Proceedings of Ecos 2021 - The 34rth International Conference On
Efficiency, **C**ost, **O**ptimization, **S**imulation and Environmental Impact of Energy Systems
June 27-July 2, 2021, Taormina, Italy

Is COVID-19 pandemic a "Black Swan" event? The impact of the pandemic on the Energy Market.

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Abstract:

The recent coronavirus disease (COVID-19) pandemic outbreak affected our society greatly, offering a chance to rebuild and rethink our way of living. Energy, as a driving factor of everyday life faced an unprecedented shock. How big was this shock for both the economic and political levels? No consolidated study exists where both aspects are considered. To rethink our way of living, we should reconsider the energy policies strategies for the upcoming years. To date, such an impact has not yet been quantified using price forecasting mathematical models. We have therefore developed a methodology, to quantify the impact of COVID-19 pandemic on European energy market. This paper is addressing the following question "Is the COVID-19 pandemic a Black Swan event?"Evidently COVID-19 had significant consequences on the European energy market. Stocks suffered historical minimum prices duringthis year, with a greater impact on coal technologies than renewable ones. Moreover, stock prices return is showing unexpected fluctuations, hence resulting in incorrectly predicted price forecasts. Despite the initial shock, the energy market is returning to pre-crisis levels, with the renewable technologies leading the comeback. Based on our findings and methods, we conclude that COVID-19 pandemic was not a Black Swan event. We foresee to extend our methodology beyond European energy market and the short-term effects of the pandemic with possible application on the impact of policy makers on energy models.

Keywords:

Black Swan Event; COVID-19 Pandemic; Energy Market; Energy Policy; Impact; Price Forecast

1. Introduction

Black Swan events are rare events, often with large negative consequences and cannot be possibly predicted beforehand. Classic black swan events include the development of modern computers, the 9/11 attacks and World War 1 (WW1). Prof. Nassim Nicolas Taleb describes in his book [8] that in order to declare a rare event as a Black Swan event the following criteria must be met it has to be unpredictable; it has to carry a massive impact, and we discover, after the fact, an explanation that makes it appear more predictable and less random.

Coronavirus disease (COVID-19) is an infectious disease caused by the most recently discovered coronavirus, subsequently named SARS-CoV-2. The first human case of COVID-19 reported by officials in Wuhan City, China, in December of 2019. On March 11th, 2020, the World Health Organization declared COVID -19 a pandemic. On January 8th, 2021, more than 88 million have been infected from COVID -19 according to John Hopkins University [1], with a number of deaths exceeding 1.9 million.

History shows that infectious diseases, epidemics and pandemics, have been the number one mass killers of people, outperforming even natural disasters and wars. More people have died from the 1918 flu outbreak [2] than in the First World War [3]. In a 2018 research study [4], investigators made the assumption that the probability of a pandemic over 50 years is almost 40%. During the 20th century,

there were 4 pandemics in total, with one of them, HIV/AIDS, active still today. As we move through the first quarter of the 21st century, 5 pandemics have already occurred including COVID-19.

COVID-19 has had an immediate and very significant impact throughout the globe, hitting different sectors differently. Aviation suffered an unprecedented shock due to travel restrictions and flights cancelation. Passenger air transport measured as revenue passenger kilometer was down 90% year-on-year in April 2020 [5]. Tourism is also among the affected sectors, according to the World Tourism Organization report issued on December 2020. The international tourist arrivals fell by 72% in between January-October 2020 compared the same period in 2019 [6].

According to the World Energy Outlook 2020 issued by International Energy Agency in October 2020 [7], the COVID-19 pandemic has caused more disruption to the energy sector than any other event in the recent history, leaving impacts that will be felt for years to come. Energy demand dropped by 5% in 2020, energy related CO2 emissions by 7%, and energy investment by 18% [7]. A recent study shows that the long-run effects of the pandemic may affect the investments in renewables and vehicle fuel economy, thus potentially leading to 2,500 additional million metric tons (MMT) of CO2 from 2020 and 2035 [8].

In this paper, we address the effects of the pandemic on the energy industry and especially on the European energy market. The uncertainty over the duration of the pandemic, its financial and social impacts, and the policy reactions from different stakeholders and players, offer a historical opportunity to transform our energy future, shifting from fossil fuels to renewables. Furthermore, we answer to the following question “Is COVID-19 pandemic a Black Swan Event?” [9]. To demonstrate whether or not it was a Black Swan event, we will use a prediction method to forecast energy stock market.

First in section 2. ,we start with an introduction on the state of the art concerning the impact of COVID-19 on different sectors . In section 3 we give a decription of the methodology that we used during our research. We present also the assumptions and parameters of our case study. In section 4, we analyse and evaluete our results and we answer the main question of this paper whether COVID-19 pandemic was a Black Swan Event or not. Finally , in section 5 are the coclusions of our research.

