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Covid-19 versus H1N1: a comparative study of the impact of viruses on small and large economies on the Stock Market – The special study of Portugal

João Miguel Lucas da Fonseca

Dissertation report presented as partial requirement for obtaining the Master's degree in Statistics and Information Management

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Advisor: Dr. Rui Alexandre Henriques Gonçalves

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ABSTRACT

Esta dissertação descreve e detalha, o impacto que as crises pandémicas têm na volatilidade dos mercados da bolsa de pequenas e grandes economias. Relativamente aos países estudados, foi escolhido como casos de estudo os Estados Unidos da América (grande economia), a Grécia (pequena economia), e Portugal, como comparação aos dois países mencionados anteriormente, contudo, apenas no que se refere à consequência da pandemia provocada pela Covid-19.

Em termos de metodologia, a volatilidade financeira diária é tradicional para modelar um processo GARCH (1,1). Este modelo foi utilizado no programa SAS para provar se a volatilidade podia ser ou não correlacionada. Adicionalmente, os coeficientes de correlação linear de Pearson foram realizados e analisados em várias variáveis, tais como o valor no fecho, casos e mortes confirmados pela OMS com a volatilidade diária entre cada país, e por fim a volatilidade histórica diária.

Finalmente, o estudo mostra como as pandemias do século XXI tiveram impacto tanto na bolsa de valores (financeira), como no produto interno bruto (económico). Esta dissertação comprova que existe, de facto, uma volatilidade no mercado de bolsa no início de um fenómeno atípico. Contudo, após um determinado período de tempo, o mercado de bolsa corrige-se.

Saliento, que na pandemia de Covid-19, apesar dos Estados Unidos da América terem sofrido uma repercussão no seu Produto Interno Bruto, Portugal teve implicações ainda mais fortes na economia, tal como a Grécia (países de economia pequena). Referente à parte financeira, Portugal compara-se igualmente à Grécia aquando se realizou as correlações entre as volatilidades históricas diárias. No entanto aproxima-se dos Estados Unidos da América nas correlações das várias variáveis, transcritas anteriormente, tais como o valor no fecho e os casos e mortes confirmados pela OMS, e a volatilidade diária entre cada país.

Conclui-se, desta forma, que as pandemias causaram impacto nos mercados de bolsa nos países estudados e mencionados supra.

KEYWORDS

Correlation; Covid-19; Financial crisis; GARCH (1,1); Gross Domestic Product; H1N1; Pandemic; Pearson´s Correlation Coefficient; SAS; Stock Market; Volatility.

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LIST OF ABBREVIATIONS AND ACRONYMS

AIC	Akaike Information Criterion
ASE	Athens Stock Exchange
Covid-19	Coronavirus or SARS-Cov-2
DFE	Degrees of Freedom for Error
GDP	Gross Domestic Product
H1N1	Swine Flu or Influenza A
MSE	Mean Square Error
OECD	Organization for Economic Co-operation and Development
PSI-20	Portuguese Stock Index
Root MSE	Root Mean Square Error
SAS	Statistical Analysis System
SBC	Schwarz information criterion
SSE	Error Sum of Squares
USA	United States of America
WHO	World Health Organization

1. INTRODUCTION

1.1. BACKGROUND AND PROBLEM IDENTIFICATION

Since the beginning of the health crisis in December of 2019, in Wuhan, province of Hubei, China, according to "The New York Times"[1], an outbreak of Covid-19 emerged (prior 2019-nCoV) caused by a familiar virus to our world, SARS-CoV-2 *(McKibbin, W. J., & Fernando, R. (2020). The global macroeconomic impacts of COVID-19: Seven scenarios.),* it has been an ongoing observed an upward concern about the world health as the economy brawls to cease the mentioned virus.

At the time of writing this paragraph (October 2020), the world remains exposed to this violent virus. While several countries have not yet been able to respond and act on the reported cases effectively and quickly. New Zealand on the other hand, successfully eliminated the transmission of Covid-19[2]. It is uncertain when and where new cases can emerge. More cases are being reported in some countries, and new countries are entering the World Health Organization's (WHO) list of zones where the virus has been exposed. Even though the cases reported from China have already reached their peak and started to decrease their number of cases per day. A second wave has been reported, which actively demonstrates that the world could only return to normality at 100% when a vaccine would be available, a procedure that will take a considered amount of time. This second wave can be seen in Europe (for example England and Portugal) and America (such as the United States of America), which, in this case, the second wave was stronger than the first.[3]

Given the public health risk, the WHO has declared this virus a pandemic and an emergency of international concern, as mentioned below on point 1.2., this health crisis has brought attention to various areas where it's a required enhancement and a significant boost for instance, in the stock market, an area that is studied along with the paper.

Historically, when a crisis occurs in a strongly integrated and connected world, the impact of the epidemic and / or pandemic goes beyond the increase in mortality rates, severely affecting markets and the economy.[4] Thus, this event caused a new reality. For that reason, the studies on the impact of Covid-19 in the stock market are significant to acknowledge. According to that information, the leaders can make proper decisions concerning their population and their environmental situation. Detailed introduction below on point 1.3.

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[1] https://www.nytimes.com/article/coronavirus-timeline.html

[2] The New England Journal of Medicine (2020) Successful Elimination of Covid-19 Transmission in New Zealand

[3] WHO Coronavirus Disease (COVID-19) Dashboard (10/10/2020)

[4] Robert J. Barro, José F. Ursúa, Joanna Weng (2020) The Coronavirus and the Great Influenza Pandemic: Lessons from the "Spanish Flu" for the Coronavirus's Potential Effects on Mortality and Economic Activity

Currently, there is more information and research on the respected area (impact on the stock market by the pandemic). There are already several publications and studies that address the comparison between Covid-19 and other epidemics and/or pandemics, and consistent research related to Covid-19 and the impact on the stock markets volatilities and returns. However, few are the ones that compare with the Influenza A pandemic (2009).

Swine flu H1N1 is a subtype of the influenza virus A, which can cause infections of the host's respiratory tract, causing symptoms such as chills, fever, loss of appetite, and nasal secretions. The H1N1 swine flu, as mentioned before, causes respiratory diseases, and can infect the respiratory tract of pigs, and sometimes when people are more proximally with those animals, people can get swine flu. If the antigenic properties of the swine influenza virus are altered by rearrangement, this virus can cause human infection, which means in these cases when the transmission of people becomes efficient, it can provoke a public danger (epidemic or pandemic), as it happened in 1918 and 2009.[5] [6]

In 1918 the deadly influenza pandemic caused by the H1N1 influenza virus (known as the Spanish flu) infected roughly 500 million people worldwide, which caused from 50 to 100 million deaths (3% to 5% of the population) throughout the scope world), making it one of the deadliest epidemics in human history. [7] On the year of 2009, a new strain of the H1N1 swine flu virus spread rapidly to humans worldwide, making the World Health Organization (WHO) acknowledge it as a pandemic. However, H1N1, 2009, virus was not zoonotic swine flu, for the fact that it has not been transferred from pigs to people, only spreading from one person to another, through the bead of water, and could spread to the eyes or nose by contact between people and inanimate objects contaminated by the virus. [8]

The 2009 swine flu strain, originated in Mexico, was denominated as H1N1 flu, considering it was mainly found infecting humans, exhibiting two main surface antigens, according to the investigators' conclusions. Centers for Disease and Control and Prevention (CDC) estimated that there were 43 to 89 million cases of swine flu reported for one year, with 1.799 deaths in 178 countries worldwide.[9] [10]

Therefore, this paper attempts to quantify the influence on the volatility concerning the Covid-19 on the stock market, regarding the small and large economies mentioned in

[5] Talha N. Jilani; Radia T. Jamil; Abdul H. Siddiqui. (2020) H1N1 Influenza (Swine Flu)

[6] Kshatriya RM, Khara NV, Ganjiwale J, Lote SD, Patel SN, Paliwal RP. Lessons learnt from the Indian H1N1 (swine flu) epidemic: Predictors of outcome based on epidemiological and clinical profile. J Family Med Prim Care. 2018 Nov-Dec;7(6):1506-1509.

[7] Keenliside J. Pandemic influenza A H1N1 in Swine and other animals. Curr. Top. Microbiol. Immunol. 2013

[8] Rewar S, Mirdha D, Rewar P. Treatment and Prevention of Pandemic H1N1 Influenza. Ann Glob Health. 2015

[9] Hasan F, Khan MO, Ali M. Swine Flu: Knowledge, Attitude, and Practices Survey of Medical and Dental Students of Karachi. Cureus. 2018

[10] Nelson MI, Souza CK, Trovão NS, Diaz A, Mena I, Rovira A, Vincent AL, Torremorell M, Marthaler D, Culhane MR. Human-Origin Influenza A(H3N2) Reassortant Viruses in Swine, Southeast Mexico. Emerging Infect. Dis. 2019

the title, such as Greece and the United States of America, respectively. Rehearsing a comparison with the Swine Flu (H1N1) that occurred in 2009 and 2010.

1.2. H1N1 Vs COVID-19

The first pandemic of XXI century, influenza A H1N1, was originated in Mexico by mid of April 2009. According to the paper of *Trifonov V, Khiabanian H, Rabadan R (July 2009). "Geographic dependence, surveillance, and origins of the 2009 influenza A (H1N1) virus"*. *The New England Journal of Medicine. 361 (2): 115–19.* The paper explains the epidemiology and virology development.

From the initial focus in Mexico, verified in the first quarter of 2009, the accelerated evolution propagation on the North American (Mexico, USA, and Canada) and soon in European countries, such, Spain, and United Kingdom. The World Health Organization (WHO) had declared a “Public Emergency of International Concern” on 26th April. On June 11, WHO declared a pandemic, once the extent of the epidemic is recognized on a large scale, reaching 74 countries (by 1 July the virus had already been identified in 120 countries). According to the *“Relatório da Pandemia da Gripe em Portugal”* by the Direção-Geral da Saúde (DGS) on October 2010.[11]

Based on the statistics available from the World Health Organization (WHO), the H1N1 2009 pandemic had 1.632.710 confirmed cases and caused 18.449 deaths[12], which makes a mortality rate of 1,13%.

The Covid-19 pandemic or coronavirus pandemic is caused by a severe acute respiratory syndrome coronavirus, in a scientific abbreviation SARS-CoV-2. As by the time mentioned, this outbreak was firstly reported in Wuhan, China in December 2019. WHO promptly declared on 30 January 2020, a “Public Emergency of International Concern” and on 11 March a “Pandemic”.[13]

Based on the statistics available from the World Health Organization (WHO), this pandemic, so far, had reached every continent except Antarctica[14]. On the 5th October 2020 at 3:54 p.m., had already been officially reported a significant number of infectious cases and deaths, respectively 35.109.317 and 1.035.341[15], as can be analyzed and comprehended in the graphic (Figure 1) below. Being the America the continent most affected in the world over the number of cases confirmed and deaths. Even though South-East Asia is the second most affected region on cases confirmed

[11] https://www.dgs.pt/documentos-e-publicacoes/relatorio-da-pandemia-da-gripe-ah1n12009-em-portugal-pdf.aspx
[12] “Pandemic (H1N1) 2009—update 112”. Organização Mundial da Saúde (OMS). 6th June 2010. Consulted 5th October 2020
[13] WHO declares the coronavirus outbreak a pandemic (https://www.statnews.com/2020/03/11/who-declares-the-coronavirus-outbreak-a-pandemic/)
[14] WHO Coronavirus Disease (COVID-19) Dashboard (5th October 2020)
[15] Data may be outdated in the current moment

(Figure 2), it is the third with the highest number of deaths, with the European continent being the second largest. (Figure 3)

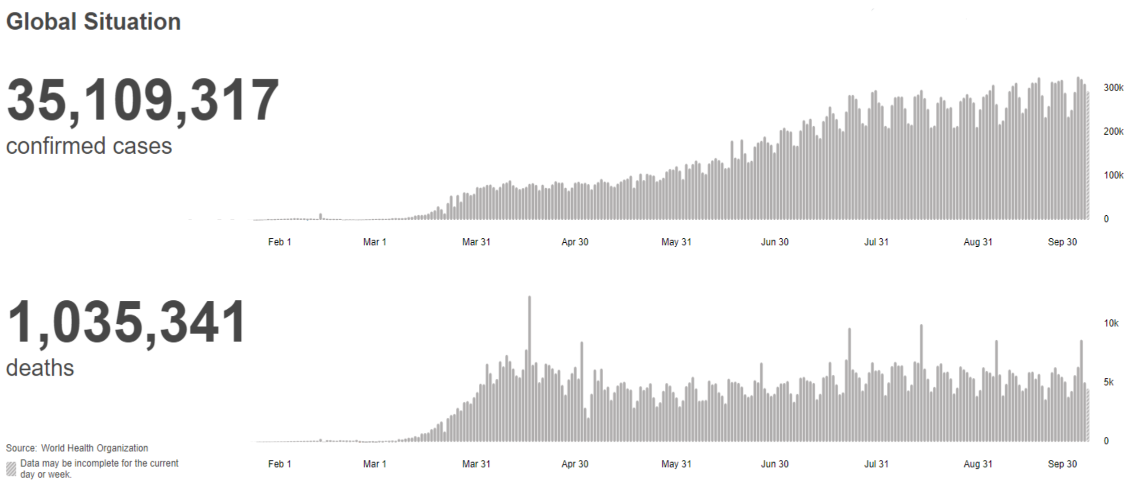

Figure 1 – Global Situation on confirmed cases and deaths (5th October 2020)

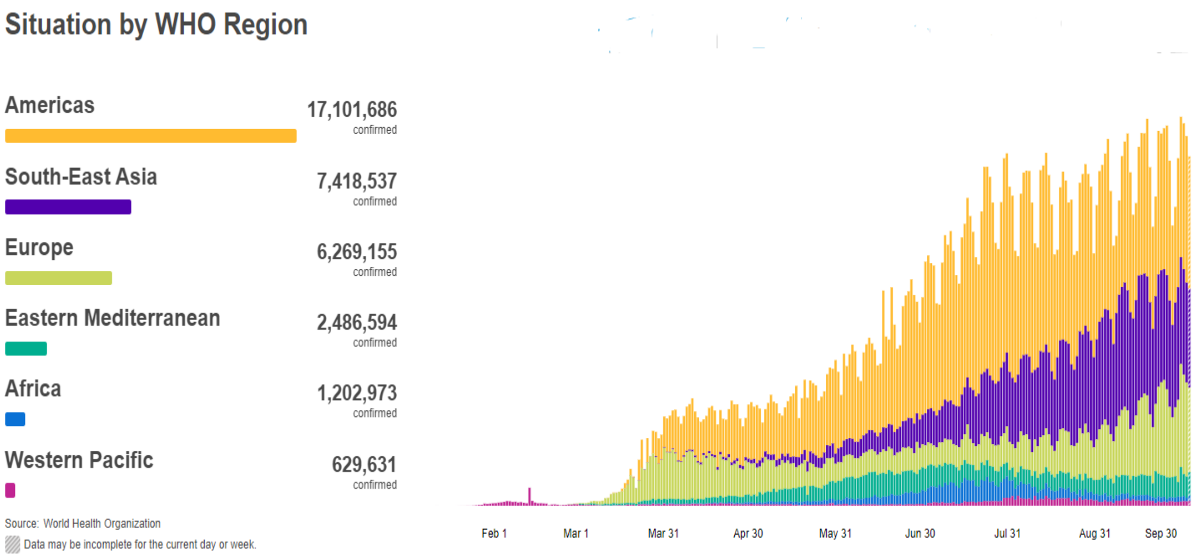

Figure 2 – Regions regarding COVID-19 official confirmed cases by WHO (5th October 2020)

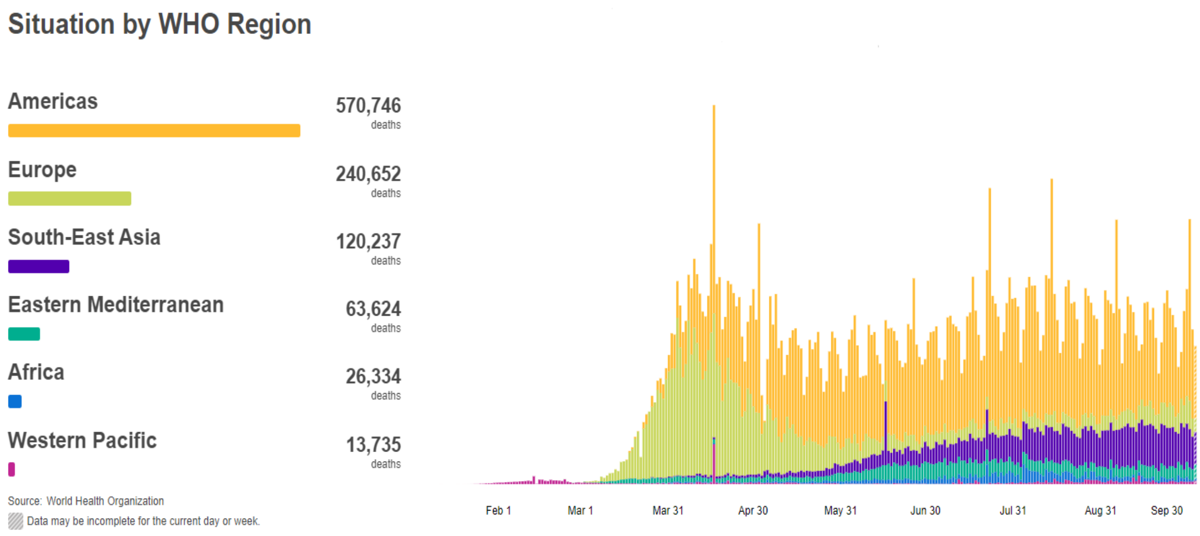

Figure 3 – Regions regarding COVID-19 official deaths by WHO (5th October 2020)

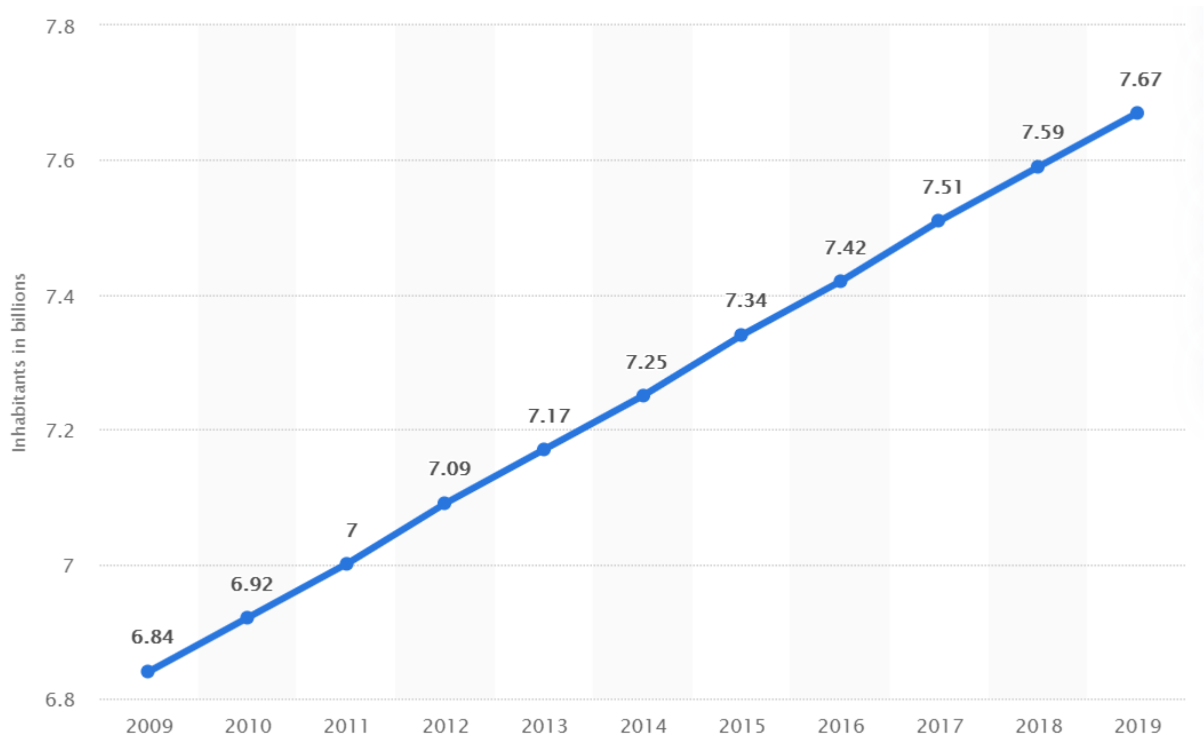

Figure 4 – World: Total population from 2009 to 2019(in billion inhabitants); Source by Statista 2020, published by H. Plecher, Aug 4, 2020.

