ABDERRAHMANE MIRA

University of BEJAIA

Faculty of Economics, Commercial Sciences and Management sciences

Department of Economic Sciences

Master's Thesis in Economic Sciences

Option: Quantitative Economics

Decision Making around Black Swan events: The case of Algeria

Authors:

DJEBARI Fayçal

HAMMACHE Amelia Rose

Thesis Supervisor:

Pr. MAZOUZ Khelifa

Members of jury:

Dr. MAHMOUDI Mourad

Dr. ATMANI Anissa

June 2022

ABSTRACT:

Title: Decision making around Black Swan events: The case of Algeria.

Authors: HAMMACHE Amelia Rose, DJEBARI Fayçal.

The Black Swan event is a term introduced by Nassim Nicholas Taleb and represents an event with three characteristics: rare, has an extreme impact and retrospective (though not prospective) predictability. In other words, it is an unpredictable event as no one can predict it by forecasting. Examples of Black Swan events include: The Covid-19, the subprime crisis of 2008 and the great recession of 1929. In this study, we will present Black Swan events in the economics context and discuss the reason why these events are inducing a major problem of predictability in Econometrics. Our analyze will be based on GARCH model, with the application to OPEC Crude Oil prices. Our purpose is to analyze the volatility of the oil market around Black Swan event and to determine whether sophisticated models, such as GARCH, can predict unpredictable events.

Keywords: Black Swan Events, Econometric Forecasting, GARCH model, Granger Causality, OPEC Crude Oil, GDP of Algeria.

Résumé :

Titre : Prise de décisions autour des évènements de type Cygne Noir : Le cas de l'Algérie.

Auteurs : HAMMACHE Amélia Rose, DJEBARI Fayçal.

L'événement de type Cygne Noir est un terme introduit par Nassim Nicholas Taleb et représente un événement avec trois principales caractéristiques : rare, a un impact extrême et une prévisibilité rétrospective (mais pas prospective). En d'autres termes, il s'agit d'un événement imprévisible car personne ne peut le prévoir en ayant recours aux prévisions économétriques. Des exemples d'événements Cygnes Noirs incluent : Le Covid-19, la crise des subprimes de 2008 et la grande récession de 1929. Dans cette étude, nous présenterons les événements Cygnes Noirs dans un contexte économique et discuterons de la raison pour laquelle ces événements induisent un problème majeur de prédictibilité en économétrie. Notre analyse sera basée sur le modèle GARCH, avec application aux prix du pétrole brut de l'OPEP. Notre objectif est d'analyser la volatilité du marché pétrolier autour de l'événement Cygne Noir et de déterminer si des modèles sophistiqués, tels que le modèle GARCH, peuvent prédire des événements imprévisibles.

Mots-Clés : Les Evènements de type Cygne Noir, Les Prévisions Econométriques, Modèle GARCH, La causalité au sens de Granger, Pétrole brut de l'OPEP, le PIB de l'Algérie.

AKNOWELDGEMENTS

This thesis is submitted for obtaining a master's degree in economic sciences, option quantitative economics, at the faculty of economics, commerce and management sciences at ABDERRAHMANE MIRA University of Bejaia.

This thesis was written under supervision of Professor MAZOUZ Khelifa who showed patience and caring with us. We wish to express our sincere gratefulness and thanks to him for helping us and motivating us to produce this.

We wish to express our thanks to Dr. ABDERRAHMANI Fares our head of Master's specialty and Dr. HIDRA Younes, Head of Licence degree specialty, who made us love Econometrics.

Also, we would like to thank Dr. AKERKAR Arezki for his support and kindness, Professor ACHOUCHE Mohamed for his encouragement and listening, Dr. BELKHIRI Aimadedine our head of the economic sciences department for his gratefulness.

Fayçal:

I would like to express my sincere thanks to my dear uncle Mr. DJEBARI Abdelkrim and his wife, my uncle Mr. DJEBARI Hafid, my aunt Ms. DJEBARI Taous, my aunt Mrs. AGLI Naima, my cousin Mr. AGLI Ayoub, Ms. DJEBARI Naima, Dr. DJEBARI Nabil and his wife, my friend Dr. BENSLIMANE Salim and everyone who supported me during this Master's thesis, especially my grandparents, my parents, my brother, my sister and Funny.

Amelia Rose:

I dedicate this work to my dear parents who have been by my side and to whom I express my sincere gratitude, to my precious brother Samy who has always supported me, to my grandparents, and all the people dear to my heart.

Table of Contents

List Of Figures

List Of Tables

List Of Abbreviations

GDP: Gross Domestic Product

ADF: Augmented Dickey Fuller

DF: Dickey Fuller

GARCH: Generalized Autoregressive Conditional Heteroskedasticity

ARCH: Autoregressive Conditional Heteroskedasticity

ARCH-LM: Autoregressive Conditional Heteroskedasticity Lagrange Multiplier

ARMA: Autoregressive Moving Average

VAR: Vector Autoregressive

DS: Difference Stationary

TS: Trend Stationary

AC: Autocorrelation

PAC: Partial Autocorrelation

OLS: Ordinary Least Squares

AIC: Akaike Information Criteria

BIC: Schwarz-Bayesian Information Criteria

SC: Schwarz Criteria

HQ: Hannan-Quinn

Introduction

Nowadays, we live in a world where everything needs to be planned, where humans want every project to be estimated with precision, whether it will be successful or a failure even before starting it. All these measures are possible thanks to many tools developed in Economic science. But despite the impressive progress in the econometric field, there are still some parameters that are unpredictable and sometimes inestimable. Events that are never observed, experienced or even suspected before they occur are referred to as « the black swan events », which we will attempt to explain in this study.

According to many economic studies, the Econometrics is the perfect mix between economical sciences, and statistics and mathematics, that is what makes econometrics one of the most sophisticated tools in terms of forecasts for most economists, but this is not as obvious as that, when we see at the subprime crisis of 2008 and recently the covid-19 pandemic, nothing suggested that such a disaster was going to happen and that it was going to change our lives forever, this one of the limit our economic science that most economists around the world don't know.

We have chosen to deal with this theme, in order to show that the economic decisions should not be based on forecasts, because we do not live in a stable and constant sphere, and these forecasts never take into account certain aspects that are not measurable, such as human choices and nature which are constantly unstable and changing over time and in changing circumstances. One of our objectives is to illustrate how the rational choice theory is violated when it concerns humans and show that this theory does not hold in the real world. If a normal human is predictable and his choices are rational, his freedom to make choices is not respected by our models and, therefore, free will cannot be added as a variable for predicting future.

Our study in this master's thesis is: How do the black swan events affect oil prices, as an unpredictable asset and his relation with the Algerian economy?

The purpose of the research questions is to explain how it is difficult to take decisions when the future is unknown and the forecasts cannot be a good tool in the presence of Black Swan events.

As main hypothesis, the black swan events are unpredictable by econometric tools, the second one, is that making decisions based on forecasts cannot be relevant, especially because of black swan events.

In the theoretical part, we will explain by the history of the economic methodology, how unpredictability is not a new phenomenon in economics and then explain and define Black Swan Events as introduced by Nassim Nicholas Taleb (2008). In the empirical part, we will estimate a GARCH model using oil prices monthly data from January 2003 to April 2022. Our aim is studying the impact of different shocks on the oil price volatility and the extent to which historical price series can forecast future trends in the presence of black swan. The second step we use Granger Causality to investigate the relation between oil prices and Algeria (GDP) over the period 2003-2020. The data on OPEC Prices for both annual and monthly were collected from the official website of the Nasdaq Stock, the annual series of the GDP of Algeria is collected from the World Bank organism.

"Without a major act of demolition—without destroying the basic conceptual framework—it is impossible to make any real progress"

Nicholas Kaldor – Cambridge Economist

Chapter 1: Background information

For contextualizing the problem of black swan events, in this chapter we will try to explain the history of the evolution from a social and philosophical economy to applied economics, using the history of political economy and the introduction of mathematics in this science, we have to know how mathematics was introduced in economic sciences after the classical economists until now for the usage of econometrics which is the most useful tool for analyzing, estimating, and forecasting. The history of methodology in economics is also important, it shows that the Black Swan events are not a modern problem in our science, but a phenomenon that has already been observed many times and never predicted despite the accuracy of the forecasts, which proves the existence of a kind of lack, that the predecessors failed to pin down in the past centuries until now.

1.1- Adam smith and Karl Marx, Political Economy:

Adam Smith, the father of the economic sciences and the major contributor for the liberal economic ideology, has published a booked entitled "*The Wealth of Nations*" in 1776. he introduces the notion of the "**Invisible Hand**", with an auto regulation in the market of the supply and demand or the interest rates in financial markets. The "**Laissez-faire**" or leave alone economic theory, is the idea that government should not make involvement in regulation of the economy in different markets, with an auto regulation mentioned above, with the invisible hand, the market can regulate itself.

The liberal theory of **Adam Smith** was strongly criticized, with the aspect of the social discrimination that creates social dominance,

The main critic of the liberal economy is from **Karl Marx** and **Friedrich Engels**, in their book *"The Manifest of The Communist Party",* who was published in 1848, for them, the problem of the liberal system is the social inequalities (the apparition of two major social classes, the bourgeois and proletarians classes)

As we see, the view of the economic sciences by **Adam Smith, David Riccardo** and **Thomas Malthus** (the trinity of classical economists) or **Karl Marx** and **Engels**, is a political and social with philosophical and historical approach. Both of **Smith** and **Marx or Engels**, have never demonstrates the interest of their economic theories by the use of mathematics, their theories are based on a vision about how they see the world, how they can contribute to change things, that's the basics of the political economics. After this part we will see the history of

methodology in economic sciences, the introduction of mathematics and statistics, used for demonstrating theories in economic and social sciences, that's another area of a new methodology in economic sciences.

1.2- History of methodology in economic sciences:

Methodology of economic sciences before the introduction of mathematics, was been entirely philosophical, as such, as political economy, it is about real appreciation of the social world and make suppositions with hypothesis or theories based entirely about observation of history, political economists make suggestions that should be considered by government, in economic fields, to make better political decisions.

The born of methodology in economic sciences was in the **18th century**, the first to use a deductive method is in the **French school of economics** represented by **Destutt de Tracy** and **Etienne Bonnot de Condillac**.

Adam smith was extremely criticized, when he came with his new theories in his two books "The Theory of Moral Sentiments" and "*The Wealth of Nations*", by using a deductive methodology, but not only, **Thomas Sowell** says: "Adam Smith's methodology was eclectic. The empirical, the theoretical, the institutional, the philosophical, the static, and the dynamic were all intermingled."[1].

