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THE IMPACT OF THE PANDEMIC ON THE INVESTMENTS EFFECTIVENESS IN THE SHARES OF IT SECTOR COMPANIES LISTED ON THE WARSAW STOCK EXCHANGE

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Abstract: The COVID-19 pandemic has forced changes in the global economy and caused the world to focus on the IT sector. The goal of the article is to determine the influence of the pandemic on the investment effectiveness in the shares of IT sector companies. The investment effectiveness during the pandemic was analyzed on the example of investments in selected stocks of companies listed on the WSE in the years 2019-2020. Returns on selected stocks and risk-adjusted measures of profitability based on the Capital Asset Pricing Model (CAPM) were used, and statistical verification of the quality of asset management in relation to the performance of the WIG index was carried out. The results show that during the pandemic, the effectiveness of investments in the shares of the Polish IT sector differed significantly from the WIG investment portfolio. This information can be discounted in the management process at the market risk estimation stage.

Key words: market risk, investment efficiency analysis, risk management, pandemic.

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Introduction

COVID-19 shook up the global economy by reminding people of their vulnerability to disease regardless of the achieved level of development and technological advances. The uncontrolled spread of the virus has caused insecurity and tension in the world economy. For this reason, governments in many countries are taking increasingly restrictive measures and restrictions to harness the pandemic, which caused the economy to decrease. Gross Domestic Product (GDP) in the second quarter of 2020 saw a dramatic decline all over the world. Even though the low base effect in 2020 caused the data from the second quarter of 2021 to be higher, with the economic growth in the EU countries as a whole exceeding 10% (GDP in Poland was 11% higher than in the second quarter of 2020), the OECD forecasts predict a further decline in GDP growth in 2022 in virtually all economies of the world. Regardless of the magnitude of monetary and fiscal policy incentives initiated by authorities, low GDP growth in subsequent pandemic waves, especially in 2020, was accompanied by high unemployment rates. Business downtime in many industries has resulted in strong revenue shocks for companies that started cutting costs by reducing employment (Amirudin et al., 2021). The lack of personal income has

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affected consumption levels and distorted the future revenues and cash flows of businesses, which is reflected in sharp declines in financial markets. In April 2020, massive packages of stimuli for domestic economies were initiated to bring normalization to markets. That also marks the beginning of a period of socio-economic uncertainty. In times of the current information chaos, investors are unsure how to manage their investments, and their attitudes grow pessimistic.

Information technology plays a crucial role in fighting the pandemic in almost every aspect of the emergency response to COVID-19. The pandemic has shown that the IT sector is the backbone of the modern economy. The year 2020 was the moment of an immense digital transformation leap. The Covid-19 pandemic forced changes in the global economy. Enterprises had to quickly adapt to new modes of work and communication, which resulted in changing business models and extensive use of digital technologies. Increased investment in IT technologies and automation, together with the rise in the value of companies from this area, also causes global investors to include their shares in portfolios in order to reap the potential benefits of their investments. The increasing dynamics of the market environment forced many entities to keep adapting to the continuously changing conditions of their operations, especially in the investment area. This necessitates continuous modification of the investment management process. The subject literature lists many titles assessing the impact of a pandemic on socio-economic processes, but there are few studies on the behavior of specific industries and sectors. The goal of the article is to determine the influence of the pandemic on the investment effectiveness in the shares of IT sector companies and, in particular, on the assessment of market risk. Tools often used in investment performance analysis were applied. The investment effectiveness of the IT industry during the pandemic was analyzed on the example of investments in selected stocks of companies from the WIG-INFORMATYKA index listed on the Warsaw Stock Exchange in the years 2019-2020. Returns on selected stocks and risk-adjusted measures of profitability based on the Capital Asset Pricing Model (CAPM) were used. Statistical verification of the quality of asset management in relation to the performance of the WIG index was carried out. The article offers an insight into the literature on the analysis of investment effectiveness. The conducted assessment of IT asset effectiveness contributes to this literature, especially with its implications for recent public health crises. The selection of tools used in the effectiveness analysis makes it possible to examine differences in risk preferences, investor sentiment, and heterogeneous market expectations that help investors in the decision-making process.

