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Decline in Share Prices of Energy and Fuel Companies on the Warsaw Stock Exchange as a Reaction to the COVID-19 Pandemic

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Abstract: Many factors influence the prices of energy commodities and the value of energy and fuel companies. Among them there are the following factors: economic, social, environmental and political, and recently also the COVID-19 pandemic. The aim of the paper is to examine what the probability and intensity of a decrease in the prices of shares of energy and fuel companies listed on the Warsaw Stock Exchange (Poland) was during the first wave of the pandemic in the first quarter of 2020. The study used the survival analysis methods: the Kaplan-Meier estimator, the test of equality of duration curves and the Cox non-proportional hazards model. The analysis showed that the probability and intensity of price decline of energy and fuel companies in the initial period was the same as that of other companies. The differences become apparent only after 50 days from the established maximum of their value. The risk of price declines in energy and fuel companies increased significantly. This situation was related both to a temporary reduction in demand for energy and fuels, pandemic restrictions introduced in individual countries and the behaviour of stock market investors.

Keywords: energy sector; fuels sector; modelling the risk of decline in share prices; survival analysis

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1. Introduction

Access to energy is a key element in economic and social development. It contributes to improving the quality of life of the population. The energy sector is considered an essential factor in the economic development of the country. Energy as a force for sustainable development—economically viable, need-oriented, self-reliant and environmentally-friendly—is gaining importance [1]. Thus, the energy and fuel sector is constantly transforming and must be adapted to changing economic conditions. On the other hand, changes in energy affect the lives of people: agriculture, industry, transportation, weapons, communication, economics, urbanization, quality of life, politics, and the environment [2]. Avtar et al. [3] write about energy expansion, energy security, increasing energy generation capacity, and the links between the energy industry, urbanisation, and society.

The energy sector is constantly changing and the management of companies must adapt to the changing environment [4,5]. The effect of the globalisation of trade and finance is a significant increase in global production. This increase in production and population growth are linked to an increase in the demand for energy [6]. The literature stresses that the increasing energy needs correlate with such problems as economic sustainability, social development, environmental sustainability [7,8], as well as health problems of the population [9].

The survival and growth of energy companies depends on many different factors, e.g., on the development of the renewable energy [10–13], climate policy [14], corporate social responsibility [15,16], or the monetary policy pursued by individual countries [17,18]. New customer preferences are increasingly cited among the factors influencing the operation and profitability of businesses. These are related to the conscious need to care for the natural environment [19–23].

Global economic developments over the past 20 years, emerging technological advances and economic, geopolitical and environmental events have resulted in a significant increase in the volatility of energy commodity prices [24]. One of such events is the emergence of the SARS-CoV-2 virus. 11 March 2020 WHO declared the COVID-19 outbreak as the global pandemic. This pandemic has hit globalised economies and energy markets with tremendous force in a short time, causing losses. The impact of the effects of the pandemic was evident in the oil futures market. The US crude oil price turned negative for the first time in history in April 2020. Oil producers paid buyers to collect their goods. Demand for crude oil had declined so much that there was concern that storage capacity would run out in May 2020. Oil companies hired tankers to store the excess supply. For example, the price of a barrel of West Texas Intermediate (WTI), the benchmark for US crude, fell as low as minus $37.63 a barrel [25]. US crude oil futures prices fell by more than 100% on 20 April 2020. The June WTI futures contract, which expired on 19 May, fell about 18% to settle at $20.43 per barrel. The July contract was roughly 11% lower at $26.18 per barrel [26]. The risk of loss associated with commodity trading can depend on economic, political and market conditions. Commodity prices are inherently volatile as they react quickly to a range of unpredictable factors, including labour strikes, weather conditions, exchange rates, speculation, inflation and now the pandemic situation [27]. It is important to understand and analyse the impact of COVID-19 on the economy. Such an analysis can help investors better cope with the surge in financial systemic risk but can also provide some basic ideas for handling similar events in the future. The lockdown, social restrictions, travel ban, unemployment and remote working have forced most people to stay at home, affecting the normal functioning of business and reducing demand for energy and fuel. In particular, the pandemic could threaten labour markets, global supply chains, affect consumption behaviour, all of which have an impact on the global economy. One of the most important elements is certainly the stock market [28,29]. Given slower economic growth rates and lack of capital inflows, emerging markets, including Poland, have relatively limited resources to deal with the impact of the pandemic and are therefore expected to suffer the most [30].

The aim of the paper is to examine what the probability and intensity of a decrease in the prices of shares of energy and fuel companies listed on the Warsaw Stock Exchange (Poland) during the first wave of the pandemic in the first quarter of 2020. The significance of the conducted research is manifested in the analysis of the reaction of the energy and fuel market to the crisis situation. The Covid-19 pandemic is an exceptional situation, resulting from a health threat, but significantly affecting the economic situation of companies and economies of countries and the world. We use the non-parametric and semiparametric methods of survival analysis, which are less commonly used in the capital market. Their advantage is the inclusion in the analysis of companies that do not experience a significant decline in share prices during the analysed period. We put forward the following research hypothesis:

Hypothesis: *The risk of decline in share prices of energy and fuel companies during the first wave of the pandemic on the Warsaw Stock Exchange (Poland) was greater than for companies in other sectors.*

We verify the hypothesis by using the survival analysis methods. They allow to include the censored observations, i.e., companies that do not experience a significant price decline in the analysed period.

