An investigative analysis on the effect of a pandemic on countries' stock market indexes within Europe: A case study of (covid 19) coronavirus

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An investigative analysis on the effect of a pandemic on countries' stock market indexes within Europe: A case study of (covid - 19) coronavirus

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Abstract

The 2019 human coronavirus pandemic (COVID-19) emerged with seemingly high transmissibility and thus contributed to unprecedented socioeconomic instability especially in the financial market. This research aims at investigating if a pandemic affects stock prices. That is if the stock market prices decreased as the number of recorded cases increased and to what extent did this occur. As an investigative experiment, panel data analysis was used to test the effect of the Covid-19 pandemic on four countries namely: Spain, France, Germany, and U.K stock markets. A Yahoo finance and John Hopkins dataset was used for this research. The dataset contained countries' stock market index prices and the number of increasing cases respectively. The dataset was imbalanced as the number obtained stock prices for Germany and U.K was less than that of France and Spain. Three model estimators under panel data analysis were compared (Pool Ordinary Least Square, Fixed effect, and Random effect) in other to obtain an unbiased result. The findings indicate that the random effect model which considers the unobserved effect to have a zero correlation with the explanatory variables as the best estimator for modeling the effect of COVID-19 pandemic of stock prices. The result showed a significant negative effect on stock prices across all countries.

Keyword: ***Covid19, Corona Virus, Pandemic, Stock Price*** **(keywords)**

1 Introduction

1.1 Background and Motivation

The novel coronavirus, SARS-CoV-2, or COVID-19 as it is popularly called came as a devastating incident with unparalleled confusion as to how deadly it was and if a vaccine could be gotten. It was initially described as an epidemic because it was limited to provinces within China until the World Health Organization [6] officially declared it a pandemic on March 11, 2020, as the outbreak which started from Wuhan (China) in late December 2019 had spread to over 216 countries, with about fifteen million confirmed cases been recorded and over six hundred thousand death as of July 24, 2020, [10]. A report by the European Centre For Disease Prevention and Control explains that many countries in Europe had been significantly affected by the pandemic and despite the numerous scientific developments over the years, infectious diseases would continue to pose a significant threat to society.

In response to the announcement made by the W.H.O and the panic caused by the news, emergency actions such as economic packages, travel restrictions, and lockdowns were taken by governments worldwide to contain the spread and reduce its economic effect. The primary

objective of these acts was to maintain social distancing, contain its spread, and above all, mitigate the adverse economic effect. Despite the fact
government objectives are assumed to generate a positive result, in the long run, the initial panic caused uncertainty in the financial market as most investors liquidated their shares and thus this affected the stock market (Okorie and Lin, 2020). While the exact economic impact of the pandemic is yet to be identified, the stock market is assumed to have been impacted.
Wagner (2020) explains the stock market as a collection of knowledgeable and opinionated investors which offers a supported survey of the anticipated outcomes of the markets. Although, previous studies from researchers such as (Bash and Alsaifi, 2019), (Guo, 2020), (Kowalewski and Spelewanowski, 2020), (Buhagiar, 2018) and (Chen, 2009) identified how stock market prices respond to major incidents like Political issues, environmental changes, disasters, sports, and other outbreaks. Notwithstanding, there is still limited research on the extent to which the present pandemic has interacted with the changes in stock prices. For the implementation of this project, a panel regression analysis
This research, therefore, contributes to the literature in two ways: First, we contribute to the existing literature on the stock market behavior to different events as earlier explained and secondly, to contribute to present literature that explores the effect of COVID-19 pandemic on stock market prices using panel data analysis on countries' that contribute significantly to Europe's G.D.P.

1.2 Research Question

Investigating the reaction of stock prices during a pandemic is important because it assists investors and policymakers in making appropriate decisions. Being motivated by previous studies on the effect of a pandemic in different sectors and economies, the key research question for this analysis is: *To what extent can a panel regression analysis be used to investigate the relationship and effect of a pandemic on stock prices?*

1.3 Objectives

- This research aims at being an investigative study to determine if there is a significant cross-sectional or significant temporary effect (poolability) in the panel dataset.
- To compare and select between fixed or random effect in the panel data.
- To contribute to existing studies on if pandemics affect changes in stock prices and to what extent. This would help in drawing accurate conclusions that will guide investors and policymakers.

1.4 Justification of Determinant

1.4.1 Panel Data Analysis

The dataset used in an exploratory analysis is divided into three: Cross-sectional data, Timeseries data, and Panel data. Time series tracks the movement of a variable over a specific period. Cross-sectional data are observations that are made up of different entities at a single period while panel data shares an element of time series and cross-sectional data. As defined by (Baltagi,2008), it is the pooling of variables on a cross-sectional unit of entities over several periods. It extracts the cross-sectional and time-series difference from a panel data and minimizes the problem of estimation bias, multicollinearity, and heteroscedasticity (Woolridge, 2010). It is a good and effective model for determining the statistical interference among variables that a time series or cross-sectional data cannot provide (Hsiao, 2007). The rest of this paper is divided as follows: Section 2 reviews past literature which shows a critical study of already published works that serve as a significant point of reference for this research. Section 3 outlines the research methodology and model specification. Section 4 presents the implementation followed, while the evaluation of the project was done in section 5 with a detailed explanation of the results illustrated in Section 6. The final Section concludes on the project stating it's a limitation and the future work of the research.