Literature Review

The subject literature lists many publications on the financial and economic impacts of COVID-19. The stability of gold as a safe asset during two phases of the COVID-19 pandemic was studied by Akhtaruzzaman et al. (2020). They carried out their studies in the U.S., Japanese and Chinese stock markets using Dynamic Conditional Correlations (DCC). The multifractality of gold and oil prices during the pandemic

period was also studied by Mensi et al. (2020). The behavior of oil prices during the Covid-19 pandemic was also the subject of studies by Salisu, Vo and Lawal (2020), Devpura and Narayan (2020) and Sharif et al. (2020). Salisu, Vo, and Lawal used an asymmetric VARMA-GARCH model to demonstrate the stability of gold in comparison to oil prices. Devpura and Narayan, using different measures of volatility, proved that the increase in oil price volatility correlated with pandemic development. Also, Sharif et al. (2020) analyzed the impact of COVID-19 on oil price volatility, as well as on the stock market, economic uncertainty and geopolitical risks. Many researchers focused attention on the impact of the pandemic on the forecasting of exchange rates (Folger-Laronde et al., 2020). Its impact on the stock market was studied by Just and Echaust (2020) and Qiu et al. (2020). Qiu et al. (2020) focused on the stock of companies using CSR tools. Using an event study methodology and a difference-in-differences approach, they showed that CSR activities during the pandemic foster higher returns. Other studies focus on contagion issues, the increase in the transmission of uncertainty between financial markets during the COVID-19 pandemic (Akhtaruzzaman et al., 2020, 2021; Okorie and Lin, 2020; Chakrabarti et al., 2021). Akhtaruzzaman et al. (2020, 2021) showed an increase in conditional correlations between different stock returns during the pandemic. Okorie and Lin (2020) demonstrated the effects of COVID-19 fractal contagion on stock market returns and volatility using Detrended Moving Cross-Correlation Analysis (DMCA) and Detrended Cross-Correlation Analysis (DCCA) techniques. The interrelationships between stock markets and the contagion effect during the pandemic were also demonstrated by Chakrabarti et al. (2021). The present paper offers insight into the existing literature on the impact of the pandemic on market risk. The research focuses on the impact of the pandemic on the efficiency of investment in the IT sector, which is an interesting research direction. The concept of effectiveness can be defined in many ways. Economic literature associates effectiveness with the concept of Pareto's Optimum, which means finding a combination of goods for which the level of utility of all market participants reaches a maximum. Many works also associate effectiveness with profitability, viability, and effectiveness in achieving goals (Samuelson and Nordhaus, 1998). The term is also connected with productivity (Pritchard, 1990). The economic sciences distinguish between organizational effectiveness and economic effectiveness, which refers to technical effectiveness or effectiveness of the allocation of outlays. There are three conceptual approaches used in this context: purposive, systemic and multicriterial. In the goal-oriented approach, effectiveness refers to the degree to which the goal is achieved and only then is the level of resource utilization evaluated. In the systemic approach, effectiveness is understood as the organization's ability to change its environment to achieve optimal operating conditions. The multicriterial concept connects efficiency with the organization's goals while meeting determined performance standards. The subject literature distinguishes the operational and strategic dimensions of the functioning of an organization. In the analysis of the effectiveness of organizations' activities, its operational and strategic dimensions

were distinguished. The former defines a way of realizing activities that brings better results with the same business concept applied in the same industry. The latter approach promotes unique and non-standard activities. Some studies also relate the concept of organizational effectiveness to profit, organizational growth and market value of the organization (Hammann et al., 2013). It is also considered in terms of the results of an organization's activities, and in this context, an organizational performance measurement is a tool for its evaluation (Henri, 2004). The literature also discusses a behavioral context for defining effectiveness in which the goals of the organization and the individual are closely related (Gaitanides, 2012). The definitional context of effectiveness is also broad. Studies focusing on investment efficiency from the perspective of the management theory at the micro-level mainly deal with the evaluation of performance, amplitude of its fluctuation, the size and distribution of dividends, employee compensation, various types of financial limitations, and decisions concerning the issue of shares or bonds (Liu et al., 2014; Dai and Kong, 2017). Research on the macro-level of management focuses on the state industrial policy, legal environment, investor protection, state financial policy and anti-corruption policy (Baker et al., 2016; Wang et al., 2017). Since the 2008 financial crisis, many researchers have focused attention on the impact of the uncertainty of economic policy on investment efficiency, using Baker's uncertainty index created in 2016 (Baker et al., 2016; Bonaime et al., 2018; Chen and Liu, 2018, Rizvi et al., 2020). The uncertainty effect has been experienced by investors since the start of the pandemic. This changing and turbulent market environment determined the activity of businesses and their involvement in investment. The article aims to answer the following research question: has the pandemic contributed to the increase in the market risk in the Polish IT sector, and did the effectiveness of investing in shares of this sector in the analyzed period differ significantly from the results of the WIG portfolio?

