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The Impact of the COVID-19 Pandemic on the Volume of Fuel Supplies to EU Countries

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Abstract: The COVID-19 pandemic is undoubtedly a destructive factor, strongly affecting the economic fields. From the perspective of the countries affected by the pandemic, almost all sectors of the economy saw declines in economic indicators. First, the lockdown and its social consequences contributed to this. The increasing time perspective since the outbreak of the COVID-19 pandemic implies increasingly more studies analyzing its impact on various economic spheres. The aim of the research is to determine the difference in the level of fuel supplies between a pandemic situation and a situation where a pandemic would not occur. We assumed that the pandemic is a determinant of the decline in fuel supplies. The subjects of the analysis were the following fuels: kerosene-type jet fuel, gas oil and diesel oil, motor gasoline, and oil products. The countries of the European Union were analyzed. Monthly data from 2015–2021 provided by Eurostat were used for the analyses. The forecasts for 2020–2021 were determined using the exponential smoothing method. The assumption was shown to be accurate in the case of kerosene-type jet fuel, gas oil, and diesel oil. In this case, there was a clear drop in the level of supplies. The analysis of forecasts shows that if it were not for the COVID-19 pandemic, in the years 2020–2021, in accordance with the forecasts obtained, approximately 31,495 thousand tons of kerosene-type jet fuel and 11,396 thousand tons of gas oil and diesel oil would have been additionally supplied to the EU countries. For oil products, supply volumes also decreased, but unlike previously mentioned fuels, supply levels had not recovered to pre-pandemic levels by the end of 2021. On the other hand, the forecast of deliveries indicates the volume of 95,683 thousand tons of oil products.

Keywords: fuel; fuel supplies; COVID-19; coronavirus; transport; UE; energy economics and management

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1. Introduction

The coronavirus (2019-nCoV-COVID-19) pandemic has affected virtually every economic sector to a greater or lesser extent, and its impact and effects are analyzed in numerous publications, taking into account different perspectives and research objects. Despite this variety of research threads, the authors, however, apart from the statistical reports about the fuel demand, did not find any scientific publications in the field of fuel supply during the pandemic times. A search for publications regarding the fuel supply was carried out in the Scopus database. The authors used various combinations of keywords such as: fuel, fuel supply, COVID-19, coronavirus, transport, and EU, as well as aviation kerosene fuel, diesel, motor gasoline, and petroleum products. The search has been narrowed to journals and articles in the field of research "economics and management", and published in 2020, 2021, or 2022. Using the Scopus database, the authors found only one article in the field of social sciences regarding this subject matter. This was the article of Nocera Alves et al. [1]. This article has been cited 2 times so far and is used in our manuscript as a reference. The paper analyses how COVID-19 affected green-fuel supply chain. In comparison with our research problem, the considerations in the cited article concerned Brazil and green fuel. Continuing the analysis of the literature on the fuel market during the pandemic beyond the Scopus base, it was noted that the manuscripts published during those several years were not analyses of the supply factor but only took into account problems related to it in some various areas. The authors grouped them into the following:

- the impact of COVID-19 on fuel consumption and its consequences, including CO_2 emissions;
- the impact of COVID-19 on the economy, financial markets, the energy market, and the environment;
- the impact of COVID-19 on product and service supply chains, transport, and infrastructure.

In the first area, the authors of analyzed publications showed that the economic slowdown caused by the pandemic resulted in a decrease in fuel consumption and energy demand and made attempts to forecast the trend for the coming years. As a result of the research on the COVID-19 impact on the oil and gas industry conducted by Norouzi [2] for the US market, it was shown that the short-term effect was a decrease in oil consumption by almost 25%, while the long-term effect was a decrease in capital expenditure and R&D investments in the oil and gas market by 30–40%, which resulted in a reduction in the demand for oil extraction from over 800 in 2019 to 265 in 2021. The expected decrease in fuel consumption reasonably implied research that also analyzed the level of CO_2 emissions. The expected decrease in fuel consumption reasonably implied research that also analyzed the level of CO_2 emissions. The natural consequence of introducing the lock down was the reduction of fuel consumption in individual passenger transport, which resulted in a lower level of CO_2 emissions [3]. In the study [4], assessing the impact of the COVID-19 pandemic on global consumption of fossil fuels and CO_2 emissions in the two-year horizon 2020Q1–2021Q4, projections of coal, natural gas, and oil consumption were prepared, depending on GDP growth scenarios on the basis of alternative IMF World Economic Outlook forecasts that were drawn up before and after the outbreak. Forecasts show that fossil fuel consumption and CO_2 emissions will return to, or even exceed, pre-pandemic levels within a two-year horizon, despite significant reductions in the first quarter after the outbreak. Interestingly, there will be stronger growth for emerging economies than for developed economies. It is also worth referring to the Fuels Europe report, prepared on the basis of the International Energy Agency's data for 2021, taking into account the impact of COVID-19 on the demand for individual fuels [5]. It shows that the change in demand did not affect all fuels and all regions equally. In fact, while in the European Union and the United States there was a decrease in the consumption of fossil fuels and an increase in the consumption of renewable energy, in Asian countries the demand for all types of fuels increased in 2021 compared with 2019.

Another group of authors and publications focused on the impact of COVID-19 on the economy, financial markets, the energy market, and the environment and presented the effects of measures introduced by the European Union or selected countries aimed at preventing the spread of the virus while also supporting the economy. Dziembała and Kłos verified the hypothesis that the planned financial instruments, implemented at the EU level, should, to some extent, limit the negative consequences of the pandemic; however, it is necessary to conduct close cooperation between Member States and European institutions in the coordination of actions taken and instruments implemented, conditioning their greater effectiveness. The conclusions reached by the authors indicated that despite the measures introduced by the European Commission to prevent the economic crisis, the burden of counteracting the effects of the epidemic rests mainly with the countries whose governments have introduced anti-crisis packages [6]. Other researchers provided a quantified assessment of the economic and environmental impacts of the blocking measures applied in France over the period of 55 years. They showed that the lockdown led to a significant decline in economic output by 5% of GDP, but a positive environmental impact, with a reduction of CO_2 emissions by 6.6% in 2020, while concluding that both declines are temporary, and in the coming years they will revert to pre-pandemic levels [7]. Investors' approach and companies' profits from fossil fuels and clean energy were also topics raised by researchers in the context of fuels and energy. The results are not conclusive. One study found that clean energy companies had superiority and greater resilience to the negative effects of the pandemic over fossil fuel companies [8], while another study found that despite viewing clean energy action as more sustainable and less prone to external shocks, fear and coronavirus-induced investor pessimism had also spread to the renewable energy sector, and no more favorable returns on clean energy shares have been observed [9]. The crisis caused by the COVID-19 virus was not indifferent to the natural environment. This relationship was investigated using the Kuznets curve [10], which allowed scientists to formulate a recommendation for economic policy. According to this, an economy in a crisis may take place through investment support and through environmentally friendly legal and organizational solutions [11].