2 Related Work

2.1 Conceptual Clarification

Pandemic, as a concept frequently used in this research project, is not uncommon in extant literature. It is generally referred to as a spreading disease affecting many countries of the world at the same time[1]. Generally, a pandemic is characterized by severity, contagiousness, infectiousness, very low population immunity, widespread and especially, adverse impact on different affairs of the national and international communities- health, economy, political, security, social etc[2]. Several cases of the pandemic had occurred previously, namely: Spanish flu; smallpox; Hong Kong flu; Cholera; AIDS; first SARS (in 2003); H1N1 influenza (in 2009); Ebola (between 2014 and 2016); and the most recent COVID-19 Coronavirus, among others (Hiscott, Alexandridi, Muscolini, Tassone, Palermo, Soultsioti and Zevini, 2020). Pandemic and Epidemic are often used interchangeably, however, a slight lexical disparity exists between both terms, as expatiated by the Merriam-Webster Online Dictionary. It showed that the difference is only in the range and coverage (affected persons and nations). In other words, while an epidemic refers to a disease outbreak with a very quick spreading rate and affecting many people at the same time, the pandemic is also similar except that it affects a higher proportion, greater range, and coverage of the population[3].

2.2 Economic Impact of Global Pandemics in Europe

Pandemic has a protracted record on the European continent and in world general, with evidence of global diseases accustomed to their widespread mortality and lasting economic impact[1]. Beginning with the 1918 Spanish flu, Europe undoubtedly faced the deadliest influenza pandemic in modern history as the time of occurrence. History showed that the 1918 influenza was a global pandemic at peak mortality offering lethal disruption in economic activities as that 2.64 million excess deaths occurred in Europe as at the potency time of the flu (ALMOND and MAZUMDER, 2004; Ansart et al., 2009). In 2003, another

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[1] BBC (2020) https://www.bbc.com/news/world-51839944
[2] Qiu, W., Rutherford, S., Mao. A and Chu. C (2017). "The Pandemic and Its Impacts." DOI 10.5195/hcs.2017.221
[3]Merriam-Webster https://www.merriam-webster.com/words-at-play/epidemic-vs-pandemic-difference
[4]Bramanti, B. *et al.* (2019) 'The Third Plague Pandemic in Europe', pp. 1–8. doi:http://dx.doi.org/10.1098/rspb.2018.2429.

pandemic struck the world which affects Europe. It was the outbreak of Severe Acute Respiratory Syndrome (SARS) (Yang et al., 2020). This deadly disease reduced consumer confidence in the economy leading to a significant reduction in consumer spending. This was heightened with increased uncertainty and risk that surrounded the economy[2]. The demand for certain goods and services declined, and output reduced since people avoided work or social connections and associated purchase of goods and services. The economic effect of such precautionary actions was substantially estimated at the US $30–$100 billion (Sadique et al., 2007). This shock left England with a 25% to 40% drop in labor supply, a roughly 100% increase in real wages, and a decline in rates of return on land from about 8% to 5%[3]. In March 2009, H1N1 influenza emerged in Mexico which started spreading across Europe and the rest of the globe. This virus was a different type of influenza A, known as "swine flu." It is highly infectious and it rapidly spread like wildfire around the world, infecting 74 different countries in all six continents within five weeks. The rate of spread of the pandemic was far more instant than hitherto observed, enabled by a large number of international air traffic. The WHO declared it as a global pandemic on June 11, 2009, and it ultimately infected thousands of people in Europe. The UK has experienced a substantial first wave of transmission in the early days (Merler et al., 2011; VERIKIOS et al., 2011) Recently, the world experienced a more dangerous pandemic outbreak known as Coronavirus (COVID-19) with its first record in December 2019. This infection, which starts with a common cold and then becomes more severe, is deemed highly contagious and infectious (Yang et al., 2020). Early March 2020, the World Health Organization (WHO) officially announced the COVID-19 Coronavirus outbreak as a global pandemic[4] and later reported that the number of confirmed patients has surpassed 2 million with about 139,000 already dead globally as at April 17, 2020[5]. Countries such as Italy, Iran, Spain, France, and the United Kingdom have been stricken beyond compare with severe COVID-19 outbreaks which can be tagged 'the once-in-a-century pathogen' (Gates, 2020). This made Zhang, Hu, and Ji, (2020) admit that going by the daily increase in infected case, the financial markets of Europe have started experiencing some decline and falls with Italy being most affected at first. In another study conducted by (Goodell, 2020), the impact of COVID-19 was shown to have led to an intensive global economic disruption with a highly adverse impact on financial sector including stock markets, banking and insurance.

2.3 Covid-19 outbreak and effect on stock market indexes

Since its outbreak from the Chinese city of Wuhan, the COVID-19 infectious disease caused by the new type of coronavirus SARS-CoV-2 has and is causing mayhem in Europe and across the world. As of July 12, 2020, the total confirmed cases in the UK, Spain, Germany,

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[5]Fan, E. X. (2003) 'SARS: Economic Impacts and Implications', ERD Policy Brief Series, (15).

[6]Jordà, Ò., Singh, S. R. and Taylor, A. M. (2020) Longer-run economic consequences of pandemics.

[7]https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19-11-march-2020

[8]https://www.who.int/emergencies/diseases/novel-coronavirus-2019/ situation-reports.

and France exceeded 810,000 cases with over 110000 deaths reported[6]. Stock prices are driven by aggregate forces of demand and supply, and thus, in place of higher uncertainty about a pandemic, the price elasticity of commodity supply and demand rises, with both supply and demand falling rapidly and steadily over time (Bakas and Triantafyllou, 2020).

This ever fast-increasing pandemic has caused stock markets around the world to suffer enormous losses in the first three months of 2020 (Cepoi, 2020). The stock market reacts directly to the effect of the COVID-19 pandemic outbreak. In the first fifty days into the pandemic, Ngwakwe, (2020) found that stock market indexes for Euronext 100, a Europe top global market, experienced a higher degree of stock value fluctuation. This circuit-breaking mechanism was witnessed with a varying degree by the crash of the US global stock market as well as the China global stock market (Ngwakwe, 2020).