Measures of investment effectiveness

Market risk is defined as the risk of loss on a portfolio caused by changes in commodity prices, stock prices, exchange rates, interest rates or other indicators influenced by financial markets. Market risk can be measured using different methods, the most popular of which is the value at risk method (VaR). A number of measures for measuring risk have been developed on the basis of VaR: conditional value at risk (CoVaR), expected shortfall (ES) or maximum loss, CFVaR, ΔCoVaR developed by Adrian and Brunnermeier in 2016 (2016). The subject literature is rich in analyses and comparisons of these measures and their usability in measuring market risk (Allen, 2007; Jorion, 2007; Najaf et al., 2020).

In this study, the market risk assessment of the IT sector was carried out through the analysis of the effectiveness of investments in selected stocks of companies from the WIG-INFORMATYKA index. In the analysis of investment effectiveness, the results obtained by financial instruments are compared with the results of an adopted reference standard called the benchmark (Pedersen and Rudholm-Alfvin, 2003; Shadwick and Keating, 2002). Effectiveness can be measured using many

measurement instruments, such as Sharpe ratio introduced by Sharpe (1966) and Treynor ratio introduced by Treynor (1965), Jensen index introduced by Jensen (1967), Adjusted Sharpe Index, Adjusted Jensen Alpha Index, Sortino Ratio (1994) and Information Ratio. Also, generally known statistical measures were useful in evaluating investments, e.g., historical rate of return, standard deviation, variation coefficient and beta coefficient. Apart from the normal rate of return, the risk premium ratio (RP) is also used. It is calculated as the difference between the return on the stock and the risk-free rate of return. For the purposes of the study, the NBP reference rate was adopted as the risk-free rate. From an investor's perspective, it is not only the measurement of risk that is important but also the level of diversification. The measure used is DR, which is the ratio of market risk to total risk and the coefficient of determination. The following are also used in the effectiveness analysis: mapping error rate and information rate (IR) or Sharpe-Israelsen index (SI) (Israelsen, 2005). Tracking Error (TE) is defined as the standard deviation between the return obtained by a financial instrument and the return obtained from a benchmark.

$$TE = \sqrt{\frac{\sum_{i=1}^{n}(R_p - R_m)^2}{n}} \quad (1)$$

The following are termed as follows R_p - financial instrument rate of return, R_m- market portfolio rate of return (reference standard) and n - number of return periods. Another equally popular measure is the information ratio (IR), which measures the amount of additional return rate per unit of relative risk.

$$IR = \frac{R_p - R_m}{TE} \quad (2)$$

TE is tracking error (standard deviation of the active rate of return). Both measures are used to evaluate the investment effectiveness of different types of financial instruments. They are often used in the literature to relate directly to the benchmark (Blatt, 2004; Schneider, 2009). Research is often complemented by using ratios, which present the performance of the financial instrument in the light of risks involved in achieving it. These are Sharpe ratio, Treynor ratio, Jensen's alpha, Sharpe's alpha, and Modigliani & Modigliani ratio (Haensly, 2022). The Sharpe ratio (S_p) is defined as the ratio of the risk premium to the standard deviation of the financial instrument's return.

$$S_p = \frac{R_p - R_f}{s_p} \quad (3)$$

Where, R_p is the average rate of return on the financial instrument at a given time, R_f is the average rate of return on risk-free instruments at the same time, and s_p is the standard deviation of the return on a financial instrument at a given time. In interpretation, index values for the studied financial instrument higher than the ones for the benchmark indicate a more effective investment. The construction of the Treynor ratio (T_p) is analogous to that of the Sharpe ratio.

$$T_p = \frac{R_p - R_f}{\beta_p} \quad (4)$$

Where β is the beta coefficient, systematic risk of a financial instrument at a given time. This measure determines the size of the premium, the difference between a financial instrument's return rate and the risk-free return rate per unit of systematic risk taken. A complete assessment of the studied financial instrument can be performed by comparing the Treynor ratio for an asset with the benchmark ratio. The bigger the positive difference between these ratios, the higher the effectiveness. Another measure used for the assessment of effectiveness is Jensen's Alpha.