Many authors of the analyzed publications raised the issues related to the supply chains of products and services, as well as related transport or infrastructure in the times of COVID-19. However, no publications dealing with the topic of fuel supplies to the European Union countries have been found, which indicates a literature and research gap in this area. Fuel supply issues were raised, but only in the context of the aviation sector, in an article presenting the relationship between the number of air operations and the volume of aviation fuel delivered to an airport. The analysis showed an increase in the strength of the relationship between the number of air operations performed and the volume of fuel supplies during the pandemic compared with the pre-pandemic period, which brought practical conclusions leading to the optimization of fuel supply chain management in the aviation sector [12]. In general, disruptions in supply chains were investigated by Butt, who showed that manufacturers were fine-tuning production schedules to meet production challenges. Distributors worked with secondary suppliers to meet stock shortages. Finally, procurement firms evaluated the impact of demand by focusing on a short-term demand and supply strategy, preparing for channel changes, opening up additional channels of communication with key customers, and becoming more flexible [13]. Another study found that global supply chains were at that time facing disruptions due to several sources of inherent uncertainty, including natural disasters, war and terrorism, external legal issues, economic and political instability, social and cultural harm, and disease. Flaws in the then-current global supply chain have been exposed, resulting in delays, non-delivery, labor shortages, and fluctuations in demand. These supply chain threats have a strong impact on supply chain performance indicators and the magnitude of their impact is amplified in the context of globalization and the COVID-19 pandemic [14].

Many of the supply studies have focused on one of the most problematic sectors, the food sector. The pandemic proved to be an unprecedented challenge for this sector. COVID-19 reduced the security of the food supply chain, increased logistics costs, and radically changed consumer preferences. The industry associated with perishable products, e.g., dairy products, was particularly severely affected by the negative effects of the pandemic. A positive effect of the pandemic is the increased awareness of food waste and the importance of the independence of food production [15–17]. The resilience of supply chains to COVID-19 in the agricultural sector was also examined, showing that agricultural transport systems proved to be extremely robust and able to innovate in real time [18]. Disruptions in supply for medical care [19] were also analyzed, and the impact of the COVID-19 pandemic on the scope and quality of services of courier companies operating on the Polish market was also assessed [20]. Supply chain issues, which may also apply to fuels, were also raised, such as:

- disruptions in freight transport—the changes resulting from the adaptation of the law to the changing situation in the Polish railway sector were analyzed, which led to the conclusion that the introduced legal solutions, although assessed positively, were insufficient [21],

- the problem of preventing COVID-19 infection by employees of hard coal mines through the implementation of safe work systems in mining during a pandemic [22].

Taking into consideration the above, to the best of authors' knowledge, no study has assessed the impacts of COVID-19 on fuel supplies to European Union countries. Therefore, the study presented in this paper is intended to fill the literature and research gap. The aim of the research is, therefore, to determine the difference in the level of fuel supplies between a pandemic situation and a situation where a pandemic would not occur. We assume that the implication of a pandemic would be a decrease in fuel supplies. The impact of the pandemic was quite easy to predict. It had been known from the beginning that the pandemic would have a negative impact on the economy and society. Regarding this context, in our study, we do not ask whether the pandemic will have negative consequences or whether it will cause a decrease in fuel supplies. We are interested mainly in the distribution of changes in fuel supply broken down by fuel groups and in the course of the phenomenon over time. We consider such research justified from the perspective of knowledge about the course of the pandemic, treating the pandemic as a crisis situation. The topic is, therefore, topical and important, although it should be emphasized that our research is cognitive rather than epistemological.

This paper is categorized into different sections as follows: Section 2 provides an explanation of the data and the methodology of this study. The estimated results and discussion are presented in Section 3. The conclusion and limitations of our research are presented in Section 4.

2. Materials and Methodology

The study covered the volume of fuel supplies to European Union countries, considering kerosene-type jet fuel, gas oil and diesel oil, motor gasoline, and oil products.

Kerosene-type jet fuel is "distillate used for aviation turbine power units. It has the same distillation characteristics at between 150 °C and 300 °C (generally not above 250 °C) and flash point as kerosene. In addition, it has specifications (such as freezing point) which are established by the International Air Transport Association. Includes kerosene blending components. Kerosene type jet fuel is a product aggregate equal to the sum of blended bio jet kerosene (bio jet kerosene in kerosene type jet fuel) and non-bio jet kerosene" [23].

Gas/diesel oil is "primarily a medium distillate distilling at between 180 °C and 380 °C. Includes blending components. Several grades are available depending on uses. Gas/diesel oil includes on-road diesel oil for diesel compression ignition engines of cars and trucks. Gas/diesel oil includes light heating oil for industrial and commercial uses, marine diesel and diesel used in rail traffic, other gas oil including heavy gas oils which distil at between 380 °C and 540 °C and which are used as petrochemical feedstocks. Gas/diesel oil is a product aggregate equal to the sum of blended biodiesels (biodiesels in gas/diesel oil) and non-biodiesels" [24].

Motor gasoline "consists of a mixture of light hydrocarbons distilling at between 35 °C and 215 °C. It is used as a fuel for land-based spark ignition engines. Motor gasoline may include additives, oxygenates and octane enhancers, including lead compounds. Includes motor gasoline blending components (excluding additives/oxygenates), e.g., alkylates, isomerate, reformate, cracked gasoline destined for use as finished motor gasoline. Motor gasoline is a product aggregate equal to the sum of blended biogasoline (biogasoline in motor gasoline) and non-biogasoline" [25].

Oil products is "petroleum products are a product aggregate equal to the sum of refinery gas, ethane, liquefied petroleum gases, naphtha, motor gasoline, aviation gasoline, gasoline type jet fuel, kerosene type jet fuel, other kerosene, gas/diesel oil, fuel oil, white spirit ad SPB, lubricants, bitumen, paraffin waxes, petroleum coke and other products" [26].

Monthly data for 2015–2021 provided by Eurostat were used for the analyses. It should be noted that because Great Britain left the EU structure on 1 February 2020, it was not included in the research. This is due to the fact that the participation of GB in the analyses and its subsequent withdrawal from them may distort forecasts.

The forecasts for 2020–2021 were determined using the exponential smoothing method. Exponential smoothing is a method where the time series of the predicted variable is smoothed using a weighted moving average. This involves replacing each element of the series with a weighted mean of *n* adjacent values, where n is the so-called width of the smoothing window. It should be noted that the weights are determined according to the exponential law. The alpha and delta parameters used in the modeling (the smoothing parameter of the seasonal syntax) were selected using an automatic search for the best value of the parameter using the quasi-Newtonian function minimization procedure (Statistica 13.3). These values are selected on the basis of minimizing the mean square error of the ex-post forecast, i.e., minimizing the sum of squared differences between the empirical values and those forecasted for one period ahead. When carrying out the exponential smoothing process, one can rely on various models, adjusted to the type of components of the predicted time series. Due to the fact that the exponential smoothing method has been extensively described in publicly available publications [27–33], this element was omitted in the study, focusing on the analysis of the obtained results.

The research methodology used might not seem innovative, but the authors believe that due to the fact that the topic itself is an element of novelty in the literature on the subject, there is no need for an innovative statistical method to be used in this respect. We believe that since the literature on the subject lacks publications on fuel supplies to EU countries, the application of the proposed methodology of statistical analyses is sufficient at this point. The authors are already filling the research gap with the topic of the lack of publications in this area toward the number that we would expect.

Due to the fact that the literature contains a multitude of formulas for determining forecast errors, the following formulas were selected for the purposes of the analysis:

Mean error (ME) is derived from the formula:

$$\mathrm{ME} = \frac{1}{\mathrm{m}} \sum_{\mathrm{t}=1}^{\mathrm{m}} \left(\mathrm{y_t} - \mathrm{y_t^P} \right) \tag{1}$$

where:

m—number of observations,

y_t—value observed over time,

y_t^P—forecast value at time t.

