, Goldman Sachs, DM Polonia NET, DM Ipopema, BM Banku BPH, DM PKO BP, HSBC Securities, Raiffeisen, WDM, BDM, USB Warburg, BM BGZ, BM BISE[5], Macquarie, BM DnB Nord, Otkriete Securities, CSFB, Bank of America, Barclays Bank.

2. The Bank declared bankruptcy on 15 September 2008 and was taken over by Barclays Bank and Nomura.
3. 2009 taken over by DM Trigon.
4. Since the year 2009 has functioned under the name Copernicus Securities.
5. Taken over by Bm DnB Nord.

Table 2. Number of recommendations for WIG 20 companies in the period 01.01.2005 - 31.03.2010.

Company	Companies' Code	Number of recommendations
Agora S.A.	AGO	185
Asseco Poland	ACP	115
Bank Pekao S.A.	PEO	198
Bank Zachodni WBK	BZW	200
Bioton	BIO	29
BRE Bank	BRE	170
Cersanit S.A.	CST	83
CEZ	CEZ	82
Getin Holding	GTN	70
Globe Trade Centre	GTC	88
Grupa LOTOS	LTS	131
KGHM Polska Miedz	KGH	195
PBG SA	PBG	79
PKN Orlen	PKN	206
PKO BP	PKO	233
Polimex-Mostostal	PXM	100
Polnord	PND	18
PGNiG	PGN	132
Telekomunikacja Polska S.A.	TPS	220
TVN	TVN	178
Kety	KTY	117
Netia	NET	68
Prokom (presently Asseco Poland)	PKM	64
Bank BPH	BPH	80
Mol	MOL	92
Orbis	ORB	43
CompLand/Sygnity	CPL/SGN	111
Boryszew	BRS	0
Softbank (presently Asseco Poland)	SFT	63
Mondi Swiecie	MPP	94
Debica	DBC	16
Stalexport	STX	0
Polska Grupa Energetyczna	PGE	10
	Total	**3470**

Source: Own analysis based on www.bankier.pl

- All recommendations have their preparation date stated. It was assumed, that the information published in the recommendations was known by the institutions as non-public information 5 days prior to its announcement.
- More than 95% of recommendations referred to average term, that is why the research focused only on the period defined as the 6-month verifiability period of a recommendation, under the assumption that no new information was published.
- Recommendation set (3470 events) was downloaded from the website: *www.bankier.pl*

- Due to shortage or insufficient number of recommendations (less than 30) the analysis does not include the following companies: Bioton, Boryszew, Dembicę, PGE, Stalexport i Polnord. What is more, Prokom and Softbank were also excluded from the research, because they were taken over by Asseco Poland. The final number of companies covered by the research is 25, with the total number of recommendations amounting to 3270.
- The rate of return values (based on the opening price) referring to the analysed stocks and values of the WIG index were collected from the website: *www.bossa.pl*
- The conducted analysis excluded recommendations of a "neutral" value, because they do not favour the decision making process and therefore provide no added value to the research.
- The regression analysis considers only case studies, where the sign of the rate of return from the stock is equivalent to the sign of recommendation variable.

Results of the empirical research

The analysis of the correlation between the conformity of the recommendation sign and the movement of the asset price (i.e. rate of return sign) was conducted for the one-sided alternative hypothesis ($H_1: \rho_{XY} \neq 0$) at the significance level α=0,05. The results obtained are presented in Table 3.

The analysis of the correlation between variables of the recommendation and the rate of return of the recommended instrument shows in most cases (22 out of 25 cases) the absence of such correlation or poor correlation between variables and therefore this correlation is not statistically significant. The only correlation coefficient estimator statistically different from 0 was found in the case of the following companies: Bank Zachodni WBK, Mol and Polimex-Mostostal, -27,54 , -36,37 and -56,74, respectively. Nevertheless, in each of these cases the sign of the estimator contradicts the ability to estimate the movement of the asset's price in the period of the analysis (t–1, t). Moreover, the correlation analysis conducted for the whole information set (3270 events), considering all analysed assets, confirms the obtained results for assets handled individually. In such cases the correlation coefficient estimator amounted to -1,57. All in all, in most cases the institutions issuing recommendations having access to information set Φ_{t-1} did not achieve a positive cash flow in period (t–1, t), which is a premise for rejecting **RH I** and supporting the hypothesis of the strong form efficiency on the Warsaw Stock Exchange.

