Risk of Decline in Share Prices of Energy and Fuel Sector on the Warsaw Stock Exchange During the Two Waves of the COVID-19 Pandemic

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Abstract:

Purpose: *The COVID-19 pandemic is now frequently cited as a factor affecting countries' economies. A decline in the share prices of companies appeared in Poland with each successive wave of the pandemic (3 waves). The aim of our research is to identify the characteristics of companies that influence the fact that their share prices decline below a certain level during the first and second waves of the pandemic. We focus on the energy and fuel companies, due to their high economic importance.*

Design/Methodology/Approach: *We use the logit model in assessment of the risk of price decline. Share prices of companies listed on the WSE were analysed. A comparison was made of the risk of a decline in the share prices of energy and fuel companies in relation to other companies, and according to stock exchange macrosectors. The research hypotheses are verified by estimating the two models: model (1) for the first wave of the pandemic (I stage) and model (2) for the second wave of the pandemic (II stage).*

Findings: *The main conclusion of the research is that the first wave of the pandemic caused panic in the stock market. This was a completely new economic disruptor. During the second wave of the pandemic, morbidity and mortality rates were much higher, but the lessons learned beforehand had a dampening effect on stock market reactions.*

Practical Implications: *A pandemic situation is a specific type of crisis. The analysis shows that the technology macrosector is the least vulnerable to this type of crisis. Teleworking and the use of new communication technologies have influenced the development of this sector. In contrast, the fuel and energy sector is very sensitive to any restrictions on movement.*

Originality/Value: *A direct comparison of the impact of the two waves of the pandemic on company prices in Poland has not been conducted so far. Particularly important is the inclusion in the analysis of macro-sectors, which made it possible to identify those most exposed to the risk of decline in prices.*

Keywords: *Energy sector, fuels sector, modelling the risk of decline in share prices, logit model.*

JEL codes: *C14, G32, Q43.*

Paper Type: *Research article.*

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*Risk of Decline in Share Prices of Energy and Fuel Sector on the Warsaw Stock Exchange
During the Two Waves of the COVID-19 Pandemic*

978

1. Introduction

The course of the COVID-19 pandemic and its social and economic impact have prompted numerous researchers to carry out studies. This research is diverse in nature. In the medical field, papers have been produced on the analysis of tools for coping with the negative consequences of future infectious diseases. The first wave of the COVID-19, compared to the others, was very shallow but had a strong impact on global GDP, prices of selected commodities (crude oil, heating oil, ULSD, or ethanol) and global stock exchange. This response was much stronger than for the other stages of the development of the pandemic.

It follows that the first wave of COVID-19 had strong negative economic effects. Temporary outages in production, services and trade resulted in increased unemployment (Svabova *et al.*, 2021). Operational risk for companies has also increased during this period (Chang and Wu, 2021). Global stock markets have also reacted to news of the spread of the virus. Capital markets tend to overreact to data and information in the short term. These reactions are the result of investor uncertainty during crisis situations. This was also the case during the first wave of the pandemic. The COVID-19 had a significant impact on the memory properties of the main indices of the analysed financial markets (Dias *et al.,* 2020). The impact of the pandemic has also affected the prices of energy commodities. The pandemic has also affected the economy indirectly. It highlighted the problem of digital exclusion. During the lockdown, people have been forced to use information and communication technologies. Countries with less prepared health systems have implemented more stringent restrictive measures. Higher levels of restrictiveness have been associated with stronger negative socio-economic impacts and have generated greater costs (Aristodemou *et al.*, 2021). The pandemic highlights the need for extensive international cooperation, free flow of information and joint international epidemiological, economic, and social action.

Other global and local factors also influence the demand and supply of energy commodities and the condition of energy and fuel companies. Not all changes in the energy market are caused by the pandemic. As Cohen indicates (2020), the "price war" between Saudi Arabia and Russia also contributed to the decline and destabilisation of oil prices in the first half of 2020. In commodity-dependent developing countries, the crisis triggered by the COVID-19 revealed structural weaknesses (Tröster and Küblböck, 2020). All these factors can be the cause of volatility in share prices in the capital market. In the case of COVID-19, investor sentiment is not insignificant. The worldwide panic over the course of the pandemic and the rapidly increasing number of cases and deaths caused panic. This is particularly evident in the case of the first wave of the pandemic.

In recent months, more and more research results have emerged on the impact of COVID-19 and other external factors on the global economic situation. We focus on companies listed on the Warsaw Stock Exchange. The aim of our study is the

identification of the internal characteristics of companies that affect the decline in their share prices below a certain level during the first and the second waves of the pandemic. We focus particularly on energy and fuel companies due to their high economic importance. We use a logit model to assess the risk of price declines. It allows the use of both quantitative and qualitative variables with appropriate coding of individual variants. The variable of great importance is the way share prices react during the first wave of the pandemic. This is due to the anticipation of the development by the investors. We conduct the analysis in two stages. First, we compare the decline in prices of fuel and energy companies in relation to other companies, and then in relation to the stock exchange macrosectors.

2. Literature Review

The COVID-19 pandemic is now a major problem, both globally and in particular countries. It is first and foremost a health problem, but one that affects the economy. The pattern of spread of the SARS-CoV-2 virus was not the same everywhere. For example, the first wave of the COVID-19 pandemic progressed more slowly in Africa than the rest of the world, and by December, 2020, the second wave appeared to be much more aggressive with many more cases. The first case of COVID-19 in Africa was reported in Egypt on Feb 14, 2020, just 14 days after WHO had declared the outbreak a public health emergency of international concern (WHO, 2020).