Mean error is known as the measurement uncertainty or the difference between the measured value and true value.

Mean absolute error (MAE) is derived from the formula:

$$\mathrm{MAE} = \frac{1}{\mathrm{m}} \sum_{\mathrm{t}=1}^{\mathrm{m}} \left| \mathrm{y_t} - \mathrm{y_t^P} \right| \tag{2}$$

Mean absolute error determines by how much, on average, the actual realizations of the forecast variable will deviate—in absolute value—from the forecasts.

Mean percentage error (MPE) is derived from the formula:

$$\mathrm{MPE} = \frac{\sum_{\mathrm{t}=1}^{\mathrm{m}} \mathrm{PE_t}}{\mathrm{m}} \tag{3}$$

where

$$\mathrm{PE_t} = \frac{\left(\mathrm{y_t} - \mathrm{y_t^P}\right)}{\mathrm{y_t}} \cdot 100 \tag{4}$$

This error determines what percentage of actual implementations of the forecasted variable are forecast errors in the prediction period.

Mean percentage absolute error (MAPE) is derived from the formula:

$$\mathrm{MAPE} = \frac{1}{m}\sum_{t=1}^{m}\left|\frac{y_t - y_t^P}{y_t}\right|\cdot 100 \quad (5)$$

This error determines the average size of forecast errors, expressed as a percentage of the actual values of the forecast variable.

3. Results

3.1. Kerosene-Type Jet Fuel Supplies

In 2015–2019, the volume of aviation fuel deliveries to EU countries was characterized by seasonality, recording increases and decreases in the same months. Stopping or significantly reducing air traffic during the COVID-19 pandemic resulted in a large drop in deliveries in 2020–2021 (Figure 1). Despite the resumption of air traffic after the pandemic stopped, the level of aviation fuel supplies at the end of 2021 was lower by 336.178 thousand tonnes than in 2015, and significantly fewer passengers were handled (Figure 2). The analysis of air traffic in selected EU countries can be found, among others, in work [34].

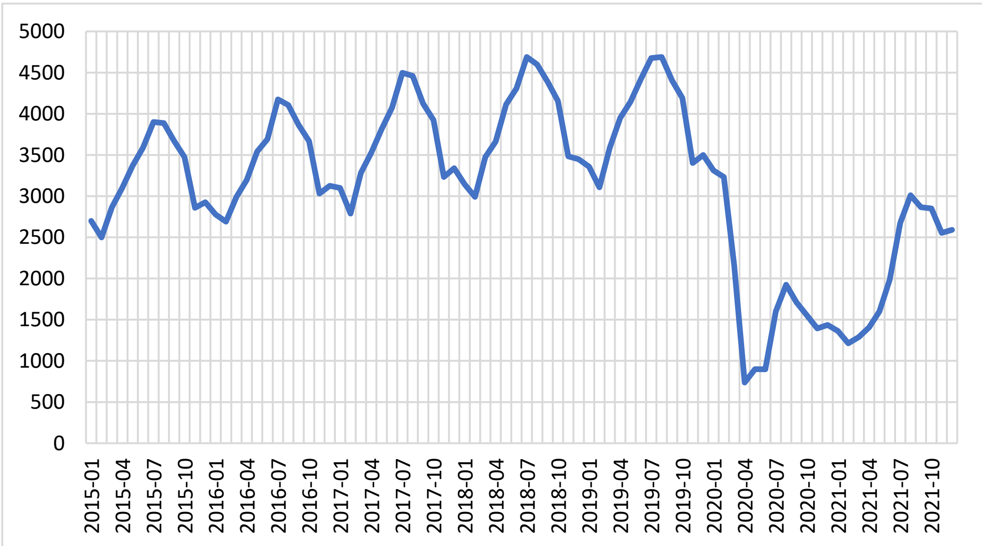

Figure 1. The evolution of the volume of kerosene-type jet fuel supplies to EU countries (in thousand tonnes). Source: own elaboration.

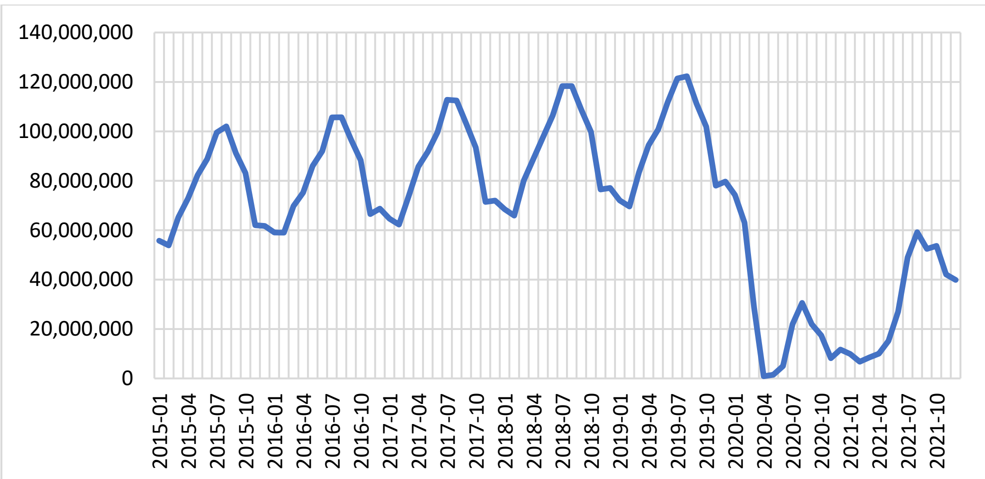

Figure 2. Number of passengers served (in persons). Source: own elaboration.

Due to the features of the series, we decided to use the exponential smoothing method with additive seasonality. The results obtained with the use of Statistica 13.3 software are shown in Figure 3.