$$J = (R_p - R_f) - (R_m - R_f)\beta_p \quad (5)$$

Where β_p is the beta coefficient of the financial instrument, its positive values indicate how much the asset's performance is higher than expected. Negative values indicate that the financial instrument is underperforming and is below the SML line. Construction-wise, the Sharpe Alpha ratio (AS) resembles Jensen's Alpha.

$$AS = (R_p - R_f) - (R_m - R_f)\frac{s_p}{s_m} \quad (6)$$

Where s_m is the standard deviation of the return on the market portfolio, and s_p is the standard deviation of the return on the financial instrument. It measures the difference between the return on a financial instrument and the return on a benchmark portfolio whose investment risk is measured by the total risk of the financial instrument. Its positive value indicates that the investment is effective. If the value is negative, on the other hand, the asset is not effective. The M^2 measure, or the Modigliani & Modigliani ratio, determines the rate of return achieved by an asset based on the total risk of the benchmark.

$$M^2 = \frac{s_m}{s_p}(R_p - R_f) + R_f \quad (7)$$

The measures presented above were used to measure the investment effectiveness in the shares of the IT sector companies in the years 2019-2020.

Analysis of the effectiveness of investment in the shares of the selected IT companies listed on the Warsaw Stock Exchange in the years 2019-2020

The socio-economic situation in Poland in 2019-2020 was shaped by the measures implemented during the year to counter the COVID-19 pandemic, which affected the performance of the economy in the core business areas with varying degrees of intensity. In 2019, the rapid growth in economic activity observed in the previous years began to clearly slow down. Gross Domestic Product (GDP) in 2019 increased by 4.5% in real terms compared to the previous year, while in 2020, it was 2.8% lower in real terms compared to 2019. The decline in GDP was due to much weaker growth in most areas of economic activity. The worst situation was observed in the second quarter of 2020. Both the industrial output sold and retail sales declined, and the labor market showed negative trends. However, the extent to which the pandemic impacted individual sectors varied. The services sector had the largest share in the decline in real gross value added because it was particularly sensitive to the social distance requirement. Gross value added (the main component of GDP) in the accommodation and catering sector declined by almost 30% y/y. For example, the industry saw a 3% y/y growth, and the information and communication sector, which includes the IT industry, recorded a 4% y/y increase (Central Statistical Office). The

total expenditure on Information Technology in Poland is continuously growing. According to IDC, in 2020, the value of the Polish ICT market increased to USD 19.3 billion (PLN 75 billion). The growth continued, reaching USD 20 billion in 2021. The value of the IT sector in 2020 grew to USD 12,55 billion, compared to 2019 when it reached USD 12,24 billion. IT professionals make up more than 3% of Poland's workforce. In the DESI 2020 Digital Economy and Society Index, Poland ranked twenty-third out of 28 member states. The EC highlights the significance of broadband services and the level of digital public services. However, only 11% of Polish companies have a high degree of digitization, compared to an average of 26% in the EU. The Polish sector of modern business services with over 338,000 employees is responsible for 3.5% of GDP. 46.5% of these companies are IT companies (ABSL, 2020). During the 2019-2020 pandemic, it was one of the few sectors of the economy where employment increased. Information Technology is an area of investment opportunity and an area of risk. High uncertainty makes it difficult to forecast the economy, as well as to make investment decisions. In the current information chaos, characterized by an excess of often contradictory opinions and analyses, one of the key sources of information about the future can be capital markets, where millions of pieces of information are discounted in a decentralized manner, which are then taken into account in the valuation of individual assets. An investor who, on the basis of available measures of investment effectiveness, is aware of the size of the risk may decide to continue the investment, enter a new company or change the terms of engagement.

The study focused on the biggest companies listed in the Warsaw Stock Exchange index, which at the same time had the largest shares in the WIG-INFORMATYKA index. Asseco Poland SA (ASSECOPOL - 38,73%), LiveChat Software SA (LIVECHAT – 16,04%), Comarch SA (COMARCH – 11,65%), Asseco South Eastern Europe SA (ASSECOSEE – 8,74%) and DataWalk SA (DATAWALK – 5,86%). Table 1 presents the companies whose shares were analyzed in the study.

Table 1. IT sector companies included in the study

Name of the company	Field of activity	Financial results in the years 2019-2020
Asseco Poland SA (ASSECOPOL, ACP)	The company is primarily engaged in high-tech software and hardware consulting business. It provides software for the banking and finance sector, as well as for enterprises and public administration, industry, trade and services. The company has gathered a unique experience in implementing advanced, complex IT projects.	Net income from sales in 2019 was: 10667,4 mln PLN, and in 2020 it was 12190,3 mln PLN. EBITDA in 2019 was 1611,6 mln PLN, and in 2020 it was 1922,1 mln PLN.