2. Literature Review

The COVID-19 pandemic has become a catalyst for scientific research. In less than a year, we managed to produce a number of effective vaccines. Between January 1st and June 30th, 2020 more than 23,500 unique scientific articles related to COVID-19 have been published [11]. Our interest is towards the energy industry and the possible impact of the pandemic. The discussion focuses on market-based approaches dealing with stock prices and their behavior. The existing literature have highlighted the financial consequences of the crisis. A recent study [12] showed that the negative impact of the COVID-19 pandemic on the stock market is more significant for emerging countries than developed ones. Another correlation was found depending on the size of enterprises, with smaller firms experiencing more the negative effects of the pandemic [13]. On their scenario-based approach, Ramelli et al. have found that the businesses interacting with China suffered negative returns during the incubation and outbreak period of the pandemic [14]. Several economic uncertainty indicators such as the stock market volatility, newspaper-based policy uncertainty and future gross demostic product (GDP) growth reached their highest values on record [15]. Pandemic affected also the oil prices, the stock market, the geopolitical risk and the policy uncertainty in USA [16]. To date, an approach using a mathematical model to forecast the stock prices of the European energy market and investigate a possible correlation with the pandemic has not been conducted.

3. Methodology

To quantify the effects of the pandemic, we focus on a market-based approach dealing with the stock prices of European enterprises in the energy sector. Our calculations include companies that are members of the Euronext Stock Exchange. Our objective is to identify the different impact of COVID-19 on renewable and nonrenewable technologies. Therefore, we distributed the enterprises into Renewables and Non-Renewables. We applied two different forecast mathematical methods to predict the stock prices for two different time periods, before and after the pandemic. Our data have been extracted from Quandl [10], a free international API with hundreds of different datasets related with the financial sector.

3.1 Mathematical Forecast Models

There are various mathematical models and methods to forecast stock prices. In our study, we choose the Geometric Brownian Motion as our main approach [17]. Since the long-term effect of the pandemic is uncertain, we focus on the short-term forecast of stock-prices based on a monthly trend. Previous studies [18] are showing a mean absolute percentage error of (MAPE) $\leq 20\%$, concerning short term forecasting when using Geometric Brownian motion. The mean absolute percentage error is a statistical measure to quantify the accuracy of a prediction. A classification of typical MAPE values shows that a value between 10%-20% (Table 1) is considered as a good forecast.

Table 1. MAPE typical values classification.

MAPE Value	Prediction Accuracy
MAPE $\leq$ 10%	Highly Accurate Forecast
10% $<$ MAPE $\leq$ 20%	Good Forecast
20% $<$ MAPE $\leq$ 50%	Reasonable Forecast
MAPE $>$ 50%	Inaccurate Forecast

Source: [19]

3.2 Geometric Brownian Motion

Geometric Brownian motion is widely used to model stock prices in finance, as it accounts both for long-term trend and for random shocks. A stochastic process S_t is said to follow a Geometric Brownian motion if it satisfies the following stochastic differential equation:

$$\mathrm{dS_t} = \mu \mathrm{S_t}\, \mathrm{dt} + \sigma \mathrm{S_t}\, \mathrm{dW_t}. (1)$$

The longer-term trend in stock prices is modelled with a drift term:

$$\mathrm{drift_k} = \mu - \tfrac{1}{2}\sigma^2 \quad (2),$$

which in our case represents the monthly trend of our predictions. The short-term fluctuation, which is daily (excluding weekends) is modelled with the diffusion component:

$$\mathrm{diffusion_k} = \sigma \mathrm{b_k} = \sigma \mathrm{z_k} \quad (3),$$

where the array b stores the random shock information we need, and retrieves random shock information from standard normal variable z.

Whereas sigma is the standard deviation or the volatility of the historical stock prices for a specific time period k, and μ is the mean return of the stock prices within the historical date range. In this approach, diffusion is the component responsible for the predictions and drift is constant. The solution of the above stochastic differential equation (1) is:

$$\mathrm{S_k} = \mathrm{S_{k-1}} * \mathrm{e}^{\left(\mu - \frac{1}{2}\sigma^2 + \sigma \mathrm{z_k}\right)} = \mathrm{S_{k-1}} * \mathrm{e}^{(\mathrm{drift_k} + \mathrm{diffusion_k})} \quad (4)$$

3.3 Case study

The main goal of this paper is to quantify the impact of COVID-19 pandemic on the energy market and assess whether it was a Black Swan event or not. Since we are interested in the European Energy

Market, we are studying the behavior of the stock prices of largest enterprises in Euronext N.V. Euronext is the largest stock exchange in Europe, operating in 5 European cities Amsterdam, Brussels, Dublin, Lisbon and London. This approach will give as the opportunity to answer the following question: How was the energy market before the pandemic? What was the initial impact on it? How did it evolve since the beginning of the pandemic?