Figure 4 shows the total population worldwide from 2009 to 2019, in billion. It is possible to observe that in 2009, the total worldwide population was approximately 6,84 billion inhabitants, and over a decade it expanded to 7,67 billion inhabitants, a growth of 12%.

Concluding, the responsible for causing the pandemics in the years 2009 and 2020, H1N1 and Coronavirus, respectively. Although being caused by different viruses they have certain similarities between, for instance, symptoms and transmissibility. According to the paper *“Comparative analysis of COVID-19 and H1N1 pandemics” (2020)* by Camila Melo do Egypto Teixeira, Gabriela de Almeida Maia Madruga, Giovanna Bezerra Santos de Medeiros, João Geraldo Teixeira de Miranda Leite Filho, Sabrina Severo de Macêdo Duarte, it was observed, in a study, that non-productive cough, fatigue, and gastrointestinal symptoms are more common in patients with coronavirus and the symptoms that prevail in H1N1 are productive cough and fever. It is relevant, to note that these two viruses have a common etiology and occur with prevalence in the same season. Coronavirus has a higher lethality and transmission rate than H1N1, which is proven by the calculation of the number of deaths divided by the total number of confirmed cases and its differential diagnosis is significant for adequate treatment and consequently, increasing the patient's chance of survival. Due to their different treatments and prognosis, it is important that doctors and epidemiologists accurately identify these two respiratory infections through their different clinical manifestations and the creation of a functional vaccine.

1.3. Truthfulness and Perception of Actions taken by Government

It is perceptible that people were losing confidence in the actions of the political administration of their respective countries. A study with a group of researchers from twelve (12) different institutions, such as IESE, Cambridge, and Harvard, had elaborated a large-scale and extremely timely survey where it is possible to verify the truthfulness of the words and actions taken by their government in response to the virus (Figure 2 and 3).

The Organization for Economic Co-operation and Development (OECD), *Organisation de Coopération et de Développement Économiques,* in French, it's an international organization of 36 countries, among them, there are countries with large scale economies suchlike, the United States of America, that stands out for negative reasons, being the reason for this circumstance, a vast majority of people feels that the government has been untruthful and performed under the standard. However, smaller economy countries, like Portugal, and Greece, according to the study realized by Caria, Fetzer, Fiorin, Goetz, Gomez, Haushofer, Hensel, Ivchenko, Jachimowiczz, Kraft-Todd, Reutskaja, Rorh, Witte, Yoeli on the paper *"Measuring Worldwide COVID-19 Attitudes and Beliefs"* (2020), have stood out for positive reasons.

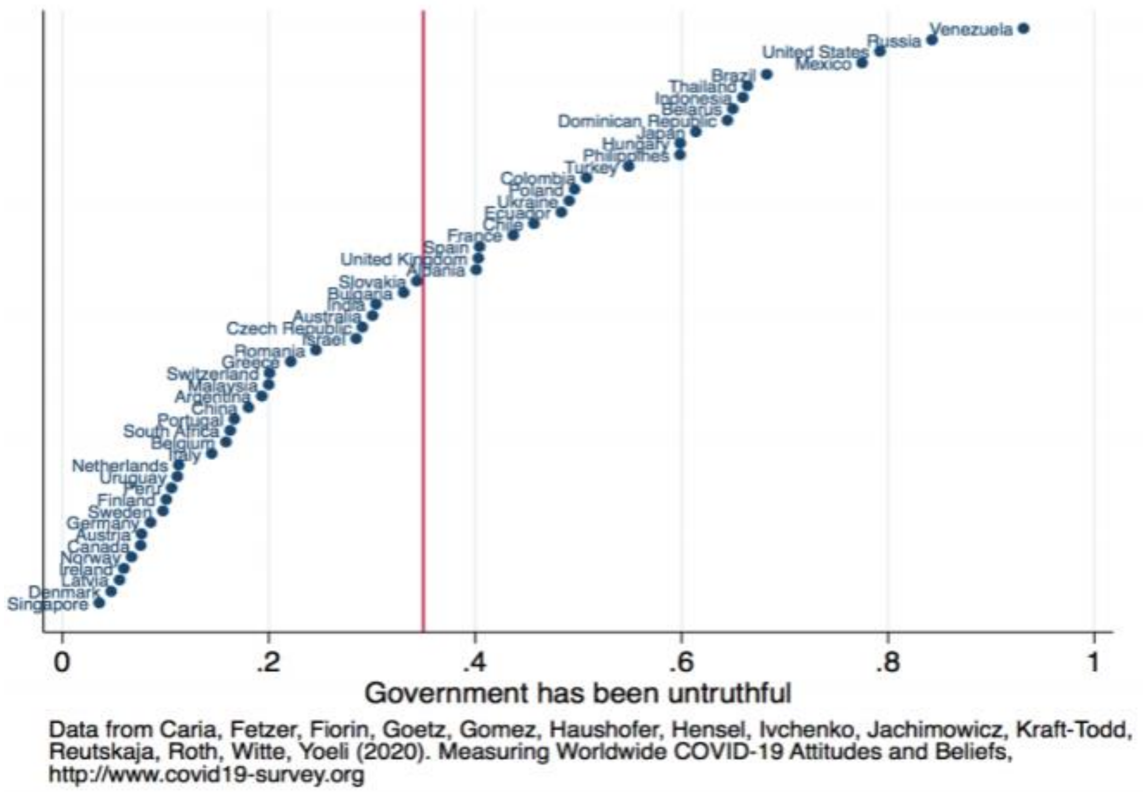

Figure 5 – Perceptions of Corona Policy Reaction – Perception of Truthfulness of the government.

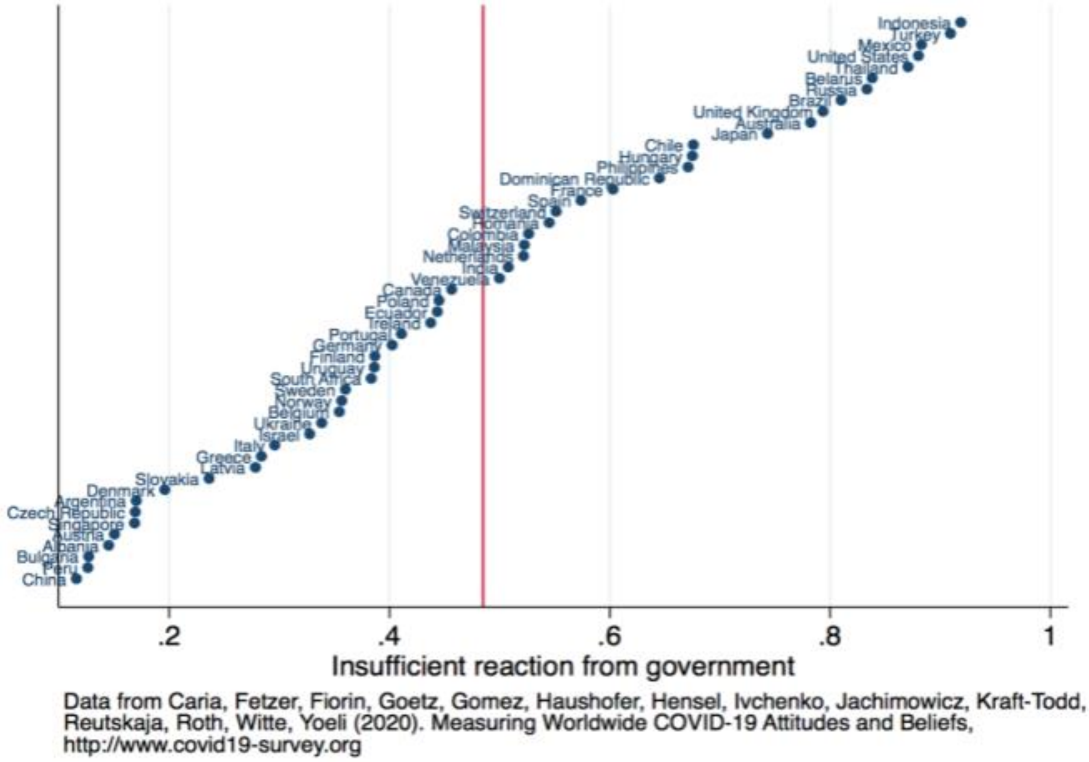

Figure 6 – Perceptions of Corona Policy Reaction – Perception of Actions taken by the government.

1.4. Study Objectives

The main goal of this study is to identify and estimate how pandemics, affect the stock market in a country with a large economy (United States of America), and a small economy (Greece), regardless of whether the pandemic comes to an end or not. Succeeding, how did Portugal react compared with the countries mentioned above regarding only the Covid-19 pandemic.

To accomplish the goal of this study it is needed to compare the pandemic crisis caused by Covid-19, the SARS-CoV-2 with the first pandemic of the XXI century, H1N1. An analysis of influencing variables will be required with similar characteristics for more coherence, with a GARCH model, explained in point 3 of this thesis.

Within these objectives, the aim is to compare the reality over the observation period in the countries studied to the reality of the H1N1 pandemic lived, such as the time reaction to acknowledge a danger to mankind by WHO, the volatility, and returns obtained in the periods mentioned below (Figure 7 and 8). Therefore, we can infer with the data and study if what had been made in the period detailed in point 3.4., had been effective and what country had been more successful, to oppugn the Covid-19 pandemic, concerning the economy.

Below are decipher questions that I pretend to answer with this study:

- Do crises have an immediate impact on the stock market volatility? Did Covid-19 react differently? If applicable, when does the impact start?

- Did H1N1 and COVID-19 pandemic produce a higher impact on larger or smaller economies (if applicable)? How did Portugal compare with the United States of America and Greece’s stock market volatility concerning only the Covid-19 pandemic?

2. STUDY RELEVANCE AND IMPORTANCE

The topic “Study Relevance and Importance” in the author´s opinion, needs to fulfill and answer the questions decipher below:

- Does this pandemic (Covid-19) compare to other pandemics (such H1N1)?
- Studying a subsequent or the current pandemic on the financial market can help countries and business leaders to take more circumspect measures in the future? Is it relevant and helpful to our society?

This study has great relevance for our society, either individuals, companies, or countries, for the fact that we are in this together and acknowledge that life goes on and we learn more about responsibility, and everything that one person does can affect the people around, so this helps us to take a time out and re-think the things that we did and still do, to improve ourselves.

The future results of the research will carry out on the effect of Covid-19. This paper will help indicate what has happened in that time period, and through the future data gathered, it will be possible to speculate either if we are going on a good path or walking backward, making it relevant to compare this global virus to the Swine Flu pandemic. This indicates whether the governors were prepared for this sort of situation to happen. Thus, also taken into consideration that these times are events without precedents.

The findings of this study will redound to the benefit of society, considering that statistics, mathematics, and the world economy plays a significant role in our daily lives, according to Fernandes, N. (2020). The greater demand for preventing the new pandemic will cause a setback in our economy, for the fact that small and medium-sized enterprises do not have the necessary working capital to sustain themselves from the obligated quarantine administrated in certain countries, which will lead to more unemployment and so forth, making this analyzation a snowball fallacy.

We will find in the literature several examples that intend to analyze this reality in other areas of the globe, such as the work of Adeyeye, P. O., Aluko, O. A., & Migiro, S. O. (2018), the study proves evidence of the impact of the global financial crisis on the behavior of stock prices in the Nigerian stock market. They found that stock prices were predictable before a catastrophe yet unpredictable during the calamity and the post-crisis period - this shows that the global financial crisis has changed the efficiency of the market. [16]

In another paper, referenced in the final of this paragraph, it was found that conditional volatilities of equity indices return show widespread evidence of asymmetry. This equity correlation between the BRICS countries, being those Brazil, Russia, India,

[16] Adeyeye, P. O., Aluko, O. A., & Migiro, S. O. (2018). The global financial crisis and stock price behaviour: time evidence from Nigeria. Global Business and Economics Review, 20(3), 373-387.

China, and South Africa (BRICS), and developed markets, increases dramatically when negative news hits the stock market.[17]

Regarding the article of Thalassinos, E., Pintea, M., & Raţiu, P. (2015), these authors explained and concluded that the decreased stock exchanges, even impacted countries that had suffered less the economic crisis and felt the effects of the recession, the example given by them, was the collapse of exports.[18]

A major study conclusion of Rastogi, S. (2014) on *"The financial crisis of 2008 and stock market volatility–analysis and impact on emerging economies pre and post crisis"* was that, due to the financial crisis of 2008, the volatility of the stock exchanges of the emerging economies has undergone great changes. According to the asymmetric models TGARCH and EGARCH, the study found that before and after the 2008 financial crisis, all countries studied had significant leverage effects. [19]

[17] Samitas, A., Kenourgios, D., & Paltalidis, N. (2007). Financial crises and stock market dependence. European Financial Management Association, 27-30.

[18] Thalassinos, E., Pintea, M., & Raţiu, P. (2015). The recent financial crisis and its impact on the performance indicators of selected countries during the crisis period: a reply.

[19] Rastogi, S. (2014). The financial crisis of 2008 and stock market volatility–analysis and impact on emerging economies pre and post crisis. Afro-Asian Journal of Finance and Accounting, 4(4), 443-459.

3. THEORETICAL FRAMEWORK

3.1. INTRODUCTION

According to the paper of Mazur, Mieszko, Dang, Man and Vega, Miguel (2020), in March of 2020, in just four trading sessions, the Dow Jones Industrial Average (DJIA) fell 6,400 points, equivalent to about 26%, one of the most dramatic declines in history on the stock market. These authors affirm that this downfall was due to the government's response to the pandemic (Covid-19). In the United States of America, the authorities imposed a strict quarantine on residents and suspended most commercial activities, adding to the devastating breakdown of the stock market. This country´s economy appears to be extra affected, with an unemployment rate above twenty (20), caused by the pandemic in the country mentioned prior. [20] [21]

It is relevant to express the relationship between the stock price variance over an event. A “random walk'' is a related concept with the effective market hypothesis, this term is used to describe a series of prices, in which all subsequent price changes represent previous prices. In other words, this logic means that the information obtained in x day, will affect the stock price of the x day and so on. Taking into consideration that, by definition, the news are unpredictable, which indicates that price changes must be random and unpredictable. [22]

Which according to Malkiel, Burton, G, the author retrieves that an event or news could affect the stock price, being that a pandemic, a tweet from Elon Musk, or a spill of oil on the ocean,[23] which actively demonstrates that information in the capital market is affected by the condition of the environment, whether economic or from the non-economic environment, though it is not directly related to the dynamics of the capital market, it cannot be separated from the activities of the capital market, which makes information not only limited to financial information but also encompasses political information, social and economic events. The efficient market hypothesis describes the response of information to the stock price, which is how information affects stock price. However, certain information is not relevant to capital market activity.

An investor, when making investment decisions, uses their own details. The COVID-19 pandemic is one incidental event that is not repeated every year, yet, a pandemic can happen at any time, drastically affecting the stock price. The Covid-19 pandemic has affected all sectors worldwide. The efficient market hypothesis according to Zaky Machmuddah, St. Dwiarso Utomo, Entot Suhartono, Shujahat Ali, and Wajahat Ali

[20] Mazur, Mieszko, Dang, Man and Vega, Miguel (2020) “COVID-19 and March 2020 Stock Market Crash. Evidence from S&P1500”.

[21] https://faculty.fuqua.duke.edu/~charvey/Audio/COVID/COVID-Harvey.html

[22] Malkiel, Burton, G. 2003. "The Efficient Market Hypothesis and Its Critics "; Journal of Economic Perspectives.

[23] Rivas Matavera, I. (2019). El Caso Tesla: El abuso de mercado en el marco de una oferta pública de exclusión.

Ghulam, explains the response of stock price to information and confirms the quickness of the market response to information.[24]

Furthermore, regarding the same article cited in the first paragraph of this chapter (Mazur, Mieszko, Dang, Man and Vega, Miguel (2020)), the objective was to investigate the effect of COVID-19 on the stock market behavior during the crash of March 2020, into the reality on the USA, using the universe of S&P1500 firms.

Taking into consideration that most companies are prohibited from maintaining full operations during the quarantine period, companies choose to adjust labor costs through layoffs. As a result, this led to a sharp reduction in consumption, economic production, and reducing expected future cash flows, representing a major income shock for the economy. However, while most sectors have been hit hard and their stock prices have plummeted, this virus was and is not necessarily harmful to all sectors, for the fact that some can benefit from the pandemic and the resulting blockade.