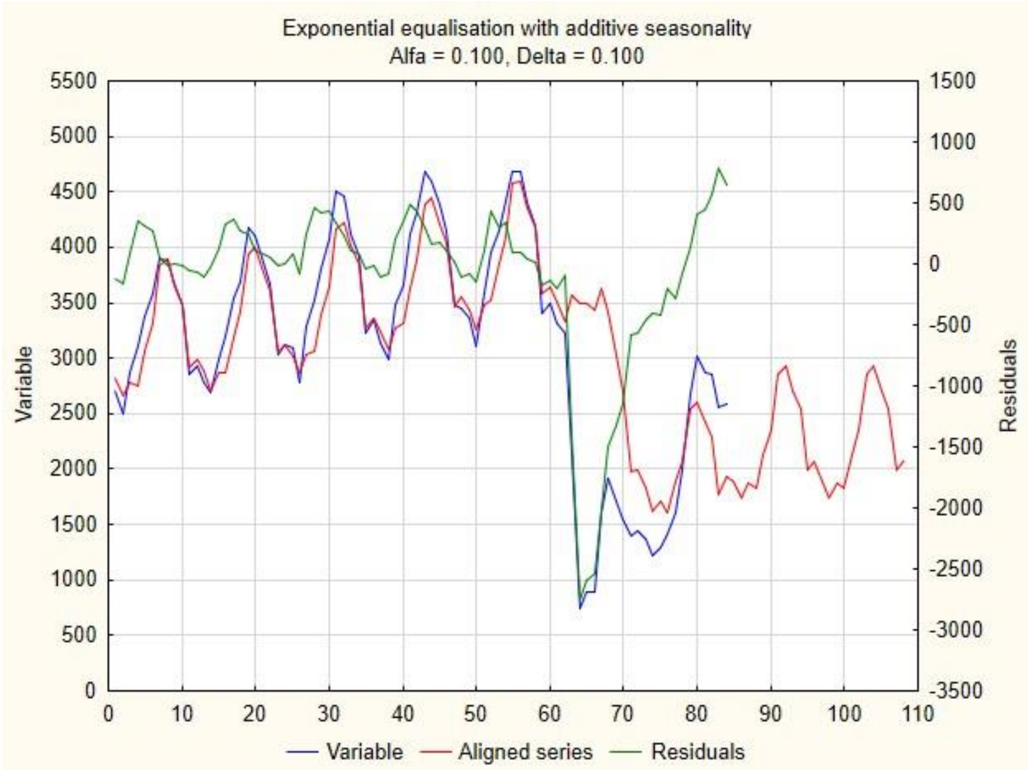

Figure 3. Exponential smoothing of kerosene-type jet fuel supplies. Source: own elaboration.

The values of the forecasts obtained on the basis of this are presented in Table 1, and the forecast errors are in Table 2.

Table 1. Monthly kerosene-type jet fuel supply forecasts for 2020–2021 (in thousands of tones). Source: own elaboration.

Period	Forecast	Period	Forecast
2020-01	1894.612	2021-01	1894.612
2020-02	1739.484	2021-02	1739.484
2020-03	1872.243	2021-03	1872.243
2020-04	1834.793	2021-04	1834.793
2020-05	2119.391	2021-05	2119.391
2020-06	2346.762	2021-06	2346.762
2020-07	2850.966	2021-07	2850.966
2020-08	2929.051	2021-08	2929.051
2020-09	2702.377	2021-09	2702.377
2020-10	2535.197	2021-10	2535.197
2020-11	1988.844	2021-11	1988.844
2020-12	2060.526	2021-12	2060.526

Table 2. Forecast errors. Source: own elaboration.

Mean Error (ME)	Mean Absolute Error (MAE)	Mean Percentage Error (MPE)	Mean Percentage Absolute Error (MAPE)
−100.0174	378.6853	15.5358	23.5667

Mean error indicates a slight positive deviation from zero. This means that the obtained forecasts are slightly underestimated. Mean absolute error indicates that the actual deliveries of kerosene-type jet fuel, in absolute terms, will diverge from forecasts by approximately 378.6853 thousand tonnes. It also shows that 15.5358% of actual deliveries of kerosene-type jet fuel are forecast errors in the prediction period (MPE), and the average value of forecast errors is 23.5667% of the volume of kerosene-type jet fuel (MAPE) deliveries.

The analysis of the obtained forecasts shows that, had it not been for the COVID-19 pandemic, in the years 2020–2021, in accordance with the forecasts obtained, approximately 31,494.910 thousand tonnes of kerosene-type jet fuel would have been delivered to the EU countries in the years 2020–2021 (Figure 4).

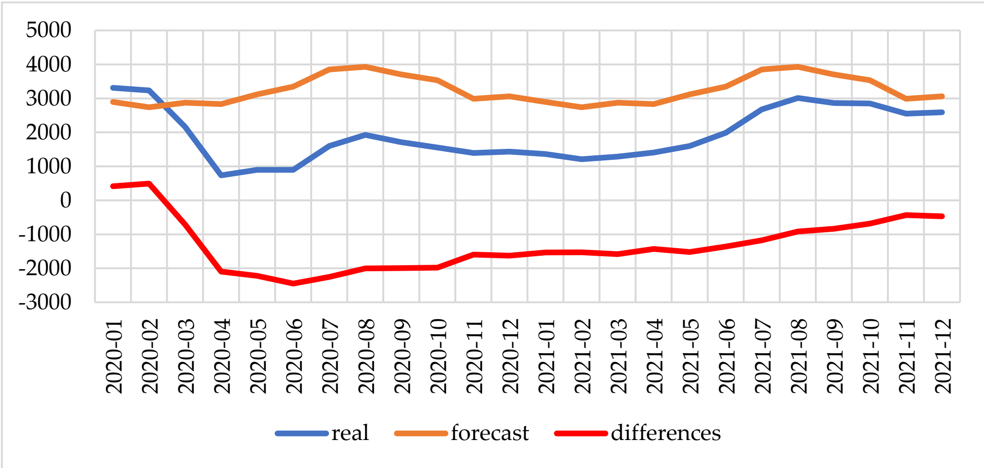

Figure 4. Comparison of the actual and forecast volumes of delivered kerosene-type jet fuel (in thousand tonnes). Source: own elaboration.

3.2. Gas Oil and Diesel Oil Supplies to EU Countries

As in the case of kerosene-type jet fuel deliveries, the volumes of gas oil and diesel oil deliveries decreased significantly as a result of the COVID-19 pandemic. By the end of 2021, the plurality of deliveries of this type of fuel was beginning to return to the pre-pandemic state (Figure 5).

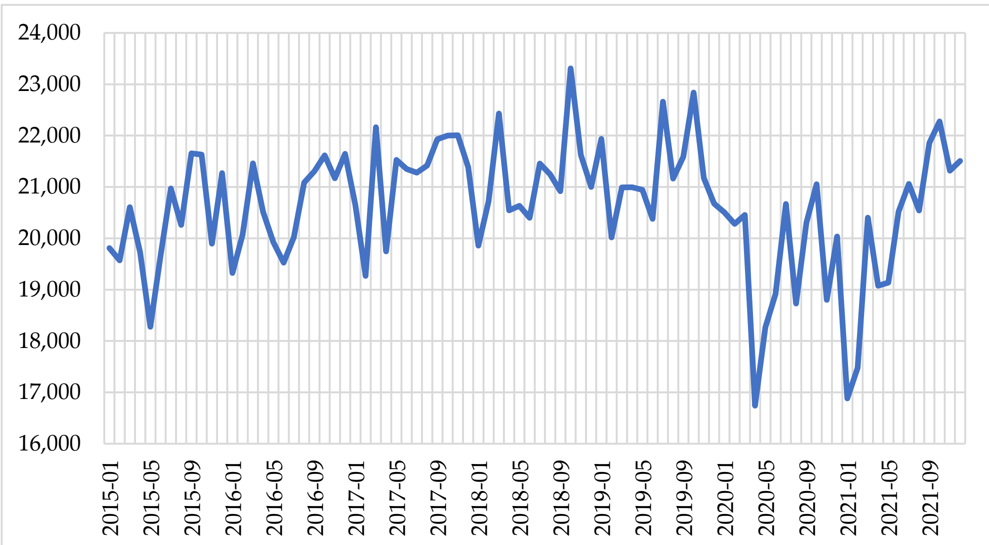

Figure 5. Changes in the volume of gas oil and diesel oil supplies to EU countries (in thousand tonnes). Source: own elaboration.

In the case of gas oil and diesel oil supplies, due to the characteristics of the series, we decided to use the exponential smoothing method with additive seasonality. The results obtained with the use of Statistica 13.3 software are shown in Figure 6.