In addition, we classify the enterprises into Renewables and Non-Renewables. The first forecast is for a period of one month starting on February 20th, 2020. The date that the World Health Organization announced that covid-19 a pandemic (11th of March 2020) is included in this period. The second period is for a period of one month starting in December 2020. We choose to run a simulation of 50 different scenario. The diffusion component (3) is the one responsible for the different scenarios as it involves a Wiener process. In order to perform more scenarios Geometric Brownian Motion should be applied together with a Monte Carlo simulation. According to these, we therefore applied our analysis on 19 (Table 3) different non-renewables enterprises and 8 enterprises (Table 2) dealing with renewable technologies. To check whether each actual stock price was within the prediction range, we choose two dates within the forecast periods, 12th March 2020 and 7th December 2020, respectively. The selection of the dates can affect the results significantly, 12th of March is the first exchanging date after the declaration of COVID-19 as a pandemic, therefore is an important date where we can observe the immediate effects. The 7th of December is the date that this experiment has been conducted for the first time.

Table 2. Renewable Technology Enterprises and their abbreviations in Euronext N.V.

Enterprise Name	Abbreviation
Global Bioenergies	ALGBE
VERGNET	ALVER
ENVIE EPS	EPS
EO2	ALEO2
EVERTIME	ALENE
MCPHY ENERGY	MCPHY
METHANOR	ALMET
SIF HOLDING	SIFG

Table 3. Non-Renewable Technology Enterprises and their abbreviations in Euronext N.V.

Enterprise Name	Abbreviation
Royal Dutch Shell	RDSA
Francaise Energie	LFDE
Total	FP
Core Laboratories	CLB
CGG	CGG
CGG BSA1	CGGBS
CGG BSA 2	CGGBT
ECOSLOPS	ALESA
ENI	ENI
ESSO	ES
FLUXYS BELGIUM D	FLUX
FUGRO	FUR
GALP ENERGIA-NOM	GALP
GTT	GTT
MAUREL ET PROM	MAU
Prosafe	PRS
Royal Dutch Shell B	RDSB
SBM OFFSHORE	SBMO
SCHLUMBERG	SLB

4. Results

The goal of this section is to answer whether COVID-19 pandemic was a Black Swan event or not. Additionally, we estimate the different consequences of the pandemic on different technologies enterprises. By analyzing our results, our aim is to provide a guideline for policy makers to seize the opportunity of the pandemic and transform the energy system by promoting renewable energy and maintaining ambitious policy, despite COVID-19.

4.1 Historical Stock Prices

The stock prices are the main parameter of this study. By investigating the stock prices for specific periods, before and after a major event, we identify how a specific enterprise has been affected. Increasing demand result to higher stock prices and decreasing demand result to lower stock prices. In the following graphs, we present the historical prices of different enterprises in EURONEXT market. Indeed, stock markets can be affected by a variety of different parameters and events, such as: a) bankruptcy of a company b) CEO's resignation c) a new policy. Therefore, we included many companies to isolate only the effects of the pandemic.

Fig. 1a-1b: History of stock prices for Non-Renewables (a) and Renewables (b) enterprises from 01/01/2020 until 31/12/2020.