We organise the manuscript as follows: in Section 2 (Literature Review), we present the current research on the impact of COVID-19 on the energy sector and on the capital markets. In Section 3 (Materials and Methods), we describe the data used in the research and applied research methodology: survival analysis methods. In Section 4 (Results) we present the obtained results. In Section 5 (Discussion) we discuss them in light of previous studies in this field. In the last section (Conclusions), we give the findings and present directions for future research.

2. Literature Review

For the moment, the pandemic is the most important challenge facing societies. The first wave had a major impact on the world economy. The scope of this impact was very wide, e.g., poverty [31], food purchasing behaviour [32], increase in food prices [33], decline in sales of goods and services [34]. The supply of electricity during such a difficult period is an essential service and of course interruptions cannot be allowed [35]. Many studies have addressed the impact of the pandemic on the energy consumption patterns [36,37] and changes in the energy mix [38,39].

In analyses related to the economic and financial impact of COVID-19, a strand of research on the impact of COVID-19 on the energy market has emerged. Shaikh [40] models the volatility of energy markets and shows the impact of different phases of the pandemic on these markets. He shows that information about the number of deaths during the pandemic negatively affects the stock and energy futures markets. The WTI oil market is characterised by an unprecedented overreaction in the face of a pandemic outbreak and recorded extreme levels of volatility. The increasing number of COVID-19 infections affects investor sentiment, with market participants concerned about protecting their energy investments. Elevated levels of volatility in the energy markets indicate a shortage of futures and options lines in the energy market segment. Navon et al. [41] states that the COVID-19 pandemic not only represents a global health crisis but may also be the sign of a new era of economic activity, the potential consequences of which we currently do not fully understand. They ask the questions: how will the pandemic affect the integration of renewable energy sources and should current plans for power system expansion be changed? The energy industry as a whole has responded to the pandemic very quickly and effectively.

Rajput et al. [42] give an indicative review of the current and likely impacts of the COVID-19 that may be seen in time to come. The sudden outbreak of the COVID-19 pandemic caused global declines in the commodity process. This has mainly affected demand, as well as the supply of commodities. The oil market was severely affected by the collapse in demand, mainly due to travel restrictions which also caused a sharp decline in oil prices. Currently, demand for fuels has fallen to unprecedented levels, with jet fuel demand being the most affected [43]. The prices of precious metals and industrial metals also declined, although the decline was smaller than in the case of oil prices. The least affected by the pandemic was the agricultural sector.

The researchers stress that the impact of the pandemic varied across regions and countries. This is related to the different degree of spread of the pandemic, but also to the different role of the analysed areas in the energy market. Nyga-Łukaszewska and Aruga [44] study the impact of the pandemic on oil and gas prices in the United States and Japan. In the USA, the COVID-19 pandemic has a significantly negative effect on the oil price, while it has a positive effect on the gas price. In Japan, this negative impact is only visible in the oil market with a two-day lag.

Other global and local factors also influence the demand for and supply of energy commodities and the health of energy and fuel companies. Not all changes occurring in the energy market are due to the pandemic. As Cohen [45] points out, the "oil price war" between Saudi Arabia and Russia also contributed to the decline and destabilisation of oil prices in the first half of 2020 [46]. In commodity-dependent developing countries, the crisis caused by the COVID-19 revealed structural weaknesses [47,48]. It is not irrelevant whether a country is only a consumer or a consumer and producer (exporter) of fuel and energy commodities [44].

According to Pardal et al. [49], the COVID-19 pandemic has a strong impact on the economy and the capital market. In times of crisis, it is important for investors to be able to diversify their investment portfolio to reduce risk. However, research suggests a very significant level of integration that reduces the chances of portfolio diversification in the long term.

Shehzad et al. [50] show that the COVID-19 and the accompanying lockdown affect crude oil (WTI) prices more than the Dow Jones index. The COVID-19 negatively affects investors' ability to determine the optimal portfolios and thus the stability of financial and energy markets more than the global financial crisis of 2007–2009.

Gunay et al. [51] study the influence of the first wave of the COVID-19 pandemic on various sectors of the Australian stock market. They show that there are three sectors mainly affected by the pandemic: consumer goods, industrials and real estate. They take the company size into account. Their main findings are that the small companies, belonging to the energy sector show a gradual deterioration. On the other hand, small companies belonging to the consumer sector experience the greatest positive impact of the COVID-19. Ahmed et al. [52] analyse the impact of the pandemic on the Indian stock and commodity markets during the different phases of lockdown and first and second waves of the COVID-19. They confirm that the pandemic has a significant and negative impact on stock market quotations and oil prices in India and selected South Asian countries. However, this impact diminishes in the second wave of the pandemic's spread.

Elavarasan et al. [53] analyse the impact of the COVID-19 pandemic on the electricity sector in India and in selected countries around the world. They point out that the pandemic changes lifestyles globally. People mostly stay at home and also work from there. Consequently, there is a significant increase in residential electricity demand with a significant decrease in commercial and industrial loads. However, the overall balance of electricity demand is negative. A sharp decline in the demand for energy is observed in March 2020. This decline is greater in countries that are particularly hard hit by the pandemic during this period. In Europe, this is France, Italy, Spain and Portugal, and among non-European countries, India.

The aim of the study conducted by Dias et al. [54] is to analyse the efficiency of the capital market, in its weak form. They use the data on selected European stock indices (BEL 20, CAC 40, DAX 30, FTSE Athex 20, IBEX 35, ISEQ, PSI 20), American DOW JONES and Chinese SSE from the period of the first wave of the pandemic. The authors show that the equity markets tend to overreact to data and information in the short term, whereby these reactions may have been the result of uncertainty familiar to investors during the global epidemic. This situation is important for investors because it means that the rates of return can be partially predicted, which creates opportunities for arbitrage operations.