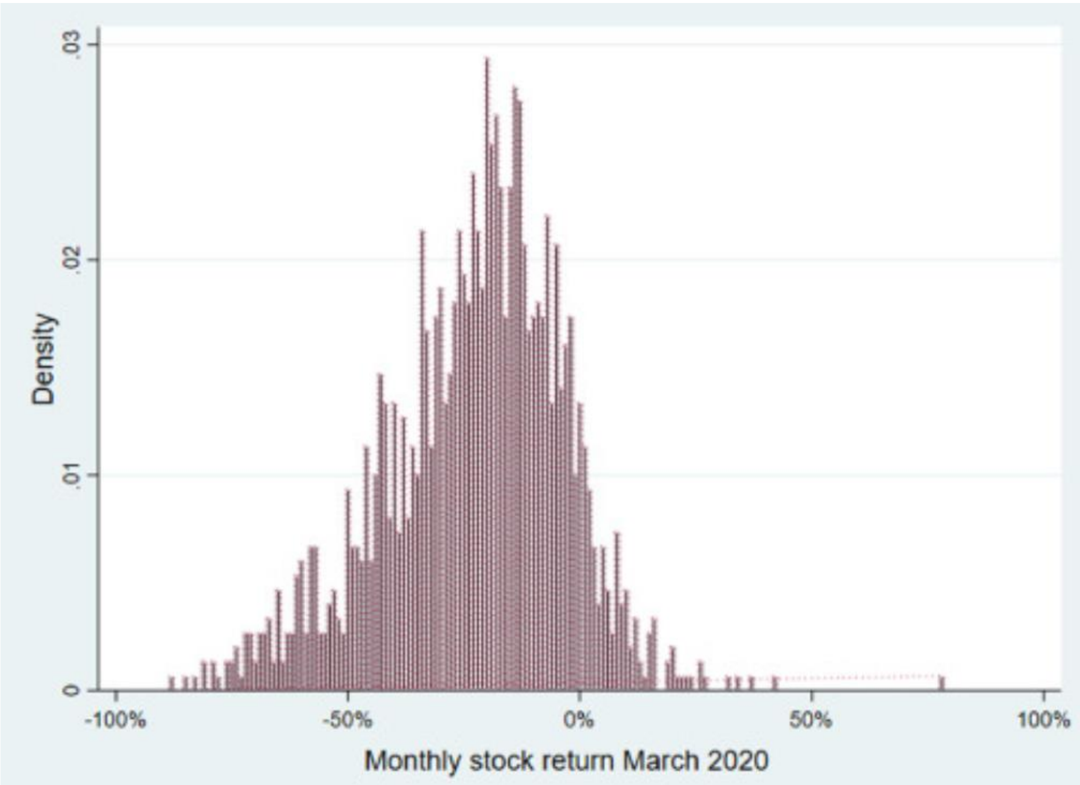

Figure 7 – March 2020 stock returns. (Plot derived from Thomson Reuters Eikon)

[24] Zaky Machmuddah, St. Dwiarso Utomo, Entot Suhartono, Shujahat Ali and Wajahat Ali Ghulam (2020) Stock Market Reaction to COVID-19: Evidence in Customer Goods Sector with the Implication for Open Innovation

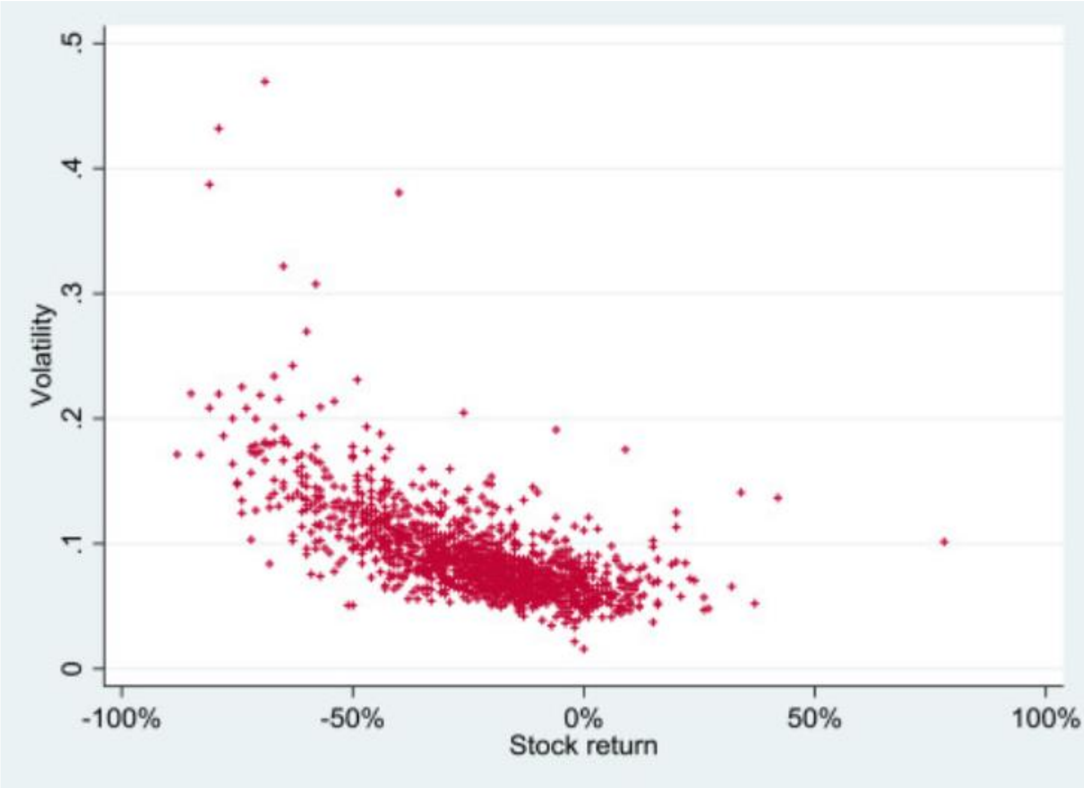

Figure 8 – March 2020 stock return and stock return volatility. (Plot derived from Thomson Reuters Eikon)

Proceeding on the analyses of figures 7 and 8, plots derived from Thomson Reuters Eikon, who shows the relative frequency distribution of monthly stock returns on the USA and the relationship between monthly stock returns and daily stock return volatility for the universe of the S&P1500 firms, in March 2020, respectively. Mazur (2020) found that roughly 90% of the S&P1500 stocks, generated asymmetrically distributed large negative returns. The fall in stock prices shows great volatility, and the extreme asymmetric volatility of the S&P1500 was recorded by the authors (prior stated). They also found that the volatility was negatively correlated with the realized return on the shares (Figure 8). [25]

As reported by Nicholas Apergies, numerous researches have shown that China´s stock markets react to oil price shocks. One of those studies was from Kilian (2009), who proposed a model that shows that the impact of the oil price shock are unpredictable. Various articles have used the model mentioned prior, to examine the effect of oil price shocks (disruption of market equilibrium) on financial markets [26].

[25] Mazur, Mieszko, Dang, Man and Vega, Miguel (2020) “COVID-19 and March 2020 Stock Market Crash. Evidence from S&P1500”.

[26] Nicholas Apergis (2020) The role of Covid-19 for Chinese stock returns: evidence from a GARCHX model

Regarding the authors Fouda, Nader Mahmoudi, Naomi Moy, and Francesco Paolucci, on the paper of 2020 “The COVID-19 pandemic in Greece, Iceland, New Zealand, and Singapore: Health policies and lessons learned”. They stated that in the countries: New Zealand, Greece, Iceland, and Singapore. The local exchange rates per US$, the drastic decline in the oil price had been caused by this pandemic due to the immense demand given by the high level of uncertainty that the World lives. In addition to fluctuations in the unemployment rate and perseverance of the lockdown.[27]

[27] Fouda, A., Mahmoudi, N., Moy, N., & Paolucci, F. (2020). The COVID-19 pandemic in Greece, Iceland, New Zealand, and Singapore: Health policies and lessons learned. Health policy and technology, 9(4), 510-524.

3.2. ARCH MODELS

3.2.1. Autoregressive Conditional Heteroscedasticity (ARCH)

Accordingly, to the author LaBarr, in his paper about *"Volatility Estimation through ARCH/GARCH Modeling"*, he explains the dependence on volatilities on each other. However, instead of a weighted average, Engle's model consists in the prediction and estimation of the asset returns volatility, which is defined as the following equation:

$$\sigma_t^2 = \alpha_0 + \alpha_1 r_{t-1}^2$$

Equation 1) – Engle´s model (ARCH). (Source LaBarr, A. (2014). Volatility Estimation through ARCH/GARCH Modelling).

Still, regarding this model and the previous author, the parameter coefficient $\alpha 1$ is non-negative (indicates that as the independent variable increases, the dependent variable tends to decrease), which makes the volatility estimation positive, and ultimately as stated by, the intercept $\alpha 0$ is always positive. Engle´s model returns are then assumed to be distributed with a mean of zero and variance of $\sigma t 2$, which is also known as the normal distribution.

LaBarr goes beyond and affirms that:

"..this model can easily to extended to include as many lags of returns as you like since it would be unreasonable to assume that today's volatility only depends on yesterday's returns." [28]

In this statement, LaBarr cares to explain that the volatility is furthermore complex than to presume that it only subsists on the previous day´s returns. Which, concerning this situation, it was produced the subsequent model, called ARCH(q):

$$\sigma_t^2 = \alpha_0 + \alpha_1 r_{t-1}^2 + \cdots + \alpha_q r_{t-q}^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i r_{t-i}^2$$

Equation 2) – ARCH(q) model. (Source LaBarr, A. (2014). Volatility Estimation through ARCH/GARCH Modelling).

[28] LaBarr, A. (2014). Volatility Estimation through ARCH/GARCH Modelling. North Carolina State University:USA.[Online] Accessed from:http://support. sas.com/resources/papers/proceedings14/1456-2014. pdf. – page 3

3.2.2. Generalized ARCH (GARCH)

Bollerslev, T. (1986) "Generalized autoregressive conditional heteroskedasticity.", a famous framework and very cited among the scientific community, proposed the GARCH (Generalized Autoregressive Conditional Heteroskedasticity) model.

Instead of dealing with the large values of the ARCH(q) model, Bollerslev developed the GARCH model, to allow a more flexible process with extended memory, compared to the ARCH(q) model, described in point *3.2.1. Autoregressive Conditional Heteroscedasticity (ARCH*). This model assumes the Normal Distribution as Engle´s model, whoever the difference between these models in the calculation, is the inclusion of the previous estimates of volatility ($\beta_1\sigma_{t-1}^2$).

$$\sigma_t^2 = \alpha_0 + \alpha_1 r_{t-1}^2 + \beta_1\sigma_{t-1}^2$$

Equation 3) – GARCH model. (Source LaBarr, A. (2014). Volatility Estimation through ARCH/GARCH Modelling).

Since the ARCH model could be extended to the ARCH(q) model, the GARCH model can be extended to the GARCH (q, p) model. In this model, the intercept must be positive as Engle´s model (explained previously), while the coefficients are always non-negative to ensure that the volatility estimate is positive. LaBarr determines that $q = p$ = 1, is an adequate model to fit real-world data. [29]

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q}\alpha_i r_{t-i}^2 + \sum_{i=1}^{p}\beta_i\sigma_{t-i}^2$$

Equation 4) – GARCH (1,1) model. (Source LaBarr, A. (2014). Volatility Estimation through ARCH/GARCH Modelling).

3.2.3. ARCH/GARCH Family

Over the years, various frameworks have been released for the ARCH/GARCH modeling framework. Several key components have been created for each model, yet the author of *"Volatility Estimation through ARCH/GARCH Modeling"* mentioned three adaptations, being those:

i. EGARCH
ii. IGARCH
iii. TGARCH

[29] LaBarr, A. (2014). Volatility Estimation through ARCH/GARCH Modelling. North Carolina State University:USA.[Online] Accessed from:http://support. sas.com/resources/papers/proceedings14/1456-2014. pdf

3.2.3.1. EGARCH Model

In 1991, Daniel Nelson regarding his paper *"Conditional heteroscedasticity in asset returns: A new approach.",* explained that some financial data sets have the leverage effect, and all the three types of ARCH/GARCH family specified above, has symmetric underlying distributions. It occurs when the volatility increases after a negative return, which is a result of the observed market condition.[30]

Nelson (1991), constructed the exponential GARCH model (EGARCH):

$$\log(\sigma_t^2) = \alpha_0 + \sum_{i=1}^{q} \alpha_i g\left(\frac{r_t}{\sigma_t^2}\right) + \sum_{i=1}^{p} \beta_i \log(\sigma_{t-i}^2)$$

Equation 5) – EGARCH model. (Source LaBarr, A. (2014). Volatility Estimation through ARCH/GARCH Modelling).

3.2.3.2. IGARCH Model

Still paraphrasing LaBarr (2014), in 1986, a paper by Bollerslev and Engle stated that a unit root can be used in the GARCH framework to create an ARMA time series process. This model can be manipulated using simple algebra. However, this model is only applicable if the sum of the αi's and βi's is less than one. If the sum is equal to one, then the model should become an Integrated GARCH (IGARCH) model. This manipulation results in the following ARMA process:[31]

$$r_t^2 = \sum_{i=1}^{p} (\alpha_i + \beta_i) r_{t-i}^2 - \sum_{j=1}^{q} \beta_j v_{t-j} + v_t$$

Equation 6) – IGARCH model. (Source LaBarr, A. (2014). Volatility Estimation through ARCH/GARCH Modelling).

3.2.3.3. TGARCH Model

It was proposed by Bollerslev (1987), an adjustment to the conditional error distribution of the GARCH/ARCH model and that the conditional error distribution be switched to

[30] Nelson, Daniel B. (1991), "Conditional Heteroskedasticity in Asset Returns: A New Approach," Econometrica, 59, 347-370;

[31] LaBarr, A. (2014). Volatility Estimation through ARCH/GARCH Modelling. North Carolina State University:USA.[Online] Accessed from:http://support. sas.com/resources/papers/proceedings14/1456-2014. pdf

a t-distribution.[32] Accordingly, with Jing Wu in his paper about *"Threshold GARCH Model: Theory and Application"*, he mentions the following statement:

"the threshold GARCH (TGARCH) model proposed by Zakoian (1991) and similar GJR GARCH model studied by Glosten, Jagannathan, and Runkle (1993) define the conditional variance as a linear piecewise function." [33]

This model (TGARCH), it would allow the model to consider the various constraints of the distribution. He argues that this method would improve the representation of financial data's clustering.

$$\sigma_t^2 = \omega + \alpha r_{t-1}^2 + \delta D_t r_{t-1}^2 + \beta \sigma_{t-1}^2$$

$$D_{t-1} = \begin{cases} 1 & r_{t-1} < 0 \\ 0 & r_{t-1} \geq 0 \end{cases}$$

Equation 7) – TGARCH model. (Source LaBarr, A. (2014). Volatility Estimation through ARCH/GARCH Modelling).

[32] LaBarr, A. (2014). Volatility Estimation through ARCH/GARCH Modelling. North Carolina State University:USA.[Online] Accessed from:http://support. sas.com/resources/papers/proceedings14/1456-2014. pdf.

[33] Wu, Jing (2010). Threshold GARCH Model: Theory and Application. Page 3.

3.3. PEARSON´S CORRELATION COEFFICIENT

Pearson´s coefficient is a test statistic of correlation that represents the relationship, measured the strength of the connotation on the interval explained below, between two variables. It is represented by the letter "r" and ranges from -1 to 1. So that:

- A perfect negative correlation between the variables, i.e., if one increases, the other always decreases, which returns **r = -1**;
- **r= 0** means that the variables do not depend linearly on each other. However, there may be another dependency that is "non-linear". Thus, the result **r = 0** must be investigated by other means.
- **r = 1** means a perfect and positive correlation between the variables;

Concerning the intensity, many studies consider that a correlation coefficient between **i)** 0 and (+/-) 0.3 as weak; **ii)** (+/-)0.3 and (+/-)0.8 as moderate, and **iii)** above (+/-) 0.8, is considered as strong.

This method is used, due the literature review studied, on the correlation structure and evolution of world stock markets with macroeconomics factors. For example, Jareño, F., & Negrut, L. (2016), and Wang, G. J., Xie, C., & Stanley, H. E. (2018). Additionally, it is known as the best method of measuring concerning the intentions of the author.[34]

Jareño, F., & Negrut, L. (2016), analyzed and developed the difference between the USA´s stock market and macroeconomic factors, in the period duration of 2008-2014. To support these results, they applied the Pearson correlation coefficients to show whether the relationships found were statistically significant. [35] From their analysis, the following figures were drawn:

[34] https://www.statisticssolutions.com/free-resources/directory-of-statistical-analyses/pearsons-correlation-coefficient/

[35] Jareño, F., & Negrut, L. (2016). US stock market and macroeconomic factors. Journal of Applied Business Research (JABR), 32(1), 325-340

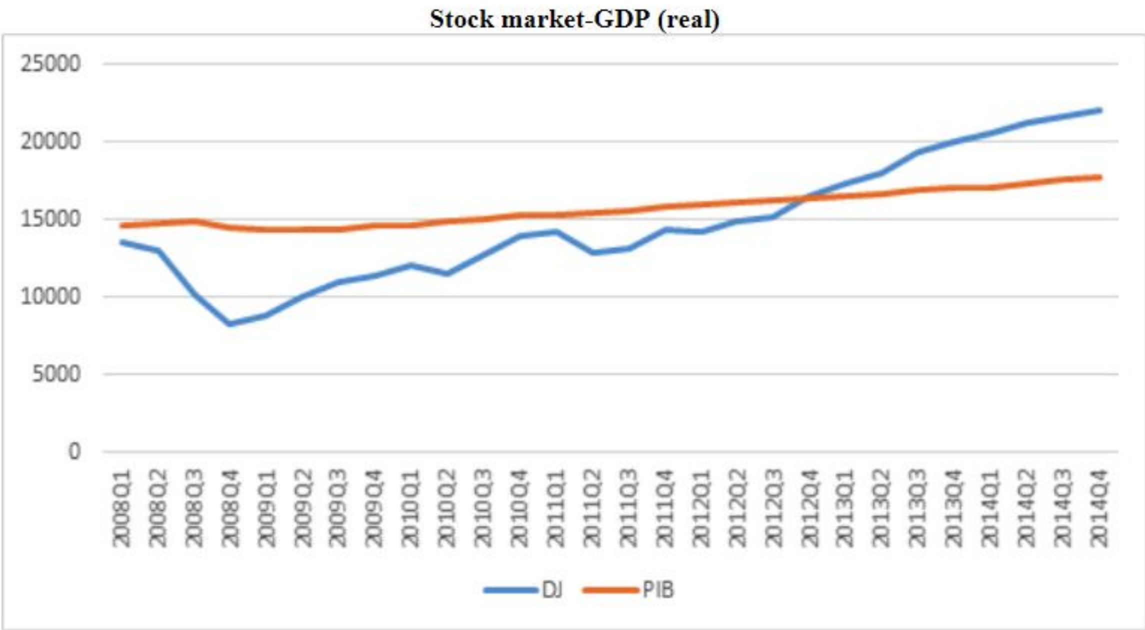

Figure 9 – DowJones Stock Market vs GDP (Source: Jareño, F., & Negrut, L. (2016)).

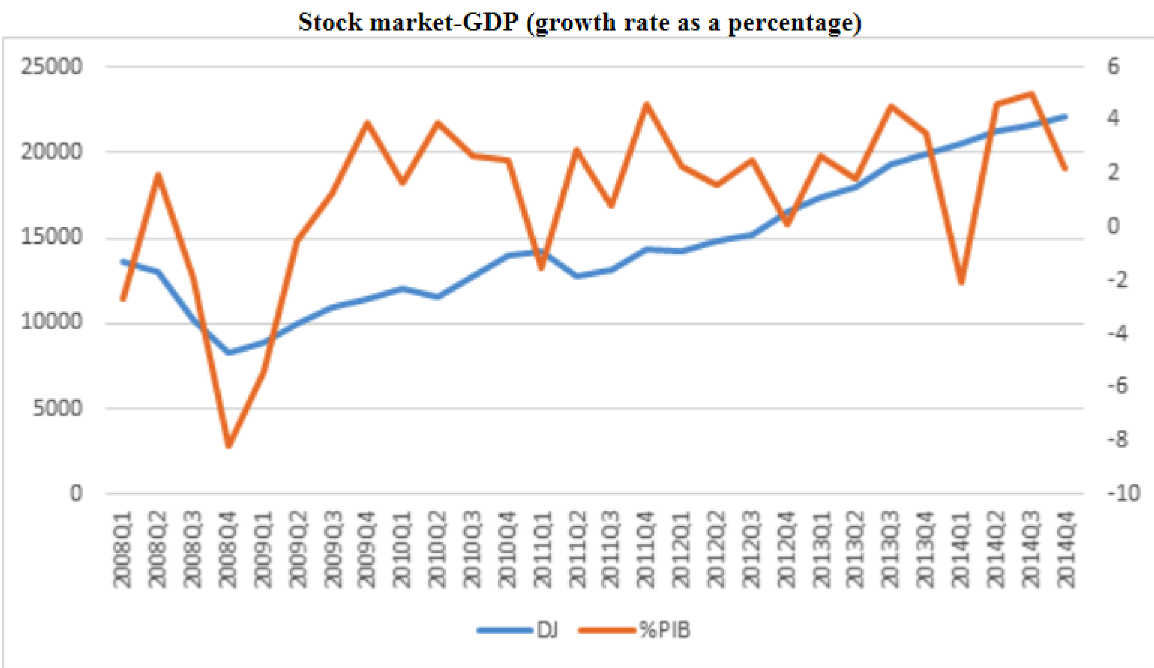

Figure 10 – DowJones Stock Market vs GDP % (Source: Jareño, F., & Negrut, L. (2016)).