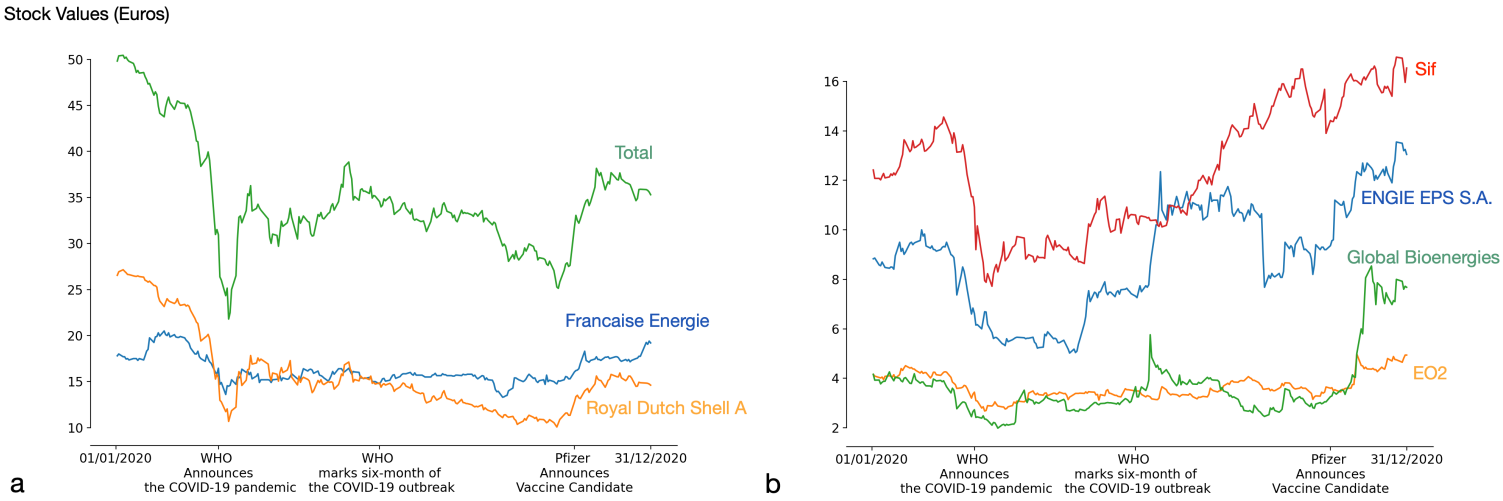

Fig. 1a and 1b, indicating the stock prices for the period from 1st of January 2020 until 31st of December 2020. These graphs focus on the development of the stock prices before, during and after a couple of months since the beginning of the pandemic. There was a significant impact both on Renewables and Non-Renewables technologies with the impact on non-renewable technologies to be higher. Stock prices dropped dramatically between January 2020 and April 2020 with a historical negative record on middle of March, the day that WHO declared COVID-19 as a pandemic. The 11th of March was probably the most important day of the year for the market because from the next trading day prices start to fall dramatically. Nevertheless, by the end of the year stock prices for renewable energy enterprises are facing an increasement compared to their initial prices before the pandemic. The situation is the opposite for non-renewable energy companies.

After the outbreak stock prices return appearing unexpected fluctuations (Fig. 2) compared to previous years and histograms return are not following normal distribution as it would be expected [20]. Daily returns histograms for both type of technologies appearing similar, concluding that both type of technologies affected from the pandemic equivalently.

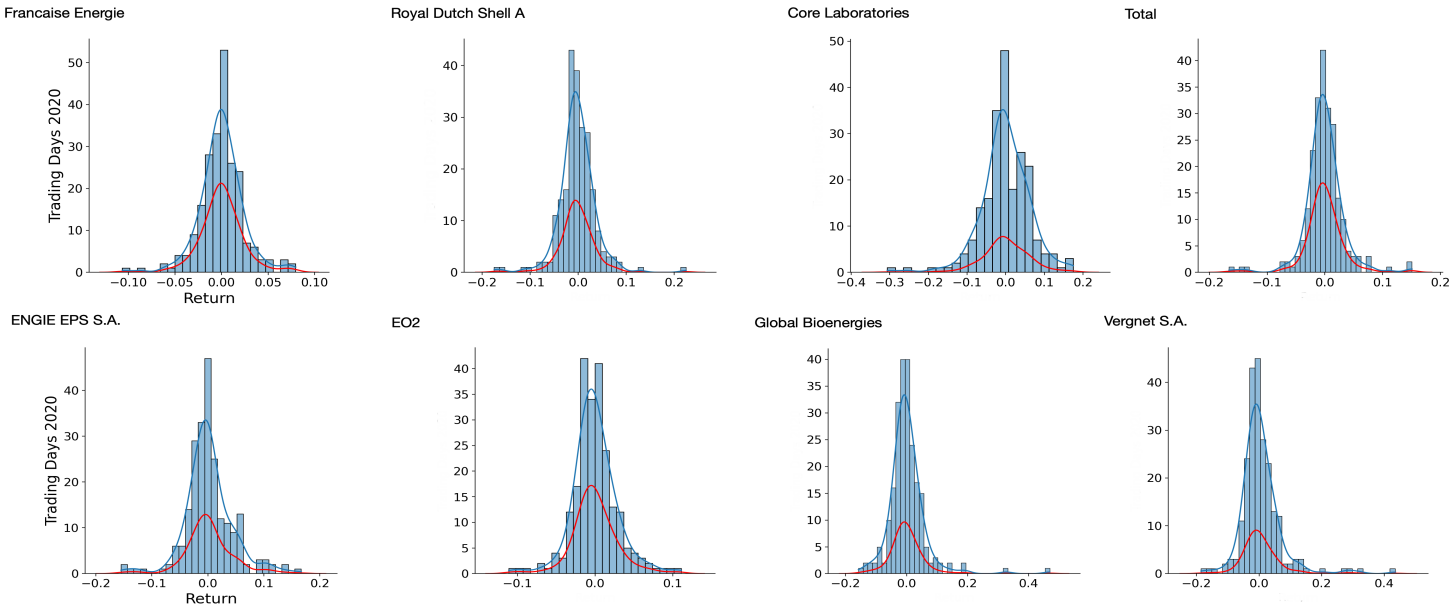

Fig. 2: Daily Stock Prices Return for Non-Renewable and Renewable Enterprises for 2020

4.2 Forecasts

COVID-19 pandemic affected our lives greatly. Understanding the consequences is important for the upcoming years, both for addressing the long-term effects of the pandemic but as well as to provide the appropriate guidelines and knowledge to the next generations and give them the opportunity to prevent such disasters. This study shows, that although our methods failed to predict the impact of the pandemic on stock prices in advance, just after a couple of months the market recovered completely and adjusted itself to the new reality. Furthermore, in line with World Energy Outlook 2020 [7], our results indicate that Renewable Energy is leading the way. The different negative effects of the pandemic are doubtless, millions of people infected, and millions lost their lives. Although, concerning the energy market, the pandemic could be a historical opportunity to shift our lives and society towards renewable energy.