An interesting research is conducted by Hammoudeh et al. [55]. Their findings show that during and before the pandemic, oil returns cause renewable equity index returns during normal market conditions, but this is not the case during extreme market conditions. During the COVID-19 pandemic, the findings suggest the absence of significant causal relationships between the oil price and the renewable energy stocks. For their research they used the NASDAQ OMX Green Economy Index, or a proxy of the renewable energy sector. According to the authors, the lack of causality at the extreme conditions of the renewable energy market indicates that investors benefit greatly from mixing oil prices and renewable energy stocks in their portfolios.

Methods of the survival analysis have also appeared in the analysis of energy related topics. Most often, it is related to the original application of these methods, i.e., the analysis of the reliability of the operation of machinery and equipment. Ozturk et al. [56] present a novel application of the survival analysis to study the reliability of wind turbines. In their study, they consider the occurrence of previous failures and the history of scheduled maintenance. The authors investigate the operational, climatic and geographical factors that affect wind turbine failure and model the risk rate of wind turbine failure based on data from 109 turbines in Germany. The survival analysis is shown to be a useful tool to guide the reduction of operation and maintenance costs of wind turbines. Kim et al. [57] apply the survival analysis to the actual unit level power generation data in Korea. They estimate the relationship between the preventive maintenance and the facility reliability.

They show that planned outage for maintenance, preventive maintenance cost, reserve margin, and use rate, lead to the longer duration of generators. In turn, it causes the lower forced outage rates.

A common phenomenon in stock markets is periodic elevated volatility of returns. This phenomenon is quite well documented in numerous studies. Grabowski [58] using GARCH models described the increase in uncertainty on stock markets in Warsaw (Poland), Prague (Czech Republic) and Budapest (Hungary) and compares the reactions on these stock exchanges with stock exchanges of other countries. The author points out that volatility is a common phenomenon for national stock exchanges in certain situations—e.g., the global financial crisis (2008–2009), the eurozone crisis (2011–2012), the COVID-19 health crisis (2020). The application of the GARCH model allows for the conclusion that shocks arising in the Polish stock market have a fairly permanent effect on the volatility of return rates. The conclusion of the research is that the time series of the stock market index in Poland are generated by stochastic processes integrated to the first degree. Analysing the structural changes in the variance of the rates of return, we can distinguish unstable sub-periods related to crises and reactions to them. Also, Samadder and Bhunia use the GARCH model in stock market time series analysis [59]. They study the impact of a 2020 pandemic on forty-five of the world's largest stock markets. It turns out that the global stock market volatility is in most cases (also in Poland) and negative information affects the stock market more than positive information. They also present research results on the links and volatility responses between energy markets (oil and gas) and stock market indices. Such a study looks, for example, at the period following the 2008 global financial crisis in five developed economies (France, UK, Japan, US, Germany) [60]. The obtained results confirm that there is a strong relationship between the energy markets and the developed stock markets in the long term. Each stock market index shows high resilience to the long-term volatility responses of each energy commodity. The results of the GARCH models indicate that the long-term volatility memory of the stock markets is highly persistent against the shocks of crude oil price.

There have also been studies on the application of the survival analysis methods in the analysis of the impact of the COVID-19 on global stock markets. Bieszk-Stolorz and Dmytrów [61] assessed the strength of the response of global stock markets to the SARS-CoV-2 coronavirus pandemic in 2019–2020. They analyse the risk and intensity of the decline in the values of the stock indices using selected survival analysis methods. They show that the intensity and risk of decline of stock indices varied by the continent. The intensity of decline was the highest in the fourth and eighth week after the peak and was the highest in the European stock markets, followed by the US and Asian stock markets (including Australia). The risk of decline in stock index prices was the highest in America, followed by Europe, Asia and Australia, and the lowest in Africa. Bieszk-Stolorz and Dmytrów [62] used the methods of the survival analysis in the research of the intensity and the chance of increase in the value of indices after the first wave of the pandemic. Also in this case, they observed differences depending on the continent. The intensity of increase is the highest in the fourth and eleventh week after the minimum is reached. It is the highest in America and the lowest in Africa. For Europe and Asia, the intensities of increase are not significantly different from each other. The highest growth chance occurred in the American stock markets, followed by the European and Asian stock markets (including Australia and Oceania), and the lowest in the African stock markets. The increase in the value of stock indices is faster than the initial decline.

3. Materials and Methods

3.1. Methods

The study uses the survival analysis methods. They are increasingly used in the economic sciences, including finance. The advantage of these methods is that the data can be either complete or incomplete. One of the causes of incomplete data is the phenomenon of censoring units, which involves their elimination from the field of observation. When tracing a set of objects, units may appear, accompanied by an event that terminates their observation. There may also be units for which such an event will not occur until the end of the observation process. In this second situation we call these units censored. Censoring may take place with respect to time (time censoring) or with respect to the end of the study within a certain time period. Among the methods of the survival analysis we distinguish the nonparametric, semi-parametric and parametric models [63,64].

The basis for the survival analysis is the survival function defined as follows [65]:

$$S(t) = P(t > T) = 1 - F(t) \tag{1}$$

where T—duration (time in days from the share price peak to the achievement of the assumed decline) and $F(T)$—cumulative distribution function of random variable T.

The survival function denotes the probability that a certain event will not occur until at least time t. By using the Equation (1), we can determine the duration quartiles. These are moments in time for which the survival function takes values 0.75, 0.5, and 0.25. Due to the probability of censored observations, quartiles may not exist. This is because the event may not occur during the assumed observation period.