In the classical school of economics, **Smith** is not the exception when we consider questions about methodology, other classical economists, like **MacCulloch**, **Riccardo** and **Malthus**, did not give importance to the methodological questions in their economical essays. Consequently, their contributions were heavily criticized, as they used statistics and historical digressions, without much justification. **Mark Blaug** says: "This is not to say that **Adam Smith, David Ricardo**, and **Thomas Malthus** lacked methodological principles, but merely that they saw no need to state them explicitly, regarding them perhaps as too obvious to require defense."[2].

The first contribution in methodology in economics, is from the French, **Jean Baptiste Say**, he has a lot of admiration from a lot of generations of economists, his work has a special admiration in the community of economists. His methodology relies on deduction, starting from the general to explain the singular.

[1] Thomas SOWELL, Classical Economics Reconsidered, Princeton University Press, 1994, pp.112-113.
[2] Mark BLAUG, The Methodology of Economics, Cambridge University Press, 1993, p.52.

John Stuart Mill, who is the author of "the principles of political economy", he reaffirmed the validity of the apriorist and deductive representation of **Say**. He defines political economy like a science which is included inside the large domain of behavioral sciences, and is particularly concerned with production and exchanges. Mill mentioned that we can't reach to good descriptions of economic processes because there are "disturbing causes" that influence and modify the application of an economic law.

John Neville **Keynes**, is one of the figures who have most marked the economy with his major contributions and his famous « The Scope and Method of Political Economy », **Joseph Schumpeter** said: « But we must record the excellent performance of **J.N. Keynes** that settled most of these methodological issues in a spirit of judicial reasonableness and to the satisfaction of the profession. For two decades this book held a well-earned position of authority. Its perusal may be recommended even at this distance of time because of its merits as well as of its success»[3].

An important Author from the **German school of economics**, **Roscher**, have insisted on the "relative" character of all economic phenomena: no economic policy is valid in a universal and timeless way; on the contrary, it depends on the state of progress and the historical conditions of each national economy. To understand these historical conditions, the use of statistics and history was to be preferred. Political economy cannot be the same for all countries and for all historical periods, because it deals with parameters that are constantly changing.

Contrary to the Classical school with their considerations and their many structuralist expositions, the Austrians defended methodological individualism: this idea that the individual is the only reality that the economist must consider. According to **Jon Elster,** the understanding of economic phenomena is necessarily more complete and more immediate by studying the individual, his actions, his choices, and his mentality.

The question about methodology in economic sciences is very important at our level, the use of an inductive or deductive method has a major impact on the results of the researches, in understanding the social impact of the political policies when based on economic researches. Methodological issues can give biased results. The black swan events appear with unseen effects due to the inability to predict these events and make decisions considering the complexity of an unpredictable environment, but we will see this later in the second chapter.

[3] Joseph A. Schumpeter, "History of Economic Analysis", edition published in the Taylor & Francis e-Library, 2006, ISBN 0-203-98391-2 Master e-book ISBN, p. 792.

1.3- The Introduction of Mathematics in Economic Sciences:

> *"It's clear that Economics, if it is to be a Science at all, must be a mathematical science"*[4]
>
> *"It is not a question as to whether mathematics is desirable or not in such a subject. We are in fact forced to adopt the mathematical method as a condition of further progress."*[5]

The introduction of mathematics in political economics, with diagrams and algebraic formulae, was just in the century after the introduction of classical school of economics (represented by **Smith, Ricardo, Malthus**…etc.). When we see, for example, when **Adam Smith** uses those words in his first book[6]: **"measures of value"**, **"measures of hardships"**, **"proportion and equality"**, etc. As a mathematical language, we see the necessity of using mathematics formula in economic sciences. By introducing a mathematical school of economics, it is the beginning of a new area of a new methodological approach in economic sciences inspired by other sciences like physics or mathematics. **William Stanley Jevons**, says that: *"our science must be mathematical, simply because it deals with quantities. Wherever the things treated are capable of being greater or less, there the laws and relations must be mathematical in nature. The ordinary laws of supply and demand treat entirely of quantities of commodities. demanded or supplied, and express the manner in which the quantities vary in connection with the price. In consequence of this fact the laws are mathematical. Economists cannot alter their nature by denying them the name; they might as well try to alter a red light by calling it blue. Whether the mathematical laws of Economics are stated in words, or in usual symbols, x, y, z, p, q, etc., is an accident, or a matter of mere convenience"*[7].

In the 19th century, after the born of the mathematical school of economics, we have a lot of **Mathematico-Economists** who have made a lot theories by using a mathematical method to justify the pertinence of their theories, an example of that is the theory of **Walras Equilibrium**, that states that the market is in equilibrium in supply and demand. In another way he says that all markets must be **cleared** of any excess supply and demand to be in equilibrium. Also, he introduces a **General Equilibrium Theory**, with a general application that explain the functioning of the **Macroeconomy** as a whole, with including all the types of markets or sectors

[4] William Stanley Jevons, "Mathematical Character of the Science," The Theory of Political Economy, p. 3.
[5] Griffith E. Evans, "General Concepts and Methods," Mathematical Introduction to Economics, p. 113.
[6] Adam Smith, first book of Wealth of the Nations.
[7] William Stanley Jevons, op. cit.., Preface, p. xxi.

in economy of a country. At the same time, we have the partial equilibrium introduced by **Alfred Marshall**, which analyses a specific market or sector in comparison to the General Equilibrium.

The outstanding mathematician economists, in the 19th century, best writers of economic essays are: **Antoine Augustin Cournot, Herman Heinrich Gossen** (who contributes at General theory of marginal utility).

We can cite major contributors in economic sciences as mathematicians: **Edgeworth, Wilhelm Laundhardt, Rudolf Auspitz, Lieben, Pareto, Barone, Irvin Fisher, Henry L. Moore, Grifiith C. Evans, C. F. Roes, Henry Schultz, Bortkevitch, Cournot and Walras** and finally **Auspetit**, whose work *"Théorie de la Monnaie",* although dealing with a special subject, contains a general introduction[8].

The process of mathematizing utility helps **William Stanley Jevons** to create a new portrait of an economic man, **Homo-economicus** is taken from a mathematical word, with expressing his human behavior in mathematical terms, this an important turn in mathematical economics, as the human or the economic man can be studied in laboratory and his behavior can be expressed in mathematical laws, **Francis Edgeworth** believed that "at least the conception of Man as a pleasure machine may justify and facilitate the employment of mechanical terms and Mathematical reasoning in social science" (Edgeworth, 1881). We will see in the second chapter the meaning of the word in behavioral economics.

But, the introduction of mathematics have made a lot of contradictions in economic methodology of the researches, for example, when we see at the Walrasian Equilibrium, he is inspired by **Leon Walras** with the same methodology of science of physics, he came with an inductive methodology to make a supposition that equilibrium can be reached in social economics as they can be in science of physics, this supposition made a lot of contradictions, because of the complexity and the instable nature of human behavior and then the equilibrium can't be reached easily as it is in the exact sciences, **Cournot** tried to make economic sciences like an exact science but he failed. **Faustino Ballve**, says about equilibrium: *"The essential principle of the economic process is not equilibrium, but disequilibrium. Equilibrium would bring about economic stagnation and death; disequilibrium is the motive force that keeps the*

[8] Ida Bell Shaw, "A History of the Development of Mathematics in the Field of Economics", Mathematics News Letter, Vol. 8, No. 2 (Nov., 1933), pp. 31-37.

economy alive and progressive. Economic life is not a condition of peace and security; it involves daring and adventure."[9].

The use of mathematics in economics must be with the right methodology, without this, the results and their interpretation can be falsified, or not representative to the right situation, and then, that can cause a lot of mistakes, especially when we make hypothesis or theories that may be wrong. As we know, economics was hugely influenced by physics and Newtonian laws, we can cite this: *"Neoclassical theory was deeply influenced by the example of Newtonian physics, for which systems are made up of atoms, being infinitely divisible and subject to mechanical laws with universal applicability. Newtonian physics in its turn was profoundly marked by the rationalist philosophy of* ***Descartes****. The rationalism of* ***Descartes*** *started from the supposition that reality can be known and explained through causal mechanisms, being an intelligible system in so far, we can identify the laws governing action and existence. The principles of rationality and causality are universal and the reality is accessible through knowledge."*[10]. That's a postulate for exact sciences, it's difficult to affirm that's applicable to the economic and social sciences, when human is complex and almost difficult to measure his behavior.

Carl Menger, from the Austrian economic school, was the first to assert that mathematical languages were not suitable for expressing the economic phenomenon and individual subjectivity.

1.4- Statistics in economic sciences:

In history of economic researches methodology, we cannot talk about mathematics in economics without citing statistics. Statistics along with mathematics is the primary reason why experimental economics along with econometrics has been widely used in our century. Using data, especially historical data, making models based on statistical and mathematical methods, testing the models, forecasting and making hypothesis, and then making theories based on the result of the modeling.

[9] Faustino BALLVE, Essentials of Economics. A brief survey of Principles and Policies, Van Nostrand, 1964, p.95-96.

[10] Ada MARINESCU, "Human nature in the economic behavior based on the neoclassical economic model", Theoretical and Applied Economics Volume XXIII (2016), No. 4(609), Winter, p. 207.

But history of **Experimental Economics** does not give much importance to statistics[11]. Firstly, because statistical methods depend on the "type of experiment", and secondly, statistics is merely a technical and non-methodological issue.

In the 20th century, the first experiment in economics is in 1931 by Louis Thurstone, a psychologist and not an economist, he is considered as a father of the quantitative psychology, he contributes in measuring the mental attitudes and abilities and establishing the Psychometric Laboratory in the university of Chicago when he was a professor. With H. Shultz who has contributes in the quantitative estimation of economic variables, especially demand, and one of the major experts on and an admirer of Pareto, Shultz suggest to Thurstone to apply the experimental methods used in psychological research to estimate an individual's indifference curve in economic theory.

After that, economists have made a special interest on this tool which is the statistics, especially with the progress of technology, the modeling became easy with compiling a lot of data in less time than manually. Statistics is a tool that with data, we can confirm or illustrate theories that are formulated with other methods, that's a correct usage for this tool, with a deductive methodology and never an inductive methodology, the induction is very hard or even impossible in economic or social sciences, the complexity of the subject treated is the first rampart. In history of methodology in economics, statistics are used, for example, by the German Historical School of economics in the past to convince that the French and English school of economics points or conclusions in political economy are wrong by using economic history, but this interpretation is exaggerated and wrong about the nature of the economy.