Concerning Wang, G. J., Xie, C., & Stanley, H. E. (2018), during the periods of 2005 to 2014, their empirical data of 57 stock market´s daily price indices. Their objective was to study the correlation structure and evolution of world stock markets using Pearson and partial correlation-based Mean Square of Treatments (MSE) methods. They observed the existence of fat tails concerning the comparison of the distributions of Pearson and partial correlation coefficients, which represents the significance influenced by other markets between the variables considered.[36]

Regarding once again, Jareño, F., & Negrut, L. (2016), by using the Pearson correlation coefficient method, they found that USA´s stock market displays a positive and significant relationship with the gross domestic product (GDP), which indicates that our study further down the text, being in line with this work analysis, will also have an outcome where the correlations between our variables: **a)** GDP and **b)** closing value of the stock market, will be significant and positive.[37]

[36] Wang, G. J., Xie, C., & Stanley, H. E. (2018). Correlation structure and evolution of world stock markets: Evidence from Pearson and partial correlation-based networks. Computational Economics, 51(3), 607-635.

[37] Jareño, F., & Negrut, L. (2016). US stock market and macroeconomic factors. Journal of Applied Business Research (JABR), 32(1), 325-340.

3.4. DATA AND METHODOLOGY FRAMEWORK

For this matter, the input data will be gathered on Dow Jones for the data of the United States of America, Euronext Lisbon for Portugal data, and Athens Stock Exchange (ATHEX) for Greece, to transform into an output to determine the real impact of Covid-19 to the world economy and what it will mean to the future. The input data and the observation period will be from six months before (T_{-1}) and six months after it emerges (T_1). The time that H1N1 and Covid-19 emerged was considered as T_0 (Figure 9 and Figure 10, respectively).

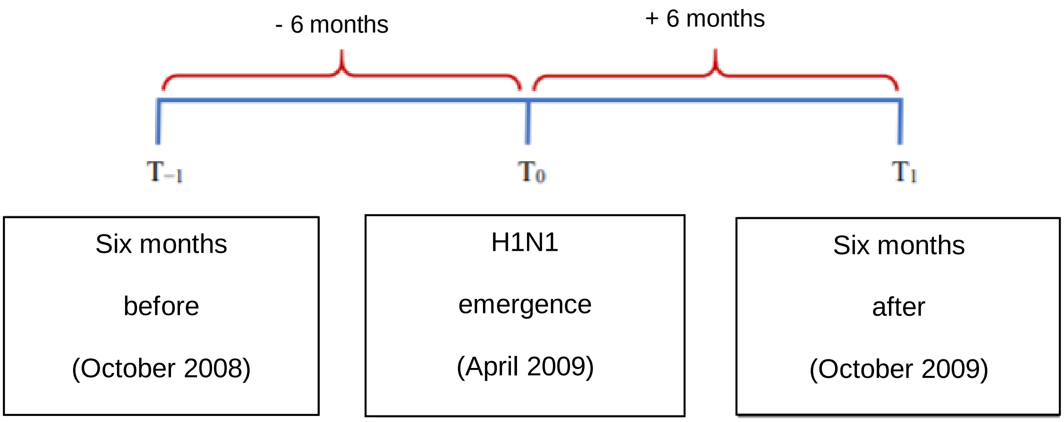

Figure 11 – Observation Period for the H1N1 pandemic

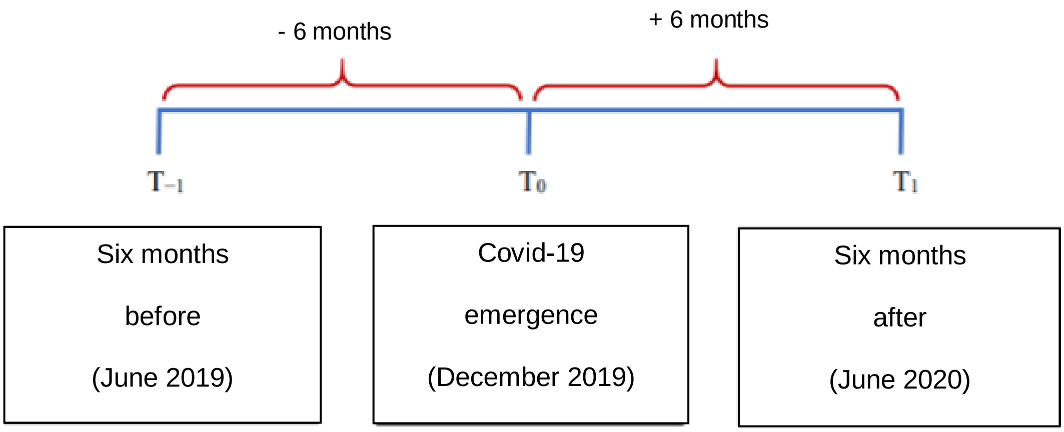

Figure 12 – Observation Period for the COVID-19 pandemic

To investigate the impact of the pandemics on the volatility and returns on shares in the United States of America, Greece, and Portugal, the analysis weighed the GARCH (1,1) model based on the GARCH structure referred above, and the Pearson´s correlation coefficient, based on the literature review of Jareño, F., & Negrut, L. (2016).

The chosen model was based on previous research, being one example the Nicholas Apergis (2020) and according to Nicholas, he mentioned that this model (GARCH (1,1)) was recommended by Engle, Ng, and Rothchild (1990), Apergis (1998), and Connor and Linton (2001), which consists of two equations:

- The conditional mean;
- The conditional variance equation.

Still, regarding Nicholas Apergies, the methodology used was the GARCHX model, a simple, yet widely used to obtain time-series volatility which allows to adding information on supplementary controls that may influence the average return on shares and consequently can alter the volatility. Taking into consideration what was said prior, this allows the COVID-19 factor to enter the equations of mean and conditional volatility. The ARMA (p, q) returns model is normally used to calculate errors, taking into reflection the author of the paper "The role of Covid-19 for Chinese stock returns: evidence from a GARCHX model", it was used the following formula:

$$r_t = a + \sum_{i=1}^{p} br_{t-i} + \sum_{i=1}^{q} cv_{t-i} + \varepsilon_t$$

Equation 8) – ARMA Formula. (Source: Nicholas Apergies (2020))

In Equation 8), the autoregressive (AR) component is represented in the first sum ($a + \Sigma br_{t-i}$) and the second sum ($\Sigma cv_{t-i} + \varepsilon_t$) the moving average (MA) component, being "a" a constant and "ε" an error term. In the next equation, he added a new variable to Equation 1), the Covid-19 factor, making the model into the following GARCHX formula:

$$r_t = a + \sum_{i=1}^{p} br_{t-i} + \sum_{i=1}^{q} cv_{t-i} + d\,Covid19_t + \eta_t$$

Equation 9) – GARCHX with Covid-19 variable. (Source: Nicholas Apergies (2020))

The equation of conditional volatility, within a GARCH (1,1) framework, is the following:

$$h_t = f + gh_{t-1} + m\eta^2{}_{t-1}$$

Equation 10) – Conditional Volatility. (Source: Nicholas Apergies (2020))

In Equation 10), h denotes the measurement of conditional volatility and η is the residuals. In his GARCHX modeling version, it was also added the Covid-19 variable, for Equation 11):

$$h_t = f + gh_{t-1} + m\eta^2_{t-1} + k\,COVID19_t$$

Equation 11) – GARCHX model with Covid-19 variable. (Source: Nicholas Apergies (2020))[38]

According to Gylych Jelilov, Paul Terhemba Iorember, Ojonugwa Usman, and Paul M. Yua, the methodology was based on the extraction of the daily data of cases confirmed of Covid-19 in Nigeria and the daily stock market returns (SMR), which was computed from the All Share Index (ASI) data published by the Nigerian Stock Exchange (NSE), using the Equation 12, demonstrated bellow.

$$\mathrm{SMR}_t = 100 * ln\left(\frac{\mathrm{ASI}_t}{\mathrm{ASI}_{t-1}}\right)$$

Equation 12) – SMR denotes stock market returns, ASI denotes all shares index, t denotes time period. (Source: Gylych Jelilov, Paul Terhemba Iorember, Ojonugwa Usman, and Paul M. Yua (2020))

These authors indicated that the financial time series have three features, being leptokurtic distribution, leverage effect, and volatility clustering.

Their methodology was based on the ARCH or GARCH type models that were used in the studies of Engle, Rastogi, and Yousef, 1982, 2014, and 2020, respectively. They employed the standard GARCH—GARCH (1,1) and the GJR-GARCH model, being both asymmetric models. This model also measures leverage or asymmetric effects, which is typical, as mentioned many times prior, on stock market returns. In Equation 13), it was referred by the authors, a generic specification of the GJR-GARCH model with inflation and Covid-19 variance, as follows:

$$\sigma_t^2 = \omega + (\gamma_1 + \delta\pi_{t-1})\mu_{t-1}^2 + \lambda_1\sigma_{t-1}^2 + \varphi_1 \mathrm{INF}_i + \varphi_2 \mathrm{COVID}_i$$

Equation 13) – Complex Volatility Formula with the Covid-19 variable. (Source: Gylych Jelilov, Paul Terhemba Iorember, Ojonugwa Usman, and Paul M. Yua (2020))

[38] Nicholas Apergis (2020) The role of Covid-19 for Chinese stock returns: evidence from a GARCHX model

Still regarding Gylych Jelilov, Paul Terhemba Iorember, Ojonugwa Usman, and Paul M. Yua, in the Equation 13), "δ" means the asymmetry or leverage effect parameter. If whenever this symbol is i) higher than 0, the asymmetry will increase, ii) equals to 0, this indicates that there are no leverage effect and the GARCH (1,1) model collapses.[39]

Finally, Jareño, F., & Negrut, L. (2016), analyzed the relationship between the US stock market and some respective relevant macroeconomic factors, one of them being the gross domestic product. The author demonstrates through a statistical perspective with the calculation of Pearson's correlation coefficients, which show whether these relationships are statistically significant. This analysis, based on the study mentioned in footnote, nº. 40, shows that USA´s stock market had a positive and significant relationship with gross domestic product (GDP).[40]

[39] Gylych Jelilov, Paul Terhemba Iorember, Ojonugwa Usman and Paul M. Yua (2020) Testing the nexus between stock market returns and inflation in Nigeria: Does the effect of COVID-19 pandemic matter?

[40] Jareño, F., & Negrut, L. (2016). US stock market and macroeconomic factors. Journal of Applied Business Research (JABR), 32(1), 325-340.

4. METHODOLOGICAL FRAMEWORK

This study´s principal goal is to identify and estimate how pandemics affect the stock market in certain countries with a large and small economy, such as the United States of America and Greece, respectively. Repeatedly, regardless of whether the pandemic comes to an end or not. Following, how did Portugal react compared with the countries mentioned above regarding only the Covid-19 pandemic.

The first stride is to withdraw the necessary input will be gathered on Dow Jones for the data of the United States of America, Euronext Lisbon for Portugal data, and Athens Stock Exchange (ATHEX) for Greece, such the quotation and market values of every day for six months before and six months after the Covid-19 officially emerges and execute the same strategy in line with the data of H1N1 pandemic.

After the data treatment, the primary procedure analysis will be made in sequence. Firstly, it will be feasible to determine if the impact of the COVID-19 virus was negative or positive, even though it is expectable to be a negative impact. Secondly, the analysis regarding the collect data, a study will be conducted to compare the impact of COVID-19 to the Swine Flu Pandemic, in each of the countries mentioned above.

The comparison from Covid-19 to the Swine Flu (H1N1) will be since:

- The time reaction of WHO to declare these diseases a pandemic;
- The number of infected cases and estimated mortality to evidence if there is a possible impact;
- The impact on the stock market volatility and return, taking into consideration also the points mentioned upon.

Additionally, to illustrate the self-serving bias concerning success against the periods studied, COVID-19 (2020) and Swine Flu (2009), it will be explained and taking into consideration the percentage of world Gross Domestic Product (GDP). Simplifying, it measures the economic activity value of for example, the country A. The higher percentage, the higher the impact on the economy of country A has on the world and consequently the provocation towards an economic-financial crisis.

4.1. DATA AND METHODOLOGY

The daily and total reported cases and deaths, worldwide, for the COVID-19 and H1N1 (2009) pandemic, respectively, are collected from these websites, indicated below:

- https://ourworldindata.org/;
- https://www.who.int/csr/disease/swineflu/updates/en/.

The input was gathered on Dow Jones for the United States of America data, Euronext Lisbon for Portugal data, and Athens Stock Exchange (ATHEX) for Greece, and has covered two periods. The first one concerning the COVID-19 pandemic, from 30 June 2019 to 30 June 2020, and the second period, for the H1N1 pandemic, from 31 October 2008 to 31 October 2009.

Regarding the last individual case update from WHO, concerning the H1N1 virus, which was reported on the 6th of July 2009, three (3) months after the emerge (T_0) of the virus, and for bias purposes, it was also considered the three months for COVID-19, which by the calculation it was on the 31st of March 2020. At these moments, WHO had reached the following number of reported cases and deaths, regarding the pandemics studied:

Country	Confirmed Cases*	Deaths*
Greece	1156	38
Portugal	7443	160
United States of America	192079	5359

*Data gather on website mentioned on this chapter, until 31 March 2020, for the COVID-19 pandemic.
https://ourworldindata.org/grapher/Covid-19-total-confirmed-cases-vs-total-confirmed-deaths?tab=table&time=2020-03-31

Country	Confirmed Cases*	Deaths*
Greece	151	0
Portugal	42	0
United States of America	33902	170

*Data gather on https://www.who.int/csr/don/2009_07_06/en/, until 6 July 2009, for the H1N1 pandemic.

Observing the difference between the number of cases and deaths that occurred in a period of 3 months, from December 31st to March 31st of 2020, one can hypothesize the following: if these factors had an impact on the returns and volatility of the Stock Market, the Covid-19 pandemic had (allegedly) more impact than the 2009 pandemic of H1N1 - Influenza A virus.

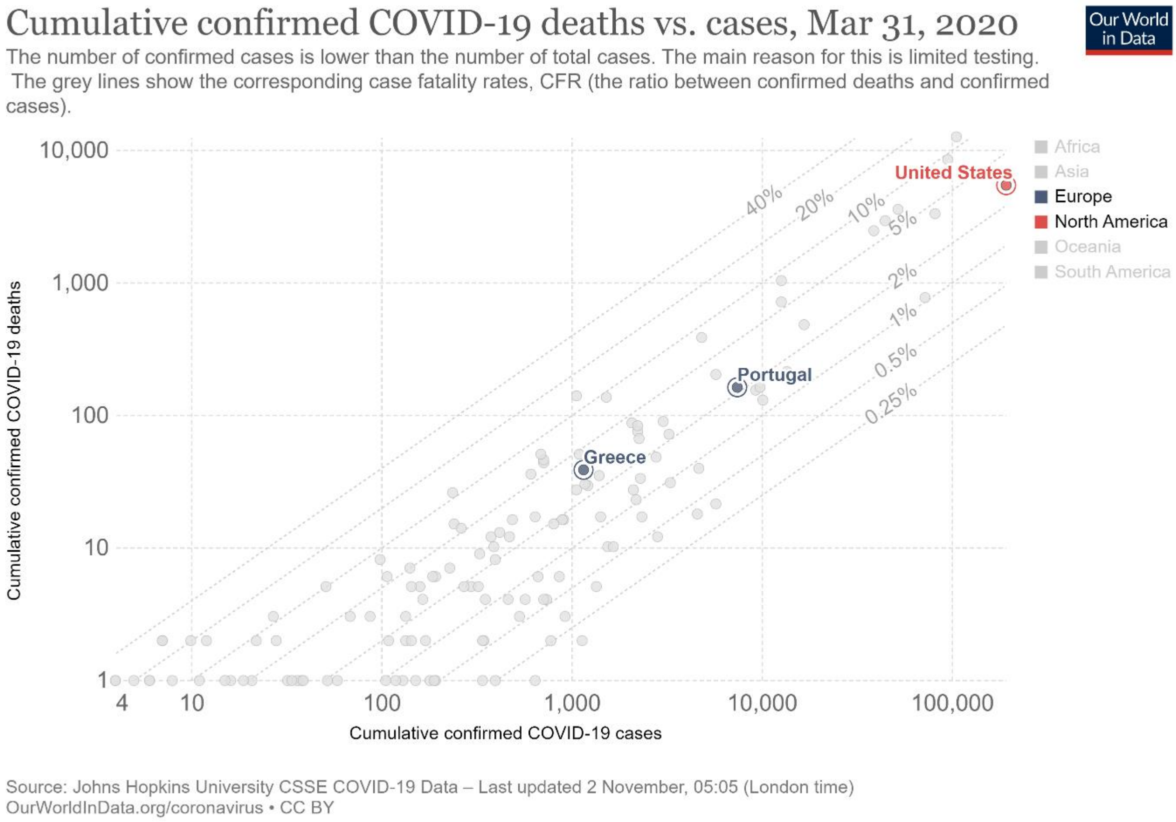

Figure 13 – Cumulative confirmed COVID-19 deaths vs cases on March 31 of 2020 (Source: https://ourworldindata.org/grapher/Covid-19-cumulative-confirmed-cases-vs-confirmed-deaths?time=2020-03-31&country=PRT~GRC~USA)

Figure 13 shows the cumulative confirmed cases and deaths of Covid-19 till 31st of March 2020. The numbers of deaths are on the y-axis, while the numbers of cases are on the x-axis. Even though this graphic represents well the situation that occurred in the period of 3 months, it is not tangible the real impact, for the facts that it doesn´t show the percentage of the population infected by Covid-19 and consequent deaths; And that each country had its first positive Covid-19 result on different dates, which will (hypothetically) cause an exponential increase in cases compared to another country that had its first case later.

Accordingly, to the website mentioned above, the first country to register a positive Covid-19 (of the three studied in detail), was the United States of America on 22nd of January 2020, the second country was Greece on 26th of February 2020, one month after the first confirmed case on the USA. Finally, the last country of the three, was Portugal on the 2nd of March 2020, one week after the first confirmed case on Greece.