The most commonly used non-parametric estimator of the survival function is the Kaplan-Meier estimator, defined by the formula [66]:

$$\hat{S}(t_i) = \prod_{j=1}^{i} \left(1 - \frac{d_j}{n_j}\right) \text{ dla } i = 1,\ 2,\ \ldots, k, \tag{2}$$

where t_i—the point in time when at least one event occurs, $t_1 < t_2 < \cdots < t_k, t_0 = 0$ (the day on which at least one company has achieved the analysed share price decline), d_i—number of events in time t_i (the number of non-censored companies), n_i—number of units observed in time t_i, $n_i = n_{i-1} - d_{i-1} - z_{i-1}$, (the number of all observed companies) and z_i—number of censored observations in time t_i, (the number of censored companies).

We can determine the survival curve for all observations in general as well as for groups separated by unit characteristics. We can compare these curves. We can find many tests for verifying the hypothesis of the significance of differences between two survival curves. All these tests have different power. Then we verify the following null hypothesis $H_0 : S_1(t) = S_2(t)$. The alternative hypothesis may take one of the following forms: $H_1 : S_1(t) \neq S_2(t)$, $H_1 : S_1(t) > S_2(t)$ or $H_1 : S_1(t) < S_2(t)$. We have no consistent set of criteria for deciding which test is the most powerful and should be used in a given study. Some of them are more sensitive to survival curves in their initial and others in their final phase. Research by Latta [67] indicates that the power of tests also varies with the size of the sample tested, the censoring mechanism and the probability density of the hazard function. We use two tests to compare the survival curves for two groups: Gehan's generalisation of the Wilcoxon test and the log-rank test. We can use both tests when the study contains censored observations. The non-parametric Wilcoxon signed-rank test [68] is an alternative to the paired Student's t-test, when the assumption of normality of the distributions of variables in both populations is not satisfied. Gehan [69] proposed a modification of the Wilcoxon test for use in studying the duration of phenomena when censored observations usually appear in the study. The log-rank test was proposed in 1966 by Mantel [70], but its name was proposed by the Peto brothers [71]. The design of this test is based on the logarithm of the survival function.

The second important function in the survival analysis is the hazard function. It describes the intensity of occurrence of an event at time t under the condition of survival to time t and is defined as follows [65]:

$$h(t) = \lim_{\Delta t \to 0} \frac{P(t \leq T < t + \Delta t | T \geq t)}{\Delta t} \tag{3}$$

Depending on the analysed phenomenon, the hazard function allows us to assess the risk or chance of occurrence of an event at the moment t. In our analysis, this is the risk of decline in share prices.

It happens that the influence of explanatory variables on the intensity of events is not constant over the time of the observed phenomenon. In such cases, the Cox non-proportional hazards models are used to assess this influence, the general form of which is as follows:

$$h(t, X(t)) = h_0(t)\exp(\beta \times X(t)) \tag{4}$$

where t—time to an event (to an established decline in share prices), $X(t) = (X_1(t), X_2(t), \ldots, X_k(t))$—vector of explanatory variables, $h_0(t)$—base hazard, $\beta = (\beta_1, \beta_2, \ldots, \beta_k)$—vector of model parameters.

This model makes it possible to assess the intensity of the occurrence of an event at time t in a selected group in relation to the reference group. When interpreting the results, we use the hazard ratios, instead of the explicit interpretation of estimators of parameters β_i. We calculate the hazard ratios as follows: $HR = \exp(\beta_i)$.

For a single dichotomous variable X, we use the following model:

$$h(t, X) = h_0(t)\exp(\beta X + \delta X \times g(t)) \tag{5}$$

where t—time to an event (to an established decline in share prices), X—explanatory variable, β, δ—model parameters and $g(t)$—time-varying function.

We use the Heaviside functions [72] in the study:

$$g_1(t) = \begin{cases} 0 & \text{for } t < t_0 \\ 1 & \text{for } t \geq t_0 \end{cases} \tag{6}$$

$$g_2(t) = \begin{cases} 1 & \text{for } t < t_0 \\ 0 & \text{for } t \geq t_0 \end{cases} \tag{7}$$

The variable X is qualitative and indicates membership to one of the two groups of companies: energy and fuel ones (coded as 1) or others (coded as 0). The adopted method of coding allows us to determine the relative risk of decline in share prices of energy and fuel companies in relation to the remaining ones.

3.2. Dataset Analysis

To study the decline in share prices of energy and fuel companies on the Polish stock exchange, we use data on share prices of companies listed in the first quarter of 2020. The data comes from the WSE database—GPW. Available online: https://www.gpw.pl (accessed on 19 June 2021) [73]. The data include the share prices of listed companies from the quotations during the period under study. For each company, we identify the day on which the share price was at its maximum and the day on which the share price reached a 37.7% decline (explained in the next section). The time, expressed in days, between these dates is the duration (in the sense of survival analysis) for each company. It is the time until the share price decline.

We analyse 417 companies listed from 1 January 2020 to 31 March 2020 on the Warsaw Stock Exchange (Poland). Among them, 24 are classified as energy and fuel companies. The observation period covers the first wave of the Covid-19 pandemic in Poland, i.e., Q1 2020. During this period, the WIG stock market index reached its maximum value and then the value decreased by about 37.3% (Figure 1). Companies belonging to the apparel sector (−47.47%) suffered the largest share price decline in the first quarter of 2020, while those belonging to the IT sector suffered the smallest (6.04%). Sectoral indices, namely energy, fuels and mining, also declined during Q1, as shown in Table 1. This value is taken as a threshold, determining the fact that prices are declining. We investigate, which companies have a corresponding decrease in share price value. The random variable T describing the time from when the companies reach the maximum of the share price value to when the 37.3% decrease is reached. If a company does not achieve the assumed decline during the observation period, such an observation is considered as censored. It turns out that 223 companies experienced the assumed decline and 194 observations were censored.