Bieszk-Stolorz and Dmytrów (2021a; 2021b) assess the strength of the reaction of global stock markets to the SARS-CoV-2 coronavirus pandemic in 2019-2020. They analyse the decline and increase in the value of stock indices during the first wave using selected survival analysis methods. They show that the intensity and risk/chance of these changes vary by continent. The increase in the value of stock indices is faster than their initial decline. Ghorbel and Jeribi (2021) examine the relationship between the volatilities of the energy index, crude oil, gas prices, and financial assets (Gold, Bitcoin, and G7 stock indexes), especially during the coronavirus crisis. The study tests the presence of regime changes in the GARCH volatility dynamics of the G7 stock indexes, Bitcoin, Gold, and energy assets (energy index, oil, and gas). The estimation results prove the volatility spillover from energy assets to financial assets. Nyga-Łukaszewska and Aruga (2020) state that the world economy has been deeply affected by the COVID-19 pandemic.

However, on a single country's scale, we can observe it in major stock indices changes and unemployment claims. Lockdowns cause changes in stock market indices, which are often regarded as leading indicators of the business cycle. Major changes have also occurred in energy markets. The situation in the oil and gas industry has weakened considerably. During the pandemic, on the one hand, the demand for energy resources (crude oil and natural gas) decreases, and on the other hand, companies reduce their investment spending. Bompard *et al.* (2021) describe the direct impact of the COVID-19 pandemic on energy systems and markets across Europe. The COVID-19-related lockdown measures significantly affected the

Risk of Decline in Share Prices of Energy and Fuel Sector on the Warsaw Stock Exchange During the Two Waves of the COVID-19 Pandemic

980

electricity demand. The increase in domestic energy consumption cannot not compensate for the drastic reduction in industrial, commercial, and service activities. The pandemic hits electricity markets in Europe, prices decline sharply in the first six months of 2020 compared to previous years, indicating that the sharp drop in demand translates directly into lower market prices.

Yousfi *et al.* (2021) make the comparative assessment of the impacts of the first and second waves of the ongoing COVID-19 pandemic for the US stock market and its uncertainty. They analyse and compare the relationship between the COVID-19 pandemic and US returns and uncertainty during the first and second waves of the pandemic. Increases in COVID-19 infections and deaths during the first and second waves increase uncertainty in the US stock market and overall economy, with serious financial implications. Nehrebecka (2021) analyses, how the banking sector is prepared to deal with losses arising from the development of the enterprise sector, in an orderly fashion, under certain macroeconomic scenarios. The pandemic crisis and the associated mass 'lockdowns' have hit all major sectors of the Polish economy hard. Large, medium, small and micro enterprises are still at risk of not starting their activities even after the quarantine is lifted. The author has shown that the deterioration in the quality of loan portfolios on banks' balance sheets in all segments is dependent on the company size.

In general, the pandemic situation is negatively affecting stock markets in the exchanges (Pardal *et al.*, 2020). In the literature, much research is devoted to the analysis of the energy market because of its vital importance in the economy. It is thought that the stock markets are more sensitive to the COVID-19 pandemic than the real economy and sensitive to the negative news/shocks (Iqbal *et al.*, 2021).

The energy and fuel sector is a very important part of the economy. It affects both the economic development and the quality of life of the population. Therefore, the development and good financial situation of enterprises in this sector is of vital importance. The functioning of all enterprises is influenced by various factors, e.g., the economic situation of the country, unemployment, investment attractiveness of the region (Roszko-Wójtowicz and Grzelak, 2021), regional business demography (Markowicz, 2014), the sector situation of companies on the stock exchange (Bieszk-Stolorz and Markowicz, 2017a; 2017b), or the international trade (Markowicz and Baran, 2020). For this sector, customer preferences, the development of renewable energy sources (Przygrodzki and Kubek, 2021), and environmental protection (Kurian, 2012). This multifaceted nature of the topic makes it necessary to narrow the scope of the study and to refer to studies by other authors.

3. Materials and Methods

During both pandemic waves, the energy demand for industrial, commercial and service companies decreased. This adversely affected the financial situation of

energy suppliers (Bompard *et al.*, 2021). On the basis of the literature research and our own analysis, we have set up a hypothesis:

Hypothesis 1 (H1): *The risk of decline in share prices of the fuel and energy companies during the first and second waves of the pandemic is greater than the risk of decline in share prices of the other ones.*

The first wave of the pandemic proved to be a great surprise and problem for the entire economy. However, the introduced protective tools for companies and the acquired experience meant that the impact of the second wave on the economy was not as severe (Dmytrów *et al.,* 2021). It seems that during the second wave of the pandemic, those sectors of companies that were most severely affected by the first wave suffered more. The energy and fuel sector in particular was affected by the introduced restrictions on movement and the restriction of company activities. We have proposed a following hypothesis:

Hypothesis 2 (H2): *The downward reaction of stock prices of listed companies during the second wave of the pandemic depends on the reaction during the first one.*

Large companies with large resources should cope better with crisis situations than small companies with limited resources. On the stock market in Poland, energy and fuel companies are among the companies with large resources. We believe that the market value of the company may have influenced its assessment by investors on the stock market.