The increase in the number of confirmed cases and death tolls in a country has been reported to influence the stock market negatively. This means that stock market returns decline as the number of confirmed cases increases in the countries (Ashraf, 2020). Building on the disastrous effect of COVID-19 pandemic, Al-awadhi, *et al.* (2020), and Zhang *et al*, (2020) similarly reported that strong negative returns emerged in the stock markets in response to COVID-19 pandemic. Focusing on government action in the containment of the pandemic, Ashraf,(2020) postulated that social distancing directives exhibit a direct negative effect on stock market returns while rapid health response and support packages will enhance investors' confidence and lead to a positive stock index. This corroborates with Zhang *et al*, (2020)'s findings that the volatility of ten stock markets in the countries with most confirmed cases over the first two months in 2020 increased substantially due to COVID-19.

The impact of COVID-19 related information also had a spin on the stock market volatility and returns. According to Okorie and Lin, (2020), there is a significant but short-lived contagion effect on the stock markets because of the COVID-19 pandemic. These considerable fractal contagion effects observed in both the stock market returns and volatilities gave reason to experience an asymmetric dependency with COVID-19 related information (Cepoi, 2020; Okorie and Lin, 2020). This leads to the consequential negative effect the pandemic had on stock market indexes. Hence the severity of COVID-19 and its economic effect is likened to the adverse economy experienced during World War 2 (Nicola et al., 2020).

Furthermore, unlike previous pandemics in the world, the COVID-19 coronavirus has a longer duration and its effect on both national and international economy is much more severe due to the strict preventive measures taken by the governments and also the large extent of uncertainties that surrounds the viral infection (Verikios, 2020). Baker, Bloom, Davis, Kost, Sammon, Viratyosin, (2020) also affirmed that there had not been an epidemic or pandemic in the history whose impact is as felt on the stock market as the present COVID-19 Coronavirus pandemic.

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[9]WHO (2020) Coronavirus disease, situation Report? 9https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports.

[10]John Hopkins, University and medicine report. https://coronavirus.jhu.edu/

2.4 An Empirical Review of COVID-19 and Stock Market Indexes

The COVID-19 pandemic is of main concern, not only to the government and policymakers but, also to several academics. This section examines different aims, methodology, and findings of relevant and related previous research on this discourse. Liu, Manzoor, Wang, Zhang, and Manzoor, (2020) employ the event study method to investigate the effect of COVID-19 on different leading stock market indexes of affected countries (which includes UK, France, and Germany). To capture the major stock market indices, the researchers also used a panel data analysis. Findings reveal that the viral infection mitigates the stock market returns in those countries affected; and that the pandemic has a negative significant effect on the Stock market returns. Similarly, Zhang, *et al* (2020) assess the state of financial markets during the COVID-19 pandemic, using simple statistical analysis and correlational analysis. The study shows a substantial increase in global financial market risks as a result of the pandemic. Summarily, the result reveals that the resultant effect of the pandemic is the high volatility and unpredictability of the markets due to uncertainties and recorded losses.

Topcu and Gulal, (2020) used the regression method to examine the impact of this present world-ravaging pandemic on emerging stock markets. As expected, the analysis shows a negative impact, but with more effect on Asian emerging markets compared to the relatively low impact experienced in Europe emerging markets. Employing a differential analysis approach, Ngwakwe (2020) aimed to ascertain the direct impact of the COVID-19 Coronavirus on global stock market indexes (Europe, USA, and China). The research gathered relevant and appropriate data on the stock index (S&P and Dow-Jones Industrial Average) for the regions under consideration for both periods before and after the emergence of the pandemic to have an equal data sample. The study found that the stock markets are differently affected by the pandemic. According to the study, the Euronext 100 indexes, in particular, have an insignificant difference in mean stock price.

Using panel data analysis, Al-Awadhi, Alsaifi, Al-Awadhi, and Alhammadi (2020) the relationship between the COVID-19 viral infection and stock market returns. The panel data analysis was engaged to determine how the viral infection impact on the Chinese stock market. This method of analysis was found most useful due to its ability to lessen bias of estimation and multicollinearity, as well as indicate the specific time-varying relationship among the variables in the study. The result of the analysis was not unexpected as it shows that the COVID-19 outbreak has a negative relationship with returns from the stock market. In the same vein, Ashraf (2020) used the panel data analysis to investigate the responses of the stock markets to the pandemic. The analysis method was embrace due to the same reasons as Al-Awadhi, et al. (2020) above; and also, its choice was due to the capability of panel data analysis to draw cross-sectional as well as time-series variation from the underlying panel data. Findings similarly reveal that there is a negative response from the stock markets to the increase in the number of COVID-19 confirmed cases.

3 Research Methodology

To examine the effect of the number of confirmed COVID-19 cases on countries' stock market indexes, this section provides a comprehensive overview of the variables and methodology used for this research and the motivation behind its selection.

3.1 Dataset

Daily stock market index of 4 European Countries (n=4) namely France, Spain, the United Kingdom, and Germany were selected from the first trading day in 2020 to the 17th of July 2020. Given the rapid rate an outbreak spreads, the economic effects on the financial market must be optimally modeled using data within a large scope as it provides a proper insight on the trend in the financial market during the pandemic. Due to the limited availability of countries' market indexes, this analysis considered four countries that contribute extensively to Europe's G.D.P.

The data used for the implementation of this project was obtained from the following data sources below

- John Hopkins University (JHU) Coronavirus Resource Centre' Website- confirmed COVID-19 cases from the 22nd of January 2020 to 17th July 2020.
- Yahoo Finance Database – Countries' daily stock market indexes for the period.

3.1.1 Dependent Variable

Ashraf, (2020) defines stock prices as the current trading price of a stock in the market which can be easily affected by changes in the economy. Following past research, the dependent variable for this analysis is the various stock market indexes which are essential in explaining the effect of the COVID-19 pandemic on the financial market of countries.