We have talked about history of methodology in economics, the introduction of mathematics and statistics, but, in our case, the use of statistics and economic history, that means history of economic events of the past, have made a lot of wrong interpretation, firstly about the comprehension, the interpretation and the analysis of those events and secondly, about trying to prevent events in the economic reality, that concerns the real world, with using mathematics and statistics in Econometrics to forecast the future with a special process, the problem is with this special process in Econometrics, **Ballve** says: *"There is no such thing as exact economic calculation, as some mathematical economists have maintained, because the economic data that are at our disposal always refer to the past, and we do not know what*

[11] Nicolas Vallois & Dorian Jullieny, Estimating Rationality in Economics: A History of Statistical Methods in Experimental Economics, GREDEG Working Paper No. 2017-20, p. 2.

tomorrow will bring. Every economic activity is a bill presented to the future, and there is always a question whether or not it will be paid."[12], forecasting events is almost very hard, especially because of black swan events, we will see that in the next chapter.

[12] Faustino BALLVE, Essentials of Economics. A brief survey of Principles and Policies, Van Nostrand, 1964, p. 96.

Chapter 2: Literature Review

2.1- Terminological origin of a black swan event:

> *"Before the discovery of Australia, people in the Old World were convinced that all swans were white, an unassailable belief as it seemed completely confirmed by empirical evidence. The sighting of the first black swan might have been an interesting surprise for a few ornithologists (and others extremely concerned with the coloring of birds), but that is not where the significance of the story lies. It illustrates a severe limitation to our learning from observations or experience and the fragility of our knowledge. One single observation can invalidate a general statement derived from millennia of confirmatory sightings of millions of white swans. All you need is one single (and, I am told, quite ugly) black bird."*[13]

Nassim Nicholas Taleb, introduces this notion of "Black Swan Event", as a mathematical statistician and trader, a specialist of a risk, analyst and essayist, he wrote a dedicated book for The Black Swan in 2007, just before the subprime crises of 2008 in united states , with the title *"The Black Swan: The Impact of the Highly Improbable",* an excellent economic essay about the uncertainty, how that can affect decisions in trading on the different markets as a trader or an investor, and about wealth, but not only, that concerns all economic decisions. That is why we are particularly interested about that in our thesis, he introduces two important notions, *Mediocristan* and *Extremistan*.

2.2- The meaning of a black swan event:

A black swan event is known as an unpredictable event which appears without any notice, it is something that is more extreme than a low-probability event, it has no prior indication that it is even possible. It is called as a black swan event not because no one has imagined it, but because it was unimaginable.

[13] Nassim Nicholas Taleb, "The Black Swan: The Impact of the Highly Improbable", Random House Trade Paperbacks, 2nd edition, 2010, p. xvii.

There are three distinctive attributes of Black Swans as mentioned by Nassim N. Taleb:

"Rarity, extreme impact and retrospective (though not prospective) predictability."

The black swan events are divided into 2 kinds, the positives ones and the negatives ones.

- Positive black swan event: The astonishing success of Google, the incredible rise in value of the bitcoin, the dazzling success of Harry Potter
- Negative black swan event: The subprime crisis of 2008, the 09/11 US attack, Covid-19 pandemic, the Ukraine war.

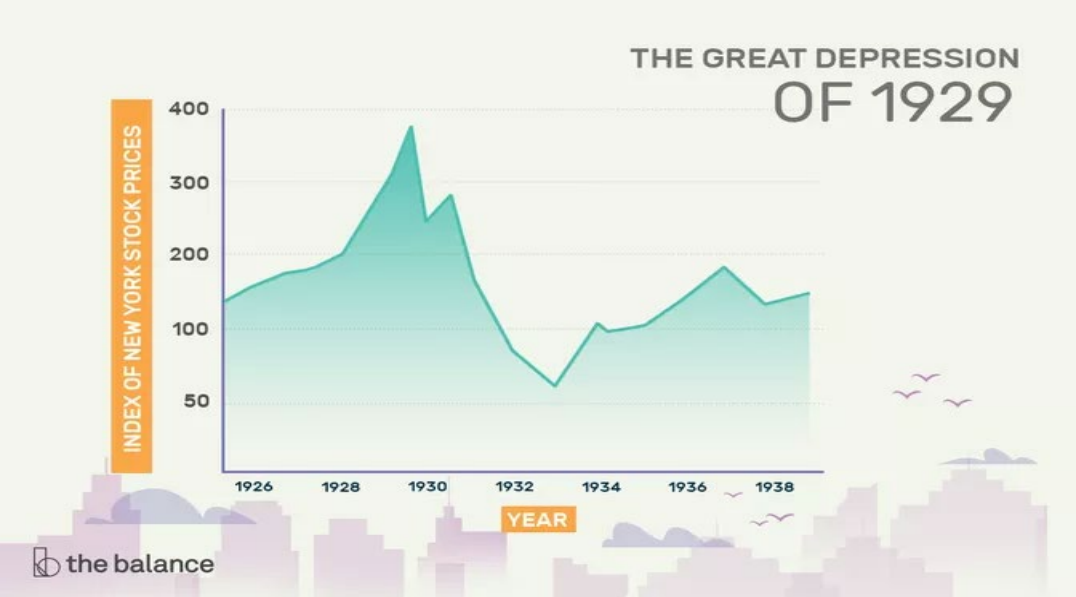
Figure 2.1: The meaning of a Black Swan Event (source: WallStreetMojo, viewed in april 2022, Url: https://www.wallstreetmojo.com/black-swan-event/)

2.3- History of major black swan events in economic fields:

In Economic History of major black swan events, we can cite those economic events:

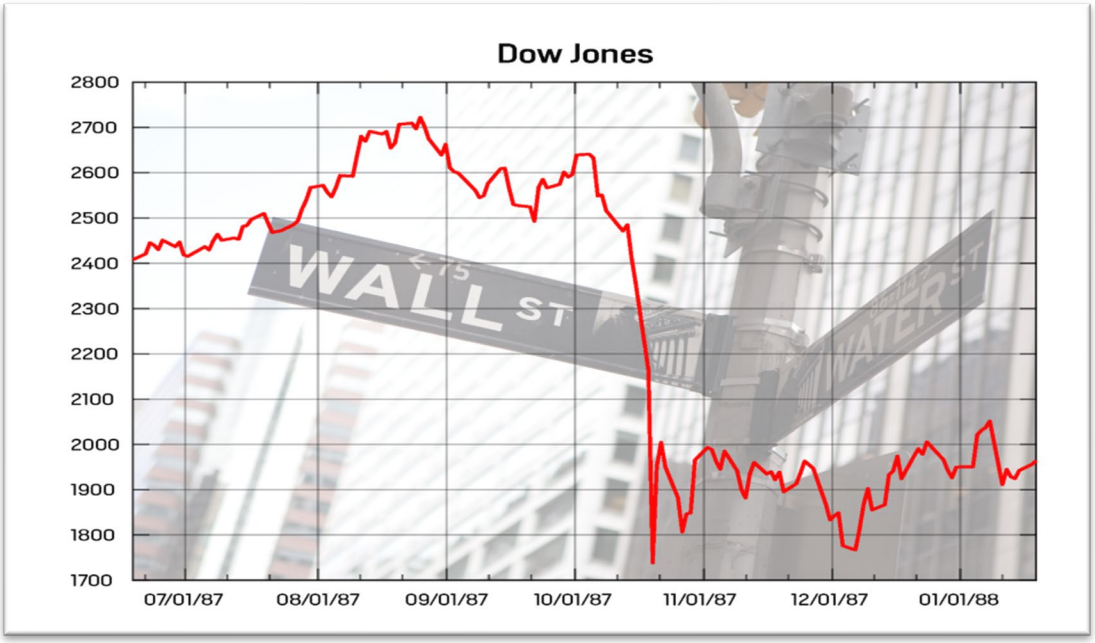
1- The first one we can cite with a major impact in worldwide economy, it's the **Great Depression of 1929**, it's started in United states with a major fall of prices in stock markets, the beginning of a worldwide crash of stock market in October 29, 1929, which was called as a Black Tuesday. Between 1929 to 1932, the Worldwide GDP has fell around 15%, the effect of this depression in many countries around the world is until the beginning of the World War II.

Figure 2.2: Index of the New York Stock prices in The Great Depression of 1929 (source: the balance, viewed in April 2022, Url: https://www.thebalance.com/the-great-depression-of-1929-3306033)



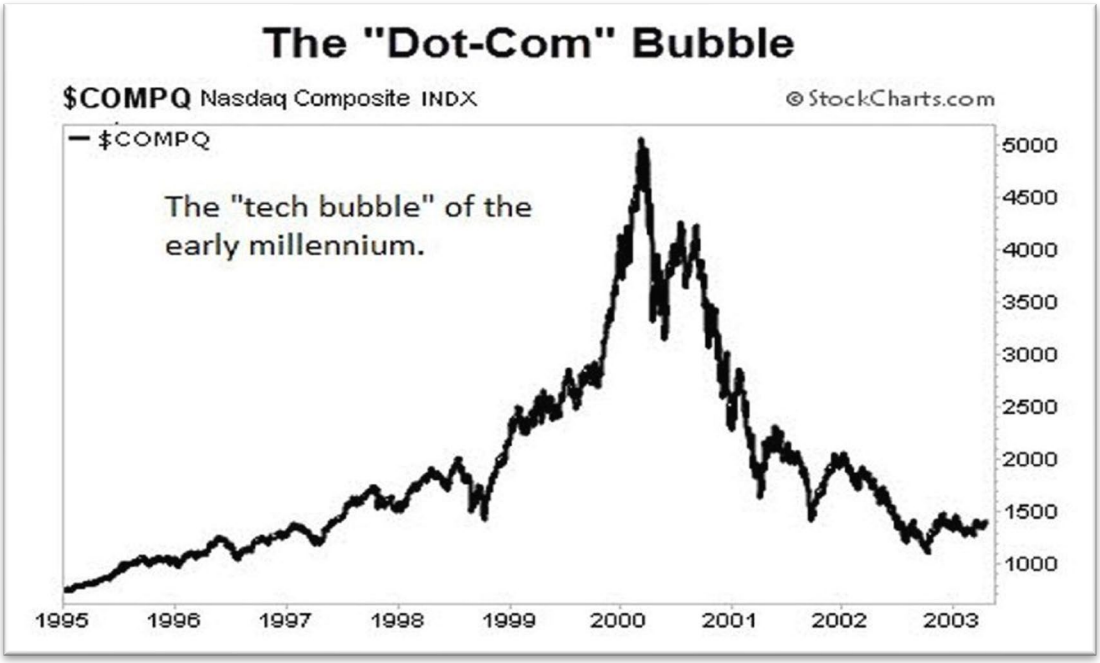
2- The **Black Monday** of the October 29, 1987, an example of an unexpected event, it's the largest decline and loss in one day of the stock market history in the United States, the Dow Jones Industrial Average (DJIA) dropped 22.6 percent in a single trading session reported in the Federal Reserve History website, as we see it in the next figure.