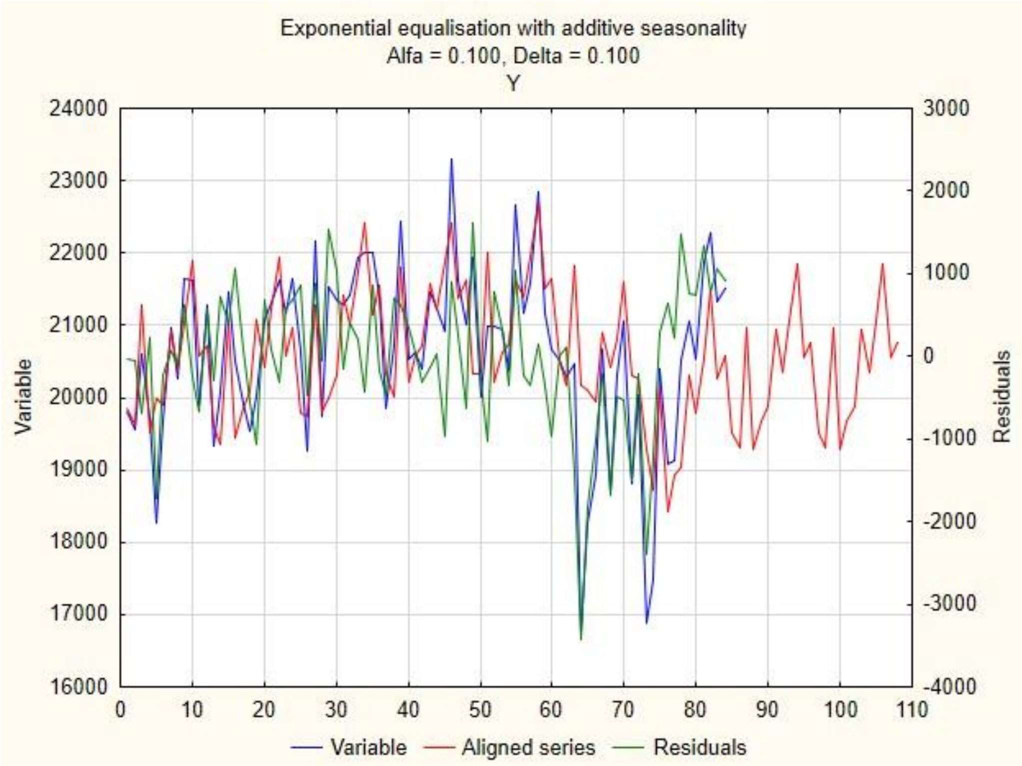

Figure 6. Exponential smoothing of gas oil and diesel oil supplies. Source: own elaboration.

The values of the forecasts obtained on the basis of this are presented in Table 3, and the forecast errors are in Table 4.

Table 3. Monthly gas oil and diesel oil supply forecasts for 2020–2021 (in thousand tonnes). Source: own elaboration.

Period	Forecast	Period	Forecast
2020-01	19,521.38	2021-01	19,521.38
2020-02	19,311.86	2021-02	19,311.86
2020-03	20,960.80	2021-03	20,960.80
2020-04	19,281.69	2021-04	19,281.69
2020-05	19,664.21	2021-05	19,664.21
2020-06	19,875.59	2021-06	19,875.59
2020-07	20,930.39	2021-07	20,930.39
2020-08	20,345.36	2021-08	20,345.36
2020-09	21,062.02	2021-09	21,062.02
2020-10	21,843.90	2021-10	21,843.90
2020-11	20,552.34	2021-11	20,552.34
2020-12	20,756.58	2021-12	20,756.58

Table 4. Forecast errors. Source: own elaboration.

Mean Error (ME)	Mean Absolute Error (MAE)	Mean Percentage Error (MPE)	Mean Percentage Absolute Error (MAPE)
−30.7180	666.4146	0.3420	3.3248

Mean error indicates a slight negative deviation from zero. This means that the obtained forecasts are slightly overestimated. Mean absolute error indicates that the actual deliveries of gas oil and diesel oil, in absolute terms, will diverge from forecasts by approximately 666.4146 thousand tonnes. It also shows that 0.3420% of the actual volume of gas oil and diesel oil supplies are due to forecast errors in the prediction period (MPE), while the average size of forecast errors is 3.3248% of the volume of gas oil and diesel oil (MAPE) supplies.

The analysis of the obtained forecasts shows that if it were not for the COVID-19 pandemic, the EU countries in 2020–2021, according to the forecasts obtained, would have received an additional amount of approximately 11,395.539 thousand tonnes of gas oil and diesel oil (Figure 7).

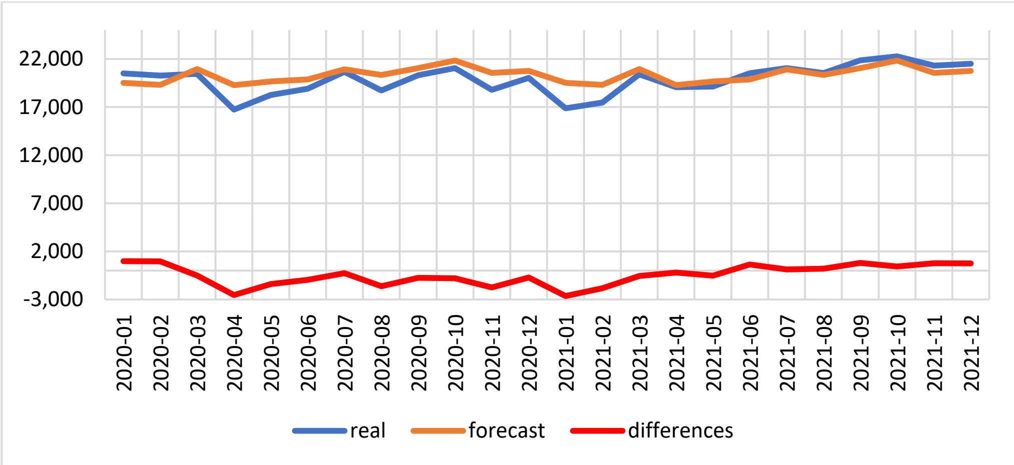

Figure 7. Comparison of the actual and forecast volumes of supplied gas oil and diesel oil (in thousand tonnes). Source: own elaboration.

3.3. Motor Gasoline Supplies to EU Countries

In the case of motor gasoline, the supply volumes did not decrease as a result of the COVID-19 pandemic. Throughout the duration of the COVID-19 pandemic, as well as after its completion, the volumes of deliveries remained at a similar level, taking into account seasonal fluctuations (Figure 8).