3.1.2 Independent Variables

In light of these methodological shortcomings, as well as the strong continuing demand for the impact of epidemics on the economy, the independent variable for this research is the number of confirmed COVID-19 cases in Spain, France, Germany, and the U.K gotten from John Hopkins University database.

3.2 Data Analysis

The Cross-Industry Standard Process for Data Mining (CRISP-DM) methodology was used for this research. The project and data understanding which are expected to be the most important aspect of a quantitative data analysis project was explained in the chapters above, While the following explains the remaining steps.

3.2.1 Data Preparation

Using the quantmod function in R, stock market indexes were gotten from yahoo finance, the data was combined with the number of confirmed cases. An exploratory data analysis was conducted to maximize insights into the dataset, test underlying assumptions, and deploy appropriate models. In conducting an insight on the dataset, the data was observed to be an unbalanced panel dataset as U.K and Germany had 115 observations while France and Spain had 116 observations, I.e. a total number of observations is not nT. The dataset was therefore cleaned and normalized using R.

4 Design Specification

Being a panel data, a panel data regression as explained by Baltagi, (2008) and Hsiao, (2007) to reduce multicollinearity and estimation bias, identify dependent and independent variables time-varying relationship and also control individual heterogeneity was conducted.

The general model for this study analysis is:

$$Y_{it} = \alpha + X_{it}\beta + \varepsilon_{it} \quad (1)$$

Where Y is the dependent variable, where i = country and t = time, X is the independent with β being the coefficient of the independent variable and u is the error term in the model. The three-panel data estimation models used were Pooled Ordinary Least Square (OLS), Fixed Effect (FE), and Random Effect (RE). The unique features of the models and model specification would be explained below

4.1 Pooled Ordinary Least Square (OLS)

Greene, (2008) considers some assumptions under this model which are: Linearity-Dependent variable formulated as a linear function of the independent and error term, Exogeneity-Disturbance expected value is zero, Homoskedasticity and Non-Autocorrelation-In this, same variance exists in its disturbance and is not related full rank- no exact linear relationship exists among independent variables. Park, (2011) however defines pooled OLS as a linear regression without fixed or random effect, i.e. for this analysis, it ignores the country and time effect (u_i=0).

Model B

$$\text{s.m indexes}_{it} = \alpha + \text{Covid}_{it}'\beta + \varepsilon_{it} (u_i = 0) \quad (2)$$

Key assumption- Individual and time effect does not exist if U_i=0

4.2 Fixed Effect Model (FE)

This model examines the relationship between variables within a group (country) that vary over time. This means that it estimates the individual attributes of each independent variable as it affects the dependent variable. In achieving an unbiased assumption, the FE model removes the time-invariants characteristics between variables. The least-square dummy variable (LSDV) and within estimates are methods under it. LSDV creates dummy variables, while the 'within' estimator does not. The within estimator was used as it considers transformed variables with time varies without creating dummies (Torres-Reyna, 2007).

Model C

$$\text{s.m indexes}_{it} = \beta 1 Covid_{it} + \alpha_i + u_{it} \quad (3)$$

α_i – The unknown intercept for each entity (not constant)

Key assumption- Any changes in the dependent variable are attributed to other factors than the fixed characteristics as the unobserved variable does not change over time, also time-invariant attributes are specific to individual variables and should not be correlated (Torres-Reyna, 2007).

4.3 Random Effect Model (RE)

In the random effect model, the variation across the dependent variable is assumed to be uncorrelated with the independent variables used. This model includes time-invariant variables unlike FE model and can also be used when it is believed that the difference across the independent variables influences the dependent variable (Torres-Reyna, 2007).

Model D

s.m $indexes_{it} = \beta covid_{it} + \alpha + (u_{it} + \varepsilon_{it})$ (4)

α- constant for each entity

Key assumption- The group's error term does not correlate with the variables, therefore, causing the time-invariant variables to act as an explanatory variable.

5 Implementation

5.1 Introduction

In this section, we enumerate the steps we took in applying our proposed methodology. For each model used, the rationale for selection would be discussed in detail in the next chapter. All tools including the hardware and software specification that aided in this analysis would be explained. The aim is to enable researchers to replicate our model findings and results alongside efficiently run and build our model on R.

5.2 Technology and Working Environment

The work environment used is a macOS Catalina software, 1.4 GHz Quad-core, intel core i5 processor with an 8GB Ram running on a MacBook Pro laptop. Version 1.3.959 R studio was the main tool for implementation, this is open-source with analytical libraries and packages for executing statistical analysis, While the Microsoft excel was used to understand our variables in its raw form.

5.3 Analysis

Most analyses were carried using R programming language and the libraries are given below.
Quantmod, Dplyr, Tidyverse, Lubridate, Plm, Foreign, data.table, lmtest, tseries.

The Analytic procedures taken in this research work are highlighted below in order:

Step 1: The stock market indexes for France, Spain, U.k, and Germany were collected and imported into R studio directly from yahoo finance database with the quantmod packages and getsymbol function from the 1st of January 2018 to the 17th of July 2020. As earlier explained, it period was collected to understand the trend in stock prices while information of the daily number of corona cases for these countries was downloaded and imported into R as a CSV file. The main period covered for analysis was 1st February 2020 to July 17th, 2020.

Step 2: Wrangling and Exploratory analysis were done to check for missings value, possible interpolation if any, and relationship between the number of cases and stock price. A visual of the relationship is as shown below. The four stock market indexes were combined using rbind function, then merged using the merge function with the Corona CSV data file by date and country.

S**tep 3:** The data was converted into panel data to run the panel regression analysis using the pdata.frame function.

The descriptive statistics for the variables were analyzed such as the mean, median, variance, standard deviation using the table.stats function. This gives the statistical properties of the dataset for the variables under study.