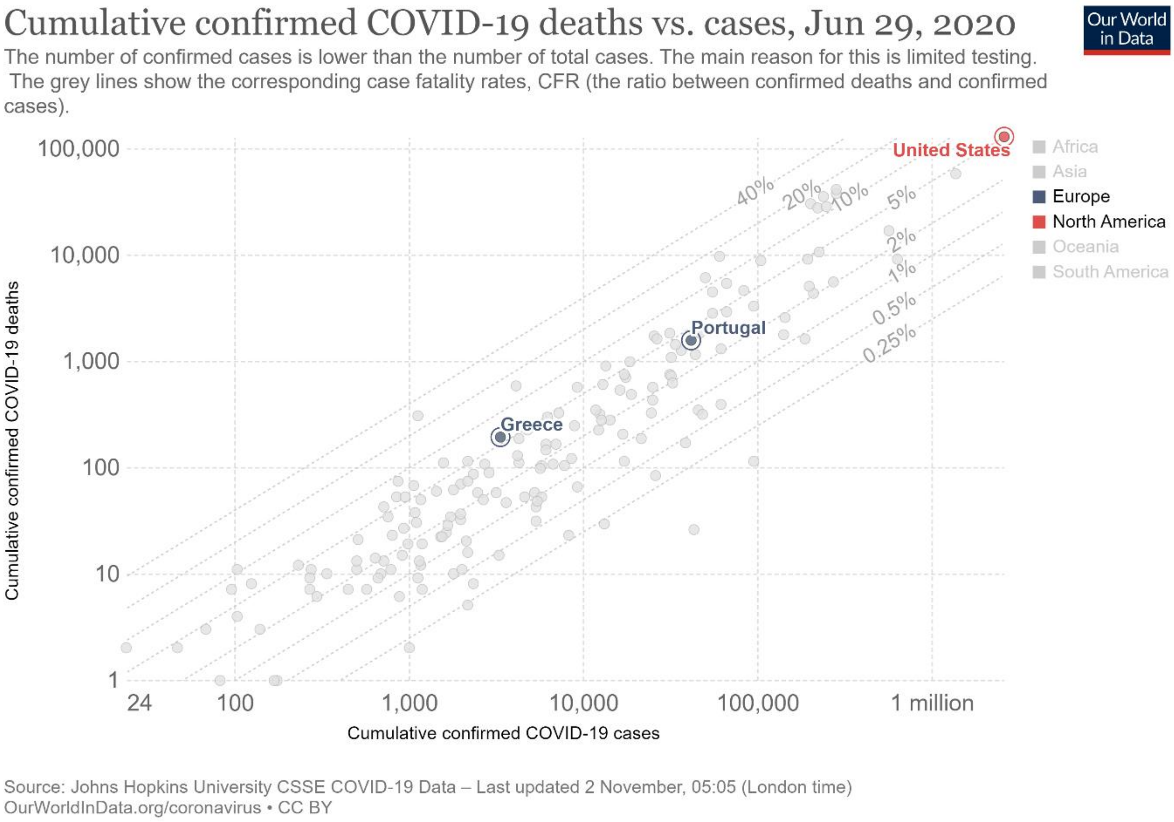

Figure 14 – Cumulative confirmed COVID-19 deaths vs cases on June 29 of 2020 (Source: https://ourworldindata.org/grapher/Covid-19-cumulative-confirmed-cases-vs-confirmed-deaths?time=2020-03-31&country=PRT~GRC~USA)

Figure 14 shows the cumulative confirmed cases and deaths of Covid-19 till the 29th of June 2020. The numbers of deaths are on the y-axis and the numbers of cases are on the x-axis. This graphic represents better the evolution of the confirmed cases and deaths by Covid-19, since that in 6 months – in the author opinion – it is possible to retrieve more information, considering the vast majority of countries (especially the ones studied in this thesis), they had a significant amount of time to settle the necessary health security and determine certain rules, for example, the lockdowns and respective duration.

Comparing the periods of 6 months (Figure 14) and 3 months (Figure 13), regarding the deaths and cases of Covid-19 pandemic, it's possible to highlight that Portugal and the United States of America had a very significant increase in both cases and deaths by Covid-19, compared to Greece, which was able to remain stable, relative to what occurred in the 3 months.

Country	Confirmed Cases*	Deaths*	Evolution Confirmed Cases (%)	Evolution of Deaths (%)
Greece	3390	191	193 %	403 %
Portugal	41912	1568	463 %	880 %
United States of America	2590000	126806	1248%	2266 %

*Data gather on website mentioned on this chapter, until 29th June 2020, for the COVID-19 pandemic.
https://ourworldindata.org/grapher/Covid-19-cumulative-confirmed-cases-vs-confirmed-deaths?tab=table&time=2020-06-29&country=PRT~GRC~USA

The table above indicates the number of confirmed cases and deaths, as well as their evolution from 3 months to 6 months since the emergence of Covid-19 in the countries studied and mentioned throughout the dissertation. Of all the countries studied, Greece managed to remain the most stable, while the USA had the worst instability (highest growth of cases and deaths).

Figure 15 – H1N1 – Influenza A pandemic timeline.

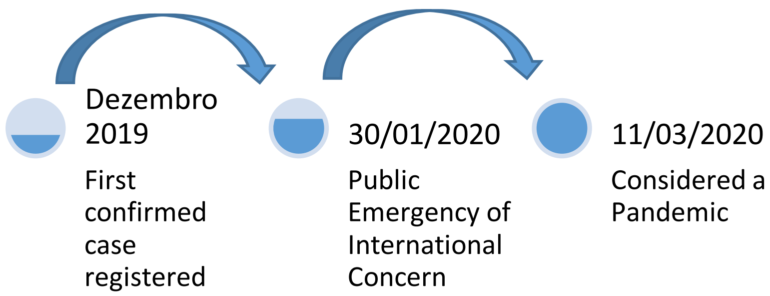

Figure 16 – COVID-19 pandemic timeline.

According to figures 15 and 16, since the first case was recorded globally, it took both pandemics, one (1) month until it was considered a Public Emergency of International Concern, and two (2) months and a half to be considered a pandemic. In conclusion, WHO had determined (more or less) the same deadlines, which in the perspective of the author it was a consistent response since every day in a pandemic environment can cause severe health and economic damage.

Prats, M. A., & Sandoval, B. (2020) explain the correlation between the financial system and economic growth and how they associate. Still, regarding the same paper, there have been several studies on this matter, being the earliest studies conducted by Goldsmith in 1969, who demonstrated the correlation – expressed at the beginning of this paragraph – by using the value of assets intermediated as a percentage of GDP as a proxy for financial development.

A study conducted by King and Levine (1993) revealed that the development of a country's financial sector is linked to long-term economic growth. They found that this link was strong enough to predict future development. Succeeding this analysis, Prats, M. A., & Sandoval, B. (2020), investigated if the stock market's effect on real GDP caused by the size of the economy was causal. The results of their study supported the hypothesis mentioned above.[41]

Additionally, Portugal will be a special case study, for the fact that this paper will compare if Portugal, being a small country economy, has managed to reduce the downfall in the stock market and respectively volatility, and in the World GDP (economic damage), in comparison to another small economy country, such as Greece, and comparison, to a large economy country, the United States of America.

Concerning Govindasamy, P., & Shankar, K. U. (2020), these authors mentioned that the financial markets witnessed unprecedented volatility in 2020, which was the first time since the global financial crisis in 2008 that it happened. The rise in the CBOE VIX Index, which measures at real-time the expectations of near-term price changes of the S&P 500 index, such as the fear level in the markets, accelerated in the United States of America.[42]

In March 2020, the price of Brent crude oil almost halved as concerns about the spread of the coronavirus globally and the lack of supply outweighed the oil demand. The price of the OPEC Reference Basket (ORB), which is used by the Organization of Petroleum Exporting Countries, dropped by over 38% in a span of a few months, which signaled

[41] Prats, M. A., & Sandoval, B. (2020). Does stock market capitalization cause GDP? A causality study for Central and Eastern European countries. Economics, 14(1).

[42] Govindasamy, P., & Shankar, K. U. (2020). Covid-19 And Global Financial Markets With Special Focus To Gdp Growth Projection, Capital Mobilization And Performance Of Stock Market. Volume XI, Issue VII, 1-9.

the worst recession since the Great Depression and the global financial crisis of 2008-2009.[43]

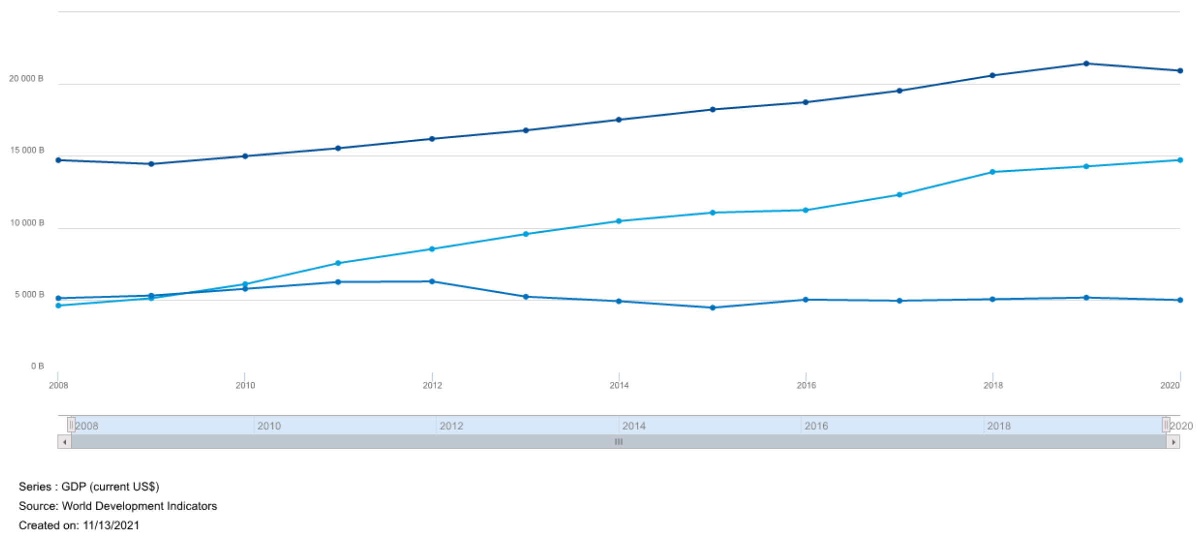

Figure 17 – Evolution of the Top 3 GDP from 2008 to 2020. (Source: World Development Indicators).

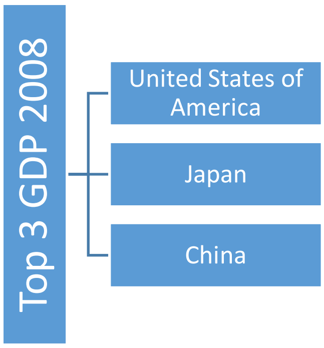

Figure 18 – Top 3 GDP of 2008 (before the pandemic of H1N1). (Source: World Development Indicators).

[43] Govindasamy, P., & Shankar, K. U. (2020). Covid-19 And Global Financial Markets With Special Focus To Gdp Growth Projection, Capital Mobilization And Performance Of Stock Market. Volume XI, Issue VII, 1-9.

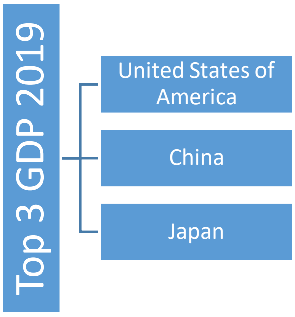

Figure 19 – Top 3 GDP of 2019 (before the pandemic of COVID-19). (Source: World Development Indicators).

In figure 17 we can observe the evolution of the top 3 countries, with the highest GDP in the world from 2008 and 2020. Figures 18 and 19 demonstrates that the United States of America has managed to, not only be on the top 3 GDP in the world, even so, it managed to be in the first place. One of the reasons for having chosen the United States of America, was that it is and was the largest economy with the highest GDP for over a decade, as can be seen in figure 19. It is also observable that of the top three GDP´s (USA, China, and Japan), only China had a positive impact on both pandemics.[44]

Figure 20 – World GDP Annual % growth from 2008 to 2020. (Source: World Development Indicators).[45]

[44] https://databank.worldbank.org/reports.aspx?source=2&series=NY.GDP.MKTP.CD&country=#advancedDownloadOptions

[45] https://data.worldbank.org/share/widget?indicators=NY.GDP.MKTP.KD.ZG

Even though the world annual percentage of the GDP, had dropped from 2008 to 2009, due to the highly known 2008 crisis in the USA that had an impact on the stock market and the GDP. In the period of the year 2019 to 2020, this indicator has suffered a higher percentage downfall, as illustrated in figure 20.

However, it is relevant to mention that GDP increased in the year 2009. The H1N1 pandemic started in mid-2009, this means that this pandemic did not create a negative impact, as one would expect, given the Covid-19 pandemic.

Figure 21 – USA, Portugal, and Greece GDP Annual % growth from 2008 to 2020. (Source: World Development Indicators).

Regarding figure 21, the objective of this graphic is to illustrate the annual percentage growth of GDP from 2008 to 2020 in the countries studied in this paper, being those countries, the USA, Portugal, and Greece. From this graphic, all these countries had a decrement in the GDP in the years that the pandemics occurred, being those years, 2009 and 2020, as previously mentioned in this dissertation.

In the next subchapter (4.2. and 4.3.), the author has analyzed the succeeding stock markets:

i. **PSI** (Portugal´s Index), from June 2019 to June 2020;

ii. **ATHEX** (Greece´s Index), from June 2019 to June 2020;

iii. **ATHEX** (Greece´s Index), from October 2008 to October 2009;

iv. **DOWJONES** (USA´s Index), from June 2019 to June 2020;

v. **DOWJONES** (USA´s Index), from October 2008 to October 2009.

Regarding the data above, a GARCH (1,1) model was performed by SAS, and correlations studies were carried out. Where, several comparison studies were conducted, such as the following:

Figure 22 – Stock Market´s Index Comparison Cycle

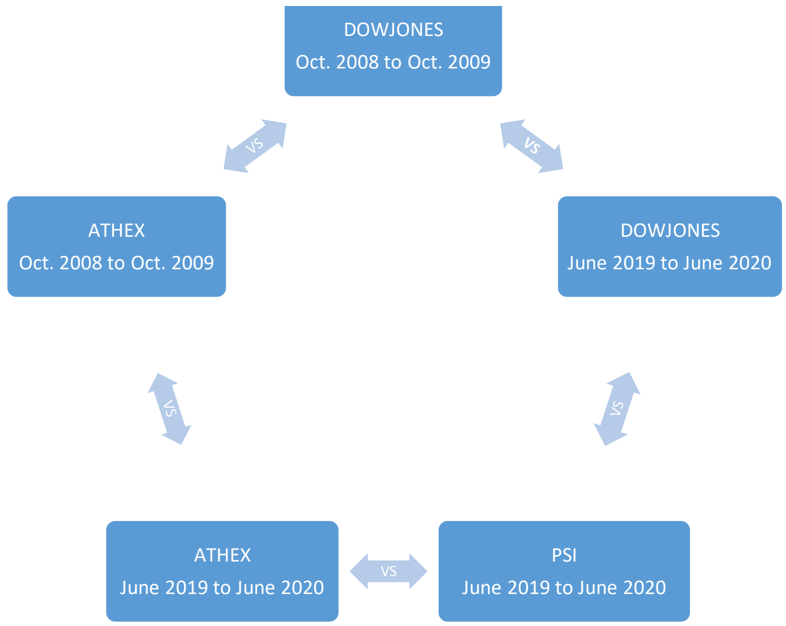

Figure 22 translates the comparison cycle that will be executed in the following chapters, since the author compares the subsequent:

i) ATHEX index, from October 2008 to October 2009 to ATHEX index, from June 2019 to June 2020, and DowJones index, from October 2008 to October 2009;

ii) ATHEX index, from June 2019 to June 2020 to PSI index, from June 2019 to June 2020, and ATHEX index, from October 2008 to October 2009;

iii) PSI index, from June 2019 to June 2020 to ATHEX index, from June 2019 to June 2020, and DowJones index, from June 2019 to October 2020;

iv) DowJones index, from June 2019 to June 2020 to DowJones index, from October 2008 to October 2009, and PSI index, from June 2019 to October 2020;

v) DowJones index, from October 2008 to October 2009 to DowJones index, from June 2019 to June 2020, and ATHEX index, October 2008 to October 2009.

5. GARCH (1,1) MODEL AND PEARSON CORRELATION COEFFICIENT RESULTS

5.1. GARCH (1,1) MODEL RESULTS

The following tables shows the AUTOREG procedure:[46]

- 1. Ordinary least-squares estimates (OLS);
- 2. Dependent variables name;
- 3. Autocorrelation estimations, including the autocovariances, and the autocorrelations;
- 4. It was also calculated by the GARCH model on SAS, the error sum of squares (**SSE**), the degrees of freedom for error (**DFE**), the mean square error (**MSE**), the root mean square error (**Root MSE**), the Schwarz information criterion (**SBC**), the Akaike information criterion (**AIC**), the Durbin-Watson test (**Durbin-Watson**), and the total R-square (**Total R-Square**);
- 5. Estimation of the Autoregressive parameters (**Estimate**), their standard errors (**Standard Error**), and the ratio of estimate to standard error (**t Value**);
- 6. Assuming the accuracy of the autoregressive parameter. The related statistics, mentioned above in this list of items, concerning the tables detailed under, the widespread for the regression estimation would be dissimilar, since the autoregressive parameters are presupposed to be designated.

[46] https://dms.umontreal.ca/~duchesne/chap8.pdf

5.1.1. PSI 2019_2020 Data

Table 1 – Ordinary Least Squares Estimates PSI - 2019 to 2020 period

Ordinary Least Squares Estimates			
SSE	0.03696709	**DFE**	273
MSE	0.0001354	**Root MSE**	0.01164
SBC	-1658.3829	**AIC**	-1661.996
Durbin-Watson	0.9157	**Total R-Square**	0.0000

Table 2 – Regression Estimation (Est. Var)

Parameter Estimates					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	0.009337	0.000703	13.28	<.0001

According the table 1, referring the AUTOREG results for Ordinary Least Squares Estimates (OLS), from the data of the Portuguese index (PSI), over the period of 2019 to 2020, the statistic output has showed that the model for root mean square error (**Root MSE**) is 0,01164. Observe that the full model (**Total R-square**) that includes the autoregressive error process, if any, in this case, an autoregressive error model is not used, since the Total R-square is 0.

Other statistics shown in table 1, are the sum of square errors (**SSE**), mean square error (**MSE**), error degrees of freedom (**DFE**) – the number of observations minus the number of parameters – the information criteria **SBC**, **AIC**, and the **Durbin-Watson** statistic. Regarding the link of paper mentioned in the footnote nº 47, the Durbin-Watson test is a method for autocorrelation experiment. Concerning the same test, the marginal probability designates positive autocorrelation (Durbin-Watson > 0), if it is less than the level of significance (*alpha*), while it's possible to conclude that a negative autocorrelation (Durbin-Watson < 0), exists if the marginal probability based on the computed Durbin-Watson statistic is greater than 1-*alpha.*[47] Still referring table 1,

[47] https://dms.umontreal.ca/~duchesne/chap8.pdf

perceiving that Durbin-Watson = 0.9157, i.e. Durbin-Watson > 0, it means that the marginal probability designates positive autocorrelation.

Table 2 shows the regression estimation, with standard errors and t-values. Meaning that the estimated model is:

$yt = 0.009337 + \in t$

$Est.\ Var(\in t) = 0.0001354 = MSE$

MSE, referring the paper mentioned prior, indicates how close a regression line is to a set of points. Which means the closer it is to the OLS parameter estimates, the reasonable the estimated error variance will be.[48]

Table 3 – GARCH (1,1) Estimation

GARCH Estimates			
SSE	0.04022271	**Observations**	274
MSE	0.0001468	**Uncond Var**	0.00008403
Log Likelihood	955.88809	**Total R-Square**	.
SBC	-1889.3237	**AIC**	-1903.7762
		Normality Test	174.7832
		Pr > ChiSq	<.0001

Table 4 – GARCH (1,1) Parameter Estimation

Parameter Estimates					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	0.005890	0.000503	11.70	<.0001
ARCH0	1	2.9237E-6	1.4838E-6	1.97	0.0488
ARCH1	1	0.2049	0.0352	5.82	<.0001
GARCH1	1	0.7603	0.0353	21.57	<.0001

48 https://dms.umontreal.ca/~duchesne/chap8.pdf

GARCH (1,1), parameter estimates, is statistically significant when a model is estimated on various examples of realized stock market volatility. According to Ashley, R. A., & Patterson, D. M. (2010), the major sufficient evidence for the acceptation of these model to be true, is the significance of the statistic parameter estimated. [49]

Though estimate of GARCH1 is significant (from Table 4), it´s possible to affirm that GARCH1 is a good fit since AIC (from table 3) is smaller than the AIC from Table 1.