Figure 1. The WIG Index (Warsaw Stock Exchange, Poland) in the period 16 April 2019–18 June 2021. Source: own elaboration on the basis of data from https://stooq.pl [74] (accessed on 19 June 2021).

Table 1. Changes of the sectoral WIG indices in Q1 2020 and in Q2–Q4 2020; Warsaw Stock Exchange (Poland). Source: own elaboration on the basis of data from https://www.gpw.pl [73] (accessed on 19 June 2021).

WIG	Percentage Change (Decline) I Quarter 2020	Percentage Change (Increase) II–IV Quarter 2020
WIG-energy	−37.81%	67.29%
WIG-oil & gas	−33.00%	13.96%
WIG-mining	−38.09%	194.06%
WIG-banking	−38.62%	14.70%
WIG-construction	−15.37%	89.90%
WIG-chemicals	−28.73%	28.71%
WIG-IT	−6.04%	45.06%
WIG-pharmaceuticals	−33.96%	36.44%
WIG-media	−23.13%	46.25%
WIG-automobiles & parts	−29.83%	61.10%
WIG-real estate	−23.32%	26.47%
WIG-clothes	−47.47%	73.35%
WIG-food	−18.64%	43.19%
WIG-telecom	−15.55%	32.43%

In the following three quarters of 2020, the WIG index increased by 37.00% and all sectors recorded an increase in index value. The largest increase was in the case of raw materials companies (as much as 194.06%), and the smallest for companies belonging to the oil & gas sector (13.96%). When comparing the size of the decline followed by the growth, it can be seen that raw materials, construction and IT companies were in the best situation. Also, energy companies made up for losses suffered in the first quarter of 2020. Banks, oil and gas companies and chemical companies were in the worst situation.

The period adopted in the study, or from 1 January 2020 to 31 March 2020, covers the first wave of the pandemic. The number of COVID-19 cases diagnosed globally is shown in the Figure 2. Looking at the longer period, i.e., from to the beginning of 2020, the first wave appears to be small and even dies compared to later trends. However, it was the first wave that had the greatest impact on the global economy. We can say that the whole world in March 2020 experienced a real shock. The declines in share prices during this period were the greatest. International organisations and national governments began to work out how to effectively protect the health of human life, but also how to counteract the negative economic effects.

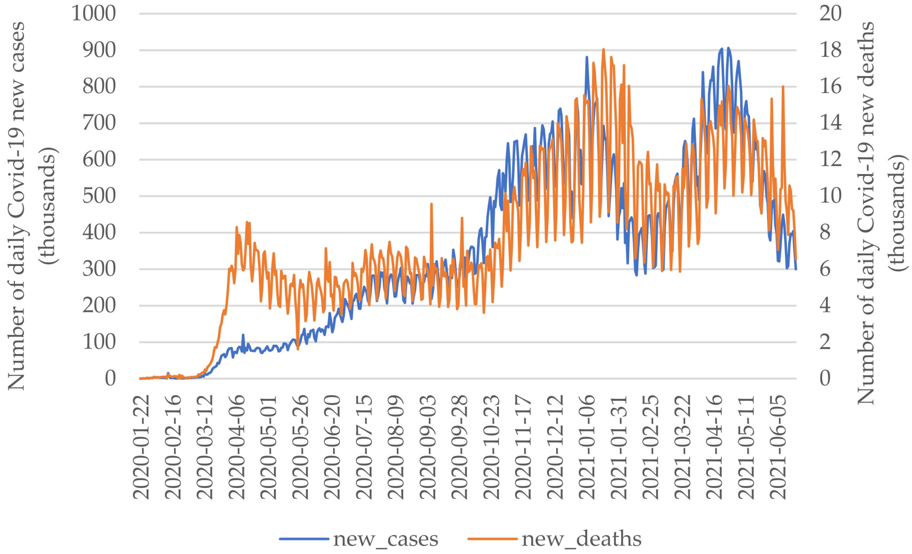

Figure 2. New cases and new deaths of COVID-19 in the period 22 January 2020–20 June 2021. Source: own elaboration on the basis of data from https://ourworldindata.org/covid-cases [75] (accessed on 20 June 2021).

4. Results

As a result of the introduction of restrictions, especially such as the reduction of car and air transport, the overall demand for energy and fuels decreased significantly. Therefore we put forth the hypothesis that the risk of decline in share prices of energy and fuel companies during the first wave of the pandemic on the Warsaw Stock Exchange (Poland) is greater than for companies in other sectors.

In the first stage of the study we determine the Kaplan-Meier estimators for eight macro sectors of companies noted on the WSE (Figure 3). Share prices of healthcare related companies declined the fastest, while those of companies in the macro sector Technology declined the slowest (starting from day 60).