In Fig. (3-6) we present our results concerning the forecasts. The figures represent the Probability density functions of companies of Energy Industry in Euronext Market for 12th of March (Fig. 3,4) and 7th of December (Fig. 5,6) respectively. As mentioned already, our forecasts referred to two different periods. The first one is based on the trend between 20/01/2020 and 20/02/2020 and for a duration of one month, namely until 20/03/2020 (Fig. 3,4). The second one is based on the trend between 01/11/2020 and 30/11/2020 for a duration of one month as well, namely until 31/12/2020 (Fig. 5,6). As we can see for March 2020 one day just after the beginning of the pandemic, almost every prediction for all enterprises failed completely both for Renewables (Fig. 3) and Non-Renewables (Fig. 4). From the other hand, concerning the second period, just a few months since the beginning of the pandemic stock prices for both Renewables (Fig. 5) and Non-Renewable (Fig. 6) enterprises are following normal prediction/forecasting path and both methods are successful.

The fact that the prices of Renewable Enterprises in most of the cases surpassing the prices that they had in the beginning of the year is pointing out that the impact of COVID-19 was positive for alternative technologies. Thus, we have to admit that covid-19 is a catalyst and an accelerator of the ongoing trend towards renewable energy. Contrastingly, Non-Renewables enterprises are still decreased, and they still need time to recover from the initial shock or maybe they will never do so.

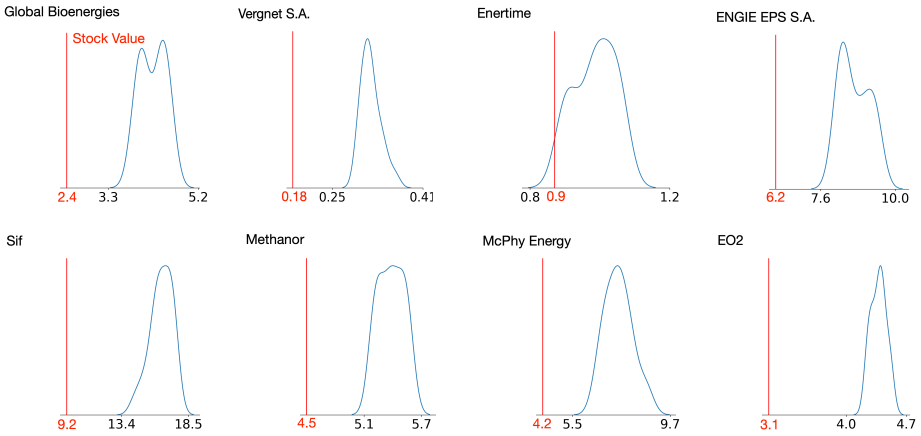

Fig. 3: Probability density function of predictions for renewable companies on the 12th of March 2020