[49] Ashley, R. A., & Patterson, D. M. (2010). A test of the GARCH (1, 1) specification for daily stock returns. Macroeconomic Dynamics, 14(S1), 137-144.

5.1.2. ATHEX 2019_2020 Data

Table 5 – Ordinary Least Squares Estimates ATHEX - 2019 to 2020 period

Ordinary Least Squares Estimates			
SSE	0.10204111	**DFE**	263
MSE	0.0003880	**Root MSE**	0.01970
SBC	-1319.8233	**AIC**	-1323.3992
Durbin-Watson	0.8637	**Total R-Square**	0.0000

According the table 5, referring the AUTOREG results for Ordinary Least Squares Estimates (OLS), from the data of the Greece index (ATHEX), over the period of 2019 to 2020, the statistic output has showed that the model for root mean square error (**Root MSE**) is 0,01970, higher than the OLS PSI index. Observe that the full model (**Total R-square**) is 0, such as the Portugal index statistic model.

Table 6 – Regression Estimation (Est. Var)

Parameter Estimates					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	0.0150	0.001212	12.41	<.0001

Table 6 shows the regression estimation, with standard errors and t-values. Meaning that the estimated model is:

$yt = 0.0150 + \in t$

$Est.\ Var\ (\in t) = 0.0003880 = MSE$

Greece's Index "Est. Var" is three times higher than the Portugal´s Index "Est. Var", this means that the lower the MSE, the better it will be the forecast. So Portugal´s index has three times better forecast than Greece´s Index.

Table 7 – GARCH (1,1) Estimation

GARCH Estimates			
SSE	0.11070331	**Observations**	264
MSE	0.0004193	**Uncond Var**	0.00022444
Log Likelihood	816.029681	**Total R-Square**	.
SBC	-1609.7556	**AIC**	-1624.0594
		Normality Test	160.3807
		Pr > ChiSq	<.0001

Table 8 – GARCH (1,1) Parameter Estimation

Parameter Estimates					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	0.009314	0.000679	13.72	<.0001
ARCH0	1	0.0000125	3.8702E-6	3.24	0.0012
ARCH1	1	0.3350	0.0953	3.52	0.0004
GARCH1	1	0.6091	0.0818	7.45	<.0001

GARCH (1,1), parameter estimates, is statistically significant when a model is estimated on various examples of realized stock market volatility. According to Ashley, R. A., & Patterson, D. M. (2010), the major sufficient evidence for the acceptation of these model to be true, is the significance of the statistic parameter estimated. [50]

Though estimate of GARCH1 of ATHEX index over the periods of 2019 to 2020, is lower than the PSI index, it is still significant (as showed in Table 8), it´s possible to affirm that GARCH1 is a good fit since AIC (from table 7) is smaller than the AIC from Table 5.

[50] Ashley, R. A., & Patterson, D. M. (2010). A test of the GARCH (1, 1) specification for daily stock returns. Macroeconomic Dynamics, 14(S1), 137-144.

5.1.3. ATHEX 2008_2009 Data

Table 9 – Ordinary Least Squares Estimates ATHEX - 2008 to 2009 period

Ordinary Least Squares Estimates			
SSE	0.07093714	**DFE**	266
MSE	0.0002667	**Root MSE**	0.01633
SBC	-1434.9666	**AIC**	-1438.5538
Durbin-Watson	1.6389	**Total R-Square**	0.0000

According the table 9, referring the AUTOREG results for Ordinary Least Squares Estimates (OLS), from the Greece index data (ATHEX), over the period of 2008 to 2009, the statistic output has showed that the model for root mean square error (**Root MSE**) is 0,01633, lower than the OLS Greece´s index over the coronavirus period studied. Observe that the full model (**Total R-square**) is 0, such as the Portugal and Greece´s index statistic model.

Table 10 – Regression Estimation (Est. Var)

Parameter Estimates					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	0.0199	0.000999	19.91	<.0001

Table 10 shows the regression estimation, with standard errors and t-values. Meaning that the estimated model is:

$yt = 0.0199 + \in t$

$Est.\ Var(\in t) = 0.0002667 = MSE$

Greece’s Index “Est. Var” in this period, is higher than the PSI over the period of 2019 to 2020, analyzed, and lower than the ATHEX´s index over the period of 2008 to 2009, this means that the lower the MSE, the better it will be the forecast. Thus, Greece´s index for the period of 2019 to 2020 has a better forecast than Greece´s Index for the periods of 2008 to 2009.

Table 11 – GARCH (1,1) Estimation

GARCH Estimates			
SSE	0.07204703	**Observations**	267
MSE	0.0002698	**Uncond Var**	0.0003288
Log Likelihood	744.302157	**Total R-Square**	.
SBC	-1466.2553	**AIC**	-1480.6043
		Normality Test	66.1367
		Pr > ChiSq	<.0001

Table 12 – GARCH (1,1) Parameter Estimation

Parameter Estimates					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	0.0179	0.000986	18.11	<.0001
ARCH0	1	0.0000116	8.4534E-6	1.37	0.1700
ARCH1	1	0.1482	0.0430	3.45	0.0006
GARCH1	1	0.8165	0.0592	13.79	<.0001

Estimate GARCH1 of ATHEX index over the periods of 2008 to 2009, is higher than the ATHEX index over the periods of 2019 to 2020. Thus, is perceptibly significant (as showed in Table 12), it´s possible to affirm that GARCH1 is a good fit since AIC (from table 11) is smaller than the AIC from Table 9.

5.1.4. DOWJONES 2019_2020 Data

Table 13 – Ordinary Least Squares Estimates DowJones - 2019 to 2020 period

Ordinary Least Squares Estimates			
SSE	0.12308907	**DFE**	270
MSE	0.0004559	**Root MSE**	0.02135
SBC	-1311.2109	**AIC**	-1314.8131
Durbin-Watson	0.5061	**Total R-Square**	0.0000

According the table 13, referring the AUTOREG results for Ordinary Least Squares Estimates (OLS), from the data of the USA index (DowJones), over the period of 2019 to 2020, the statistic output has showed that the model for root mean square error (**Root MSE**) is 0,02135, higher than the OLS Greece index regarding both periods, of 2008 to 2009, and 2019 to 2020. Note that the full model (**Total R-square**) is 0, such as the previous index statistic models.

Table 14 – Regression Estimation (Est. Var)

Parameter Estimates					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	0.0136	0.001297	10.52	<.0001

Table 14 shows the regression estimation, with standard errors and t-values. Meaning that the estimated model is:

$yt = 0.0136 + \in t$

Est. Var $(\in t) = 0.0004559 = MSE$

USA's Index "Est. Var" in this period, is higher than the preceding index´s studied and analyzed, this means that the lower the MSE, the better it will be the forecast. Thus, USA´s index for the period of 2019 to 2020 has a worst forecast than all the other index studied.

Table 15 – GARCH (1,1) Parameter Estimation

GARCH Estimates			
SSE	0.14848625	**Observations**	271
MSE	0.0005479	**Uncond Var**	.
Log Likelihood	902.239083	**Total R-Square**	.
SBC	-1782.0697	**AIC**	-1796.4782
		Normality Test	396.9855
		Pr > ChiSq	<.0001

Table 16 – GARCH (1,1) Parameter Estimation

Parameter Estimates					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	0.003966	0.000318	12.47	<.0001
ARCH0	1	9.115E-7	7.3105E-7	1.25	0.2125
ARCH1	1	0.4792	0.1005	4.77	<.0001
GARCH1	1	0.6485	0.0341	19.03	<.0001

Though estimate of GARCH1 USA´s index for the period of 2019 to 2020, is lower than the PSI index, yet still higher than Greece´s index for the period of 2019 to 2020, this statistic is motionless significant (as showed in Table 16), it´s possible to affirm that GARCH1 is a good fit since AIC (from table 15) is smaller than the AIC from Table 13.

5.1.5. DOWJONES 2008_2009 Data

Table 17 – Ordinary Least Squares Estimates DowJones- 2008 to 2009 period

Ordinary Least Squares Estimates			
SSE	0.08683162	**DFE**	271
MSE	0.0003204	**Root MSE**	0.01790
SBC	-1411.9792	**AIC**	-1415.585
Durbin-Watson	1.1251	**Total R-Square**	0.0000

According the table 17, referring the AUTOREG results for Ordinary Least Squares Estimates (OLS), from the USA index data (DowJones), over the period of 2008 to 2009, the statistic output has showed that the model for root mean square error (**Root MSE**) is 0.01790, lower than the OLS Greece index regarding both periods, of 2008 to 2009, and 2019 to 2020 and lower than the OLS USA index.

Table 18 – Regression Estimation (Est. Var)

Parameter Estimates					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	0.0175	0.001085	16.15	<.0001

Table 18 shows the regression estimation, with standard errors and t-values. Meaning that the estimated model is:

yt = 0.0175 + ∈ t

Est. Var (∈ t) = 0.0003204 = MSE

USA’s Index “Est. Var” in this period, is inferior then the preceding index´s studied and analyzed, this means that the lower the MSE, the better it will be the forecast. Thus, USA´s index for the period of 2008 to 2009, has a worst forecast than all the other index studied, except the USA´s Index over the periods of 2019 to 2020.

Table 19 – GARCH (1,1) Parameter Estimation

GARCH Estimates			
SSE	0.10228924	**Observations**	272
MSE	0.0003761	**Uncond Var**	.
Log Likelihood	786.847977	**Total R-Square**	.
SBC	-1551.2727	**AIC**	-1565.696
		Normality Test	105.7046
		Pr > ChiSq	<.0001

Table 20 – GARCH (1,1) Parameter Estimation

Parameter Estimates					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	0.009989	0.000668	14.96	<.0001
ARCH0	1	1.0864E-6	2.1716E-6	0.50	0.6169
ARCH1	1	0.1820	0.0367	4.96	<.0001
GARCH1	1	0.8448	0.0304	27.75	<.0001

Estimate of GARCH1 of DowJones index over the periods of 2008 to 2009, is higher than the DowJones index over the periods of 2019 to 2020. Thus, is perceptibly significant (as showed in Table 20), it´s possible to affirm that GARCH1 is a good fit since AIC (from table 19) is smaller than the AIC from Table 17.

5.1.6. Data Estimation Resume

Figure 23 – Estimation Resume Table

Estimation Resume Table				
Index	**SSE**	**MSE**	**Durbin-Watson**	**GARCH1**
PSI_2019-2020	0.03696709	0.0001354	0.9157	0.7603
ATHEX_2019-2020	0.10204111	0.0003880	0.8637	0.6091
ATHEX_2008-2009	0.07093714	0.0002667	1.6389	0.8165
DowJones_2019-2020	0.12308907	0.0004559	0.5061	0.6485
DowJones_2008-2009	0.08683162	0.0003204	1.1251	0.8448

SSE, as mentioned prior, is the sum of squared errors, in other words is the weighted sum of squared errors if the heteroscedastic errors option is not equal to constant variance. The mean squared error (MSE) is the SSE divided by the degrees of freedom for the errors for the constrained model.

MSE, as detailed in the text above, is the mean squared error, which indicates how close a regression line is to a set of points. This results by taking the interspace from the points to the regression line and squaring them, further, the more weight it will have. The squaring is the removal of any negative signs that may appear. It’s designated has mean squared error, for the fact that it’s finding the average of a set of errors. The lower the MSE, the better the forecast.

The Durbin Watson (DW) statistic is a test for autocorrelation in the residuals from a statistical model and / or regression analysis. The Durbin-Watson statistic will constantly have a value ranging between 0 and 4. A value of 2 indicates there may be no autocorrelation detected inside the pattern. In the other hands the values from 0 to less than 2 points, tend to insinuate a positive autocorrelation, and values from 2 to 4 means negative autocorrelation.

For instance, stock prices do not tend to volatile to abruptly from day x to day x+1. This volatility could be correlated, autocorrelation shows if there is a momentum issue related to a stock. A stock value exhibiting positive autocorrelation would indicate that yesterday´s value contains a direct correlation on the today´s value. Thus, if the stock fell yesterday, it's additionally possible that it falls again in the day after. On the opposite hand, a negative autocorrelation, contains a negative influence on itself over time, this means that if it fell in one day, there's a higher probability that it'll rise in the day after.

The GARCH1 estimation, indicates the persistence of the volatility, however what is exactly persistence? According to McAleer, M., Hoti, S., & Chan, F. (2009), persistence of volatility occurs when $\gamma 1+\delta 1=1$, and thus at is non-stationary process, i.e., the closer it is to 1, the higher the persistence[51].

[51] McAleer, M., Hoti, S., & Chan, F. (2009). Structure and asymptotic theory for multivariate asymmetric conditional volatility. Econometric Reviews, 28(5), 422-440.

5.2. CORRELATION RESULTS

5.2.1. Value at Close Correlation

5.2.1.1. Value at Close – USA H1N1 vs USA Covid-19

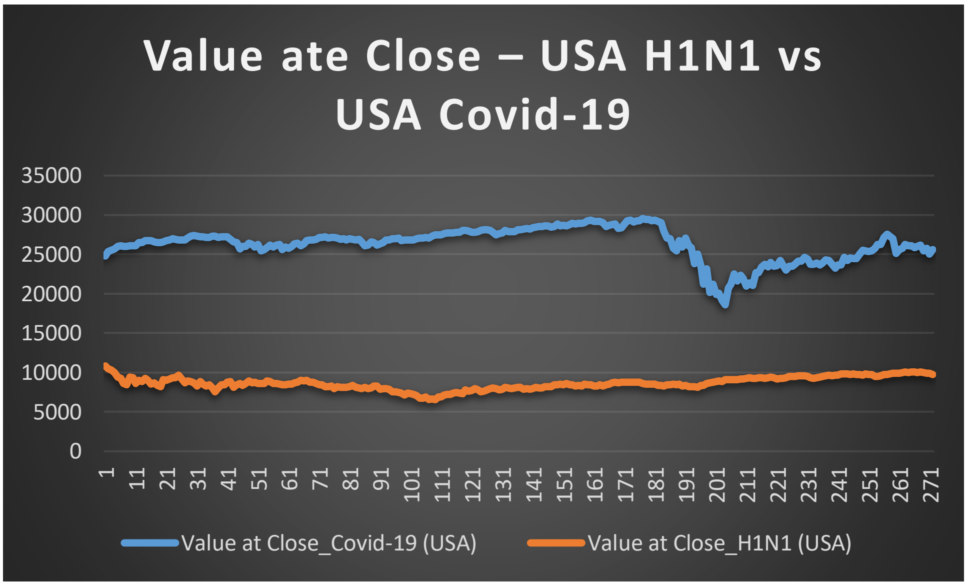

Figure 24 – Value at Close USA H1N1 vs USA Covid-19

Figure 24 compares, during the periods studied, the *value at close* regarding the United States of America´s pandemic, being those the H1N1 pandemic and the Covid-19 pandemic.

Additionally, it is possible to identify the moment when the impact on the stock market occurred – concerning the *value at close* of the Covid-19 pandemic (blue line) – which starts to fall on day 184 of the studied period, i.e., roundly, when the pandemic broke out, and recovered after approximately 1 month, as can be seen in the graph above.

	Value at Close_H1N1 (USA)	*Value at Close_Covid-19 (USA)*
Value at Close_H1N1 (USA)	1	
Value at Close_Covid-19 (USA)	-0,460011121	1

Table 21 – Value at Close USA H1N1 vs USA Covid-19

Regarding the *value at close* of H1N1 pandemic, there were no significance changes, especially in comparison to the Covid-19 pandemic.

The author can conclude that what concerns this graphic, there is a moderate negative correlation between these two pandemics in the evolution of the market value.

5.2.1.2. Value at Close – Greece H1N1 vs Greece Covid-19

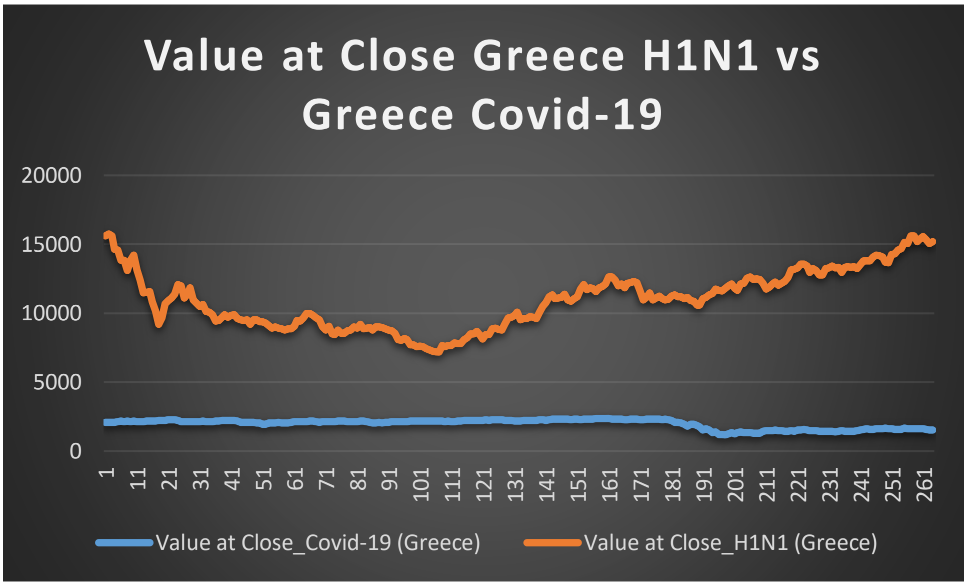

Figure 25 – Value at Close Greece H1N1 vs Greece Covid-19

In figure 25, during the periods studied, is compared between the value at close regarding the Greece´s pandemic, being those the H1N1 pandemic and the Covid-19 pandemic, as mentioned above.

Once again, it is observable that the Covid-19 pandemic had an impact on market values (the same as in figure 24, such as the United States of America´s *value at close*) referring the Covid-19 pandemic.

Whereas the H1N1 pandemic had a slightly downfall after the 180 days, which is the time that the pandemic emerged. However, it only lasted 10 market days, afterward that situation, in H1N1 pandemic, the *value at close* had a significant increase.

	Value at Close_H1N1 (USA)	*Value at Close_Covid-19 (USA)*
Value at Close_H1N1 (USA)	1	
Value at Close_Covid-19 (USA)	-0,541667984	1

Table 22 – Value at Close Greece H1N1 vs Greece Covid-19

Thus, the author can conclude that what concerns this graphic, in figure 25 and the table above (22), that there is a moderate negative correlation between these two pandemics in the evolution of the market value.

5.2.1.3. Value at Close – H1N1 – USA vs Greece

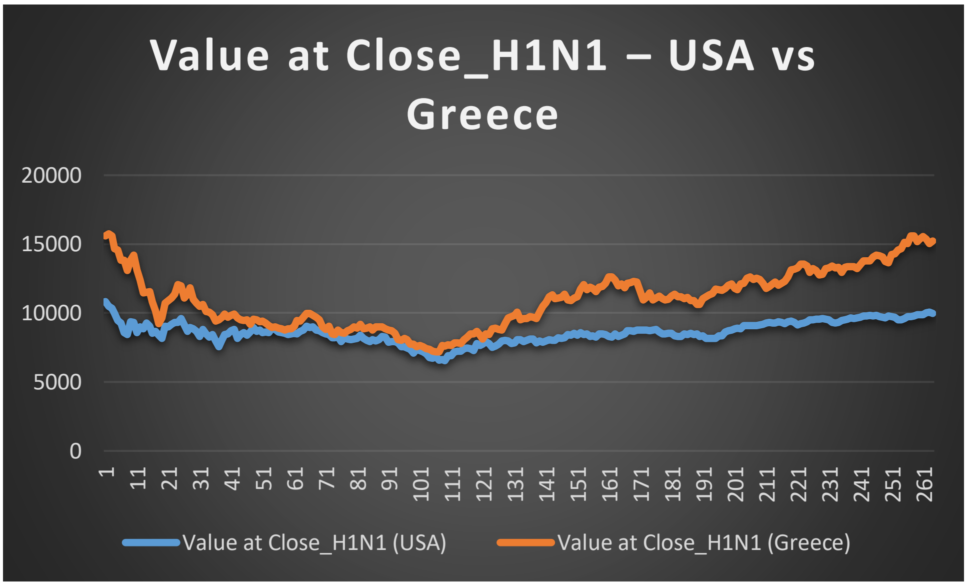

Figure 26 – Value at Close_H1N1 – USA vs Greece

Figure 26 compares the *value at close* of a large economy (United States of America) and a small economy (Greece), regarding H1N1 pandemic.