Figure 2.3: The Dow Jones index in the Black Monday of 1987 (source: International Banker, viewed in April 2022, Url: https://internationalbanker.com/history-of-financial-crises/black-monday-1987/)



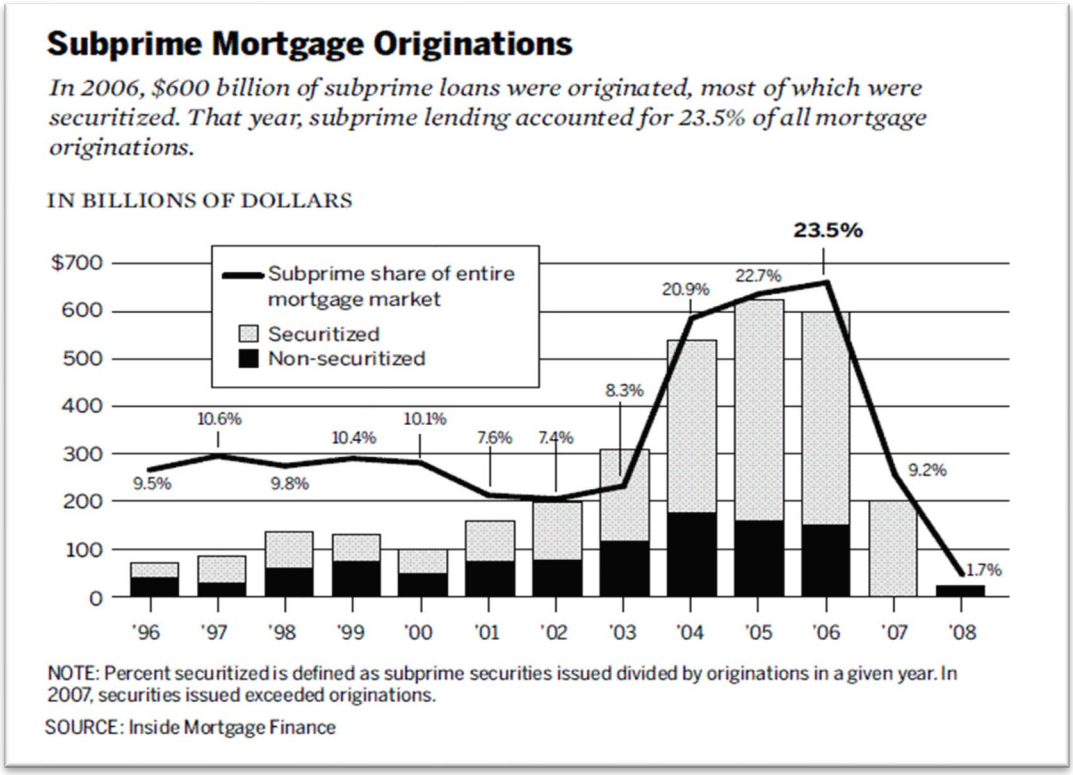
3- The **Dotcom bubble**, in the late of the 1990s, the value of equity markets grew exponentially during this period, with the **Nasdaq** index rising from under 1,000 to more than 5,000 between 1995 to 2000, but in the year of 2001 to 2002 the bubble burst, as we see it in this figure.

Figure 2.4: The Nasdaq Composite Index in the Dot-com Bubble (source: Forex Training Group, viewed in April 2022, Url: https://forextrainninggroup.com/wp-content/uploads/2021/05/dot-com-bubble.jpeg)



4- The **Subprime Mortgage Crises**, like the great depression of 1929, it's a huge global financial crisis, in the beginning of 2007, a lot of banks have made a lot of a high-risky mortgages, to a special category of people, called Subprime, this category is reputed risky, because, they don't have assets, they are poor's, they can't make payments on their mortgages, especially when the interest rates rise. In this period, the interest rates of those mortgages has never stopped growing, due to high risk and rising real estate prices, and then a bubble of housing started to grow, the price of houses has become very high, until the bubble burst, with severe damages around the world, an example of those damages, is the bankrupt of a huge centenary bank *"**Lehman Brothers**"* in 2008.

Figure 2.5: Subprime Mortgage Originations (source: from Wikipedia, by Inside Mortgage Finance, viewed in April 2022, Url: https://en.wikipedia.org/wiki/File:Subprime_mortgage_originations,_1996-2008.GIF)



In the Figure 5, we see the subprime mortgages has reached 23.5% of total mortgages in the United States, as we know those mortgages are very risky, main part of the subprime mortgages are securitized and they are called **MBS** for "***Mortgage-backed securities***", it's the same principle as Bonds in the stock market, but they concern mortgages, they are made by bank as an intermediary between the homebuyer and the investment industry.

Note: all of these crises have reached the entire world because of the hegemony of the US. Dollar.

2.4- Three different types of black swans in a risk context:

1) Unknown unknowns: These are events that were completely unknown to the scientific environment. These events are unthinkable, unpredictable and carry extreme consequences. An example of this type of event is a new type of virus.

2) Unknown knowns: These are events that were not on the list of known events from the perspective of those who carried out a risk analysis (or another stakeholder). This implies that these events were not captured when risk assessment is carried out. The reason for this may be that there was no awareness of such events, or there was limited consideration. An example of this type of event is the September 11 attack on the pentagon.

3) Known knowns: These are events that are on the list of known events in the risk assessment but were judged to have negligible probability of occurrence, and therefore not believed to occur. Despite the negligible probability of occurrence, the events still occur with extreme consequences, and this was because of the fact that cautionary measures that should be implemented were not put in place. An example of this type of event is "the tsunami that destroyed the Fukushima Daiichi nuclear plant was similarly removed from the relevant risk lists due to the judgement of negligible probability"[14] .

2.6- The problem of uncertainty in econometric researches:

As mentioned earlier, in econometrics, the purpose of modeling is to predict the future of economic variables, with a forecast, but, the future as we know it is unknown.

The methodology in econometrics, is that we use exogenous variables to try to explain endogenous variables, but, with a limit, as mentioned by Nassim Nicholas Taleb. In theory, we try to make a causality effect between those variables (the exogenous and the endogenous), but in the reality, we are not always sure that the endogenous variables are caused only by the exogenous variables that are chosen for the modeling (with a relation cause-effect introduced by the Neoclassics), that is the first limit, and secondly, the problem of the complexity of the economic reality, just because, the economic reality is made by individuals, in economic sciences, as the limit mentioned previously in the first chapter, about the theory of **Homo-Economicus**, that is just an unverified theory or a fiction. With the progress of the behavioral

[14] Aven, Terje & Krohn, Bodil S., 2014. "A new perspective on how to understand, assess and manage risk and the unforeseen," Reliability Engineering and System Safety, Elsevier, vol. 121(C).

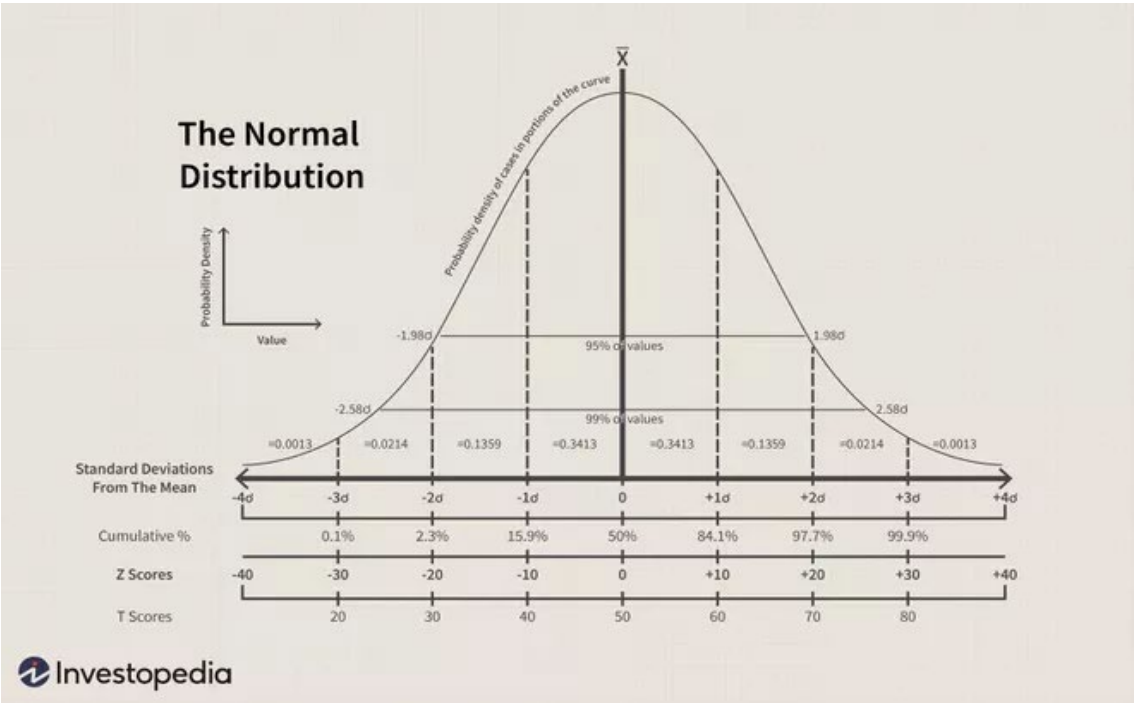
economics, by David Kahneman, Daniel Tversky, Vernon L. Smith, Robert Shiller and Richard Thaler (who are the major contributors of that new discipline), we know that, no human in the entire world can make rational decisions, except Economic PhD's, who have an excellent knowledge about the economic world, as Richard Thaler's says in his Book "*Misbehaving: The Making of Behavioral Economics*". The human psychology can change from day to day (sometimes, every second), this reflects the complexity of preventing the human behavior and then economic cycles.

These two limits alone can explain why forecasts are sometimes impossible, and then, how we can make a forecast for an unknown reality, for N.N Taleb, Black Swans Events are always from *Extremistan*, and never from *Mediocristan*. One of the specificities of the *Mediocristan*, is that gaussian statistics prevail, with a stationary Log-Normal or Normal distribution, with the width of the bell curve described by its standard deviation, and then the forecasting can be possible, because the unknown can be known, as we do in the econometric methodology, with supposing that the errors are normally distributed:

$$E(X) = \mu; \ Var(X) = \sigma^2$$

The bell curve that defines the normal law distribution is in the next figure.

Figure 2.6: The Bell Curve of the Normal Distribution (source: Investopedia, viewed in April 2022, Url: https://www.investopedia.com/terms/b/bell-curve.asp)



This particular world (*Mediocristan*), can't be subjected to Black Swan Events, and can't be representative of the real economic world with a lot of Black Swan Events like financial crises.