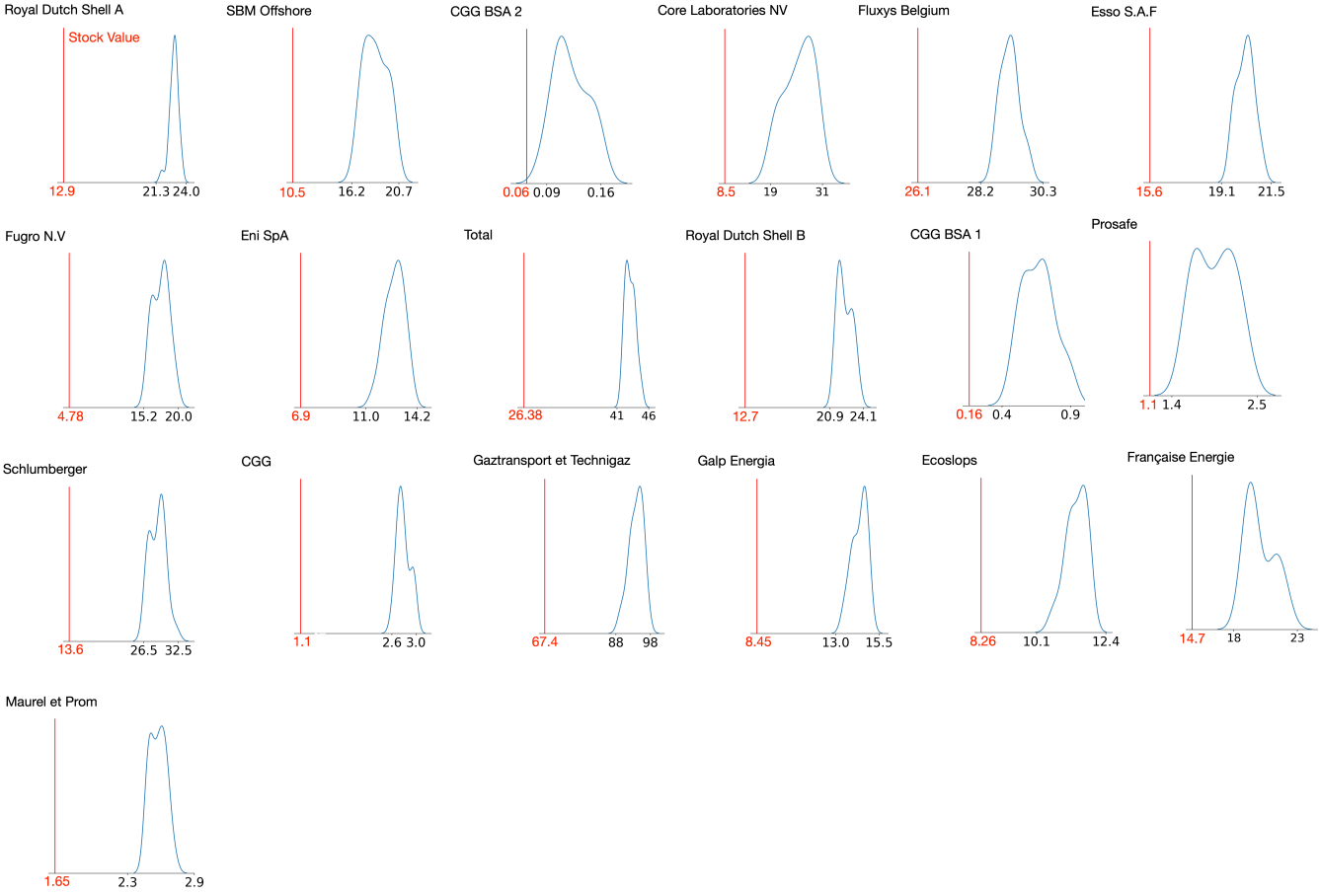

Fig. 4: Probability density function of predictions for non-renewable companies on the 12th of March 2020

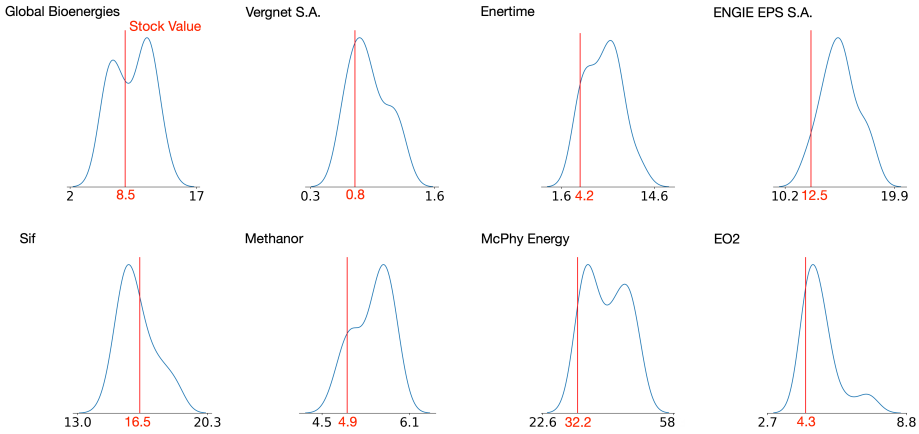

Fig. 5: Probability density function of predictions for renewable companies on the 7th of December 2020