LiveChat Software SA (LIVECHAT, LVC)	IT company operating in the software sector. It offers services supporting sales and customer service (SaaS model - Software as a Service). The company's main product is LiveChat used for quick and intuitive contact between customers visiting a company's website and the company's employees.	Net income from sales in 2019 was: 94,9 mln PLN, and in 2020 it was 130,9 mln PLN. EBITDA in 2019 was 62,4 mln PLN, and in 2020 it was 88,4 mln PLN.
Comarch SA (COMARCH, CMR)	The company designs and develops information systems, including software, computer and network hardware, implementation, training and operation services. The offer is directed to the telecommunications, finance, banking and public insurance sector, as well as trade and services.	Net income from sales in 2019 was: 1437,4 mln PLN, and in 2020 it was 1536,8 mln PLN. EBITDA in 2019 was 228,3 mln PLN, and in 2020 it was 277,9 mln PLN.
Asseco South Eastern Europe SA (ASSECOSEE, ASE)	The company is the largest player in Southeast Europe in terms of sales of proprietary software and IT services. It mainly offers services to the banking sector connected with authentication, supply, installation and maintenance of ATMs and payment terminals. It offers solutions and services for the telecommunications sector as well as integration services and the supply and implementation of IT systems and equipment.	Net income from sales in 2019 was: 881,3 mln PLN, and in 2020 it was 1026,5 mln PLN. EBITDA in 2019 was 175,9 mln PLN, and in 2020 it was 222,9 mln PLN.
DataWalk SA (DATAWALK, DAT)	The company has its own analytical platform for advanced data analysis. It operates in the area of financial and insurance sector. The company's area of operation is fraud detection and prevention of money laundering, as well as analysis and monitoring of business processes.	Net income from sales in 2019 was: 3,5 mln PLN, and in 2020 it was 15,7 mln PLN. EBITDA was negative in the analyzed period and in 2019 it was (-10,3) mln PLN, and in 2020 it was (-5) mln PLN.

Source: own elaboration on the basis of information posted at www.gpw.pl (accessed 30.10.2021).

The measures presented in the previous section were used to assess the effectiveness of investments in a selected group of IT sector companies listed on the WSE in the years 2019-2020 and in a portfolio based on the WIG-INFO index. Monthly rates of return on the considered stocks were used for the research. The effectiveness was evaluated in relation to the benchmark – the WIG index.

The relationship between the benchmark rates of return represented by the WIG index, the WIG-INFO index, and selected medical company stocks were examined

using Pearson linear correlation coefficients determined for daily return series in 2019 and 2020. They are presented in Tables 2 and 3. The first column and the first row show the abbreviated names of the listed companies, according to the WSE classification.

Table 2. Pearson linear correlation coefficients for the returns on the WIG index, the WIG-INFO sub-index and the selected IT sector stocks listed on the WSE in 2019

	WIG	WIG-INFO	ACP	ASE	CMR	DAT	LVC
WIG	1	0,40154	0,33595	0,17105	0,14859	0,09381	0,20050
WIG-INFO	0,40154	1	0,94727	0,2369	0,24091	0,03666	0,25014
ACP	0,33595	0,947277	1	0,11915	0,04572	-0,0039	0,10258
ASE	0,17104	0,2369	0,11915	1	0,03399	-0,0072	0,15829
CMR	0,14859	0,240911	0,04572	0,03399	1	-0,0256	0,05383
DAT	0,09381	0,03666	-0,0039	-0,0073	-0,0256	1	0,03537
LVC	0,20050	0,25014	0,10258	0,15829	0,05383	0,03537	1

Source: own calculation

An analysis of the correlation coefficients of the daily returns in 2019 in Table 2 shows no significant correlation between the returns of the WIG index and the other stocks, except for WIG-INFO, which shows a weak correlation relationship. The only strong relationship exists between the returns on the WIG-INFO index and the daily returns on ACP stocks.