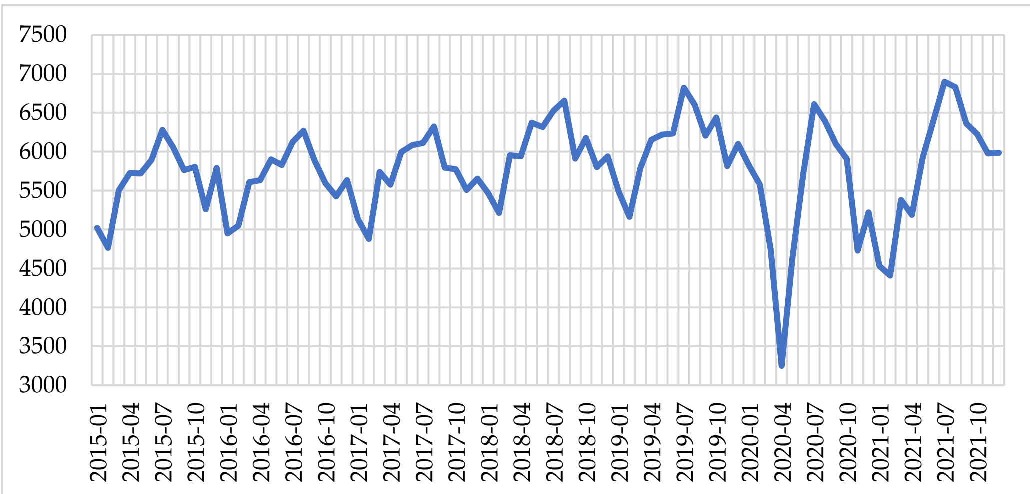

Figure 8. Changes in the volume of motor gasoline supplies to EU countries (in thousand tonnes). Source: own elaboration.

In this case, the method of exponential smoothing with additive seasonality was also used. The results obtained with the use of Statistica 13.3 software are shown in Figure 9.

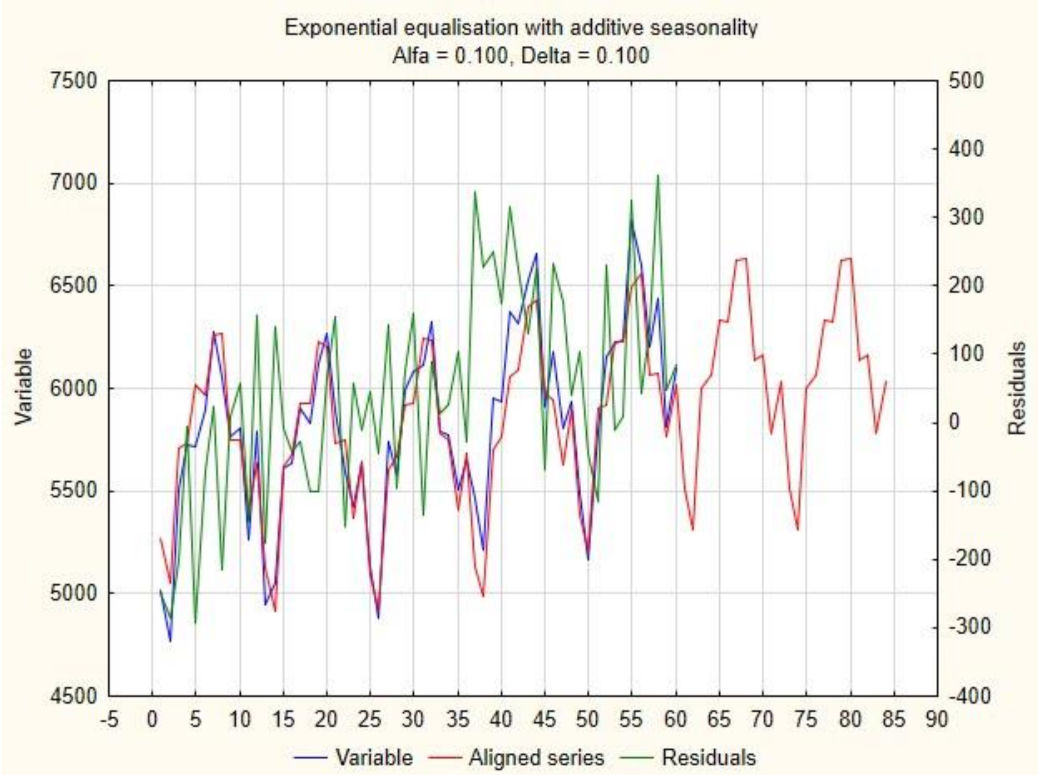

Figure 9. Exponential smoothing of motor gasoline supplies. Source: own elaboration.

The values of the forecasts obtained on the basis of this are presented in Table 5, and the forecast errors are in Table 6.

Table 5. Motor gasoline supply forecasts on a monthly basis for 2020–2021 (in thousand tonnes). Source: own elaboration.

Period	Forecast	Period	Forecast
2020-01	5512.601	2021-01	5512.601
2020-02	5311.355	2021-02	5311.355
2020-03	6002.709	2021-03	6002.709
2020-04	6063.418	2021-04	6063.418
2020-05	6328.656	2021-05	6328.656
2020-06	6325.850	2021-06	6325.850
2020-07	6625.590	2021-07	6625.590
2020-08	6631.529	2021-08	6631.529
2020-09	6141.273	2021-09	6141.273
2020-10	6159.025	2021-10	6159.025
2020-11	5785.373	2021-11	5785.373
2020-12	6031.271	2021-12	6031.271

Table 6. Forecast errors. Source: own elaboration.

Mean Error (ME)	Mean Absolute Error (MAE)	Mean Percentage Error (MPE)	Mean Percentage Absolute Error (MAPE)
39.3798	127.1338	0.5838	2.1901

Mean error indicates a slight positive deviation from zero. This means that the obtained forecasts are slightly underestimated. Mean absolute error indicates that the actual deliveries of motor gasoline, in absolute terms, will deviate from the forecasts by an average of 127.1338 thousand tonnes. This also shows that 0.5838% of the actual deliveries of motor gasoline are forecast errors in the prediction period (MPE), and the average value of forecast errors is 2.1901% of the volume of motor gasoline (MAPE) deliveries.

The analysis of the obtained forecasts shows that despite the apparent maintenance of the trend throughout the entire duration of the COVID-19 pandemic in 2020–2021, according to the forecasts obtained, approximately 11,042.207 thousand tonnes of motor gasoline would have been delivered to the EU countries (Figure 10).

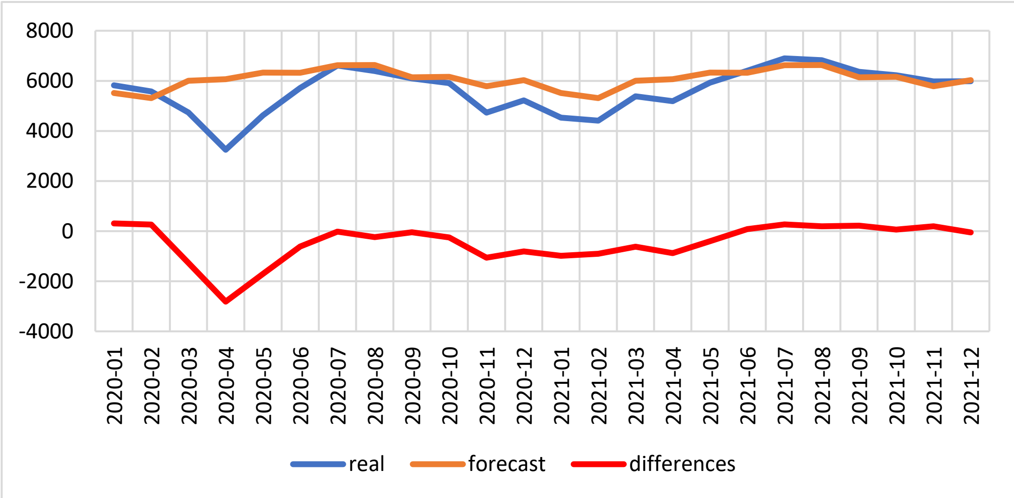

Figure 10. Changes in the volume of motor gasoline supplies to EU countries (in thousand tonnes). Source: own elaboration.