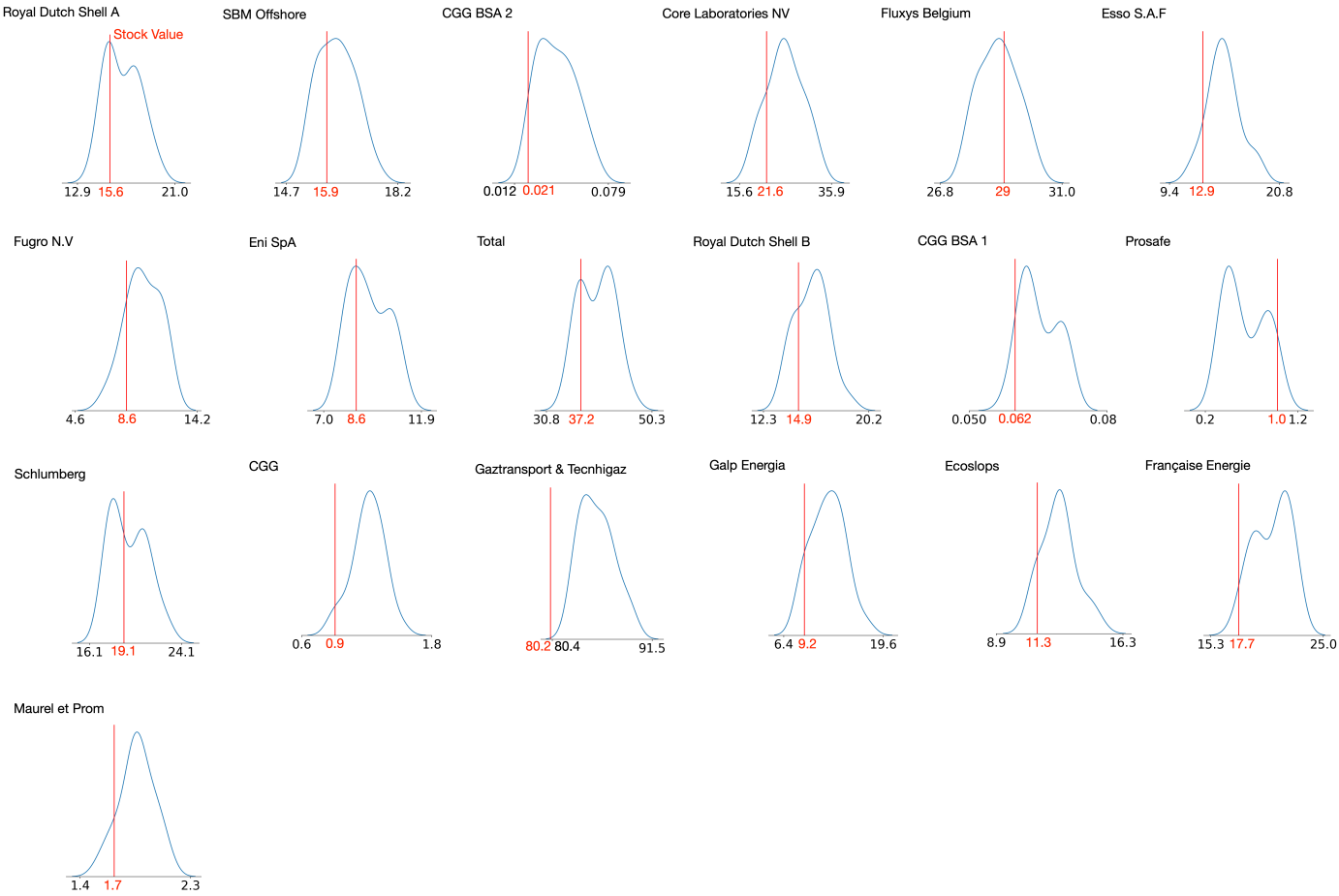

Fig. 6: Probability density function of predictions for non-renewable companies on the 7th of December 2020

4.3 Black Swan Event

It seems that COVID-19 pandemic is not a Black Swan Event. The reason is that first of all the pandemic was predictable, many scientists and personalities such as Nicholas Taleb, Bill Gates and the former president of the United States of America Barack Obama predicted that a pandemic is possible [9,21, 22]. Sufficient warnings can be found also in scientific papers and articles describing that pandemics are like “Minnesota winters” that some of them are worse than others but inevitable, that they were 10 pandemics in the past 300 years and that our main concern should have been to build a sufficient health care system and prepare our societies [23]. The last decades, an understanding of the process of emergence and spread of a pandemic has moved from hypothesis to potentially predictive but the most important parameter is remaining the political willingness of the countries to act together to strengthen a global network against pandemics [24]. The results of this study are indicating that the pandemic had an impact on the energy sector and as we mentioned already in many other industries as well. Eventually, we understood already that a pandemic was inevitable [25,26] and that now we are shifting as a global community the focus to errors in judgement or some other form of causation. According to these, pandemic resembles as a “White Swan” in a sense that: it was certain; it carried a short-term impact that could be easily estimated and after the fact, we concoct an explanation that recognizes the certainty of occurrence [9].

5. Conclusion

Covid-19 pandemic after all it seems a less rare event as we might thought in the beginning, thus it is not a Black Swan Event. The unprecedented effects are still ongoing though. Therefore, it is uncertain to decide when it will be over and study the long-term effects at the moment. Concerning, the short-term effects of the pandemic on the energy market it is certain that the consequences were more significant on the stock prices of coal industry enterprises. By December 2020, the stock prices of non-renewable were still decreased compared to their initial prices before the beginning of the pandemic. From the other hand, alternative technologies prices for the same period were increased. The market overcome the initial sock and our methods are capable to provide reliable forecasts. The pandemic appearing as a critical factor to shift our policies and societies towards renewable energy. We aim to extend this method and further investigate the energy policies and the prices of different technologies. Our goal is to implement a model which will be able to quantify the impact of a policy changing taking into account different parameters such as the frequency, a geographical indicator and the social acceptance. Future research should also focus to a consideration of possible impacts of COVID-19 on financial markets and institutions [27].

Acknowledgments

The authors acknowledge the support of the Energy Transition Fund of Belgium.

References

[1] John Hopkins University, CORONAVIRUS RESOURCE CENTER, COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at John Hopkins University (JHU) at:< https://coronavirus.jhu.edu/map.html> [accessed: 08.01.2021]

[2] Centers for Disease Control and Prevention, 1918 Pandemic (H1N1 virus) at:< https://www.cdc.gov/flu/pandemic-resources/1918-pandemic-h1n1.html#:~:text=It%20is%20estimated%20that%20about,occurring%20in%20the%20United%20States> [accessed: 08.01.2020]

[3] Nadège Mougel, REPERE- module 1.0- explanatory notes- World War 1 casualties, English Translation: Julie Gratz, Centre Robert Schuman

[4] Pandemic risk: how large are the expected losses? (Bull World Health Organ 2018 Feb 1;96(2):129-134. doi: 10.2471/BLT.17.199588. Epub 2017 Dec 5.)