Hypothesis 3 (H3): *The decline in share prices of listed companies during the waves of the pandemic is influenced by their market value.*

The duration of a company's existence is not insignificant in crisis situations. Companies which have been present on the market for a long time have more experience in running their business and are better evaluated by the investors than the young ones. We believe that this may influence the reaction of investors on the stock exchange (Bieszk-Stolorz and Markowicz, 2017b).

Hypothesis 4 (H4): *The decline in share prices of listed companies during pandemic waves is influenced by their time in the stock exchange.*

These hypotheses are verified by estimating the two models: model (1) for the first wave of the pandemic (I stage) and model (2) for the second wave of the pandemic (II stage). We carry out the research in two stages:

- I stage – analysis of the decline in share prices during the first wave of the pandemic; observation period Jan 1, 2020 – Mar 31, 2020,

Risk of Decline in Share Prices of Energy and Fuel Sector on the Warsaw Stock Exchange During the Two Waves of the COVID-19 Pandemic

982

- II stage – analysis of the decline in share prices during the second wave of the pandemic; observation period Mar 12, 2020 – Dec 31, 2020.

The first case in Poland was recorded as late as 4 March, 2020. However, the economic situation and, above all, investors' moods are always affected by the global situation. This is always the case during the crises. One week passed between the first case in Poland and the official WHO announcement about the state of the pandemic (11 March 2020). Among the companies listed on the Warsaw Stock Exchange there are companies with foreign capital of international range. Poland is a member of the EU, so its economy is primarily affected by what happens around the world and especially in Europe. Hence, we decided to include the entire 1st quarter of 2020 in the study and take this period as the 1st wave of the pandemic.

The study covers 417 companies listed in the first period and 409 companies listed in the second period (8 companies were withdrawn after the first wave) on the Warsaw Stock Exchange (Poland). Of these, 24 are classified as energy and fuel companies. The observation relates to two periods in which the WIG stock index declined. These periods are correlated with COVID-19 pandemic waves in Poland (Figure 1). The WIG index declined from its maximum value by 37.30% in the first period and by 16.62% in the second period (Figure 2).

Figure 1. *New cases and new deaths of COVID-19 in Poland in the period Mar. 4th, 2020 – Jul. 22nd, 2021*
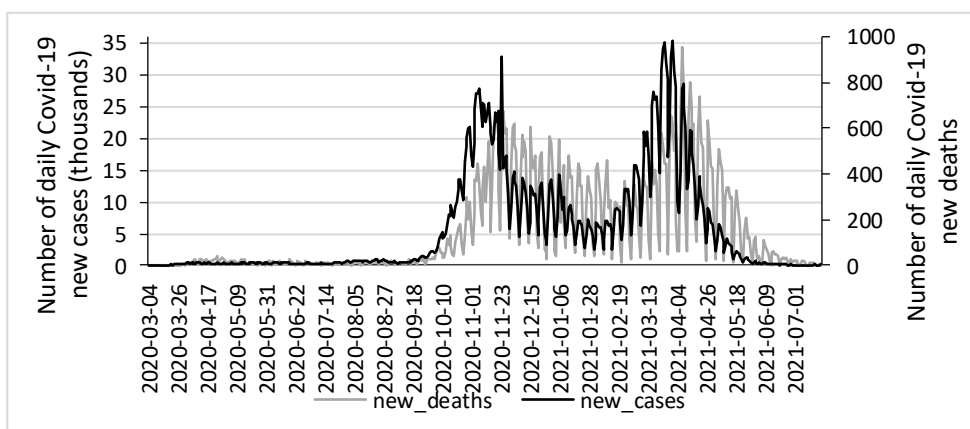
Source: Own elaboration based on data from Our Word in Data. Available online: https://ourworldindata.org/covid-cases (accessed on 19.07.2021).

During the periods of decline of the overall WIG index, the energy and fuel sector indices, or WIG-energy, WIG-oil&gas and WIG-mining also declined, what is presented in Table 1.

Figure 2. *WIG index (the Warsaw Stock Exchange, Poland) in the period Jan 2, 2020 – Jun 30, 2021*
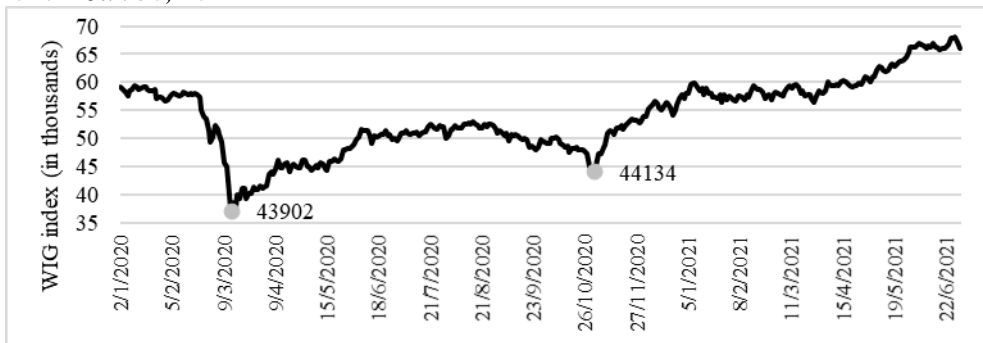
Source: *Own elaboration based on data from Stooq. Available online: https://stooq.pl (accessed on 19 July 2021).*