Table 3. Pearson linear correlation coefficients for the returns on the WIG index, the WIG-INFO sub-index and the selected IT sector stocks listed on the WSE in 2020

	WIG	WIG-INFO	ACP	ASE	CMR	DAT	LVC
WIG	1	0,69534	0,41485	0,53028	0,51402	0,43504	0,39341
WIG-INFO	0,69533	1	0,83096	0,52738	0,47841	0,49129	0,51282
ACP	0,41485	0,83096	1	0,22657	0,15865	0,17060	0,20467
ASE	0,53028	0,52738	0,22657	1	0,33305	0,30278	0,19491
CMR	0,51402	0,47840	0,15865	0,33305	1	0,25704	0,05384
DAT	0,43504	0,49129	0,17060	0,30278	0,25704	1	0,27176
LVC	0,39341	0,51282	0,20467	0,19491	0,27175	0,249043	1

Source: own calculation

The analysis of the correlation coefficients of daily returns in 2020 presented in Table 3 indicates that there are no significant correlations between the returns on the WIG and LVC index, and between stock returns. The WIG index moderately correlates with the other stocks, except LVC. Similarly to 2019, the only strong relationship exists between the WIG- INFO index returns and the daily returns on ACP stocks.

In the next step of the calculation based on the WIG benchmark for monthly return rates of the WIG-INFO index and a selected group of stocks listed on the WSE in 2019 and 2020, the following measures were calculated: R_p- simple annual rate of return, s_p- standard deviation of monthly returns, RP- risk premium, DR- ratio of market risk to total risk, Jensen J-Alpha, Sp- Sharpe ratio, beta- beta coefficient, AS- Sharpe alpha, Tp- Treynor ratio, M2- Modigliani & Modigliani ratio, TE- mapping error and IR- information ratio. The results for each year are shown in Tables 4-7. The bold font indicates better results than the benchmark, i.e. indicating higher investment effectiveness in a given stock than in the case of the benchmark.

Table 4. Key indicators for the WIG benchmark and monthly return rates of a selected group of stocks and the WIG-INFO sub-index in 2019

Name of the company	R_p	s_p	RP	TE	IR
ACP	**2,29776**	5,73482	**0,7978**	6,58041	**0,36864**
ASE	**6,26045**	5,78642	**4,7604**	8,60394	**0,74251**
CMR	**1,82461**	6,40461	**0,32461**	7,68052	**0,25424**
DAT	**8,66131**	30,89618	**7,16131**	30,85513	**0,28486**
LVC	**5,14915**	5,69808	**3,64915**	8,14451	**0,64795**
WIG-INFO	**2,20575**	3,31274	**0,7058**	4,56387	**0,51135**
Benchmark (WIG)	-0,12805	2,413192	-1,628		

Source: own calculation

Table 5. Risk-adjusted effectiveness measures for the WIG benchmark and monthly return rates of a selected group of stocks and the WIG-INFO sub-index in 2019

Name of the company	J	S_p	Beta	AS	T_p	M^2
ACP	**2,20089**	**0,37887**	0,11114	**2,77412**	**19,5495**	**1,03929**
ASE	**6,26779**	**1,06032**	0,52298	**6,74221**	**11,73169**	**2,68375**
CMR	**1,51852**	**0,26537**	-0,71563	**2,37120**	-2,37498	**0,76539**
DAT	**10,39635**	**0,27629**	7,35052	**11,77609**	**1,16132**	**0,79174**
LVC	**5,01996**	**0,88173**	-0,01654	**5,62165**	-303,701	**2,25277**
WIG-INFO	**2,11151**	**0,62811**	0,12153	**2,42813**	**17,12167**	**1,64074**
Benchmark (WIG)		-0,10486	1		-0,25305	-0,12805

Source: own calculation

Table 6. Key indicators for the WIG benchmark and monthly return rates of a selected group of stocks and the WIG-INFO sub-index in 2020

Name of the company	R_p	s_p	RP	TE	IR

ACP	**0,18775**	**7,48379**	-0,34555	6,41616	**0,04171**
ASE	**5,01621**	10,17629	**4,48287**	11,99361	**0,42490**
CMR	**0,80677**	**5,66688**	**0,27344**	9,15663	**0,01058**
DAT	**14,84701**	34,54627	**14,31368**	33,14806	**0,45031**
LVC	**8,08887**	12,77279	**7,55553**	14,80622	**0,55171**
WIG-INFO	**2,26640**	**6,82454**	**1,73307**	6,36920	**0,36838**
Benchmark (WIG)	-0,07987	9,69858	-0,6132		

Source: own calculation

Table 7. Risk-adjusted effectiveness measures for the WIG benchmark and monthly return rates of a selected group of stocks and the WIG-INFO subindex in 2020