The *Extremistan*, has the particularity that, he is the world of Black Swan events, when we see at the variations of the markets, the different crises, they have the particularity that they are not governed by gaussian laws, but with a savage hazard as mentioned by Nassim Nicholas Taleb, the use of the normal distribution law is almost impossible to prevent the extreme events like Black Swan events. The particularity of those events, is that they are unpredictable, that make the forecast of those events even impossible, by the way, the use of sophisticated models doesn't change anything in the predictability. All of this, is because we don't have the necessary information to make predictions, the limit of the variables that can be added to the model to explain a certain situation or even, to have more information about the real economic world without biased data or a false sense of causality.

The problem of historic data used in time series is even a huge problem in the predictability, when we see at the historical data including black swan events like what we have seen in the previous point about history of black swan events in the economic world, without including the world war I and II, wars are even considered as unpredictable events. Each Black Swan event has the distinction of being unprecedented, thus complicating the task of forecasting with using historical data. Another problem is the incapacity of the statistical normal distribution law used in econometrics to take into account an extreme event with an extreme huge standard deviation, like what we see in a sharp drop or a sharp rise in financial markets.

Those two limits mentioned previously, send back to the problems of the economic research methodology, as discussed in the previous chapter, the questions about methodology in economic sciences are fundamentally at the origin of problems like Black Swan events when we try to prevent them. Our comprehension and knowledge about the future in economic sciences is the major handicap to be able to make predictions. We will discuss in the next point of this chapter about psychology and how decisions can be distorted when we try to make predictions of the real economic world.

2.7- Making a forecast in economics can false our decisions under uncertainty:

The limit of econometrics and time series in forecasting black swan events, made the decisions taken from the forecasts automatically inapplicable to the real economic world. When an unpredictable event happens, making decisions is the hardest part, especially when forecasts doesn't see it.

At the moment, unfortunately, we don't have the necessary tools that can be a serious help in forecasting, even sophisticated econometric models have failed. But, by chance our forecasts can be correct and representative: *"Regrettably, only by luck will economic forecasts be `right': there are inevitable sources of uncertainty that make perfectly accurate predictions of the future impossible."*[15].

2.7- Human psychology under uncertainty:

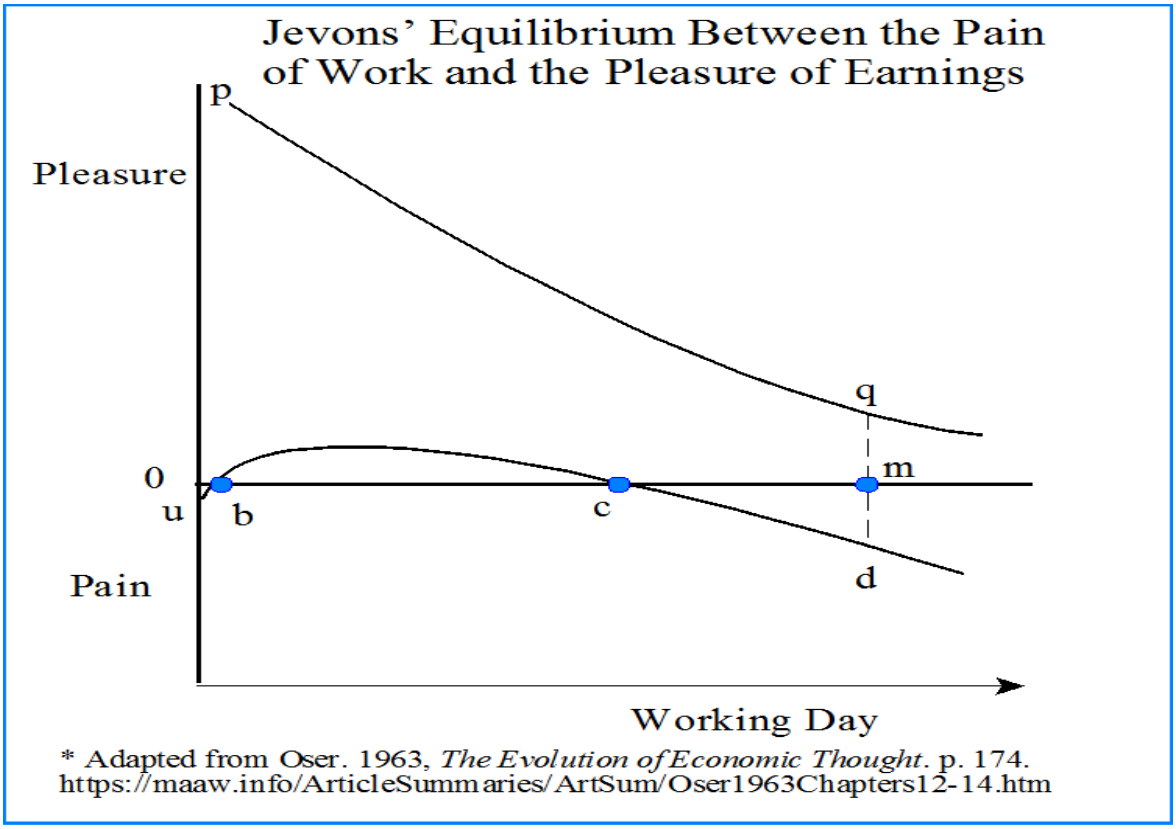
2.7.1- Behavioral economics and human nature:

Homo-economicus, a word introduced by John Stuart Mill, who defines a rational person, as he is self-interested, insatiable and competitive, this hypothesis is important in economics, especially in micro-economics, for measuring the utility. The consumer or the producer have to make good decisions as possible for providing a highest amount of utility, but both of thus can't make that happen without being rational. William Stanley Jevons in 1871, with a combining calculations and psychology, made a graphic of how pleasure work when we are consuming goods, for him *"Each individual gains a certain utility from the consumption of a certain good, and this pleasure or utility gain is decreasing when more units from the respective good are consumed. We have here the action of the psychological principle of saturation."*[16].

The next figure will explain how the pleasure or utility of earnings and the pain of work, work together to define the human psychology and behavior as defined by W. S. Jevons.

[15] M. W. Watson and J. H. Stock, "Time Series: Economic Forecasting", International Encyclopedia of the Social & Behavioral Sciences, 2001, ISBN: 0-08-043076-7.
[16] Ada MARINESCU, "Human nature in the economic behavior based on the neoclassical economic model", Theoretical and Applied Economics Volume XXIII (2016), No. 4(609), Winter, p. 206.

Figure 2.7: Equilibrium Between the pleasure of Earning and the pain of Work (source: Management and Accounting Web, viewed in April 2022, Url: https://maaw.info/ArticleSummaries/ArtSumOser1963Chapters12-14.htm)



In the first chapter we have seen, how mathematics and other methodology's inspired in other sciences, have perturbed different economic analyses with the extension of principles applicable in the world of natural phenomenon, and then producing completely unrealistic effects and a completely mechanized conception of human nature.

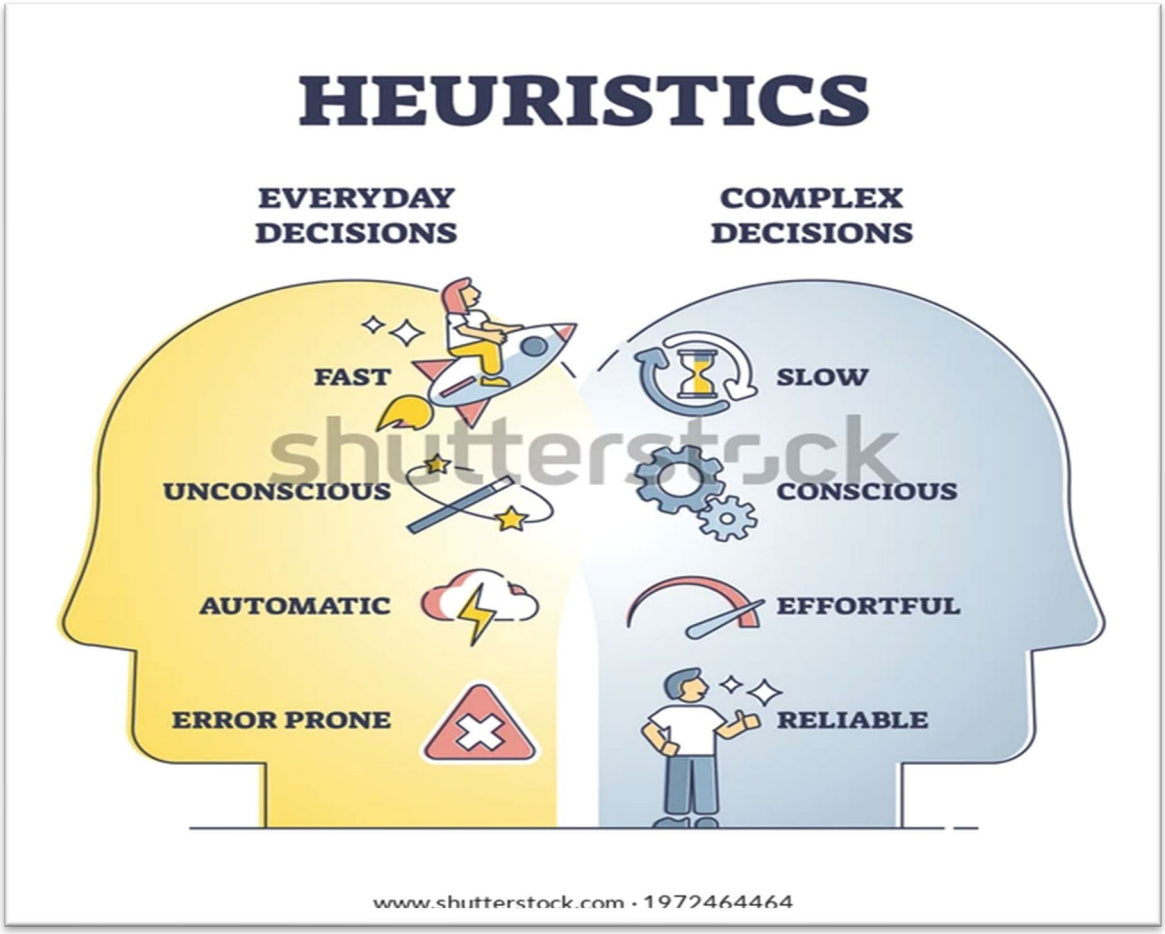
The Neoclassics are mostly the responsible of this deformation of the real world to be most quantifiable and predictable as possible, in microeconomics we suppose only two main hypothesis, the pursuit of satisfaction for the consumer and the search for profit from the producer, in macroeconomics, every individual define the behavior of the economy as the whole, the combination of those two selfish and possessive humans combined (consumer and producers), define how the markets interact, with a predictive issues. This is a very limited definition of the real world, the behavior economics try to redefine this falsified view of the Platonian economic world, where everything is quantifiable and predictable, but this is not really the case, human behavior is not predictable and not rational, human nature has one particularity, that is complexity, and he can change depending on situations or their history.