[5] Organisation for Economic Co-operation and Development, Tackling CORONAVIRUS (COVID-19): Contribution to a global effort. COVID-19 and the aviation industry: Impact and Policy Responses. 15.03.2020

[6] World Tourism Organisation, A United Nations Specialized Agency. Impact Assessment of the COVID-19 Outbreak on International Tourism. December 2020

[7] International Energy Agency, World Energy Outlook 2020, 13.10.2020

[8] Kenneth T. Gillingham, Christopher R. Knittel, Jing Li, Marten Ovaere, Mar Reguant., The Short-run and Long-run Effects of Covid-19 on Energy and the Environment. Joule, Volume 4, Issue 7,2020. Pages 1337-1341

[9] Nassim Nicholas Taleb., The Black Swan: The Impact of the Highly Improbable. London, United Kingdom: Penguin Books ltd; 2008.

[10] Quandl: A Nasdaq Platform at:< https://www.quandl.com/>

[11] Teixeira da Silva, J.A., Tsigaris, P. & Erfanmanesh, M. Publishing volumes in major databases related to Covid-19. Scientometrics 126, 831–842 (2021). https://doi.org/10.1007/s11192-020-03675-3

[12] Maretno Agus Harjoto, Fabrizio Rossi & John K. Paglia (2020) COVID-19: stock market reactions to the shock and the stimulus, Applied Economics Letters, DOI: 10.1080/13504851.2020.1781767

[13] Yan, Chao, COVID-19 Outbreak and Stock Prices: Evidence from China (April 13, 2020)

[14] Ramelli S, Wagner AF. Feverish Stock Price Reactions to COVID-19. The Review of Corporate Finance Studies. 2020 July 7.

[15] Dave Altig & Scott Baker & Jose Maria Barrero & Nick Bloom & Phil Bunn & Scarlet Chen & Steven J Davis & Julia Leather & Brent Meyer & Emil Mihaylov & Paul Mizen & Nick Parker & Thomas Renault & Pawel, 2020. Economic uncertainty before and during the COVID-19 pandemic, Discussion Papers 2020/07, University of Nottingham, Centre for Finance, Credit and Macroeconomics (CFCM).

[16] Sharif, Arshian & Aloui, Chaker & Yarovaya, Larisa, 2020. "COVID-19 pandemic, oil prices, stock market, geopolitical risk and policy uncertainty nexus in the US economy: Fresh evidence from the wavelet-based approach," International Review of Financial Analysis, Elsevier, vol. 70(C).

[17] Hull, J.. “Options, Futures, and Other Derivatives.” (1989).

[18] W Farida Agustini, Ika Restu Affianti, Endah RM Putri, Stock price prediction using geometric Brownian motion. Journal of Physics: Conference Series, Volume 974, International Conference on Mathematics: Pure, Applied and Computation 1 November 2017, Surabaya, Indonesia

[19] Lewis, C.D., Borough Green, Sevenoaks, Kent., Industrial and business forecasting methods. Butterworth, 1982

[20] Kathryn Christopher, Ph.D. Why Do Stock Market Returns Look Like a Bell Shaped Curve?, ZACKS: Our Research. Your Success, Available at:< https://finance.zacks.com/stock-market-returns-look-like-bell-shaped-curve-6458.html >

[21] Bill Gates, The next outbreak? We’re not ready. TED Talks, April 3,2015. Available at < https://www.youtube.com/watch?v=6Af6b_wyiwI&ab_channel=TED >

[22] Bernard Avishai, The Pandemic Isn’t a Black Swan but a Portent of a More Fragile Global System. The New Yorker, April 21,2020. Available at: <https://www.newyorker.com/news/daily-comment/the-pandemic-isnt-a-black-swan-but-a-portent-of-a-more-fragile-global-system>

[23] Michael T. Osterholhm, Ph.D., M.P.H. Preparing for the next Pandemic. The New England Journal of Medicine. May 5, 2005.

[24] Stephen S Morse, Jonna AK Mazet, Mark Woolhouse, Colin R Parrish, Dennis Carroll, William B Karesh, Carlos Zambrana-Torrelio, W Ian Lipkin, Peter Daszak, Prediction and prevention of the next pandemic zoonosis,The Lancet,Volume 380, Issue 9857,2012,Pages 1956-1965,ISSN 0140-6736.

[25] Hunter P. Inevitable or avoidable? Despite the lessons of history, the world is not yet ready to face the next great plague. EMBO Rep. 2007;8(6):531-534. doi:10.1038/sj.embor.7400987

[26] Betsy Mckay, Phred Dvorak, A Deadly Coronavirus Was Inevitable. Why Was No One Ready?. The Wall Street Journal, Aug. 13, 2020. Available at: <https://www.wsj.com/articles/a-deadly-coronavirus-was-inevitable-why-was-no-one-ready-for-covid-11597325213>

[27] John W. Goodell,COVID-19 and finance: Agendas for future research,Finance Research Letters,Volume 35,2020,101512,ISSN 1544-6123