Name of the company	J	S_p	Beta	AS	T_p	M^2
ACP	**0,21532**	**0,01915**	0,57926	**0,23924**	**0,24739**	**0,23016**
ASE	**5,02446**	**0,48856**	0,42388	**5,10220**	**11,72915**	**4,78281**
CMR	**0,79082**	**0,13452**	0,2292	**0,83496**	**3,32602**	**1,34912**
DAT	**15,07451**	**0,42849**	2,18751	**15,24539**	**6,76684**	**4,20014**
LVC	**8,11362**	**0,629801**	0,5566	**8,20815**	**14,45275**	**6,1527**
WIG-INFO	**2,29172**	**0,32558**	0,5612	**2,30944**	**3,95932**	**3,20214**
Benchmark (WIG)		-0,01282	1		-0,12432	-0,07987

Source: own calculation

Summarizing the results of the calculations in Tables 4-7, it should be noted that in 2019 and 2020, the return rates of the discussed stocks showed high volatility, which was also reflected in the standard deviation values of the monthly return rates with the highest values for the DAT company. This phenomenon was caused by dynamic changes in the value of stock prices on the WSE. Analyzing the results in Tables 4 and 6 for the estimated measures of expected return rates in the years 2019-2020, one can see that although the benchmark showed a loss, investments in the remaining companies and the WIG-INFO index were profitable. The most attractive investment in both 2019 and 2020 by the criterion of the expected rate of return was the purchase of the shares of DAT. The company's monthly return rate was on the average level of 8.66% in 2019 and 14.85% in 2020. In 2019, the values of the market risk premium index, which indicates the additional rate of return achieved by stock over the level of the risk-free rate, were positive for all companies under consideration and the WIG-INFO index. In 2020, only the result of ACP was negative. The highest positive result in the years 2019-2020 presented in Tables 4 and 6 was also achieved by DAT. The systematic risk values, measured by the beta coefficient in relation to the WIG index in Tables 5 and 7, indicate that only DAT was highly responsive to market changes in 2019 and 2020, while the other companies and the WIG-INFO

index behaved defensively. The negative values of the indicators show that in 2019 some of the stocks reacted conversely to changes in the WIG return rate. On the other hand, the high values of the tracking error rate in both 2019 and 2020 in Tables 5 and 7 indicate that all discussed companies realized an active risk management strategy. Only in the case of the shares of ASE, DAT and LVC, the obtained values of the information index allow us to conclude that the application of active management strategy in the years 2019-2020 brought the expected high rate of return.

The evaluation of the results of the basic indicators in Tables 4 and 6 has shown that in the years 2019-2020, the most effective investment in relation to the WIG benchmark among the ones under consideration was the investment in the shares of DAT. Comparing only rates of return does not provide a complete assessment of investment effectiveness. It is also necessary to measure the risk of investment associated with the rate of return achieved by a given investment. Based on Jensen's Alpha, Sharpe ratio, Sharpe Alpha, Modigliani & Modigliani ratio in 2019 (Table 5), the group of investments effective in relation to the considered WIG benchmark should include investments in all analyzed stocks and investments in the portfolio based on the WIG-INFO index. In 2019, Treynor ratio showed that the following stocks were effective in relation to WIG: ACP, ASE, DAT, and the portfolio based on the WIG-INFO index. In 2020, risk-adjusted effectiveness measures of the WIG benchmark showed that the selected group of stocks and the portfolio based on WIG-INFO were effective in terms of investment (Table 7). It should be noted that the assessment of investment effectiveness based on a given benchmark does not yield information that the considered company achieves the best or the worst economic results. It only indicates whether the stock investment was effective in relation to the used benchmark. However, this kind of information is beneficial while assessing the market risk of an investment.

The study of the effectiveness of the stock market using the Sharpe ratio, Jensen's Alpha and Treynor ratio was carried out, among others, by Zakarias and Tumewu (2015). Pangestuti et al. (2017), using Sharpe, Treynor, Jensen ratio and Adjusted Sharpe Index, Adjusted Jensen Alpha Index, and Sortino examined the effectiveness of Indonesian investment funds. Sharpe Ratio, Treynor Ratio and Jensen Index were also used in the study of stock portfolios by Suryani and Herianti (2015). The effectiveness of stocks on the Indonesian market was also studied by Catherine and Robiyanto (2020). The impact of the pandemic on the effectiveness of Islamic investment funds was studied by Mirza et al. (2022). Akhataruzzaman et al. (2020), Sharif et al. (2020) also carried out studies, which confirmed the impact of the pandemic on various financial assets and products. This article is a contribution to the growing literature on COVID-19. The study presents an analysis of the influence of the pandemic on the Polish stock market.