The application of the regression method requires firstly the verification of assumptions of the Gauss-Markov method of least squares, referring to autocorrelation and homoscedasticity of the residuals. The authors used the Durbin-Watson test to verify the autocorrelation of the residuals with the use of the first order condition. The conducted analysis eliminated the possibility of using the method of least squares for the following companies: Compland/Sygnity, KGHM Polska Miedź, PGNiG i

PKO BP. The homoscedasticity was in turn verified by conducting the F-test, which provided results rejecting the hypothesis of homoscedasticity of the residuals for the following companies: Asseco Poland, Grupa LOTOS, Mondi-Świecie i PGNiG. In a further part of the analysis the authors use the generalized least squares method (GLS) to estimate the structural parameters of regression in case of autocorrelation and/or homoscedasticity of the residuals for the above mentioned companies.

Table 3. The analysis of correlations between variables X and Y for companies making up the WIG 20 index in the period 01.01.2005 - 31.03.2010.

Company	ρ_{XY} [in%]	*t* –student test	*p* -value	Hypothesis
Agora S.A.	12,16	1,42	0,08	H_0
Asseco Poland	6,11	0,43	0,32	H_0
Bank BPH	10,51	0,77	0,21	H_0
Bank Pekao S.A.	-3,56	-0,14	0,39	H_0
Bank Zachodni WBK	-27,54	-2,38	0,01	H_1
BRE Bank	2,75	0,21	0,41	H_0
Cersanit S.A.	3,09	0,14	0,43	H_0
CompLand/Sygnity	-12,47	-1,07	0,17	H_0
CEZ	-12,11	-1,12	0,15	H_0
Getin	-5,22	-1,17	0,15	H_0
Globe Trade Centre	-4,33	0,52	0,28	H_0
Grupa LOTOS	7,12	0,55	0,31	H_0
Kęty	-0,55	-0,04	0,48	H_0
KGHM Polska Miedź	14,49	1,37	0,07	H_0
Mol	-36,37	-3,07	0,02	H_1
Mondi Swiecie	13,26	1,01	0,14	H_0
Netia	6,02	0,29	0,37	H_0
Orbis	-7,67	-0,43	0,31	H_0
PBG SA	6,83	0,14	0,45	H_0
PGNiG	3,91	0,16	0,41	H_0
PKN Orlen	-6,67	-0,76	0,29	H_0
PKO BP	-2,71	-0,35	0,42	H_0
Polimex-Mostostal	-56,74	-4,11	0,00	H_1
TP S.A.	-0,77	-0,09	0,46	H_0
TVN	-4,37	-0,28	0,36	H_0
Total	-1,57	-0,47	0,32	H_0

Source: Own analysis

The analysis of the coefficient of determination and the linear correlation between variables allow us to define the model and quality of the conclusion. The empirical results excluded companies with no linear correlation between the analysed variables, among them: Netia, Orbis, PGNiG i Polimex-Mostostal. Moreover, they were characterized by a very low coefficient of determination.

The last stage of verifying the **RH II** is the analysis of alternative hypothesis in the following form: $H_0: \beta_1 = 0$ *versus* $H_1: \beta_1 \neq 0$. What is more, next to the analysis of significance of the structural parameter, the most important aspect is to draw conclusions on the basis of structural coefficients' values, and therefore when $\hat{\beta}_1 > 1$, one can support the **RH I** and reject the hypothesis of the strong form efficiency of chosen shares listed on the Warsaw Stock Exchange. The results of this part of the research are presented in Table 4.