3.4. Deliveries of Oli Products to EU Countries

For oil products, supply volumes have decreased as a result of the COVID-19 pandemic. By the end of 2021, these figures did not return to the pre-pandemic state (Figure 11).

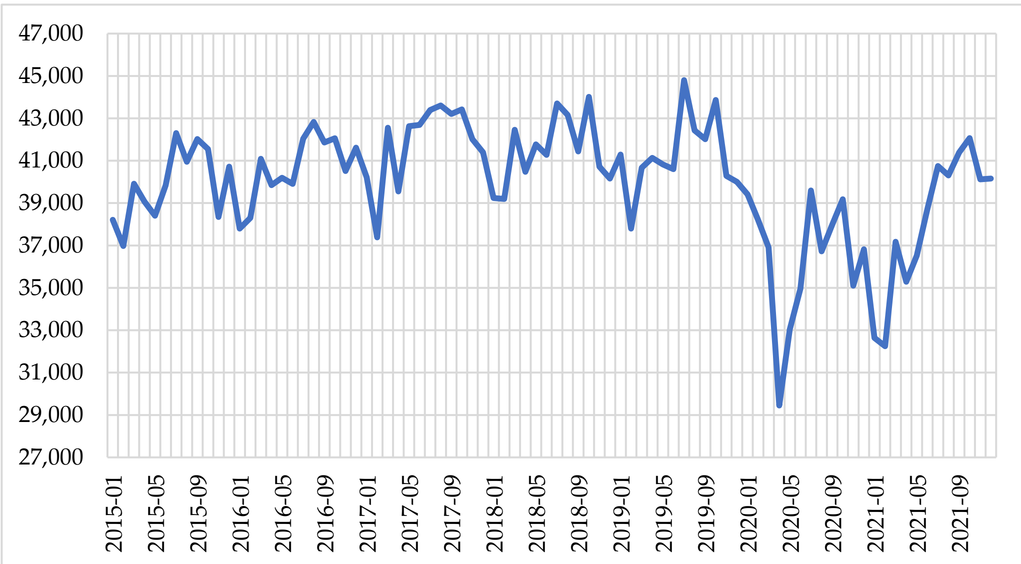

Figure 11. Shaping the volume of deliveries of oil products to EU countries (in thousand tonnes). Source: own elaboration.

In this case, the method of exponential smoothing with additive seasonality was also used. The results obtained with the use of Statistica 13.3 software are shown in Figure 12.

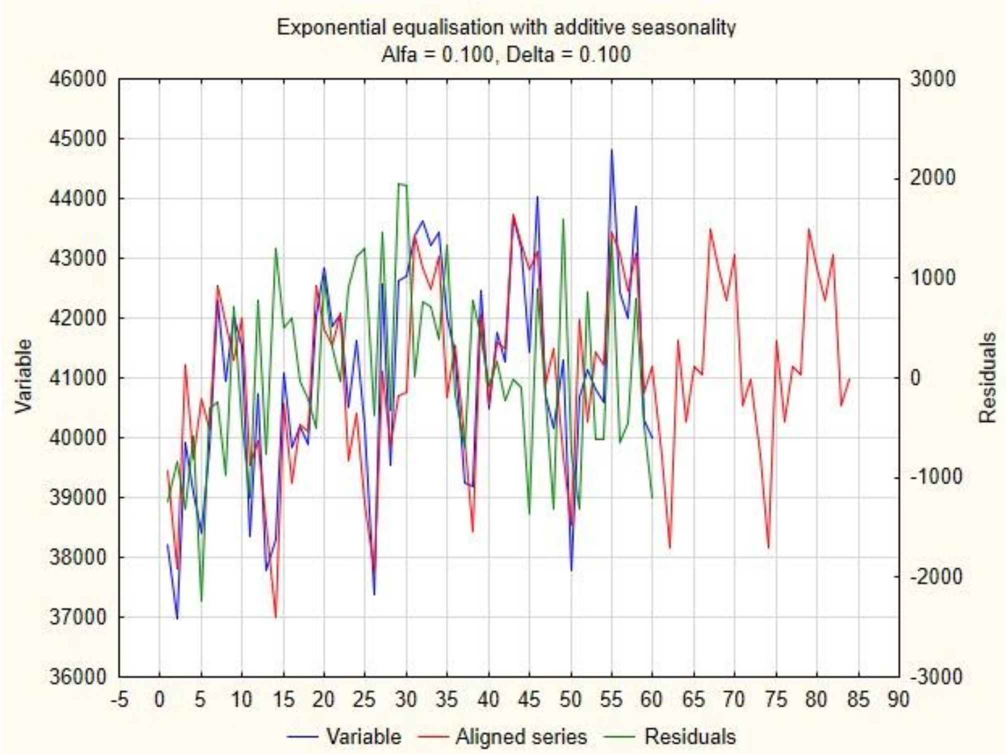

Figure 12. Exponential smoothing of supply volumes of oil products. Source: own elaboration.

The values of the forecasts obtained on the basis of this are presented in Table 7, and the forecast errors are in Table 8.

Table 7. Forecasts of the volume of oil products supplies on a monthly basis for 2020–2021 (in thousand tonnes). Source: own elaboration.

Period	Forecast	Period	Forecast
2020-01	39,698.28	2021-01	39,698.28
2020-02	38,173.78	2021-02	38,173.78
2020-03	41,634.89	2021-03	41,634.89
2020-04	40,258.81	2021-04	40,258.81
2020-05	41,199.79	2021-05	41,199.79
2020-06	41,043.89	2021-06	41,043.89
2020-07	43,486.50	2021-07	43,486.50
2020-08	42,830.51	2021-08	42,830.51
2020-09	42,296.38	2021-09	42,296.38
2020-10	43,062.50	2021-10	43,062.50
2020-11	40,545.24	2021-11	40,545.24
2020-12	40,973.40	2021-12	40,973.40

Table 8. Forecast errors. Source: own elaboration.

Mean Error (ME)	Mean Absolute Error (MAE)	Mean Percentage Error (MPE)	Mean Percentage Absolute Error (MAPE)
36.8596	764.8841	0.0406	1.8740

Mean error indicates a slight positive deviation from zero. This means that the obtained forecasts are slightly underestimated. Mean absolute error indicates that actual oil product deliveries, in absolute terms, will deviate from forecasts by an average of 764.8841 thousand tonnes. It also shows that 0.0406% of the actual oil product deliveries are due to forecast errors in the prediction period (MPE), while the average forecast error is 1.8740% of the oil product deliveries (MAPE).

The analysis of the obtained forecasts shows that if it were not for the COVID-19 pandemic, in the years 2020–2021, in accordance with the forecasts obtained, approximately 95 683.166 thousand tonnes of oil products would have been delivered to the EU countries in the years 2020–2021 (Figure 13).