Conclusion

The pandemic and the global crisis have made the entrepreneurs realize and act according to once-established patterns that may give a false sense of security. The market reality is full of various types of threats that significantly affect the results of business operations (Wierzbicki, Nowodziński, 2019). In the present study, the focus was placed on analysing market risk as an intrinsic element of investment management. The risk assessment was carried out with tools used for investment effectiveness analysis. The assessment of the key indicators based on the return rate showed that in the years 2019-2020, the most effective of the discussed investments in relation to the WIG benchmark were investments in the shares of DAT. Comparing only rates of return does not provide a complete assessment of investment effectiveness. It is also necessary to measure the investment risk associated with the given investment. The majority of the considered risk-adjusted measures: Jensen's alpha, Sharpe ratio, Sharpe alpha, Modigliani & Modigliani ratio in 2019 qualified investments in all analyzed stocks and the portfolio based on WIG-INFO to the effective groups in relation to the considered WIG benchmark. Treynor ratio for WIG in 2019 showed only the following stocks were effective: ACP, ASE, DAT as well as the portfolio based on the WIG-INFO index. In 2020, all measures confirmed the investment effectiveness of the selected group of stocks and the portfolio based on WIG-INFO. All of these empirical findings provide new information for investors and managers in securing and diversifying risk in times of extreme market conditions.

IT sector stocks dominated during the peak months of the pandemic, which was evidenced by the study results covering the period discussed in this article. Investment managers should be aware of the importance of these assets, which can be a safe investment during periods of financial turmoil. Pandemics like COVID-19 are rare, making this type of analysis a unique comparative assessment of investments in an extremely turbulent environment. The posted research covers the IT sector, and at a later stage, the behavior of other sectors of the economy during the pandemic can be analyzed. Further research can also include a comparison of the Polish stock market with other markets to assess their resilience in the pandemic period. In particular, the application of effectiveness analysis can provide additional insights and implications for managers to make informed investment decisions at various stages of the management process.

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WPŁYW PANDEMII NA EFEKTYWNOŚĆ INWESTYCJI W AKCJE SPÓŁEK SEKTORA IT NOTOWANYCH NA GPW W WARSZAWIE

Streszczenie: Pandemia COVID-19 wymusiła zmiany w światowej gospodarce i spowodowała, że cały świat przeniósł uwagę na sektor IT. Celem artykułu jest określenie wpływu pandemii na efektywność inwestycji w akcje spółek sektora IT. Efektywność inwestycyjną w czasie pandemii analizowano na przykładzie inwestycji w wybrane akcje spółek notowanych na GPW w latach 2019-2020. Wykorzystano stopy zwrotu wybranych akcjach i skorygowane o ryzyko miary rentowności oparte na modelu wyceny aktywów kapitałowych (CAPM). Przeprowadzono statystyczną weryfikację jakości zarządzania aktywami w odniesieniu do indeksu WIG. Wyniki pokazują, że w czasie pandemii efektywność inwestycji w akcje polskiego sektora IT znacznie różniła się od portfela inwestycyjnego WIG. Tego typu informacje mogą być dyskontowane w procesie zarządzania na etapie szacowania ryzyka rynkowego.

Słowa kluczowe: ryzyko rynkowe, analiza efektywności inwestycji, zarządzanie ryzykiem, pandemia

大流行对在华沙证券交易所上市的 IT 行业公司股票投资有效性的影响

总结： COVID-19 大流行迫使全球经济发生变化，并导致全世界将注意力转移到 IT 部门。本文的目的是确定大流行对 IT 股票投资有效性的影响。以2019-2020年对WSE上市公司部分股票的投资为例，分析了疫情期间的投资效率。使用了基于资本资产估值模型 (CAPM) 的选定股票的回报率和风险调整后的盈利能力指标。资产管理质量通过与 WIG 指数相关的统计验证。结果表明，在大流行期间，波兰 IT 部门股票投资的有效性与 WIG 投资组合存在显着差异。此类信息可能会在市场风险评估阶段的管理过程中进行折扣

关键词：市场风险，投资效果分析，风险管理，流行病