2.7.2- Human Behavior Under Uncertainty:

In human behavior, the static definition of the homo economicus is not realistic, he has no free choice, because he is deemed to perfect knowledge and acting in a predictable manner, he knows in every situation what is best for him, he has no place for improvement and for revising convictions in accordance with bayes rules, a normal human behavior can learn and revise older convictions when he is confronting to new situations or information received, but that's not the case of the homo economicus because his behavior is theoretically perfect as possible, this could be called a static state, nothing can emerge. The world made up from economic individuals seems rather a place without novelties or events (that's what N. N. Taleb called Medioctristan), this particular world is not subjected to the black swan events, and he is perfectly predictable because of the homo economicus behavior.

The recent critics for this vison of human nature is from Daniel Kahneman, one of the founders of the behavioral economics, he showed that the assumption of rationality is strongly related to liberalist conceptions for public policies, for him, people have two systems to take decisions: Fast Thinking which resort to heuristics and Slow Thinking. With laboratory experiments on human behavior, he made the conclusion that individuals have an irrational behavior (Kahneman, 2012).

Figure 2.8: Mental Heuristics on decision making (source: Shutterstock, viewed in April 2022, Url: https://www.shutterstock.com/fr/image-vector/heuristics-decisions-mental-thinking-shortcut-approach-1972464464)



But our question is, if individual is rational or emotional?

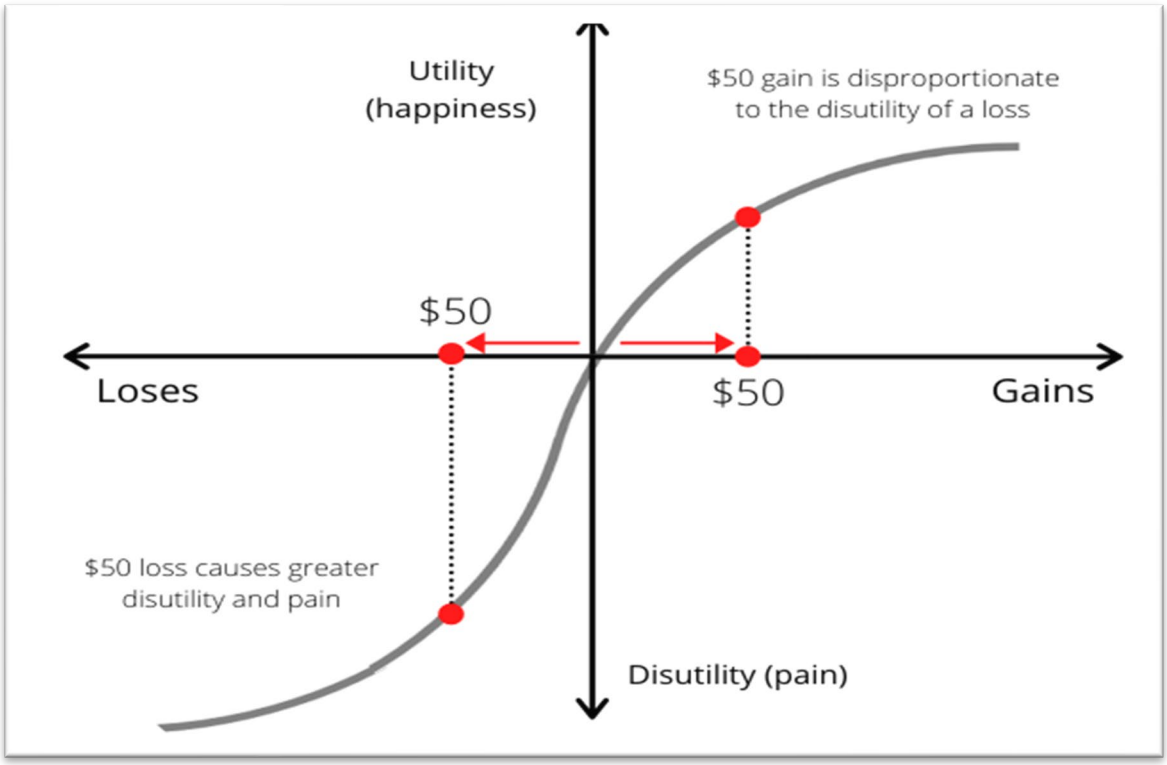
The response is evidently that it's emotional more than rational, psychologists and economists' specialists in human behavior have made a lot of experiences to study the question, as the experience of Kahneman mentioned previously, the response is that normal human behavior are particularly non-rational.

Let's study the question of the decision making under risk, and how the human nature work under uncertainty, in this area, the best experience to translate the response of this important question, is from also Daniel Kahneman and Amos Tversky, with the **Prospect Theory** (1979).

The Prospect Theory, is made from a critic to the traditional **Expected Utility Theory** with the fundamental idea of the Homo Economicus, this last one has dominated the analysis

of decision making under risk, it has been generally accepted as a normative model of rational choice and widely applied as a descriptive model of economic behavior, individuals obey to the axiom of the utility theory. With making a system that translates certainty, probability and possibility of gains, they have made an experience on a random sample of peoples with giving them a chance with a probability to have a lot of gains or a certainty to have a moderate gain, they have observed the different responses of the chosen individuals on the laboratory. After that, they have complicated the task with adding a chance to gain a lot or nothing, or a certainty to gain a moderate amount of money, the interpretation of the results have made a graphical to explain how individuals made decisions under risk with psychological law of the human nature[17], they made this particular observation, a loss is more painful than the happiness that a gain can give.

Figure 2.9: Individual preferences in Prospect Theory (source: thebepost, viewed in April 2022, Url: https://www.thebepost.com/post/prospective-disruption)



[17] Daniel Kahneman and Amos Tversky, "Prospect Theory: An Analysis of Decision under Risk", The Econometric Society, Econometrica, Vol. 47, No. 2 (Mar., 1979), pp. 263-291.

For more details on the experiences made by Daniel Kahneman, Amos Tversky and Richard Thaler on the prospect theory, with a huge comprehension of the Human Nature and the Behavioral Economics, we recommend the amazing book of Richard Thaler *"Misbehaving: The Making of Behavioral Economics".*

2.8- The oil market and Black Swan events:

The oil market is affected by a lot of Black Swan events, in our context, we need to see the impact of those events over a period of 2003-2022, multiple studies have analyzed this impact concerning the oil market, we can cite Aboura (2012) who analyzes the tail of the risk of the US oil market from 1983 to 2011 with a data filtering process using an ARMA (p, q) + GARCH (p, q), by providing evidence about the existence of a tail risk in crude oil market.

Žiković (2011) studied the effect of the subprime crisis 2008 on oil market, who is considered as the biggest collapse on history of oil, the commodities market, such as oil, contain certain risk characteristics that are different from assets like stocks and bonds, with some external factors cannot be controlled, the economy can be affected by this volatility as he says: *"The idea that rising oil price volatility serve to stifle economic activity and reduce asset values has by now become widely accepted in the literature and seems virtually axiomatic."*[18].

Ferderer (1996) analysis about how oil price volatility can impact the global US economy and concluded that, there is a relation between those two parameters, who makes the risk of uncertainty and sectoral shocks increasing in term of forecasts.

Hamilton (1983) concluded with a Granger Causality method that oil prices affect macroeconomic aggregates.

In our study, we need to see by an empirical analysis, how the economy of Algeria can be affected by the high volatility of the oil market?

[18] Saša Žiković, "Measuring risk of crude oil at extreme quantiles", 2011, Proceedings of Rijeka School of Economics 29, page 2.

Chapter 3: Data and Descriptive statistics

For our study, the goal is to see how uncertainty can affect our decisions based on forecasting future volatility or trends of the market, or in generally all types of decisions based on forecasting in econometrics. With examining how black swan events can be unpredictable, how the risk can grow dramatically without any particular reason or with information (variables) that are not integrated to the modeling process.

3.1- Data Description:

After a long period of observation of the commodities market, we have made a special interest concerning The OPEC CRUDE OIL PRICES, especially The SAHARA BEND, that concerns the principal oil market of Algeria, with a monthly data from January 2003 to April 2022, downloaded from the website of the Nasdaq, for studying four major events, with a huge increase or decrease of the prices to determinate how it can be possible to forecast those events. For analyzing the effect on the OPEC Crude oil prices of four recent black swan events (Subprime crises, Collapse of 2014, Covid-19 crises, Ukraine War) we will use a dummy variable.

Also, for determining the relation of causality between The OPEC CRUDE OIL PRICES and The GDP of Algeria, we used an annual data for both series, from 2003 to 2020, the OPEC Crude Oil Prices data are downloaded from the Nasdaq Website, and The GDP of Algeria data is from The World Bank data.

3.2- Variable Definition:

The endogenous variable that will be used in the first part is the OPEC Crude Oil prices as endogenous variable, with using a GARCH approach for monthly data for expressing variation of the market and trying to see the reaction of the model concerning the rare events, the exogenous variable is expressed by the past of the OPEC Crude Oil Prices.

In the second part, for searching a relation of causality between The OPEC Crude Oil prices and The GDP of Algeria, used as endogenous variables in the first step and expressed by their past as exogenous variables, for determining a possible causality relation or influence of the OPEC Crude Oil prices to determine The GDP of Algeria.