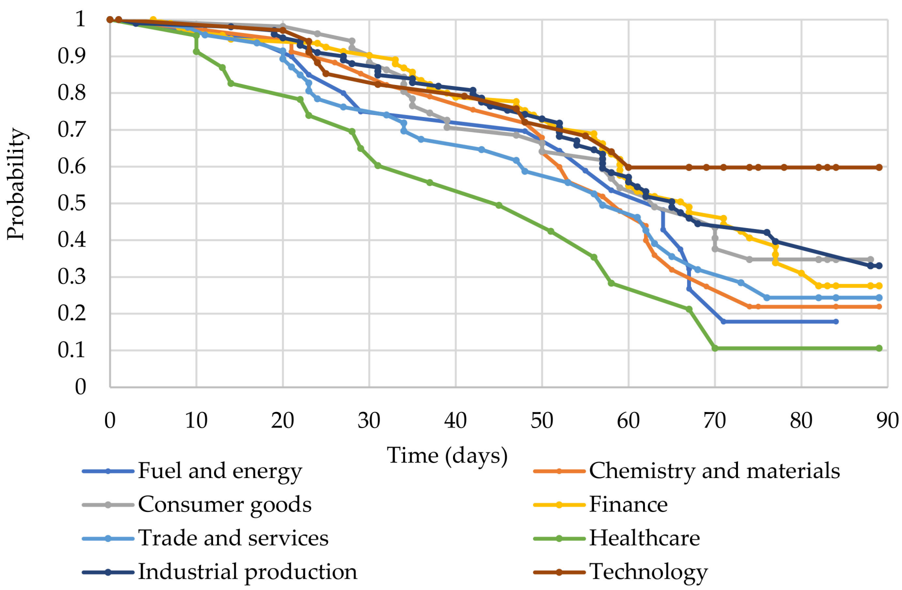

Figure 3. Kaplan-Meier estimators for macro sectors on the Warsaw Stock Exchange. Source: own elaboration on the basis of data from https://www.gpw.pl [73] (accessed on 19 June 2021).

To test for differences in duration curves, we use a multiple-sample test that is an extension (generalisation) of the Gehan test, the Peto-Peto test and the log-rank test. The value of the test statistic is equal to 13.32482 (p = 0.0646). This shows that at the significance level of p = 0.05, the hypothesis of a similar course of duration curves determined for macro-sectors cannot be rejected. Therefore, we decide to determine Kaplan-Meier estimators for two subgroups: energy and fuel companies and other companies (Figure 4). This approach allows us to use the Cox regression model in further analysis. We examine the differences in the course of estimators by using the Gehan-Wilcoxon test. This test does not require the assumption of proportionality of the group event intensity function, and more weight is given to the initial part of the distribution. The p-value of the Gehan-Wilcoxon test is 0.2950. Thus, it does not show statistically significant differences, which indicates that the survival curves in the initial course are similar to each other. Therefore, we perform another test: the log-rank test. Its p-value is equal to 0.0738. The second test confirms, at the significance level of 0.1, the differences in the course of the survival curves. Based on the values of both tests, we can assume that, up to a certain point, the probabilities of decline in the share prices of energy and fuel companies and other companies are similar to each other. Using the Kaplan-Meier estimators plot, we determine that the change in their course occur at around 50th day from the time of the peak. From this point onwards, the risk of decline in the share prices of energy and fuel companies with relation to the remaining ones increases.

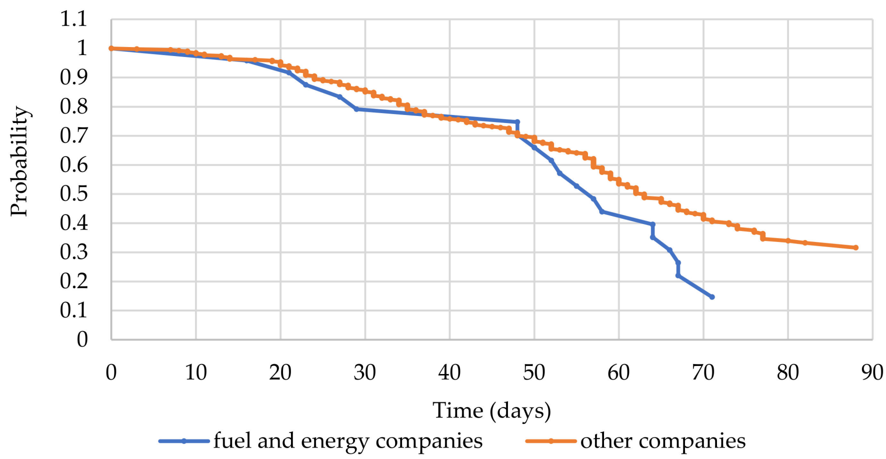

Figure 4. Kaplan-Meier estimators for energy and fuel companies and other companies. Source: own elaboration on the basis of data from https://www.gpw.pl [73] (accessed on 19 June 2021).

On the basis of the survival curves, we determine the duration quartiles for the energy and fuel and other companies (Table 2). The values of the first quartiles and the medians indicate a similar probability of share price decline (difference of 6 days). The third quartile for the energy and fuel companies is equal to 67 days, which means that 75% of these companies record the required decline within 67 days of the price peak. The third quartile for the remaining companies does not exist. For almost 32% of the companies the time to the required fall is longer than the observation period. The values of the quartiles also support the observation that in the initial period, the probability of achieving a 37.3% share price decline for the energy and fuel companies is similar to that of the other companies, and is higher afterwards.

We also determine the quartiles for the remaining macro sectors. Their values confirm that technology companies were in the best condition. 25% of these companies recorded the required decline in value after 48 days. 55 companies did not experience the required decline until the end of the observation period (31 March 2020). Companies from the Healthcare macro sector were in the worst situation during the first wave of the pandemic. The values of the quartiles were equal: 23, 45, 67 (days), respectively, testify to the rapid decline in the value of share prices.

Table 2. Quartiles of survival for macro sectors. Source: own elaboration on the basis of data from https://www.gpw.pl [73] (accessed on 19 June 2021).