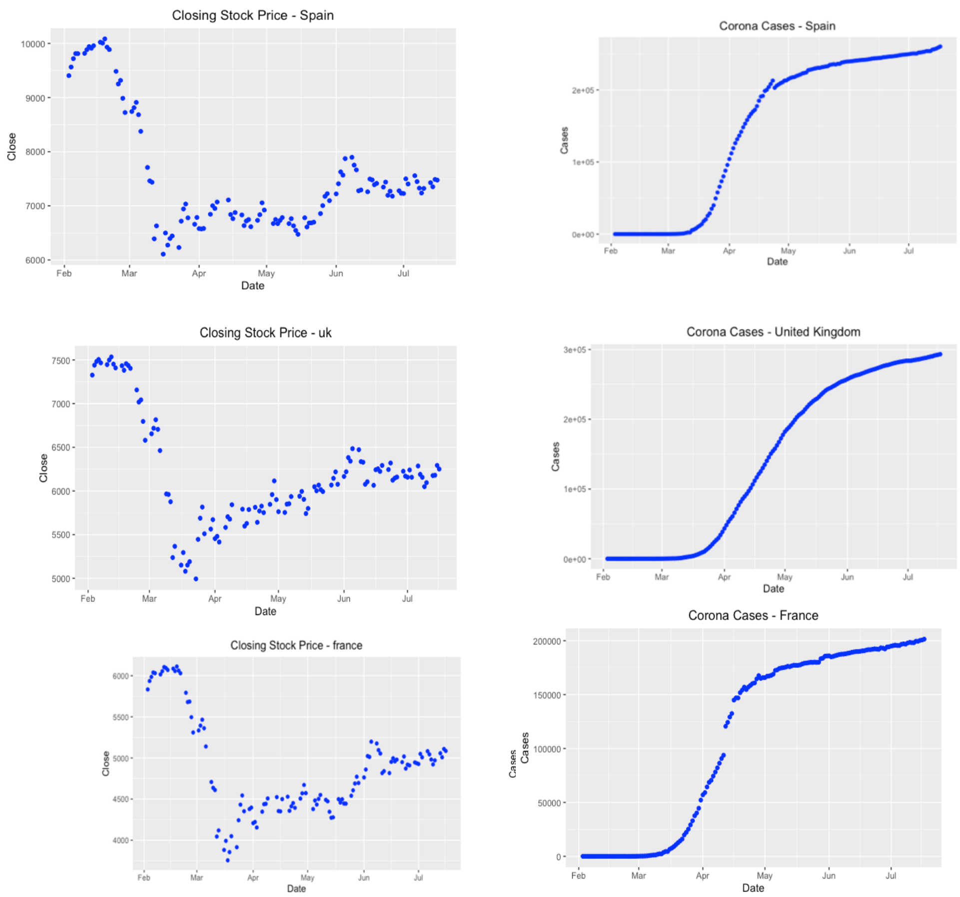
Step 4: Panel data regression assumptions such as Heteroscedasticity, serial correlation, and cross-sectional dependencies for the panel dataset were conducted.

Step 5: The poolability of the panel data set was determined using the pooltest and plmtest function, while the fixed and random model estimators were modeled on the panel dataset. The panel Hausman test was therefore conducted to determine the better model.

Step 6: Finally the model was controlled for heteroscedasticity and serial correlation in other to provide a more efficient estimator without bias.

6 Evaluation

A panel regression analysis evaluated the effect of a pandemic on stock market prices in an unbiased manner, using three major regression assumptions, we were able to evaluate if an ordinary least square regression would provide an unbiased result and if not, what was the best estimator to use. This analysis considered the daily stock market prices from 1st of January 2018 to 17th of July 2020, and from figure 1 below, we observed a significant decrease in stock prices in March 2020 when COVID-19 was declared a pandemic and all necessary economic measures such as lockdowns were announced. Further statistical analysis would be explored in the sections below.



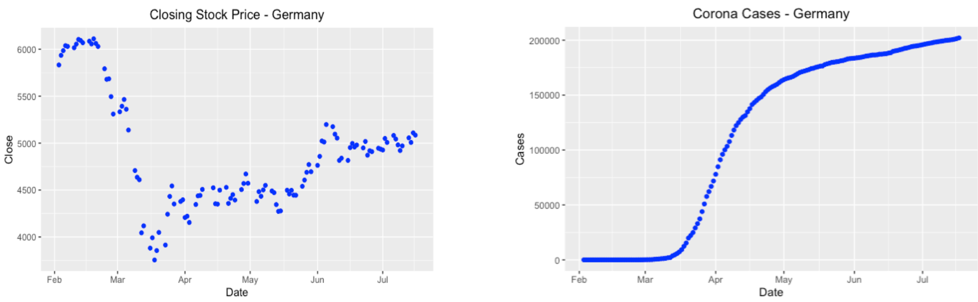


Figure 1: Exploratory Data Analysis of all Variables

6.1 Descriptive Statistical Summary

From table 1 below, during the period covered the minimum number of reported corona cases in a single day is 1 while the maximum number of reported cases was 2992552. Corona cases are not normally distributed as it is skewed to the left. The closing price, on the other hand, has a minimum value of 3754.8 in a single day and a maximum value of 13789 making its distribution positively skewed.

Table 1: Table of descriptive statistics for Closing prices and cases

Variables	**Min**	**Max**	**Mean**	**Standard deviation**	**Skewness**	**Kurtosis**
Closing Price	3754.8	13789.0	7526.6	2677.4	0.8	-0.5
Corona Cases	1	292552	127690.6	100243.9	-0.1	-1.5

6.2 Assumption of Regression and Diagnostic

6.2.1 Heteroscedasticity test

One of the assumptions of the regression model is the assumption of the equal variance of the error(disturbance) term. That is, being homoscedastic. In the absence of homoscedasticity y, the error variance is not constant and it changes for every error term(ε_i) and this can result in the estimate of the coefficient being biased and unreliable (Myoung, 2011).