3.3- Descriptive Statistics:

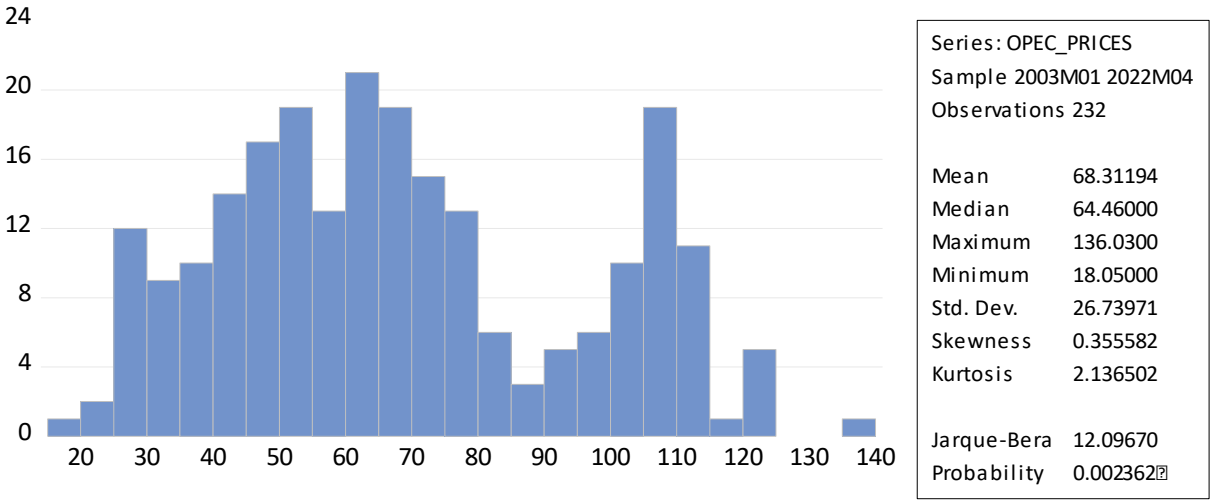
We have used different data for the principal analysis for our thesis and an additional analysis. In the first one, for modeling the volatility of the OPEC Crude Oil Prices we have used a monthly data with descriptive statistics on the Table 3.1. For the additional analysis, a yearly data of the OPEC Crude Oil Prices with descriptive statistics represented in Table 3.1 too, and the Annual GDP of Algeria with his Statistics represented in the Table 3.2. Concerning the OPEC Crude Oil Prices, for the monthly data, it is from January 2003 to April 2022 and for the yearly data, it is from 2003 to 2020 same as the GDP of Algeria.

Table 3.1: Descriptive statistics for the OPEC Crude Oil Prices

OPEC_PRICES	*Monthly Data*	*Yearly Data*
Mean	*68.31194*	*64.52778*
Median	*64.46000*	*54.72000*
Maximum	*136.0300*	*107.9400*
Minimum	*18.05000*	*29.87000*
Std. Dev.	*26.73971*	*26.32880*
Skewness	*0.355582*	*0.456584*
Kurtosis	*2.136502*	*1.973467*

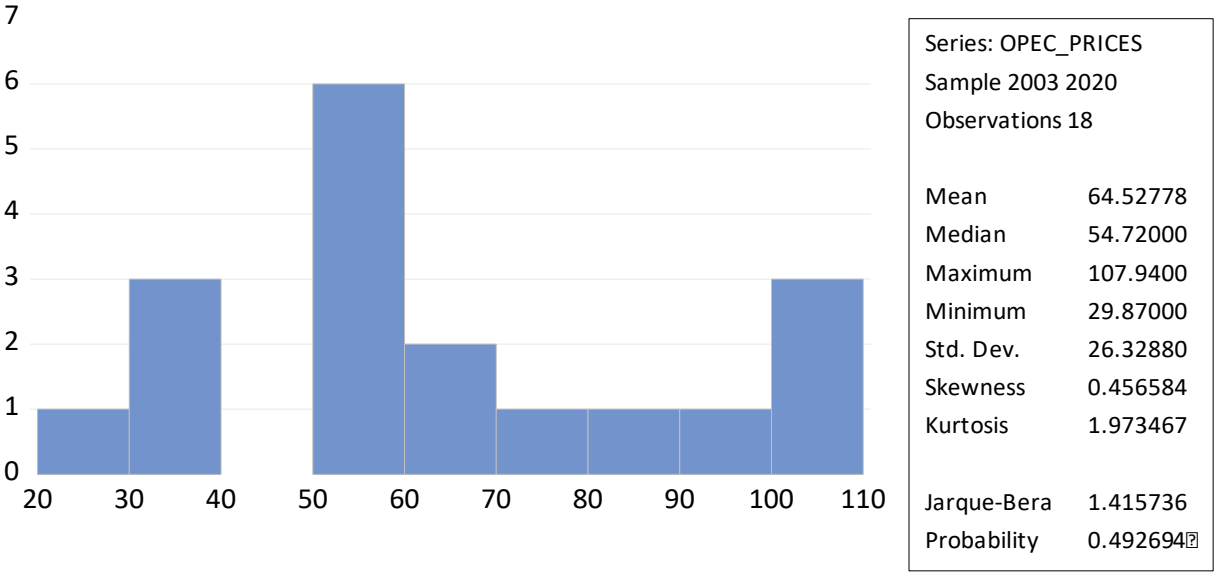
- The monthly data of the OPEC Crude Oil Prices has a Mean of 68,31$, a Median of 64,46$, with a maximum value of 136.03$ reached in June 2008 and a minimum value of 18,05$ in April 2020. The positive value of the skewness (0.355) traduce that the tail of the distribution is spreading on the right side with a higher mean than the median. The kurtosis value of 2.136 traduce a Platykurtic with lower tail and stretched around center with data points are present in high proximity with mean. The Jarque-Bera value of 12.096 with probability of 0.002 < 0.05, implying that the data does not follow a normal law distribution as represented on the Figure 3.1.

Figure 3.1: Histogram and stats of the monthly OPEC Crude Oil Prices data (source: EViews 12 Output)



- The annal data of the OPEC Crude Oil Prices has a Mean of 64,52$ with a median of 54,72$, the maximum value reached of this series is 107.94$ in the year of 2013 and the minimum of the price is 29.87$ in 2003. The positive value of the skewness (0.456) traduce that the tail of the distribution is spreading on the right side with a higher mean than the median. The kurtosis value of 1.973 traduce a Platykurtic same as the monthly data, with lower tail and stretched around center with data points are present in high proximity with mean. The Jarque-Bera value of 1.415 with probability of 0.492 > 0.05, indicating that the data is normally distributed (Figure 3.2).

Figure 3.2: Histogram and stats of the annual OPEC Crude Oil Prices data (source: EViews 12 Output)



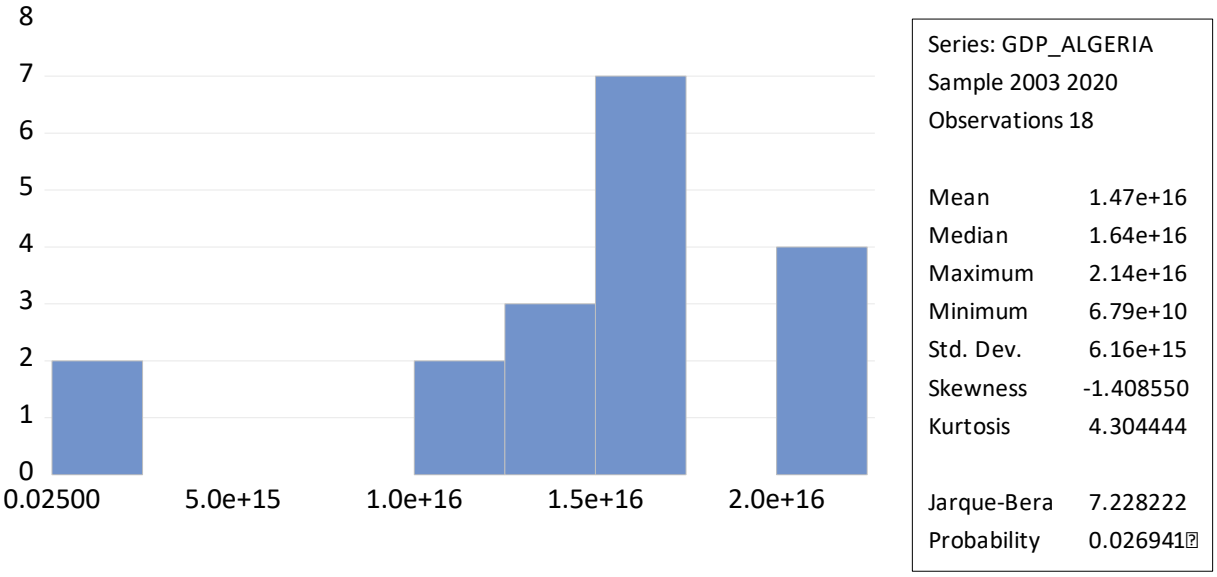
- For the annual data of the GDP of Algeria:

Table 3.2: Descriptive Statistics of the GDP of Algeria from 2003 to 2020

GDP_Algeria	*Yearly Data*
Mean	*1.47E+16*
Median	*1.64E+16*
Maximum	*2.14E+16*
Minimum	*6.79E+10*
Std. Dev.	*6.16E+15*
Skewness	*-1.408550*
Kurtosis	*4.304444*

The annual data of the GDP of Algeria has a Mean of ($1{,}47*10^{16}$ \$), a Median of ($1{,}64*10^{16}$ \$), a maximum value of ($2{,}14 * 10^{16}$ \$) in 2014 and a minimum value of ($6.79 * 10^{10}$ \$) in 2003, the standard deviation is ($6{,}16*10^{15}$), the negative value of the skewness (-1.408) traduce that the tail of the distribution is spreading on the left side with a higher median than the mean. The kurtosis value of 4.304 traduce a Leptokurtic with a very long and skinny tail of the distribution. The Jarque-Bera value of 7.228 with probability of $0.029 < 0.05$, implying that the data does not follow a normal law distribution as represented on the Figure 3.3.

Figure 3.3: Histogram and stats of the GDP of Algeria data (source: EViews 12 Output)



Chapter 4: Methodology

The analysis of black swan events as a fundamental problem in econometric forecasting, have made a serious questioning concerning the efficiency of forecasting in our discipline in economics. For our study, the proposal is to see how black swan events are even unpredictable, we will use a sophisticated model, the GARCH Model in the first part of the next chapter to see how this model can capture volatility for forecasting future trends in the market of commodities, especially the oil market.

In the additional analysis, we will see the effect of the oil market volatility on the economy of Algeria, with testing the sense of causality between the prices of oil market and the GDP of Algeria.

4.1- Modeling the volatility of financial series:

The first part of the modeling, is to determine the goal or the purpose of the study, in our case the objective is to try to capture the volatility and see how this one affects the model and the reliability of forecasting the future of the financial series.

The GARCH model seems a good alternative to respond to our purpose, as a sophisticated model with taking into account the conditional heteroskedasticity of a financial series with extreme volatility.

The conditions of estimating a GARCH model will be enumerated in this part.

4.1.1- The stationarity of the series:

The stationarity of the series is a preliminary condition to estimate the ARMA model, who will help us to determine the number of lags and the specification of the GARCH model.