Table 1. *Changes of the WIG sector indices in first and second waves of the COVID-19 pandemic in 2020; the Warsaw Stock Exchange (Poland)*

WIG	First wave Percentage change	Second wave Percentage change
WIG-energy	−37.81%	−37.26%
WIG-oil&gas	−33.00%	−38.76%
WIG-mining	−38.09%	−15.37%

Source: *Own study.*

It turns out that the situation on the stock exchange in subsequent waves of the pandemic was not the same. The decline in the WIG index indicates a greater reaction during the first wave (down 37.30%) than the second (down 16.62%). This was undoubtedly influenced by investors' experience. The first examined period was the beginning of the pandemic in Poland and worldwide. This phenomenon was associated with the lack of knowledge, lack of prospects for the end of the health and economic crisis and high uncertainty. During the second wave of the pandemic, the doctors, politicians, economists, and investors already had greater access to knowledge, tools to limit the spread of the SARS-CoV-2 virus, and economic support tools, which to some extent facilitated investment in the stock market.

However, the energy and fuel sector concern a specific activity. Of particular importance was the restriction of air and road transport (travel ban) and the restriction of production (lack of demand, workers' illness). This situation also undoubtedly has an impact on the stock market risk of listed companies. Therefore, the decline in the WIG value of energy companies in both periods was similar, and of fuel companies even greater.

In the study, we assume a decline in the value of the overall WIG index as a threshold. The reasonable initial point is the maximum share price in each of the examined periods. And then we determine its decrease. If a company achieves a

Risk of Decline in Share Prices of Energy and Fuel Sector on the Warsaw Stock Exchange During the Two Waves of the COVID-19 Pandemic

984

share price decline of 37.30% in the first stage or 16.62% in the second stage, we consider it to have experienced a share price decline. The results of the study are to indicate the impact of specific variables on the risk of stock price decline in the stock market. The dependent variable in the model is dichotomous and has been coded as 1 if the company achieves an assumed decline in share prices and 0 if no such decline has occurred. We adopt the following explanatory variables:

- COM – companies (energy and fuel companies/other),
- DEC – decline in first waves (by the threshold value),
- MV – market value (million PLN),
- TSE – time on the stock exchange (years),
- SEC – macrosectors of companies listed on the WSE.

The first two variables (COM and DEC) are qualitative and dichotomous (0-1). On the other hand, the next two variables (MV and TSE) are quantitative. The last variable (SEC) is qualitative and polytomous (1-8). The proposed model can use variables measured on different scales (nominal, ordinal, interval, ratio). The variables MV and TSE are expressed on the ratio scale, or the strongest one. However, replacing such a variable by several variables (dummy variables) and thus weakening the measurement scale gives good results for modelling and interpreting the results (Wiśniewski, 2013; Markowicz, 2015). Therefore, each quantitative variable was divided into four intervals (k), and at the same time for three (k–1) dichotomous variables (0-1). The qualitative variable SEC (8 states) was divided into 7 dichotomous variables. The coding of all explanatory variables is shown in Table 2.

Table 2. *Variables used in the study (coding of variables)*

Variable	Description
COM	1 for the energy and fuel companies, 0 otherwise
DEC	1 for the decline in share prices in the first wave of the pandemic, 0 otherwise
MV2	1 for the market value from 100-500 (million PLN), 0 otherwise
MV3	1 for the market value from 500-10000 (million PLN), 0 otherwise
MV4	1 for the market value over 10000 (million PLN), 0 otherwise
TSE2	1 for the time on the stock exchange from 5-10 (years), 0 otherwise
TSE3	1 for the time on the stock exchange from 10-20 (years), 0 otherwise
TSE4	1 for the time on the stock exchange over 20 (years), 0 otherwise
SEC1	1 for oil and energy, 0 – otherwise
SEC2	1 for chemicals and materials, 0 – otherwise
SEC3	1 for consumer goods, 0 – otherwise
SEC4	1 for financials, 0 – otherwise
SEC5	1 for trade and services, 0 – otherwise
SEC6	1 for health care, 0 – otherwise
SEC7	1 for industrials, 0 – otherwise

Source: Own study.

The continuous original variable MV (market value in million PLN) is included in the model as MV2, MV3 and MV4. The reference group is MV1, i.e., the market

value of a listed company up to 100 million PLN. Also, the continuous original variable TSE (time on the stock exchange in years) is included in the model as TSE2, TSE3 and TSE4. In this case the reference group is TSE1, i.e., the time of presence on the stock exchange of a listed company up to 5 years. For the variable SEC (macrosectors), the reference group is SEC8, technologies. The variables SEC1, SEC2, SEC3, SEC4, SEC5, SEC6, SEC7 are included in the models.

During the first wave of the pandemic, 417 companies are analysed, of which 223 companies experience a decline in share prices (by the threshold value). During the second wave, 409 companies are analysed, and 350 companies experience a decline in price. The number of companies in each subgroup is presented in Table 3. We calculate basic descriptive statistics for subgroups created by creating dummy variables (Table 4). Companies in subgroups according to time on the stock exchange (TSE – in years) are not much differentiated, and means and medians have similar values. On the other hand, subgroups for the variable market value (MV – in million PLN) are characterised by greater diversity.