Groups	Decline (Days)		
	First Quartile	**Median**	**Third Quartile**
Energy and fuel companies	48	57	67
Other companies:	42	63	-
Chemistry and materials	48	59	74
Consumer goods	37	63	-
Finance	49	67	-
Trade and services	32	57	76
Healthcare	23	45	67
Industrial production	48	65	-
Technology	48	-	-

As the duration curves intersect, so the Cox proportional hazards model cannot be used in further analysis. The hazard ratio changes over time. In the second stage of the analysis, we use the Cox non-proportional hazards model. In order to thoroughly investigate the differences in survival curves, we estimate the parameters of the following two models:

$$h(t,X) = h_0(t)\exp(\beta_1 X + \delta_1 X \times g_1(t)) \quad (8)$$

$$h(t,X) = h_0(t)\exp(\beta_2 X + \delta_2 X \times g_2(t)) \quad (9)$$

where g_1, g_2—Heavyside functions, defined as follows:

$$g_1(t) = \begin{cases} 0 & \text{for} \quad t < 50 \\ 1 & \text{for} \quad t \geq 50 \end{cases} \quad (10)$$

$$g_2(t) = \begin{cases} 1 & \text{for} \quad t < 50 \\ 0 & \text{for} \quad t \geq 50 \end{cases} \quad (11)$$

The model using the g_1 function allows the direct determination of the hazard ratio for the duration of less than 50 days, while the model using the g_2 function allows the determination of the hazard ratio for the duration of 50 days and more. Both models report the change in the hazard ratios at the intersection point $t_0 = 50$ (days). We present the estimation results of both models in Table 3.

Table 3. Parameter estimation results for Cox regression models.

Parameter	Parameter Estimator	Standard Error	Wald's Statistics	*p*-Value
Model (8): $\chi^2 = 5.73767$, p = 0.05678				
β_1	−0.0223	0.3899	0.0033	0.9543
δ_1	0.8408	0.4973	2.8584	0.0909
Model (9): $\chi^2 = 5.73767$, p = 0.0568				
β_2	0.8185	0.3088	7.0266	0.0080
δ_2	−0.8408	0.4973	2.8584	0.0909

The first model indicates no significant differences in the intensity of decline up to day 50 and a significant change (at the significance level of 0.1) in the intensity of decline from day 50 onwards. The second model indicates significant differences in the intensity of the decline from day 50 and confirms a significant change (at the significance level of 0.1) in the intensity from day 50. Figure 5 shows the hazard ratios for the two periods: less than 50 days and from at least 50 days. We can see that in the first period, shorter than 50 days, the intensity of the decline in share prices of energy and fuel companies do not differ significantly compared to other companies (HR = 0.98). From day 50 onwards, the intensity is 2.27 times higher than for the other companies.

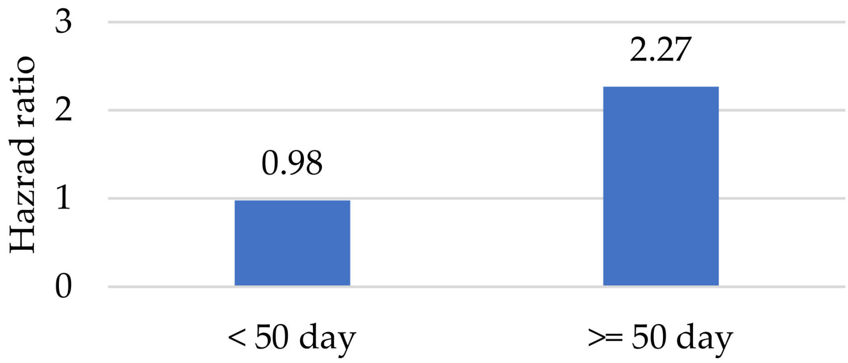

Figure 5. Hazard ratios—the intensity of the decline in share prices before and after day 50. Source: own elaboration on the basis of data from https://www.gpw.pl [73] (accessed on 19 June 2021).

The initial period of the pandemic was very difficult and affected the whole economy. The phenomenon of such widespread infection was an unexpected problem. The ways of combating the virus were also unknown, apart from the restrictions in social contacts. It was therefore a period of shock for the economy in general and also for the stock market. The restrictions introduced affected all companies. However, some sectors suffered more severely from the effects of the pandemic. Hence, after some time, the differences in the reaction of share prices of companies belonging to particular sectors could be more clearly seen.

This shows that the development of the pandemic and the restrictions undertaken in an attempt to contain it, have had a significant impact on the energy and fuel sector. Initially, all companies react similarly to news of the spread of the COVID-19. However, introduced limitations, such as restrictions on road and air transport, limitations on the operation of manufacturing companies and even shops and offices significantly reduce overall demand for energy and fuel. It results in the decline in the share prices of companies in the sector.

5. Discussion

The use of the survival analysis for the capital market is not a common study. Hence, it is difficult to compare the results of our study with those obtained by other authors and additionally related to the impact of COVID-19 on the energy and fuel sector. Buszko et al. [76] in their research address the problem of stock market stability during the first wave of the COVID-19 pandemic. They analyse the Warsaw Stock Exchange. They assess the stability of behaviour of various sectors of the economy represented by sectoral sub-indexes and macro-indexes. They divide the sectors into five clusters. Sectors related to the fuel and energy industry are in cluster 3, together with companies in the WIG-chemicals, WIG-energy, WIG-mines, WIG-oil & gas. This cluster is characterised by instability in terms of profitability and high stability in terms of volatility. The authors show that the cluster with fuel and energy companies is one of the most stable. This is in line with the results of our research, which shows that the risk of decline in share prices of fuel and energy companies has stabilised relatively quickly compared to the other companies.