Table 2: Breusch pagan test for heteroscedasticity

Breusch Pagan	**Df**	**P-value**
7.8786	1	0.005002

Breusch Pagan test hypothesis is given as
H0: The disturbance term have the same variance- homoscedasticity
H1: The disturbance term has a varying variance- heteroscedasticity
The hypothesis of homoscedasticity is rejected as the p-value (0.005002) is less than the significant level at 5%. reject null hypothesis The disturbance term has a varying variance and its heteroscedastic.

6.2.2 Heteroscedasticity test

Non-autocorrelation is another assumption of the OLS regression model, It assumes that the disturbance term is not correlated with each other.it is pairwise independent. The disturbance of one period is not correlated with the disturbance of another period.

Table 2 Durbin Watson test for serial correlation in panel data

Durbin Watson Statistics	P-value
0.027702	2.2e-16

The Durbin Watson test hypothesis is given as

H_0: There is no serial correlation in the disturbance term

H_1: there is serial correlation in the disturbance term

The hypothesis of no serial correlation in the disturbance term is rejected, the p-value(2.2e-16) is less than the level of significance(5%). Therefore, there is a serial correlation in the disturbance term of the model.

6.2.3 Cross-sectional dependence Test

Another important test in the panel data regression analysis is the cross-sectional dependence test. It is a test that determines if, for a given panel data, a shock in a particular cross-sectional unit will have an impact on another cross-sectional unit.

Table 4 Pesaran CD test for cross-sectional dependence

Z score	P-value
25.718	2.2e016

H_0: There is no cross-sectional dependence in the panel data

H_1: there is a cross-sectional dependence in the panel data

The P-value is 2.2e-16 is less than 5% level of significance, the null hypothesis is rejected. There is cross-sectional dependence among the cross-sectional unit. This implies that the countries (Cross-sectional unit) have an impact on one another.

6.2.4 Poolability Test

It is important before pooling the data and running a pooled OLS on the panel data to test if the data is poolable. In essence, we are trying to determine the stability and instability of the regression equation across cross-section or across time(Baltagi, 2008). The Chow- test is used to determine if the data is poolable.

Table 3 Chow Poolability Test

F statistics	df1	df2	P-value
9.4069	3	464	4.834e - 06

The chow poolability test hypothesis is given as

H_0: The panel data is poolable- The coefficients of the regression are the same regardless of the individual

H_1: The panel data is not poolable- The Coefficients of the regression is not the same regardless of the individuals.

At the 5% level of significance, the Null hypothesis is rejected as the value is less than the significant level. Therefore, the panel data is not poolable, the coefficients of the regression are not the same regardless of the individuals.

Our result is consistent with (Myoung, 2011) which state that, if the individual effects (U_i) is not zero in panel data, the disturbance term will be correlated with the regressor

(Heterogeneity), the disturbance term will have a varying variance (heteroscedasticity) and finally the disturbance will be correlated with one another (autocorrelation). Therefore, the OLS will no longer be an unbiased estimator of the linear regression parameters.

6.3 Modeling

This section shows the result from modeling the dataset, the various tests conducted in determining the best model, and result from analysis. In figure 2 below, a scattered plot was generated to understand the movement in stock prices during the present pandemic, while the subsections illustrate the results gotten.

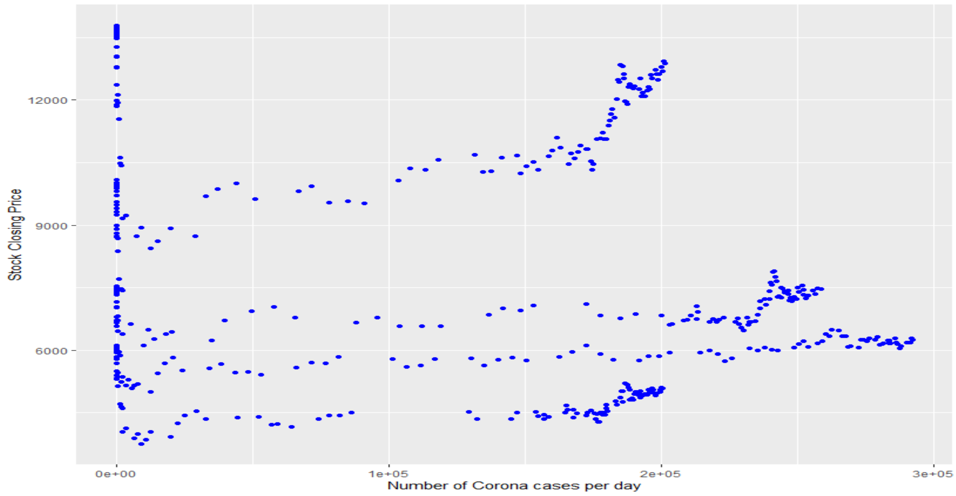


Figure 2: The scatter plot of Number of daily corona cases and Closing stock prices

6.3.1 Fixed Effect Model Estimates

In the fixed-effect model, the key assumption is that any changes in the dependent variable are attributed to other factors than the fixed characteristics as the unobserved variable does not change over time, also time-invariant attributes are specific to individual variables and should not be correlated (Torres-Reyna, 2007), Here it is assumed that the slope is constant but the intercept differs according to the cross-sectional unit (Robert, 2003).
The estimates of the model are given in the tables below.
Unbalanced Panel: n = 4, T = 115-116, N = 462

Table 6 Fixed Effect Model Residuals

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
-3318.594	-622.667	42.343	0.000	505.412	2184.346