Table 3. *Number of listed companies in subgroups*

Variable	Number of listed companies	
	First wave	Second wave
MV1 (market value up to 100 million PLN)	154	148
MV2 (market value from 100-500 million PLN)	124	123
MV3 (market value from 500-10000 million PLN)	116	115
MV4 (market value over 10000 million PLN)	23	23
TSE1 (time on the stock exchange up to 5 years)	34	32
TSE2 (time on the stock exchange from 5-10 years)	109	107
TSE3 (time on the stock exchange from 10-20 years)	186	183
TSE4 (time on the stock exchange over 20 years)	88	87
SEC1 (macrosector: oil and energy)	20	20
SEC2 (macrosector: chemicals and materials)	35	35
SEC3 (macrosector: consumer goods)	53	52
SEC4 (macrosector: (financials)	95	95
SEC5 (macrosector: (trade and services)	49	45
SEC6 (macrosector: health care)	27	27
SEC7 (macrosector: industrials)	102	101
SEC8 (macrosector: technologies)	36	34

Source: *Own study*

Table 4. *Basic descriptive statistics for subgroups MV and TSE*

Variable	Mean	Median	Standard Deviation	Coefficient of Variation
MV1	45.60	43.60	27.33	59.93
MV2	241.67	207.74	117.14	48.47
MV3	2146.51	1169.94	2053.63	95.67
MV4	49758.47	28627.68	54167.75	108.86
TSE1	3.56	3.83	1.09	30.56
TSE2	8.07	8.25	1.44	17.83

Risk of Decline in Share Prices of Energy and Fuel Sector on the Warsaw Stock Exchange During the Two Waves of the COVID-19 Pandemic

986

| TSE3 | 13.74 | 13.33 | 2.24 | 16.32 |
| TSE4 | 23.58 | 23.50 | 1.94 | 8.21 |

Source: *Own study*

In this study, we use the logistic regression model, which belongs to the group of probability models, for data analysis. The logistic function was first used in the 19th century to describe the population growth and to describe the course of autocatalytic chemical reactions. Pioneers in this field were Verhulst (1838) and Pearl and Reed (1920), who completely developed the form of the logistic curve and applied it in practice. Nowadays, logistic regression is commonly used to describe phenomena in medicine, epidemiology, social sciences and economics, including finance (Markowicz, 2012; Zanka, 2020).

The logistic function is of the form (Cramer 2002):

$$P(Z) = \frac{\exp Z}{1 + \exp Z} \tag{1}$$

where: Z is a real number, and $P(Z)$ rises monotonically between the bounds and 1.

Logistic regression is used when the dependent variable Y is defined on a dichotomous scale, that is, it takes only two values. The model can then be written as follows (Kleinbaum and Klein, 2010):

$$P(Y = 1|X) = \frac{\exp(\alpha_0 + \sum_{i=1}^{n} \alpha_i X_i)}{1 + \exp(\alpha_0 + \sum_{i=1}^{n} \alpha_i X_i)} \tag{2}$$

where: $P(Y = 1|X)$ – conditional probability of the occurrence of an event,
    Y – dichotomous dependent variable,
    $X = [x_1, x_2, \ldots, x_n]$ – vector of independent variables,
    $\alpha_1, \alpha_2, \ldots, \alpha_n$ – model coefficients,
    α_0 – intercept.

The parameters of the logit model $\alpha_0, \alpha_1, \alpha_2, \ldots, \alpha_n$ are generally estimated using the maximum likelihood (ML) method, by maximising the natural logarithm of the likelihood function. When the dependent variable is multinomial or ordinal, multinomial or ordinal logit models may be used. Logit models perform not only the analytical and descriptive function of econometric models, but also a diagnostic and forecasting function. Independent variables in logistic regression analysis can be measured on the following scales: nominal, ordinal, interval, or ratio. In the case of nominal and ordinal variables they should be recoded. The most used is coding for the number of zero-one variables the same or by 1 less than the number of categories in its definition. If the survey requires it, other coding methods may also be used (Kleinbaum and Klein, 2010).

The notation $p = P(Y = 1|X_1, X_2, \ldots, X_k)$ defines the conditional probability of occurrence of a specific event. Depending on the analysed phenomenon, it may be a success or failure The expression $\frac{p}{1-p}$ is called the odds of occurrence of an event (Agresti, 2007). If the analysed event is an undesirable phenomenon (death, collapse of a company, fall in share prices), we use the term risk instead of chance. We write the expression $\ln\left(\frac{p}{1-p}\right)$ as logit(p) and use it in the notation of the logit model (Kleinbaum and Klein, 2010):

$$\text{logit}(p) = \ln\left(\frac{p}{1-p}\right) = \alpha_0 + \sum_{i=1}^{k} \alpha_i X_i \qquad (3)$$

where: $p = P(Y = 1|\mathbf{X})$ – conditional probability of the occurrence of an event,
$\mathbf{X} = [x_1, x_2, \ldots, x_n]$ – vector of independent variables,
Y – dichotomous dependent variable,
$\alpha_1, \alpha_2, \ldots, \alpha_n$ – model coefficients,
α_0 – intercept.