According to the graphic above, it is apparent that there is a correlation between the two countries in the H1N1 pandemic. For this reason, a detailed linear correlation study was performed, as can be seen in the table below:

	Value at Close_H1N1 (USA)	*Value at Close_H1N1 (Greece)*
Value at Close_H1N1 (USA)	1	
Value at Close_H1N1 (Greece)	0.86279465	1

Table 23 – Value at Close_H1N1 – USA vs Greece

Regarding the intensity of Pearson´s coefficient correlation, between **i)** 0 and (+/-)0.3 as weak; **ii)** (+/-)0.3 and (+/-)0.8 as moderate, and **iii)** above (+/-)0.8, is considered as strong.

Thus, regarding Pearson´s coefficient, the *value at close* of the H1N1 pandemic of USA, were correlated with the *value at close* of the H1N1 pandemic of Greece, r = 0.86, which can be considered as strong.

5.2.1.4. Value at Close – Covid-19 – USA vs Greece

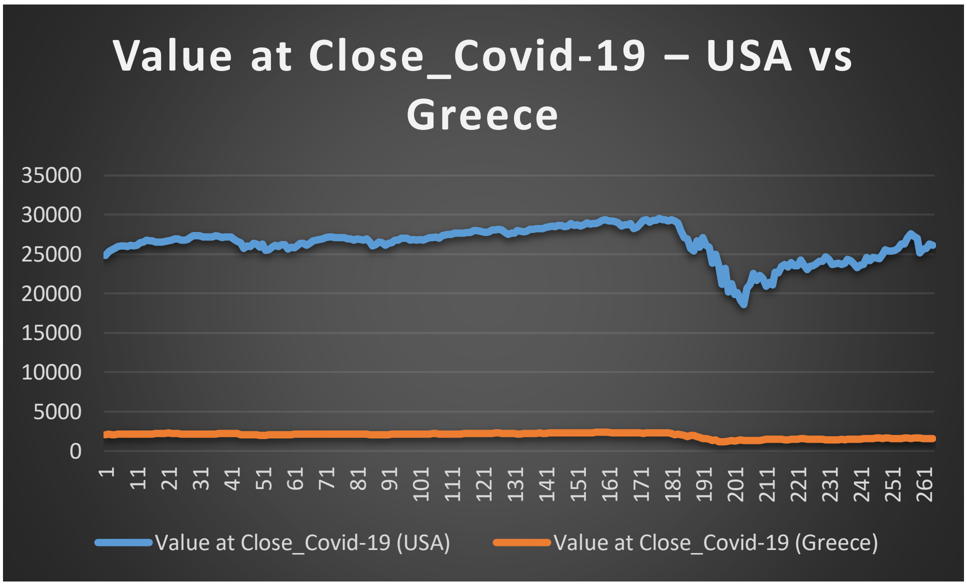

Figure 27 – Value at Close_Covid-19 – USA vs Greece

Figure 27, compares, the *value at close* of a large economy (United States of America) and a small economy (Greece), regarding the Covid-19 pandemic.

According to the graphic above, it is not as apparent that there is a correlation between the two countries, such the H1N1 pandemic. However, thorough linear correlation study performed via Excel, as can be seen in the table below, will indicate us, if there was a correlation between the two variables:

	Value at Close_Covid-19 (USA)	*Value at Close_Covid-19 (Greece)*
Value at Close_Covid-19 (USA)	1	
Value at Close_Covid-19 (Greece)	0.865818862	1

Table 24 – Value at Close_Covid-19 – USA vs Greece

As indicated in the prior figure, regarding the intensity, a correlation coefficient between **i)** 0 and (+/-) 0.3 as weak; **ii)** (+/-)0.3 and (+/-)0.8 as moderate, and **iii)** above (+/-)0.8, is considered as strong.

The *value at close* of the Covid-19 pandemic of USA, these variables were correlated with the *value at close* of the Covid-19 pandemic of Greece, being the Pearson´s coefficient, r = 0.87, which can be considered as strong, even slightly stronger, than the previous coefficient over the H1N1 pandemic.

5.2.1.5. Value at Close – Covid-19 – USA vs Portugal

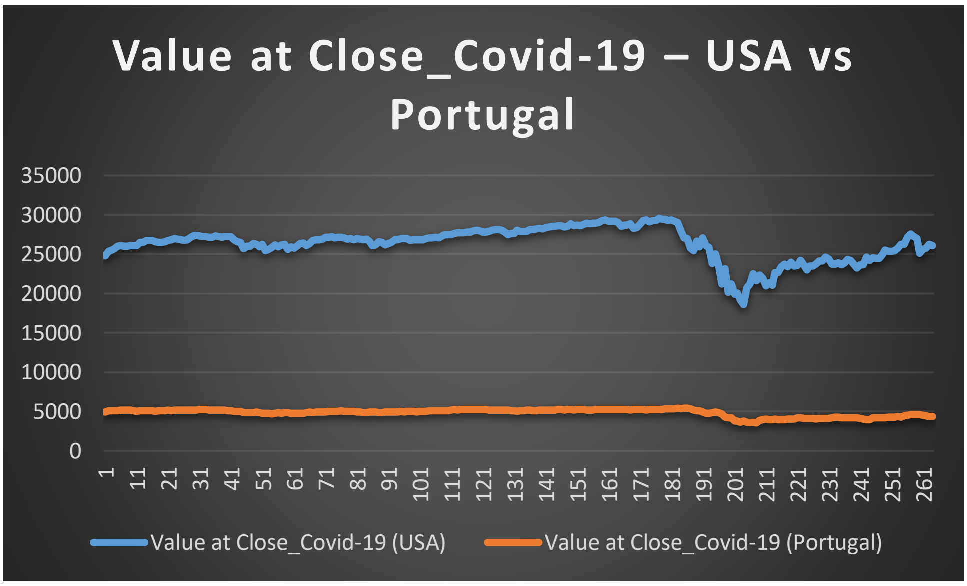

Figure 28 – Value at Close_Covid-19 – USA vs Portugal

Figure 28, compares Portugal, a small economy country, to one of the largest economies in the world (number one in GDP). The comparison was over the Covid-19 pandemic.

Thorough linear correlation study performed via Excel, as can be seen in the table below, will indicate us, if there was a correlation between the two variables:

	Value at Close_Covid-19 (USA)	*Value at Close_Covid-19 (Portugal)*
Value at Close_Covid-19 (USA)	1	
Value at Close_Covid-19 (Portugal)	0.877333163	1

Table 25 – Value at Close_Covid-19 – USA vs Portugal

Concerning the intensity, a correlation coefficient between **i)** 0 and (+/-) 0.3 as weak; **ii)** (+/-)0.3 and (+/-)0.8 asmoderate, and **iii)** above (+/-)0.8, is considered as strong.

Regarding Pearson´s coefficient, the *value at close* of the Covid-19 pandemic of USA, were correlated with the *value at close* of the Covid-19 pandemic of Portugal, r = 0.88. This coefficient is considered as strong, slightly stronger, than the previous coefficient referring the Covid-19 pandemic of USA versus Greece.

5.2.1.6. Value at Close – Covid-19 – Greece vs Portugal

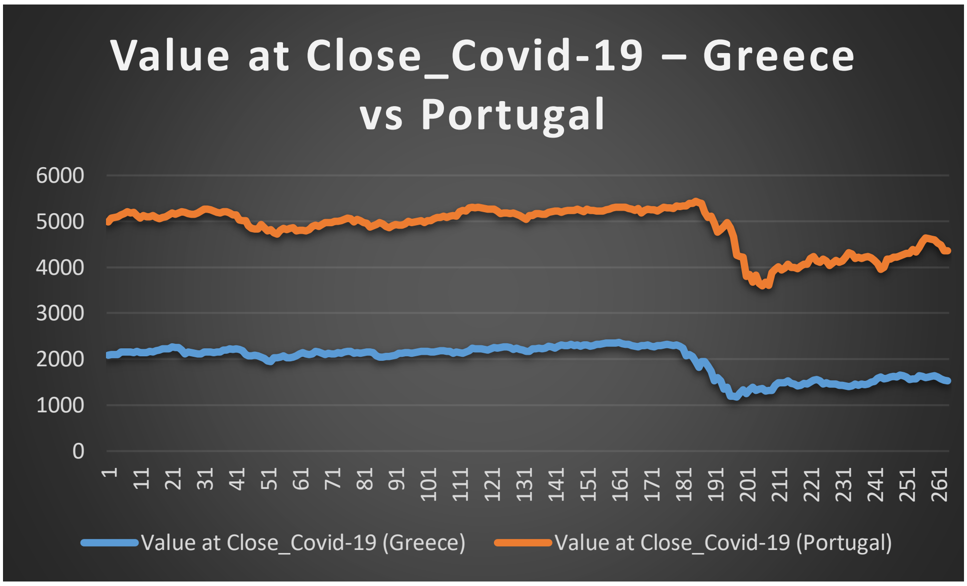

Figure 29 – Value at Close_Covid-19 – Greece vs Portugal

Figure 29, compares Portugal, a small economy country, to another small economy country, Greece. Greece was selected due to the fact that it is as an identical similar economy structure as ours, since it is a country with good agronomy, depends on tourism, and finally it went through a crisis alike Portugal´s. The comparison concerned the Covid-19 pandemic.

Through linear correlation study performed via Excel, as can be seen in the table below, will indicate us, if there was a correlation between the two variables:

	Value at Close_Covid-19 (Greece)	*Value at Close_Covid-19 (Portugal)*
Value at Close_Covid-19 (Greece)	1	
Value at Close_Covid-19 (Portugal)	0.898219073	1

Table 26 – Value at Close_Covid-19 – Greece vs Portugal

A correlation coefficient between **i)** 0 and (+/-) 0.3 as weak; **ii)** (+/-)0.3 and (+/-)0.8 as moderate, and **iii)** above (+/-)0.8, is considered as strong.

Regarding Pearson´s coefficient, explained in point 4.3.1.3., the *value at close* of the Covid-19 pandemic of Greece, were correlated with the *value at close* of the Covid-19 pandemic of Portugal, since the coefficient was roundly, r = 0.90. Being the strongest correlation, regarding the *value at close*.

5.2.2. Correlation between cases and deaths confirmed with daily volatility for each country

5.2.2.1. Daily Confirmed Cases by Covid-19 USA vs USA´s Daily Volatility

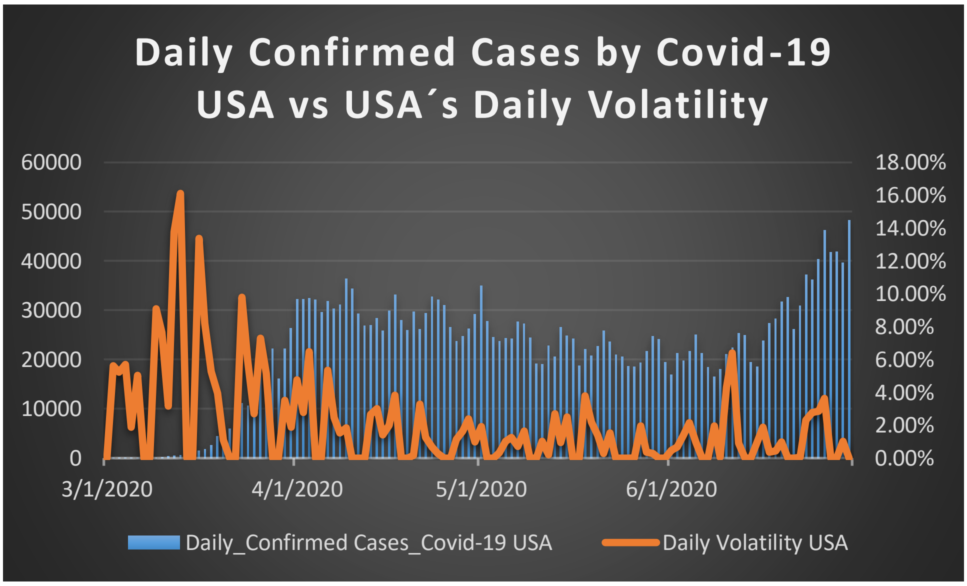

Figure 30 – Daily Confirmed Cases by Covid-19 USA vs USA´s Daily Volatility

Figure 30 compares the daily confirmed cases regarding the United States of America, Covid-19 pandemic. This comparison, as showed in the graphic above, details that a possible correlation is conceivable. For that reason, a Pearson´s coefficient correlation test was performed (table below).

	Daily_Confirmed Cases_Covid-19 USA	*USA´s Daily Volatility*
Daily Confirmed Cases_Covid-19 USA	1	
USA´s Daily Volatility	0.424449426	1

Table 27 – Daily Confirmed Cases by Covid-19 USA vs USA´s Daily Volatility

Concerning the intensity, many studies consider that a correlation coefficient between **i)** 0 and (+/-) 0.3 as weak; **ii)** (+/-)0.3 and (+/-)0.8 as moderate, and **iii)** above (+/-)0.8, is considered as strong.

Regarding Pearson´s coefficient, the value of the correlation was r = -0.42, which can be considered as moderate. However, it's notable that the highest moments of volatility were in the beginning of the pandemic, whereas the firsts confirmed cases started to appear in the USA.

5.2.2.2. Daily Confirmed Cases by Covid-19 Greece vs Greece´s Daily Volatility

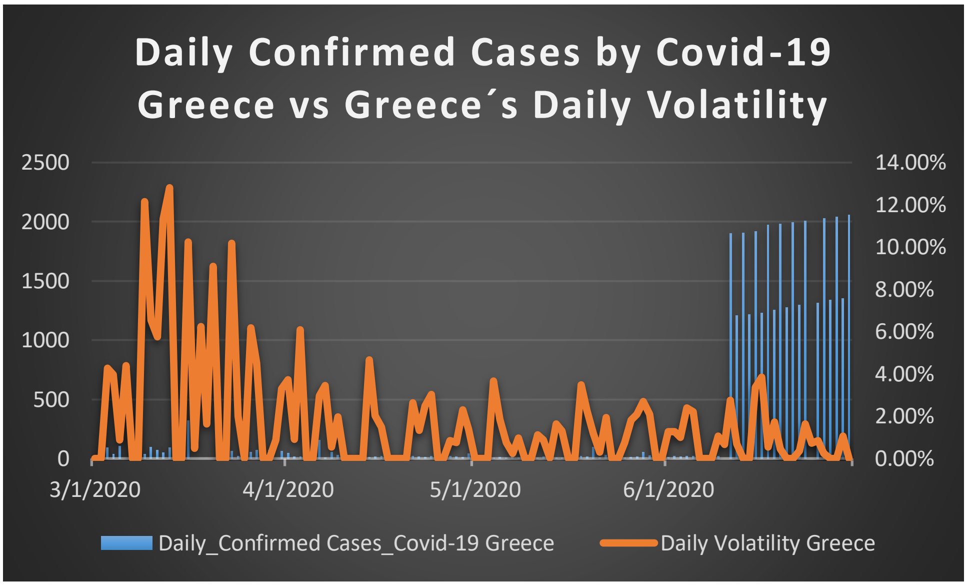

Figure 31 – Daily Confirmed Cases by Covid-19 Greece vs Greece´s Daily Volatility

Figure 31 compares the daily confirmed cases regarding Greece in Covid-19 pandemic. This comparison, as showed in the graphic above, details if there could be a correlation between these two variables. A Pearson´s coefficient correlation study was performed (table below).

	Daily_Confirmed Cases_Covid-19 Greece	*Greece´s Daily Volatility*
Daily Confirmed Cases_Covid-19 Greece	1	
Greece´s Daily Volatility	0.367314308	1

Table 28 – Daily Confirmed Cases by Covid-19 Greece vs Greece´s Daily Volatility

Concerning the intensity, many studies consider that a correlation coefficient between **i)** 0 and (+/-) 0.3 as weak; **ii)** (+/-)0.3 and (+/-)0.8 as moderate, and **iii)** above (+/-)0.8, is considered as strong.

Regarding Pearson´s coefficient, the value of the correlation was, roundly, r = -0.37, which can be considered as moderate. However, it’s notable that the highest moments of volatility were in the beginning of the pandemic, similar of what happened with the USA´s data, whereas the firsts confirmed cases started to appear in Greece.

Additionally, relevant to mention that, even though there was no significant difference between the Pearson´s coefficient between USA and Greece, USA had a higher correlation, concerning the two variables studied.

5.2.2.3. Daily Confirmed Cases by Covid-19 Portugal vs Portugal´s Daily Volatility

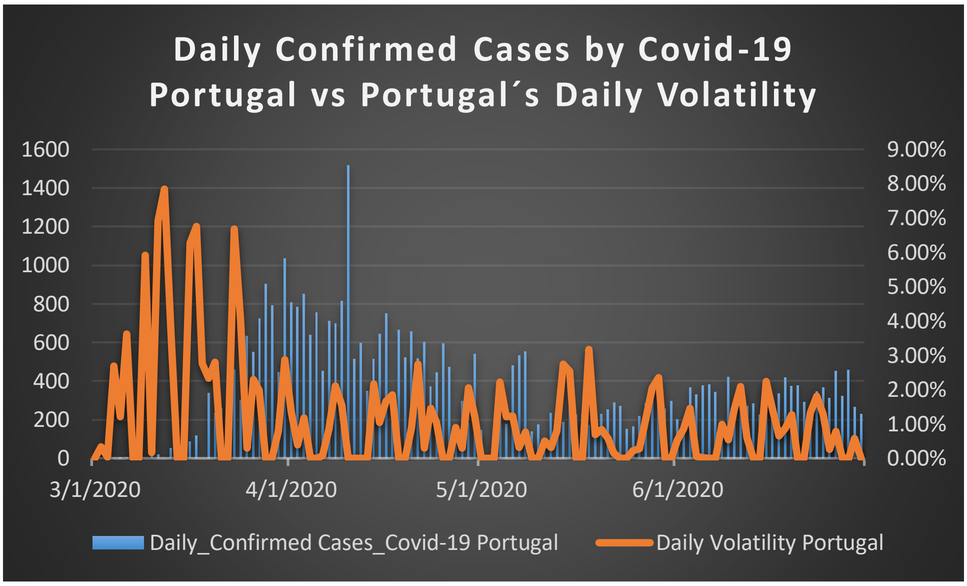

Figure 32 – Daily Confirmed Cases by Covid-19 Portugal vs Portugal´s Daily Volatility

Figure 32 compares the daily confirmed cases regarding Portugal in Covid-19 pandemic. This comparison, as showed in the graphic above, details if there could be a correlation between these two variables. A Pearson´s coefficient correlation study was performed (table below), such as with the previous countries (USA, and Greece).