Table 7 Model coefficients

	Estimate	Std.Error	t-value	Pr(>|t|)
Cases	-0.00238758	0.00045064	-5.2981	1.823e-07 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 8 Coefficient of determination

Total Sum of Square	Residual sum of squares	R-Squared	Adj. R-Squared	F-statistic	DF
444370000	418650000	0.057869	0.049622	28.0704	457

From the output above, the fixed-effect model is significant for modeling the effect of COVID 19 on the stock price, it is significant even at a 1% level of significance. COVID 19 has a negative effect on the stock price, the relationship is also significant at 10%, 5% and 1% level of significance. It implies that for a 1 unit increase in COVID 19 cases, Stock price decreases by 0.238758%. The R squared indicates that only approximately 5% change is the closing stock price can be explained by the number of COVID 19 cases. The R squared of the within estimator is not correct because the intercept is suppressed (Myoung, 2011).
The fixed effect for the cross-sectional unit is given in table 9 below.

Table 9 The fixed effect summary table for all country

	Estimate	Std. Error	t-value	Pr(>|t|)
France	5133.43	101. 97	50.341	2.2e-16
Germany	11789.74	102.60	114.908	2.2e-16
Spain	7899.26	110.82	71.278	2.2e-16
UK	6526.48	109.44	59.638	2.2e-16

The country fixed effects are all significant, the p values are smaller than the level of significance at 5%.

Table 10 F test for individual effects

F	df1	df2	p-value
1033.3	3	457	2.2e-16

$H_0 =$No significant effects
The p-value is less than the level of significance at 5%, their null hypothesis of no significant effect is rejected. The Fixed effect model is appropriate and there is significant time-invariant effect.

6.3.2 Random Effect Model Estimates

The key assumption of this model is that the group's error term does not correlate with the variables therefore, causing the time-invariant variables to act as an explanatory variable.
The estimates are given in the tables below.

Table 11 Random Effect Model Residuals test

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
-3216.2	-619.2	25.0	-0.1	478.2	2185.9

Table 12 Model coefficients

	Estimate	Std. Error	z-value	Pr(>|z|)
(Intercept)	7.8373e+03	1.7214e+03	4.5529	5.292e-06 ***
Cases	-2.3881e-03	4.5019e-04	-5.3047	1.129e-07 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 13 Model coefficients

Total Sum of Square	Residual sum of squares	R-Squared	Adj. R-Squared	chisq	DF
446300000	420550000	0.057675	0.055627	28.1545	1

From the output above, the random model is significant for modeling the effect of COVID 19 on the stock price, it is significant even at a 1% level of significance. COVID 19 has a negative effect on the stock price, the relationship is also significant at 10%, 5% and 1% level of significance. It implies that for a 1 unit increase in COVID 19 cases, Stock price decreases by 0.23881%. This is close to the estimate of the fixed-effects model.

The R squared indicates that only approximately 5% change is the closing stock price can be explained by the number of COVID 19 cases.

Table 14 Lagrange Multiplier Test - (Breusch-Pagan) for unbalanced panels

chisq	df	p-value
19930	1	2.26-16

H_0=Significant effect

The p-value is less than the level of significance at 5%, their null hypothesis of no significant effect is rejected. The random effect model is appropriate. There is heterogeneity among individuals. (Significant difference among the cross-sectional unit).

6.4 Hausman Test

Hausman is a statistical test that compares the consistency of the random effect model relative to the fixed effect model. If the random model is consistent under the null hypothesis then the fixed model is consistent under the alternative hypothesis.

Table 15 Hausman test for the best estimator

chisq	df	p-value
1.0075	1	0.3155

H_0=Random Effect Model is consistent

H1=Fixed Effect Model is consistent

The p-value is bigger than the level of significance (at 5%). Therefore, the null hypothesis that the random effect model is consistent is not rejected. The variation across the closing price is assumed to be uncorrelated with the number of daily corona cases.

6.4.1 Controlling Heteroscedasticity and Autocorrelation

The robust covariance matrix is performed on the random effect model to correct for heteroscedasticity and autocorrelation. Below is the adjusted result that is controlled for heteroscedasticity and autocorrelation.

Table 15 Test for controlling Heteroscedasticity and Autocorrelation

	Estimate	Std.Error	t-value	Pr(>|t|)
(Intercept)	7.8373e+03	1.2210e+03	6.4188	3.423e-10 ***
Cases	-2.3881e-03	1.2048e-03	-1.9822	0.04806 *

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

After controlling for heteroscedasticity and autocorrelation the result obtained explains that when making hypothesis decision for the slope, that we are at most 95% confidence of our decision, compared to the uncontrolled model (presence of heteroscedasticity) which shows a 99.99999% confidence of our decision.

6.5 Discussion

Research by (Cepoi, 2020) explains how stock market prices of countries around the world have fallen enormously in the first quarter of 2020 due to the rapid increase in the number of COVID-19 cases. Investors are a major concern with limiting loss on investment and having resources to survive the fluctuation in stock market prices. The uncertainty regarding COVID-19 pandemic has therefore made them very skeptical about investing and has also made them sell off their positions in companies thus affecting the overall performance of the stock markets.

The medical research community has thus gone into rigorous study on the virus as well as policymakers on how to stop the virus or minimize its effect. Until any major medical breakthrough, the future of the virus and its effect on various industries remains uncertain. Being motivated by this, we continue on the study to determine and explain the effects of the pandemic on the stock market prices and to determine if the effects are statistically significant.