Table 4. The analysis of the structural coefficient for companies making up the WIG 20 index in the period 01.01.2005 - 31.03.2010.

Company	$\hat{\beta}_1$	t -student test	p -value	Hypothesis
Agora S.A.	0,82	2,55	0,01	H_1
Asseco Poland	0,71	5,33	0,00	H_1
Bank BPH	0,71	2,53	0,02	H_1
Bank Pekao S.A.	0,94	9,87	0,00	H_1
Bank Zachodni WBK	0,84	3,73	0,00	H_1
BRE Bank	1,09	6,31	0,00	H_1
Cersanit S.A.	1,45	2,02	0,04	H_1
CEZ	0,57	2,11	0,04	H_1
Getin	0,87	9,12	0,00	H_1
CompLand/Sygnity	0,57	2,43	0,01	H_1
Globe Trade Centre	0,71	2,23	0,04	H_1
Grupa LOTOS	1,05	2,55	0,02	H_1
Kęty	0,77	2,87	0,01	H_1
KGHM Polska Miedź	1,51	6,54	0,00	H_1
Mol	0,77	3,02	0,03	H_1
Mondi-Świecie	0,86	2,12	0,04	H_1
PBG SA	0,81	5,12	0,00	H_1
PKN Orlen	0,83	4,72	0,00	H_1
PKO BP	0,84	6,27	0,00	H_1
TP S.A.	0,76	6,03	0,00	H_1
TVN	0,92	5,33	0,00	H_1

Source: Own analysis

The results of the analysis confirm in each case the statistical significance of the structural parameter $\hat{\beta}_1$ ($p<\alpha$). Nevertheless, the analysis of the parameters does not provide an unequivocal answer to the question about the possibility of achieving the above-market returns. The following companies were described by the $\hat{\beta}_1 > 1$ coefficient: Bank Pekao S.A., BRE Bank, Cersanit S.A., Grupa LOTOS i KGHM Polska Miedź. However, when estimating the confidence intervals for each of those cases, with confidence level equal to $\alpha = 0{,}01$ holds that $\hat{\beta}_1 - t_{(\alpha,T-3)} D(\hat{\beta}_1) < 1$ in 4 of 5 cases, which could be caused by estimator variance. Nonetheless, further analysis of the results shows that in most cases (17 out of 21 observations, i.e. 76% of cases) having access to the information set Φ_{t-1} could not guarantee the achievement of an abnormal rate of return. The results of the research point to the rejection of **RH II** and support the hypothesis of the strong form efficiency of the WIG 20 index shares, which could be treated as a representative stock portfolio for the Warsaw Stock Exchange.

Conclusions

Can the use of non-public information in developing investment strategies help to "beat the market" and are there grounds for accepting or rejecting the hypothesis of the strong form efficiency of the Polish capital market? The following paper aimed at answering these questions. The results obtained in course of the empirical research provided arguments for rejecting **Research hypothesis I** and in most cases also **Research hypothesis II,** and therefore, they support the thesis of the existence of the strong form efficiency of the Warsaw Stock Exchange. Nevertheless, the results do not allow us to draw unequivocal conclusions and cannot be related to each capital market. The aim of the following paper was rather an attempt to conduct introductory research into a complex problem and use the results obtained to initiate further and more detailed research into the issue. The possible confirmation of the obtained thesis may play a crucial role in building investment portfolios, because, even if access to some information does not guarantee the achievement of abnormal rates of return, all costs incurred in order to get the information automatically become unjustified financial losses. In such circumstances technical and fundamental analysis, as well as the use of non-public information, does not allow investors to "beat the market", giving arguments for constructing passive portfolios as the best investment strategy. These most often are replaced by the market capitalization-weighted index or investment in Index Participation Units, which, from the perspective of reducing transaction costs and mitigating risk, could be an attractive investment alternative.

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