	Daily_Confirmed Cases_Covid-19 Portugal	*Portugal´s Daily Volatility*
Daily Confirmed Cases_Covid-19 Portugal	1	
Portugal´s Daily Volatility	0.366478038	1

Table 29 – Daily Confirmed Cases by Covid-19 Portugal vs Portugal´s Daily Volatility

Concerning the intensity, many studies consider that a correlation coefficient between **i)** 0 and (+/-) 0.3 as weak; **ii)** (+/-)0.3 and (+/-)0.8 as moderate, and **iii)** above (+/-)0.8, is considered as strong.

Regarding Pearson´s coefficient, the value of the correlation was, roundly, r = -0.37, which can be considered as moderate. However, it's notable that the highest moments of volatility were in the beginning of the pandemic, whereas the firsts confirmed cases started to appear, alike what happened with the USA and Greece´s data.

Additionally, relevant to mention that, even though there was no significant difference between the Pearson´s coefficient USA had a higher correlation, and Greece had the same (roundly) correlation, concerning the two variables studied, being those the daily confirmed cases by Covid-19 and the daily volatility percentage.

5.2.2.4. Daily Confirmed Deaths by Covid-19 USA vs USA´s Daily Volatility

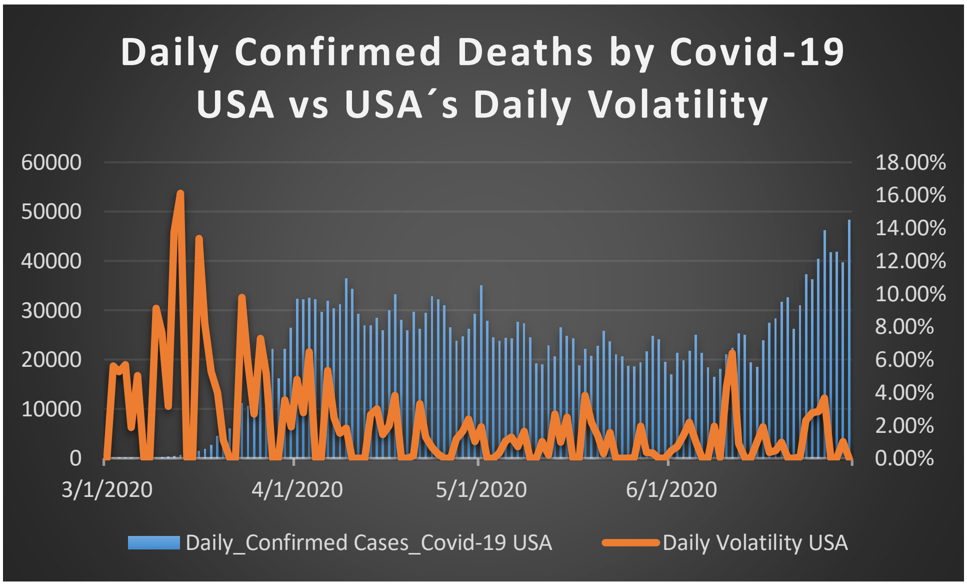

Figure 33 – Daily Confirmed Deaths by Covid-19 USA vs USA´s Daily Volatility

Figure 33 compares the daily confirmed deaths regarding the United States of America in Covid-19 pandemic. This comparison, as showed in the graphic above, details that a possible correlation is not has conceivable as the figure 28. Nevertheless, a Pearson´s coefficient correlation test was performed (table below).

	Daily_Confirmed Deaths_Covid-19 USA	*USA´s Daily Volatility*
Daily Confirmed Deaths_Covid-19 USA	1	
USA´s Daily Volatility	0.29453	1

Table 30 – Daily Confirmed Deaths by Covid-19 USA vs USA´s Daily Volatility

As mentioned, prior, a correlation coefficient between **i)** 0 and (+/-) 0.3, is weak; **ii)** (+/-) 0.3 and (+/-) 0.8 is moderate, and **iii)** above (+/-)0.8, is considered as strong.

Pearson´s coefficient, the value of the correlation was r = 0.29, which can be considered as weak. Different values than expected, taking into consideration the results obtained in the correlation between the USA´s daily confirmed cases and the daily volatility of the same market.

Thus, the author can conclude that what concerns this graphic, in figure 31, there is no significant correlation between these two variables (Daily Confirmed Deaths by Covid-19 USA vs USA´s Daily Volatility).

5.2.2.5. Daily Confirmed Deaths by Covid-19 Greece vs Greece´s Daily Volatility

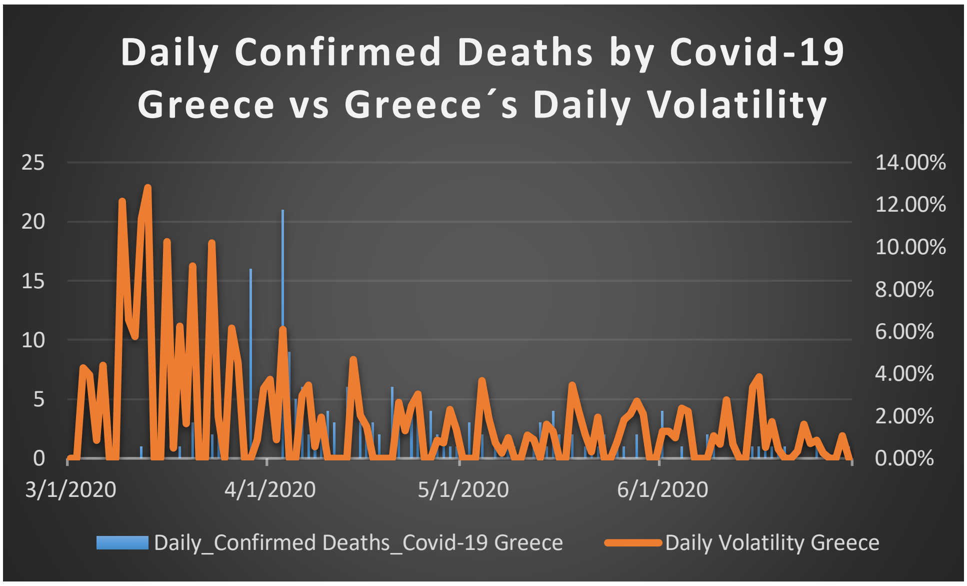

Figure 34 – Daily Confirmed Deaths by Covid-19 Greece vs Greece´s Daily Volatility

Figure 34 compares the daily confirmed deaths regarding Greece in Covid-19 pandemic. A Pearson´s coefficient correlation test was performed (table below).

	Daily Confirmed Deaths_Covid-19 Greece	*Greece´s Daily Volatility*
Daily Confirmed Deaths_Covid-19 Greece	1	
Greece´s Daily Volatility	0.00121	1

Table 31 – Daily Confirmed Deaths by Covid-19 Greece vs Greece´s Daily Volatility

Concerning the intensity, many studies consider that a correlation coefficient between **i)** 0 and (+/-) 0.3 as weak; **ii)** (+/-)0.3 and (+/-)0.8 as moderate, and **iii)** above (+/-)0.8, is considered as strong.

Taking into consideration the results obtained in the correlation between the USA´s daily confirmed deaths and the daily volatility of the same market, the following coefficient, was further dissimilar than expected.

Pearson´s coefficient, value of the correlation was r = 0.001, which can be considered as weak or null, since roundly, that coefficient equals 0. Thus, it's possible to conclude that there is no correlation between the deaths occurred in Greece over the Greece´s index daily volatility. A possible explanation, for this coefficient to be weak, is that Greece was the country with the fewest deaths per population, compared to the others studied in this paper.

5.2.2.6. Daily Confirmed Deaths by Covid-19 Portugal vs Portugal´s Daily Volatility

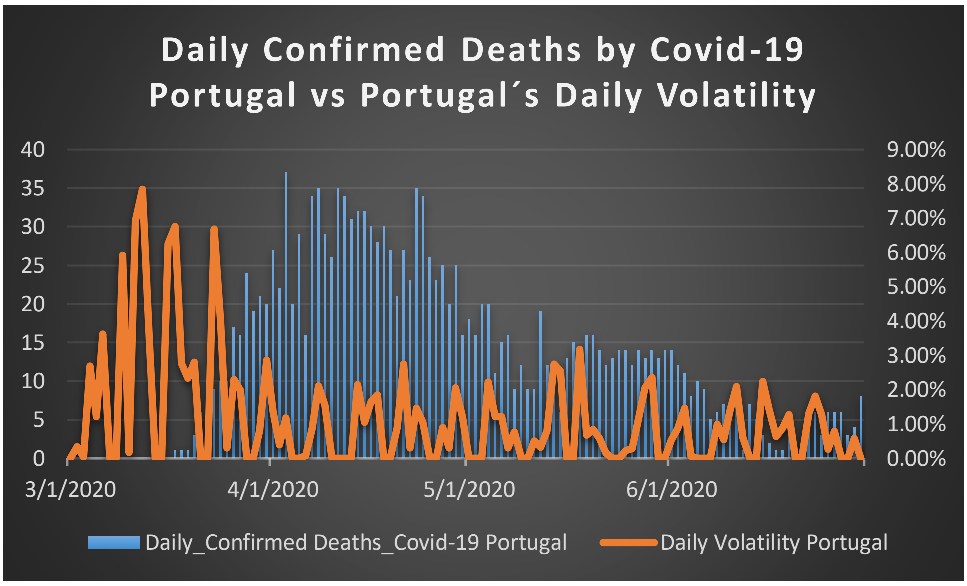

Figure 35 – Daily Confirmed Deaths by Covid-19 Portugal vs Portugal´s Daily Volatility

Figure 35 compares the daily confirmed deaths regarding the United States of America in Covid-19 pandemic. This comparison, as showed in the graphic above, details that a possible correlation is not has conceivable as the figure 28. Nevertheless, a Pearson´s coefficient correlation test was performed (table below).

	Daily Confirmed Deaths_Covid-19 Portugal	*Portugal´s Daily Volatility*
Daily Confirmed Deaths_Covid-19 Portugal	1	
Portugal´s Daily Volatility	0.20984	1

Concerning the intensity, many studies consider that a correlation coefficient between **i)** 0 and (+/-) 0.3 as weak; **ii)** (+/-)0.3 and (+/-)0.8 as moderate, and **iii)** above (+/-)0.8, is considered as strong.

Table 32 – Daily Confirmed Deaths by Covid-19 Portugal vs Portugal´s Daily Volatility

Pearson´s coefficient, the value of the correlation was, roundly, r = 0.21, which can be considered as weak. Different values than expected, taking into consideration the results obtained in the correlation between the Portugal´s daily confirmed cases and the daily volatility of the same market. However, it did not vary from the calculations performed, referring to the correlations of the variability of the USA´s daily confirmed deaths by Covid-19, and USA´s Daily Volatility.

Thus, the author can conclude that what concerns this graphic, in figure 33, there is no significant correlation between these two variables (Daily Confirmed Deaths by Covid-19 Portugal vs Portugal´s Daily Volatility).

5.2.3. Daily volatility Correlation

For this chapter, as prior, a Pearson's coefficient correlation study was performed. This coefficient is represented by the letter "r" and ranges from -1 to 1. Thus, that:

- A perfect negative correlation between the variables - that is, if one increases, the other always decreases returns an **r = -1**;
- **r = 0** means that the variables do not depend linearly on each other. However, there may be another dependency that is "non-linear". Thus, the result **r = 0** must be investigated by other means.
- **r = 1** means a perfect and positive correlation between the variables;

Concerning the intensity, a correlation coefficient (as indicated in point 4.3.2.) between **i)** 0 and (+/-) 0.3 as weak; **ii)** (+/-)0.3 and (+/-)0.8 as moderate, and **iii)** above (+/-)0.8, is considered as strong.

	Daily Historical Volatility H1N1 USA	*Daily Historical Volatility Covid-19 USA*
Daily Historical Volatility H1N1 USA	1	
Daily Historical Volatility Covid-19 USA	-0.205521541	1

Table 33 – USA´s Daily Historical Volatility – H1N1 vs Covid-19

In Pearson´s r (correlation coefficient), between the USA´s daily historical volatility on the H1N1 pandemic versus the USA´s daily historical volatility on the Covid-19 pandemic. Higher daily volatility percentage of H1N1 were correlated with lower overall daily volatility percentage of Covid-19, in USA, being the coefficient, r = -0.206, which is considered as weak.

Thus, the author concludes that there is no significant correlation between these two variables mentioned above.

	Daily Historical Volatility H1N1 Greece	*Daily Historical Volatility Covid-19 Greece*
Daily Historical Volatility H1N1 Greece	1	
Daily Historical Volatility Covid-19 Greece	-0.098519476	1

Table 34 – Greece´s Daily Historical Volatility – H1N1 vs Covid-19

Between the Greece´s daily historical volatility on the H1N1 pandemic versus the Greece´s daily historical volatility on the Covid-19 pandemic. In Pearson´s r (correlation coefficient), higher daily volatility percentage of H1N1 were correlated with lower overall daily volatility percentage of Covid-19, in Greece, being the coefficient, r = -0.099, which is considered as weak.

This coefficient, was however, in accordance with what was observed in the correlation examination on the variables of USA´s daily historical volatility on the H1N1 pandemic versus the USA´s daily historical volatility on the Covid-19 pandemic.

Thus, the author concludes that there is no significant correlation between these two variables mentioned above.

	Daily Historical Volatility H1N1 USA	*Daily Historical Volatility H1N1 Greece*
Daily Historical Volatility H1N1 USA	1	
Daily Historical Volatility H1N1 Greece	0.323423346	1

Table 35 – H1N1 Daily Historical Volatility – USA vs Greece

In Pearson´s r (correlation coefficient), between the USA´s daily historical volatility on the H1N1 pandemic versus the Greece´s daily historical volatility on the H1N1 pandemic. Higher daily volatility percentage of H1N1 USA were correlated with higher overall daily volatility percentage of H1N1 Greece, r = 0.32, which can be considered as moderate.

This coefficient shows differences to what was observed previously, a possible reason for this is that we are now making a correlation between the same pandemic (H1N1).

Thus, the author concludes that there is a slight significant correlation between these two variables mentioned above.

	Daily Historical Volatility Covid-19 USA	*Daily Historical Volatility Covid-19 Greece*
Daily Historical Volatility Covid-19 USA	1	
Daily Historical Volatility Covid-19 Greece	0.4971039	1

Table 36 – Covid-19 Daily Historical Volatility – USA vs Greece

Between the USA´s daily historical volatility on the Covid-19 pandemic versus the Greece´s daily historical volatility on the Covid-19 pandemic. In Pearson´s r (correlation coefficient), higher daily volatility percentage of Covid-19 USA were correlated with higher overall daily volatility percentage of Covid-19 Greece, r = 0.50, which can be considered as moderate.

This coefficient, in accordance with what was observed in the exanimated correlation over the variables of USA´s daily historical volatility on the H1N1 pandemic and the Greece´s daily historical volatility on the H1N1 pandemic.

Thus, the author concludes that there is a slight significant correlation between these two variables mentioned above.

	Daily Historical Volatility Covid-19 USA	*Daily Historical Volatility Covid-19 Portugal*
Daily Historical Volatility Covid-19 USA	1	
Daily Historical Volatility Covid-19 Portugal	0.552888741	1

Table 37 – Covid-19 Daily Historical Volatility – USA vs Portugal

In Pearson´s r (correlation coefficient), between the USA´s daily historical volatility on the Covid-19 pandemic versus the Portugal´s daily historical volatility on the Covid-19 pandemic. Higher daily volatility percentage of Covid-19 USA were correlated with higher overall daily volatility percentage of Covid-19 Portugal, r = 0.55, which can be considered as moderate.

This coefficient is in accordance with what was observed in the correlation of the variables of USA´s daily historical volatility on the Covid-19 pandemic and the Greece´s daily historical volatility on the Covid-19 pandemic.

Thus, the author concludes that there is a slight significant correlation between these two variables mentioned above.

	Daily Historical Volatility Covid-19 Greece	*Daily Historical Volatility Covid-19 Portugal*
Daily Historical Volatility Covid-19 Greece	1	
Daily Historical Volatility Covid-19 Portugal	0.410628749	1

Table 38 – Covid-19 Daily Historical Volatility – USA vs Portugal

Between the Greece´s daily historical volatility on the Covid-19 pandemic versus the Portugal´s daily historical volatility on the Covid-19 pandemic. In Pearson´s r (correlation coefficient), higher daily volatility percentage of Covid-19 Greece were correlated with higher overall daily volatility percentage of Covid-19 Portugal, r = 0.41, which can be considered as moderate.

This coefficient is in accordance with what was observed in the correlation of the variables of **i)** USA´s daily historical volatility on the Covid-19 pandemic and the Greece´s daily historical volatility on the Covid-19 pandemic, and **ii)** USA´s daily historical volatility on the Covid-19 pandemic and the Portugal´s daily historical volatility on the Covid-19 pandemic.

Thus, the author concludes that there is a slight significant correlation between these two variables mentioned above.

6. CONCLUSIONS

The objective of this dissertation is to understand the impact of the pandemics of the 21st century (H1N1 and Covid-19) on the stock markets of countries with large and small economies, comparing and understanding how Portugal fits in and what was the impact on the market.

To accomplish what was mentioned in the first paragraph, this analysis was based on a set of variables that includes the daily historical volatility, confirmed cases and deaths by the virus, and the market *value at close* of each day during the period established in point 3.4.

First, a literature review was conducted about the previous and current impacts caused by pandemics on the stock markets, as well as other crises, a research was also made about what would be the best method to apply and study volatility, after a deep study, it was concluded that the best for the author was the GARCH of Bollerslev, T. (1986).

The empirical work involved developing the SAS program and performing linear correlations with Pearson's coefficients to answer the proposed objectives. This empirical study yielded some results. First, it was verified that in general and according to the GARCH (1,1) program, both pandemics presented significant data concerning volatility, and it was proven that this volatility could be correlated. Autocorrelation values in figure 23 shows if there is a momentum issue related to a stock, that stock value exhibited a positive autocorrelation which indicates that yesterday's value contains a direct correlation on the today's value. It was also possible – by correlating within each pandemic the countries studied – to conclude that there is a strong correlation in market values.

It can also be concluded that in the specific study of the Covid-19 pandemic, regarding the possible correlation between volatility and confirmed cases, a moderate correlation was noted, while the correlation between volatility and confirmed deaths, a weak correlation was recognized. In the case of Greece, the correlation was almost zero/null.

Even though the study was successful in comparing each pandemic individually, when the pandemic comparison study was conducted, i.e., Covid-19 pandemic versus H1N1 pandemic, the results were disappointing, as the results appear to have no significance, as mentioned in the points above.

Additionally, crises have an immediate impact on the stock market volatility, observable from figures 30 to 35. One of the possible reasons for this elevated volatility at the beginning of pandemics could be caused by people's fear and panic when witnessing unusual phenomena. However, I would suggest that such a hypothesis could be confirmed by further analysis, to come to a more concrete conclusion about the high volatility.

Finally, the Covid-19 pandemic created a more substantial impact on the economy of the countries studied and the world than the H1N1 pandemic. Portugal, regarding the impact on GDP, had similar behaviors to the United States of America in the H1N1 pandemic. However, homogeneous behaviors to Greece in the Covid-19 pandemic, regarding the impact on GDP. Referring to the impact on the market volatility, it dependent since Portugal had certain similarities as one as with the other. Thus, through the research of Jareño, F., & Negrut, L. (2016), paper mentioned in point 3.4, we were able to conclude the same as the investigations carried out, which was that USA´s stock market exhibits a positive and significant relationship with the gross domestic product (GDP), and consequently did the further countries premeditated (Greece and Portugal). Studying a subsequent (and / or the current) pandemic, or other crises that occur, on the financial market, in the opinion of the author it can help countries and business leaders to take more cautious measures for the future.

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