A panel data was created comprising of four cross-sectional units namely (Germany, Spain, UK, and France), N=4, information on stock price, and Corona cases on these countries were collected daily (T = 115-116) to determine the relationship and the significance that exits. The poolability of the data set was tested to determine if the slope and the intercept coefficient of the model were the same (i.e. Homogenous). It was observed that the slope and the intercept coefficient are different among the cross-sectional unit, this indicates the heterogeneity of the panel model. A study conducted by (Myoung, 2011) explains if a country's effect is not zero, its heterogeneity will affect the assumptions of homoscedasticity and autocorrelation which renders the OLS estimator no longer unbiased. This was confirmed in our study as heterogeneity and autocorrelation existed and as such, the data set is not poolable and the pooled OLS is not a good estimator for the parameters of the model.

6.5.1 The fixed effect Model

The fixed-effect model helps in addressing the problem of poolability, it allows for correlation between the unobserved effects (α_i) and the observed independent variables. It assumes that some countries' specific effects not modeled are correlated with the regression variable. It also assumes that the unobserved effects are fixed and are treated as a parameter to be estimated for each cross-sectional unit. As observed from the result, the COVID-19 cases have negative and significant effects on the closing stock price. That is, for a one-unit increase in the number of cases, the closing stock price decreases by 0.00238758 units.

The unobserved effects estimated result for the four countries (France, Germany, Spain, and the UK) have a positive and significant unobserved effect on the closing stock price. For France, a one-unit increase in the unobserved effects is assumed to increase the closing stock price by 5133.43 units. For Germany, a one-unit increase in the unobserved effects is assumed to increase the closing stock price by 11789.74 units. For Spain, a one-unit increase in the unobserved effects is assumed to increase the closing stock price by 7899.26 units while the UK, a one-unit increase in the unobserved effects is assumed to increase the closing stock price by 6526.48 unit.

6.5.2 Random Effect Model

In the random effect model, the unobserved effects that correlated with the explanatory variables were treated as a random variable and not to be estimated. This effect is considered as a sample from a population of unobserved effects. It, therefore, implies a zero correlation.

The result also indicated that the number of increased corona cases has a negative and significant effect on the closing stock. Typically, for a one-unit increase in the number of corona cases the closing stock price decreases by 0.0023881 unit. These unobserved effects on the closing stock prices in specific countries could be due to factors such as Inflation rate, GDP, Interest rate, etc. that were omitted.

6.5.3 Random or Fixed Effects Model

In selecting between the fixed effects model, where the unobserved effects are fixed and considered to be a parameter to be estimated, and the random effect model, where the unobserved effects are considered to have a zero correlation with the explanatory variables, The Hausman Test was conducted, and the result obtained shows the random model estimator as a better model for evaluating the effects of coronavirus on the closing stock price when compared to the fixed-effects model.

In summary**,** as observed in Figure 5.1 above, the closing stock price of the countries used for analysis (France, Spain, Germany, and the UK) had maintained some relative level of stability which can be explained by the interaction between micro and macro-economic variables and laws relating to the stock market(The law of demand and Supply and Macro economies). The declaration of novel coronavirus as a pandemic by the World Health Organisation in March 2020 [6], caused a sharp decrease as observed, which explains the negative impact the virus had on closing stock prices initially. However, figure 5.1 also shows that despite the continuous increase in the daily cases, closing stock prices are still experiencing some relatively steady growth in value which could be attributed to investors regaining confidence in the market or other factors like policies or economic variables impacting it significantly.

It is important to note that although the obtained R square is relatively low (5.5%), a 5.5% decrease in stock market prices within a short period due to the uncertainty or panic from the virus is significant (i.e. it cannot be ignored).

7 Conclusion and Future Work

A pandemic such as the present novel corona virus is observed to have a significant effect on stock prices, but the extent and level of significance is yet to be determined. Hence, the objective of this study was to investigate the relationship between closing stock prices and an increase in corona cases. It was also used to determine if there was any cross-sectional effect among variables and which estimator was consistent in modeling the data. We collected the closing stock prices and the daily corona cases for France, Spain, Germany, and the UK were collected starting from 1st of January 2018 to 17th of July 2020, in other to explore the trend in prices. A panel data was created from the 1st of February 2020 to 17th July 2020 using countries stock market indexes to examine the effect the present COVID-19 pandemic had on stock prices. The period was chosen because as of the first of February, all the countries used for this analysis had reported a significant amount of COVID-19 cases. The Pooled OLS was initially tested, and the data was observed to be non-poolable as it exhibits heteroscedasticity, autocorrelation in the disturbance term, and also a cross-sectional dependency in the data. The fixed-effect model and random effect were modeled on the data, to determine if they were appropriate for modeling using the F test and Lagrange Multiple tests respectively. It was observed that both models were suitable for the panel data analysis. Finally, the Hausman test was performed to determine which model fits better. The result obtained indicated that the random effect model was the best for this study which implies that the cross-sectional effect is random and has zero correlation with the independent variable (Corona cases). After conducting this research, we discovered the following followings: stock market prices were negatively impacted by the increase in Covid-19 cases with an approximately 5.5% change as earlier explained in the discussion, and also a cross-sectional relationship between countries' stock prices i.e. a disruption in a country's stock market index could significantly affect other countries. This could, however, be linked to the fact that the financial market of countries is interconnected. The pandemic concern and policy measures to control the outbreak has led to a global shock within industries with companies reducing labor force or closing down offices and investors not getting a return on their investment. Whether this emerging crisis would have a lasting effect on the financial market remains a question to many investors. We, therefore, suggest that in other to boost investors' confidence, there is an urgent call for a medium and long term plan by the government and other financial institutions to reinforce and rebalance the financial market.

7.1.1 Limitation and Future Work

The determination of the effect of a pandemic on stock market indexes can be made more effective if more countries were considered around the world. Due to limited availability of data and time frame to carry out this research, just four countries were considered with the research also not considering other economic and demographic variables that could affect stock prices or investor's decision during a pandemic. Therefore, for future analysis, researchers could consider other economic variables, techniques, or methodologies to model a balanced dataset, to provide a more robust result.

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