This method of transformation reduces the logistic regression model to a linear form. The term "logit" first appeared in the work of the American scientist Berkson (1994) on the description of biological experiments. By transformation (3), we can transform model (2) into a linear form, and the scale from 0 to 1 – into the scale from $-\infty$ to $+\infty$. This transformation has led to logistic regression being increasingly used in the statistical research. The most commonly used interpretation is the odds ratio (OR) defined by the formula (Cramer, 2002):

$$OR = \exp(\beta_i) \text{ for } i \in \{1, 2, \ldots, n\} \qquad (4)$$

Expression (4) describes the chance of an event occurring for individuals in group number i ($i \in \{1, 2, \ldots, n\}$) relative to the chance of an event occurring for individuals in the reference group. This is therefore the relative chance of the occurrence of an event. In the case of the intercept parameter α_0, the expression $\exp(\alpha_0)$ represents the chance of the occurrence of the analysed event for the units in the reference group.

4. Results

We conduct the research in two stages. In the first one, we build two logit models: model (1) and model (2). To assess the risk of decline in share prices of companies during the first wave of the pandemic, we use a logit model (1) with 7 explanatory variables: COM, MV2, MV3, MV4, TSE2, TSE3, TSE4. To assess the decline in share prices of companies during the second wave of the pandemic in model (2), we include an additional eighth variable DEC. We perform the calculations in the Statistica software.

Risk of Decline in Share Prices of Energy and Fuel Sector on the Warsaw Stock Exchange During the Two Waves of the COVID-19 Pandemic

988

In each step of the study, the first step is to estimate the parameters of the model with all variables. We then apply the backward stepwise method to remove statistically insignificant variables from the model at $p = 0.1$. Two variables remain in the model (1): COM and TSE4. Also, two variables remain in the model (2): DEC and MV3. We present the results of the estimation of parameters of both models in Table 5. We use the odds ratios (OR) to interpret the results. The results show that in the first wave of the pandemic the risk of a 37.3% decline in the share prices of energy and fuel companies is 248% higher than for other companies. The companies with the longest history on the WSE (over 20 years) have a 44 percent lower risk of decline. Market value is not a differentiating factor for the risk of share price decline.

During the second wave of the pandemic, the risk of 16.67% decline in the share prices of energy and fuel companies does not differ from the other companies at the assumed significance level. The risk of decline is 177% higher for companies that experienced a 37.3% decline in the 1st wave of the pandemic. The variable MV3 is also a differentiating factor in this case. This means that the companies with a market value between PLN 500m and PLN 10,000m have a 44% lower risk of decline than the remaining companies. Time of presence on the WSE is not a differentiating factor of the risk of decline during the 2nd wave of the pandemic.

Table 5. *Estimation results of parameters of logit models of the risk of decline in stock prices of companies listed on the Warsaw Stock Exchange during the 1st and the 2nd wave of the pandemic – model(1) and model (2)*

Specification	Parameter estimators (standard errors)					
	First wave – model (1)			Second wave – model (2)		
	Original	Transformed	OR	Original	Transformed	OR
Intercept	0.0266 (0.3596)	0.2045 (0.1137)	-	1.3658** (0.5488)	1.3941*** (0.2002)	-
COM	1.2004** (0.5276)	1.2470** (0.5154)	3.48	0.1115 (0.6640)	-	-
DEC	-	-	-	1.1448*** (0.2987)	1.0204*** (0.2860)	2.77
MV2	0.4971** (0.2486)	-	-	-0.7734** (0.3773)	-	-
MV3	0.3332 (0.2544)	-	-	-1.0952*** (0.3740)	-0.6084** (0.2889)	0.54
MV4	0.2103 (0.4699)	-	-	-0.7085 (0.6441)	-	-
TSE2	-0.0239 (0.3873)	-	-	0.6777 (0.5390)	-	-
TSE3	-0.1133 (0.3653)	-	-	0.1998 (0.4970)	-	-
TSE4	-0.6638* (0.3983)	-0.6098** (0.2464)	0.54	0.7478 (0.5582)	-	-
Chi2	18.2260	13.4862	-	25.7772	17.3662	-
p	0.0110	0.0012	-	0.0012	0.0002	-
AIC	573.8407	568.5803	-	350.4105	346.8214	-

BIC	606.1054	580.6796	-	386.5339	358.8625	-
R2 Cox-Snell	0.0428	0.0318	-	0.0611	0.0416	-
R2 Nagelkerk	0.0571	0.0425	-	0.1047	0.0712	-
Log(like. ratio)	-278.9204	-281.2901	-	-166.2052	-170.4107	-

*Note: * – significance level 0.1, ** – significance level 0.05, *** – significance level 0.01.*
Source: Calculations based on the WSE data: GPW. Available online: https://www.gpw.pl (accessed on 19 June 2021).

During the first wave of the pandemic, energy and fuel companies on the Warsaw Stock Exchange were in a worse situation than companies belonging to other sectors. The introduced restrictions affected the entire economy, but the greatest uncertainty for investors concerned the energy and fuel sector. Company size did not matter. The risk of decline in share prices was similar for all adopted value ranges: MV1, MV2, MV3 and MV4. Companies listed on the stock exchange for the longest time, i.e. more than 20 years (TSE4), were in a slightly better situation. The risk of decline in their share prices was lower than in the case of companies with a shorter history of listing on the WSE (TSE1, TSE2, TSE3).