The situation on stock markets reflects the economic situation in individual countries and emerging global crises. Risk studies of domestic stock markets provide valuable information on the financial situation of the listed companies. The results of studies on crisis periods are particularly important. Bieszk-Stolorz and Markowicz [63] studied the situation of Polish listed companies on the bear market in 2011 and over the next two years. Cui et al. [77] compared the risk of different sectors in the Chinese stock market during the relevant phases. The results show that the risk in the real estate, industrial and telecommunication services sectors is significantly higher during the financial downturn. Often, analyses involve identifying the "bull" and "bear" phases in the financial market. Gonzalez et al. [78] indicate that periods of stock market index returns can be divided into economically and statistically significant bull and bear states. The determination of turning points in the business cycle is analysed by Harding and Pagan [79], Pagan and Sossounov [80]. Olbrys and Majewska [81] studied the liquidity factors of Polish listed companies in the pre-crisis, crisis and post-crisis periods.

The pandemic period starting in late 2019/early 2020 is also considered a crisis period in national economies. The impact of the unexpected factor of the spread of the COVID-19 virus on national stock exchanges will certainly be analysed in the near future. But already now, during the pandemic period, such studies are being conducted. Olbrys [82] analysed the returns on bonds in Poland. According to Baker et al. [83] the U.S. stock market reacted so much more forcefully to COVID-19 than to previous pandemics in 1918–1919, 1957–1958 and 1968. According to Hong et al. [84] the effect of COVID-19 on stock market performance has important implications for both financial theory and practice. The authors suggest that the pandemic crisis was associated with market inefficiency, creating profitable opportunities for traders and speculators. Ashraf [85] examined the stock markets' response to the COVID-19 pandemic (64 countries). According to Takyi and Bentum-Ennin [86] empirical results show that COVID-19 has a negative but short-term impact on stock markets of affected countries.

During the first wave of the COVID-19 pandemic, energy commodity prices declined. They recovered quite quickly. By spring 2021, commodity prices were above the pre-pandemic levels. Dmytrów et al. [87] compared the time series of energy commodity prices with the time series of daily COVID-19 cases from 5 January 2020 to 12 March 2021. They find that the commodities such as ULSD, fuel oil, crude oil, and gasoline are weakly associated with the COVID-19 cases. In contrast, natural gas, palm oil, CO_2 allowances, and ethanol are strongly associated with the development of the pandemic. European electricity and natural gas markets show very similar behaviour during a pandemic, with very high correlations, despite their different geographical location [88].

The worse situation of the oil sector in the US market is indicated by the research of Mazur et al. [89]. The authors found that natural gas, food, healthcare, and software stocks earned high positive returns, whereas equity values in petroleum, real estate, entertainment, and hospitality sectors fall dramatically (the US stock market). An interesting phenomenon was the decline in share prices of oil companies and the rise in share prices of natural gas companies. The reason was that for oil producers, natural gas is a by-product of the oil extraction. As oil prices declined sharply in March 2020, crude oil producers decided to reduce oil production and therefore automatically reduced the production of natural gas.

This article also contributes to research on the effects of the pandemic on the stock market. The effect of the COVID-19, an infectious disease caused by the new type of coronavirus SARS-CoV-2, is undoubtedly economic downturns. Its economic impact will be studied and evaluated for many years to come. We believe that this research will address many socio-economic issues in addition to the financial market analysed here [90]. Among them, we can mention those of interest to the authors, such as unemployment [91,92], corporate sustainability [93,94], or foreign trade [95]. These studies will certainly reveal distortions of hitherto observed regularities.

6. Conclusions

In theory, the value of shares reflects expected future cash flows. However, cash flows are affected by macro-finance variables and the financialisation of the markets. In Poland, as in other countries, the fall in energy demand during the pandemic contributed to a decline in the turnover of energy and fuel companies. The reduction in consumption was the result of restrictions introduced to prevent the transmission of the virus. This caused uncertainty in terms of economic development and corporate profit growth. This, in turn, was the cause of the decline in share prices. Thus, share prices in the long term were affected by the unfavourable financial results of companies. In the short term, declines in stock market prices were caused by investors' fears about the development of the pandemic, following the news from around the world relating to an increase in the number of cases of the disease. The governments of countries affected by the pandemic were first to introduce restrictions resulting in a reduction in energy demand. Investors in Poland feared a decline in their discounted cash flows from investments in energy and fuel companies.

The study using the survival analysis methods partially confirms the hypothesis. The results of the analysis indicate that there is no significant differences in the intensity of price decreases in both groups of companies during the first 50 days. However, after this period, the development of the pandemic and the introduced restrictions had a particularly negative impact on the situation of energy and fuel companies. Government measures such as the restriction of road and air transport, work restrictions in schools, manufacturing companies and even shops and offices significantly reduces overall demand for energy and fuel. The result is a decline in the share prices of companies in this sector. The intensity of the decline for them is more than double that of other companies.

It can be concluded that the situation of the fuel and energy sector deteriorated significantly during the crisis period under review—the first wave of the COVID-19 pandemic.

The results of this research have important implications for investors and financial managers and can help to design low-risk portfolios when the energy stock market is in specific conditions (e.g., health crisis). Our paper extends the existing literature on the impact of a pandemic on the stock market in Poland. Many studies have been published on the impact of Covid-19 on the shares of energy and fuel companies in various countries. Therefore, the contribution of this manuscript will be an extension to the global energy finance literature.

Our future research plans include an analysis of the situation of companies in the further course of a phenomenon that threatens both the health and the economic situation of the society.

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