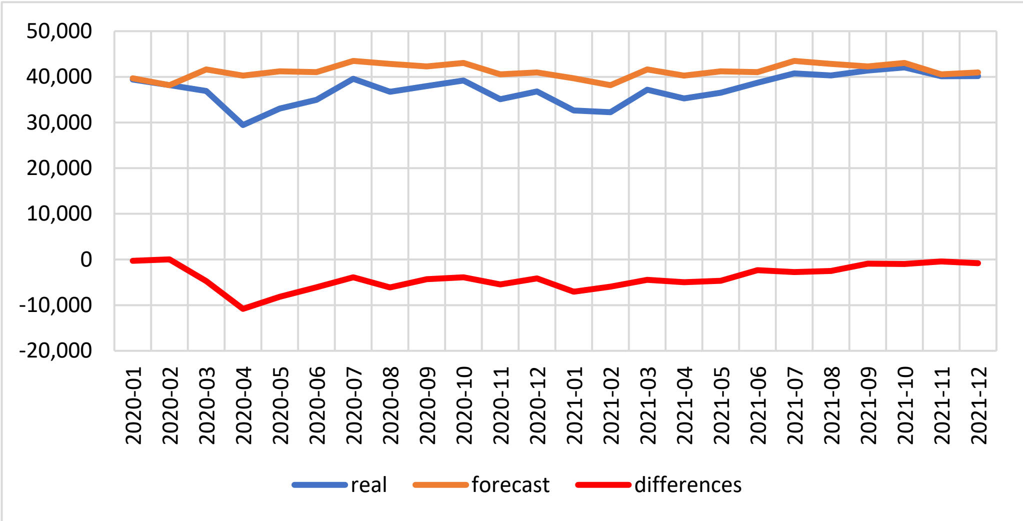

Figure 13. Comparison of the actual and forecast volumes of supplied oil products (in thousand tonnes). Source: own elaboration.

3.5. Discussion

On 30 January 2020, the World Health Organization (WHO) announced a public health emergency of international concern in connection with the COVID-19 epidemic. At the end of February 2020, WHO issued a recommendation [35] underlining the importance of not imposing any travel or trade restrictions due to the outbreak. Toward the end of the first quarter of 2020, governments around the world began imposing restrictions and then prohibitions on international travel. While these restrictions initially applied primarily to China, where the pandemic began, they quickly spread to other areas as well. On 11 March 2021, the WHO classified the epidemic COVID-19 as a pandemic [36]. The United States announced a suspension of travel from Europe, and a week later, the EU closed its external borders to air passengers [37,38]. As the epidemiological situation worsened, individual countries EU Member States began closing their borders to commercial air traffic from other countries within the EU. By April 2020, 14 Schengen Member States introduced internal border controls. The tourist traffic was closed, as was business travel, which was replaced by on-line business sessions.

While previous crises have slowed down the growth of the aviation industry, none of them led to a complete halt to operations. For example, in 2002, after the terrorist attacks in the United States, air traffic in Europe fell by 2%. The 2009 financial crisis saw a decline of 6.6%, and the eruption of Iceland's Eyjafjallajökull volcano in April 2010 resulted in the cancellation of 111,000 flights [39]. However, it is the COVID-19 pandemic that is unprecedented in history in terms of the magnitude of the effects and the timing of the impact. The International Air Transport Association (IATA) expects a recovery to the pre-pandemic situation no sooner than post-2024. Overall, the number of travelers is projected to reach 4.0 billion in 2024 (counting multi-sector connecting journeys as one passenger), exceeding pre-COVID-19 levels (103% of the 2019 total) [40].

The lockdown introduced as a result of COVID 19 also influenced the level of mobility in road transport. In this case as well, there was practically no tourist traffic. Restrictions on social distancing and the need to close hotels prevented people from going anywhere. The transition to distance learning and remote work led people to reduce the use of their cars. Interestingly, many companies discovered the advantages of remote work to such an extent that they want to either completely or partially stay with this form of work.

Fuel supplies are a response to the demand for them. It is of a secondary nature, as it results from the demand for transport [41]. This relationship has been highlighted by the pandemic.

An interesting situation occurred with regard to cargo transportation. Despite the freezing of economies in the EU countries, transport companies did not suffer due to the bad economic situation. The main factor behind this situation was the dynamic growth of e-commerce as a result of restrictions in traditional trade. In the EU-27.2, retail sales via mail order houses or the internet increased by 30% in April 2020 compared with April 2019, while total retail sales decreased by 17.9% [42]. The pandemic, together with its limitations, became a strong stimulus for the growth of online purchases, which, in turn, influenced the situation of transport and logistics companies, and consequently also the demand for fuel.

A pandemic is a crisis. It creates uncertainty and unpredictability. Contemporary supply chains, including those in which fuel flows, must be resilient. Resilience is a synergy of flexibility and adaptability [43,44]. The desired state of resilience is security, stability, and functionality. The resilient supply chain is characterized by the ability to reactive response, adaptation, and resilience in changing, unpredictable, and uncertain operating conditions. Unfortunately, analyzing the COVID-19 pandemic in terms of the resilience of fuel supply chains is still an unspoken but necessary discussion.

4. Conclusions

The COVID-19 pandemic had a significant impact on many sectors of the economy. The fuel sector in the EU was one of the sectors of the economy that felt its direct effects, as it led to massive disruptions to mobility, air traffic, and traditional trade. The aim of our research was to estimate the difference in fuel supplies between the situation where the COVID-19 pandemic occurred and the situation where there was no pandemic. The analysis covered the countries of the European Union. The research was based on the assumption that during the pandemic, fuel supplies had decreased. Our assumption proved to be correct. Only in the case of motor gasoline, the supply volumes did not decrease as a result of the COVID-19 pandemic. Throughout the pandemic, and after its completion, the volumes of deliveries remained at a similar level, taking into account seasonal fluctuations. The decline in fuel supplies was caused mainly by the introduction of lockdown and related social restrictions, which translated into the functioning of almost all sectors of the economy.

This study showed that all lower fuel supplies were, in fact, determined by top-down blockades (hence regional discrepancies) and, thus, "artificially" caused by lower demand. However, the differences between the period—without a pandemic and during a pandemic—are not as great as it seems since the whole world practically stopped. This, in turn, leads to the conclusion that as long as we do not replace fossil fuels with low or zero emission sources, we will not be able to significantly move away from burning fossil fuels (e.g., through energy saving, the pandemic showed that even "forced" did not provide much change) and greenhouse gas emissions.

When reviewing the literature in the research area, it was revealed that there is a huge research gap in this area. There are practically no studies on the impact of COVID-19 on fuel supplies in EU countries. The statistical data are available, however, and this enables various analyses to be performed. The lack of literature is a limitation for our research as no direct comparative analysis is possible. Perhaps a longer time perspective is needed. In addition, as part of the limitations of the study, the research methodology used might not seem innovative, but the authors believe that due to the fact that the topic itself is a novelty, there is no need to use a very innovative method of analysis in this respect. We believe that since the literature on the subject lacks publications on fuel supplies to EU countries, the application of the proposed methodology of statistical analysis is sufficient at this point.

Since the authors find the topic very significant, in terms of further research directions, the plan is to continue the analysis with the use of other statistical methods. The study of the impact of COVID-19 on the volume of fuel supplies has great research potential. In the current study, we wanted to analyze the supply–demand relationship. Having the results of these studies in mind, we will analyze supply and demand in more detail in subsequent studies, and we will certainly pay attention to the segmentation of supply and demand curves. Our research covered the EU countries, but it may be interesting to compare the analyses conducted for other groups of countries, e.g., Asian countries or highly developed countries compared with economically less-developed countries. Forecasts projected for a longer time horizon may also be interesting. The topic of the influence of COVID-19 on various spheres of economic and social life will certainly be both current and attractive for researchers in the coming years.

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