During the second wave of the pandemic, the situation was somewhat different. The sentiment of investors investing in fuel and energy companies did not differ significantly from those investing in companies from other industries. In this case, stock market seniority was not important. However, there was an increased risk of a decline in the share prices of companies that had been in a downward trend during the first wave of the pandemic. The implication is that the companies that performed well during the first wave were also well regarded by the investors during the second wave.

As a first step, we compare the prices of oil and energy companies with other ones. It is also interesting to see how they behaved in comparison with other stock market macrosectors. Hence, in the second step of the study, we analyse the eight macrosectors described by the variable SEC. Also in this case we estimate the parameters of two logit models: model (3) and model (4) with explanatory variables SEC1, SEC2, SEC3, SEC4, SEC5, SEC6, SEC7. The first of these models relates to the first wave of the pandemic, the second model describes the risk of decline in share prices during the second wave. We present the results of the estimation of parameters of both models in Table 6. In addition, Table 6 shows the odds ratios.

Table 6. *Estimation results of parameters of logit models of the risk of decline in stock prices of companies listed on the Warsaw Stock Exchange during the 1st and the 2nd wave of the pandemic – model(3) and model (4)*

Specification	First wave – model (3)		Second wave – model (4)	
	Parameter estimators (standard errors)	OR	Parameter estimators (standard errors)	OR
Intercept	-0.6931** (0.3536)		0.8755** (0.3764)	
SEC1	1.7918*** (0.6258)	6.00	0.8591 (0.7306)	2.36

Risk of Decline in Share Prices of Energy and Fuel Sector on the Warsaw Stock Exchange During the Two Waves of the COVID-19 Pandemic

990

SEC2	1.0986** (0.4940)	3.00	1.1722* (0.6511)	3.23
SEC3	0.8824** (0.4485)	2.42	0.8293 (0.5380)	2.29
SEC4	0.8408** (0.4091)	2.32	1.2646** (0.5034)	3.54
SEC5	0.9808** (0.4564)	2.67	1.2040** (0.6055)	3.33
SEC6	1.0678** (0.5276)	2.91	0.3773 (0.5966)	1.46
SEC7	0.6931* (0.4052)	2.00	0.5868 (0.4544)	1.80
Chi2	6.6627		4.7819	
p	0.0098		0.0288	
AIC	573.4036		357.405	
BIC	581.4698		365.4327	
R2 Coxa-Snella	0.0159		0.0116	
R2 Nagelkerka	0.0212		0.0199	
Log (like. ratio)	-284.7018		-176.7027	

Note: *– significance level 0.1, ** – significance level 0.05, *** – significance level 0.01.*
Source: *Calculations based on the WSE data: GPW. Available online: https://www.gpw.pl (accessed on 19 June 2021).*

The results presented in Table 6 show that during the first wave of the pandemic the lowest risk of falling prices characterised the macrosector taken as reference, i.e. technologies. All other macrosectors were characterised by higher risk, with the risk in the case of oil and energy companies being as much as 6 times higher (the highest), and in the case of companies belonging to the chemicals and materials macrosector being 3 times higher than in the case of the technologies macrosector. During the second wave of the pandemic, the situation was somewhat different.

Lack of significance (at the assumed level of $p = 0.05$) for five variables indicates similarity of risk of decline in share prices of companies from six macrosectors (including the oil and energy macrosector). The higher risk was observed only in the following macrosectors: financials and trade and services. The prolonged epidemic situation resulted in the credit default of many companies and households. State aid was limited and targeted at the survival of companies rather than debt settlement. This caused some imbalances in the banking and insurance markets. The greater risk of decline in the share prices of companies belonging to the trade and services macro-sector was due to the reduced demand for goods and services during the pandemic by both households and companies and was caused by their worse financial situation.

5. Discussion

To the authors' knowledge, no analysis comparing the two pandemic waves in relation to the Warsaw Stock Exchange using logit models has appeared so far. Therefore, it is difficult for us to refer to the results of the same analyses. We have

therefore referred to similar studies conducted using other methods. The analysis confirms the results obtained by other researchers about the different impact of successive waves of the COVID-19 pandemic on the socio-economic situation. The way the virus spreads means that different countries experience successive waves at different times. The impact of the pandemic is felt differently by each country depending on its level of socio-economic development and its economic links with other countries. It all depends on how the virus spreads and how governments react.

After the first wave of the pandemic, countries prepared to mitigate the course of subsequent waves (Liu *et al*., 2020). The results obtained for the first wave of the pandemic are in line with the authors' earlier studies on the intensity of share price decline of companies listed on the Warsaw Stock Exchange. The application of survival analysis methods showed that the intensity of share price decline in oil and energy companies was higher than for other sectors (Bieszk-Stolorz and Markowicz, 2021).

Research on the second wave of the pandemic confirms that its impact on the energy sector was less than that of the first wave. This is also consistent with the results of our study. Li *et al.* (2021) analyse the empirical link between COVID-19 fear and stock market volatility. They show the existence in the first phase of the pandemic of a long-term relationship between stock market performance and cumulative daily COVID-19 cases and deaths worldwide. Smaller effects of the economic impact of successive waves of the pandemic are evident in various economic areas. In the second wave of COVID-19, despite the relaxation of general quarantine restrictions, the correlation remained. Based on their research, they suggest investing not in the stock market but in the gold market, which, according to them, seems to be more stable.

Ahmed *et al.* (2021) analyse the impact of the COVID-19 on Indian stock and commodity markets during the first and second waves of the pandemic. Layoffs, company and production closures hurt profitability in most sectors of the economy, including tourism, real estate, aviation, among others. Low profitability and insufficient demand, combined with uncertainty, cause the stock market to plummet during the first wave of the pandemic. As people adapt to the pandemic, the stock market becomes more stable, despite the increase in the number of cases. Government measures that reduce the impact of the pandemic such as the COVID-19 have a positive impact on stock returns. This is particularly evident in the second wave. Central banks around the world are also trying to mitigate the negative impact of the COVID-19 pandemic on financial markets by introducing temporary financial measures. All these cumulative actions during the second wave are causing a recovery in the stock markets.

The impact of the pandemic on different sectors of the economy varied. Reducing commuting to work or school has on the one hand positive effects such as improved air quality, reduced traffic and accidents, reduced fossil fuel consumption. However,

Risk of Decline in Share Prices of Energy and Fuel Sector on the Warsaw Stock Exchange During the Two Waves of the COVID-19 Pandemic

992

on the other hand, it causes a decrease in the demand for fuels, which is a problem for fuel trading companies. The closure of borders has resulted in a drastic reduction in tourism and restrictions on foreign trade. Road and sea freight transport has declined. This has had a direct impact on aviation fuel, petrol and diesel consumption. It is not insignificant that increased unemployment and production stoppages have reduced the income of the population. This also affected the lower demand for electricity, gas and fuel oil. Consumption has decreased significantly, which in turn has reduced the production of consumer goods. The reduction in production has affected the lower energy demand by manufacturing companies.

Energy consumption has also been affected by the introduction of remote working – mostly from home. However, as mentioned earlier, the increase in household energy consumption could not compensate for the reduction in industrial, commercial and service activities. Due to limited revenues, spending on innovation in the energy and fuel industry also decreases.

The aim of the research conducted by Duttilo *et al.* (2020) is the examination of the impact of the two waves of COVID-19 infections on the return and volatility of the stock market indices of the euro area countries. Their results indicate that equity markets in the euro area are reacting differently to the COVID-19 pandemic. The first wave of the COVID-19 infection has a significant impact on the volatility (a measure of risk) of the equity market of euro area countries with medium and large financial centres (the Netherlands, Austria, Belgium, France, Germany, Italy, Spain, Ireland, Finland), while the second wave has a significant impact only on Belgian equity market volatility. Thus, almost all euro area countries show a weakening effect of the COVID-19 on volatility as the crisis unfolds.

6. Conclusions

The COVID-19 pandemic is currently an undoubted factor affecting the socio-economic situation of individual countries, but also the world as a whole. It also obviously has an impact on the stock market risk of listed companies. Therefore, the reaction to the unexpected factor is visible on the financial markets. According to numerous studies, a decline in share prices of companies appeared on stock exchanges, also in Poland, with each subsequent wave of the pandemic. The studies show, however, that this reaction is getting weaker with each subsequent wave of the disease. This is influenced by the experience gained by investors, support from central banks and governments, and growing optimism about the prospects for combating the epidemic.

However, share price declines in listed companies have occurred as a result of both pandemic waves. The aim of this research is to identify the characteristics of companies that influenced the fact that share prices fell below a certain level during the second wave of the pandemic. We focus particularly on energy and fuel companies, due to their high economic importance. As a result of modelling the risk

of falling share prices, we verify the four hypotheses initially set out. We obtain the following conclusions regarding each of them.

We verify the hypothesis H1 positively for the first pandemic wave. The risk of decline in share prices of oil and energy companies is 248% higher than that of other companies and as much as 6 times higher than the best performing technologies macrosector. However, for the second wave the parameter standing next to the COM variable is statistically insignificant (no significant differences in the reaction of fuel and energy companies and other companies). The analysis extended to individual macrosectors allows us to distinguish trade and services and financials as those with the highest risk of decline. In the case of the remaining macrosectors (including oil and energy) the lack of significance of the parameters did not allow us to reject the hypothesis of the same risk of decline in share prices.

We verify hypothesis H2 positively. The risk of price decline in the second wave of the pandemic is 177% higher for companies that experienced price decline in the 1st wave of the pandemic. We confirm hypothesis H3 only for the second wave of the pandemic. Market value is a differentiating factor for the risk of decline in share prices only in the second wave of the pandemic (MV3). Companies with a market value between PLN 500m and PLN 10000m have a 44% lower downside risk than other companies. We confirm hypothesis H4 for the first wave of the pandemic, during which the longest-established companies on the WSE (more than 20 years) have a 44% lower downside risk than other companies. This experience of companies is important for the investors.

The prices of companies on the stock market are affected by both their financial condition and investor sentiment. On the basis of the study we make a theoretical conclusion. The first wave of the pandemic caused panic on the stock market. It was a completely new factor disrupting the economy. During the second wave of the pandemic, morbidity and mortality rates were much higher, but the experience gained earlier had a dampening effect on stock market reactions. This is the result of 'learning' by market participants.

Other conclusions from the research, resulting from the verification of the assumed hypotheses, have a practical character and may guide the decisions made by both investors and company managers. We plan to continue the research presented in the article. It may be interesting to study the chances of listed companies recovering their losses after temporary difficulties related to pandemic waves.

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994

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During the Two Waves of the COVID-19 Pandemic

996

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