As a stationarity test, we will refer to the Augmented Dickey Fuller (ADF) test, introduced by Dickey and Fuller (1981) for testing the unit root, in three specific models for detecting a Trend Stationary (TS) or a Difference Stationary (DS), the series will be tested with the following model in level, who contain an intercept and a trend as follow:

$$\Delta x_t = \gamma x_{t-1} + \sum_{j=2}^{p} \Phi_j \Delta x_{t-j+1} + c + bt + \varepsilon_t \text{ ... (Model 6 -ADF-)}$$

The efficiency of the model tested statistically following the Dickey-Fuller table will determine if the series contain a significative trend (bt), that means that the mean is not stable over time, if the trend is not significative, we will estimate a model without a trend:

$$\Delta x_t = \gamma x_{t-1} + \sum_{j=2}^{p} \Phi_j \Delta x_{t-j+1} + c + \varepsilon_t \ldots \text{(Model 5 -ADF-)}$$

If the intercept is not significant following the DF table, we will eliminate the intercept and estimate a final model without the intercept:

$$\Delta x_t = \gamma x_{t-1} + \sum_{j=2}^{p} \Phi_j \Delta x_{t-j+1} + \varepsilon_t \ldots \text{(Model 4 -ADF-)}$$

In the last step, we test the presence of the unit root to determine if the model need a difference of the series to be stationary, that include the first difference and the second difference (only if the first difference is not stationary yet), in this step we create a differenced series if the null hypothesis is accepted, the series following a DS process, the hypothesis are:

H0: $\Phi_1 = 1$ (presence of unit root)

or

H1: $\Phi_1 < 1$ (the process is stationary)

If the trend of the model 6 is significant, and $\Phi<1$ as H1 is accepted, the appropriate method to make the series stationary is a TS method, if $\Phi=1$ as H0 is accepted, the appropriate method is a DS. Concerning the TS, the estimation of an ARMA model is not possible.

4.1.2- Estimating an ARMA (p, q) model:

The estimation of the appropriate model ARMA (p, q), after verifying the stationarity of the series needs to determine the number of the optimum lag of the ARMA model.

The autoregressive AR(p) process is generated by a variable y as endogenous variable, and represented by his past with the number of lags (p) as exogenous variable, the form of the model is:

$$\text{AR(p): } y_t = \Theta_1 y_{t-1} + \Theta_2 y_{t-2} + \ldots + \Theta_p y_{t-p} + \varepsilon_t$$

The moving average MA(q) process is generated by a weighted average of errors with a (q) lags period:

$$\text{MA(q): } y_t = \varepsilon_t - \alpha_1 \varepsilon_{t-1} - \alpha_2 \varepsilon_{t-2} - \ldots - \alpha_q \varepsilon_{t-q}$$

The Autoregressive Moving Average ARMA model, is constituted as ARMA (p, q) with including an intercept, that give us:

$$y_t = c + \Theta_1 y_{t-1} + \Theta_2 y_{t-2} + \ldots + \Theta_p y_{t-p} + \varepsilon_t - \alpha_1 \varepsilon_{t-1} - \alpha_2 \varepsilon_{t-2} - \ldots - \alpha_q \varepsilon_{t-q}$$

For determining the (p) and (q) lag order, we will use the autocorrelation function AC and the partial autocorrelation function PAC of the stationary series (stationarity is a condition to estimate an ARMA model). The partial autocorrelation function PAC define the (p) order of the AR(p):

$$\rho_k = \rho^k$$

The Autocorrelation function AC define the number of lags (q) of the MA(q), the function formula is:

$$\rho_k = \frac{\sum_{i=0}^{i=q-k} a_i a_{i+k}}{\sum_{i=0}^{i=q} a_i^2} \text{ (for k=0, 1..., q and } \rho_k = 0 \text{ for k > q)}$$

With the correlogram, we can observe clearly and determine the order of an ARMA (p, q) with using the AC and the PAC function. With using the Wold (1954) method we can estimate the ARMA model, that we will use to estimate the mean equation of the GARCH model, after determining the presence of an ARCH effect with a Heteroskedasticity Test.

4.1.3- 2S-ARCH-LM Heteroskedasticity test:

The Engle's (1982) ARCH-LM test is the first test for detecting Heteroskedasticity with the ARCH effect for estimating an Autoregressive Conditional Heteroskedasticity (ARCH) model. With the Lagrange Multiplier, the ARCH-LM test is biased in the sense that in finite samples it does not take into account if the stationarity constraints are satisfied or not.

In our case, for estimating a GARCH (1, 1) model, the appropriate test to detect a possible ARCH effect in the series is to do a traditional Two-Step 2S-ARCH-LM, the principle is to use the ARCH noise in the residuals for searching a possibility of using a stationary GARCH (1, 1) model for the series, the hypothesis of the 2S-ARCH-LM will be:

H0: An ARCH model up to order (q) cannot be detected as the stationarity constraints are violated for the GARCH (1, 1) model, that means that a GARCH (1, 1) model cannot be estimated.

H1: An ARCH model up to order (q) can be detected and the stationarity constraints are satisfied for the GARCH (1, 1) model.

The limits of the 2S-ARCH-LM in limit samples have also made a critic concerning the traditional approach and the development of an alternative Sjölander (2008) new Two-Step Unbiased 2S-UARCH-LM.

4.1.4- Estimating a GARCH (p, q) model:

The Bollerslev (1986), Generalized Autoregressive Conditional Heteroskedasticity GARCH (p, q) model, a generalized model of the Engle's (1982) ARCH model, the objective is clear, he is made for forecasting volatility of returns on financial assets, with using time series data, the variance equation of the ARCH (1) model is constituted as following:

$$\boldsymbol{\sigma_t^2 = h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2}$$

For the Generalized Autoregressive Conditional Heteroskedasticity GARCH (p, q), the variance equation is constituted as following:

$$\boldsymbol{h_t = a_0 + \sum_{i=1}^{q} a_i \varepsilon_{t-i}^2 + \sum_{j=I}^{p} \gamma_j h_{t-j}}$$

- $\boldsymbol{\alpha_0}$ is a constant term.
- $\boldsymbol{\varepsilon_{t-i}^2}$ is the news about volatility from the previous period (lag of the squared residual from the mean equation). -ARCH term-
- $\boldsymbol{h_{t-j}}$ is the last period's forecast variance. -GARCH term-

A simple GARCH (1, 1) specification with the mean and the variance equation, is represented as following:

Mean equation:

$$\boldsymbol{y_t = x_t' \theta + \varepsilon_t}$$

Variance equation:

$$\boldsymbol{h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \gamma_1 h_{t-1}}$$

In our case, we will test if a GARCH (1, 1) can be useful and representative for modeling the volatility of our data of the OPEC Oil Crude Prices series.

4.2- Additional analysis:

As an additional analysis, for our context we will search the relation between the GDP of Algeria and the OPEC Oil Crude, an appropriate method to use is the Granger causality between those two series.

4.2.1- VAR (p) Model:

The Vector Autoregressive model were made popular by Sims (1980), but the definitive technical reference for the VAR is made by Lütkepohl (1991), the condition of making a VAR model is the stationarity of the series, he is estimated with an OLS method, the structural form of the VAR (p) model is:

$$\boldsymbol{Y_t = A_0 + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + \varepsilon_t}$$

With:

$$\boldsymbol{Y_t = \begin{bmatrix} y_{1,t} \\ y_{2,t} \\ . \\ . \\ . \\ y_{k,t} \end{bmatrix};\ A_0 = \begin{bmatrix} a_1 \\ a_2 \\ . \\ . \\ . \\ a_k \end{bmatrix};\ A_{i\neq 0} = \begin{bmatrix} a_{1i}^1 & a_{1i}^2 \dots & a_{1i}^k \\ a_{2i}^1 & a_{2i}^2 \dots & a_{2i}^k \\ & . & \\ & . & \\ . & & \\ a_{ki}^1 & a_{ki}^2 \dots & a_{ki}^k \end{bmatrix};\ \varepsilon = \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ . \\ . \\ . \\ \varepsilon_{kt} \end{bmatrix}}$$

A VAR model is stationary when the following conditions are satisfied:

- E (Y_t) = μ ∀t;

- Var (Y_t) < ∞;

- Cov (Y_t, Y_{t+k}) = E [(Y_t – μ) (Y_{t+k} – μ)] = Γ_t ∀t

For determining (q) lag order of the VAR (q), we proceed by choosing the significant statistically estimated model of the VAR who minimize the common information criteria, the Akaike (AIC), Schwarz-Bayesian (BIC) and Hannan-Quinn (HQ):

$$\mathbf{AIC(p)} = \ln\left|\widetilde{\boldsymbol{\Sigma}}(\boldsymbol{p})\right| + \frac{2}{T}\boldsymbol{pn^2}$$

$$\mathbf{BIC(p)} = \ln\left|\widetilde{\boldsymbol{\Sigma}}(\boldsymbol{p})\right| + \frac{\boldsymbol{ln\, T}}{\boldsymbol{T}}\boldsymbol{pn^2}$$

$$\mathbf{HQ(p)} = \ln\left|\widetilde{\boldsymbol{\Sigma}}(\boldsymbol{p})\right| + \frac{\boldsymbol{2\ ln\ ln\, T}}{\boldsymbol{T}}\boldsymbol{pn^2}$$

Where $\widetilde{\boldsymbol{\Sigma}}(\boldsymbol{p}) = \boldsymbol{T^{-1}} \sum_{\boldsymbol{t=1}}^{\boldsymbol{T}} \hat{\boldsymbol{\varepsilon}}_{\boldsymbol{t}} \hat{\boldsymbol{\varepsilon}}_{\boldsymbol{t}}'$ is the residual covariance matrix without a *degree of freedom correction*. More information on the model selection criteria is available on Lütkepohl (1991) chapter four.

4.2.2- The Granger Causality test:

The Granger (1969) causality test, is a statistical concept based on predictions of the future, he assumes two hypotheses for an example of two variables Y_{1t} and $Y_{2t,}$ with two simultaneous tests between the two variables with a basic and classic significance Fisher test as following:

Test 1: H0: Y_{2t} does not granger cause $Y_{1t,}$ with: $\boldsymbol{b_1^1 = b_2^1 = \cdots = b_P^1 = 0.}$

Test 2: H2: Y_{1t} does not granger cause Y2t, with: $\boldsymbol{a_1^1 = a_2^1 = \cdots = a_P^1 = 0.}$

Sims (1980), with a slightly different approach of the Granger causality test, by considering the future value of Y_{1t} and if it can be predicted by the present value of Y_{2t}, that means that Y_{2t} cause Y_{1t}. This test can be explained by the VAR model equations with testing the significance of the parameters with a classic coefficient nullity Fisher test as explained by the Test 1 and Test 2 previously mentioned.

Chapter 5: Empirical Results

In the first part of our empirical results, as the main results we will study the OPEC Crude Oil market, by analyzing and modeling the monthly data of their prices with a GARCH Model.

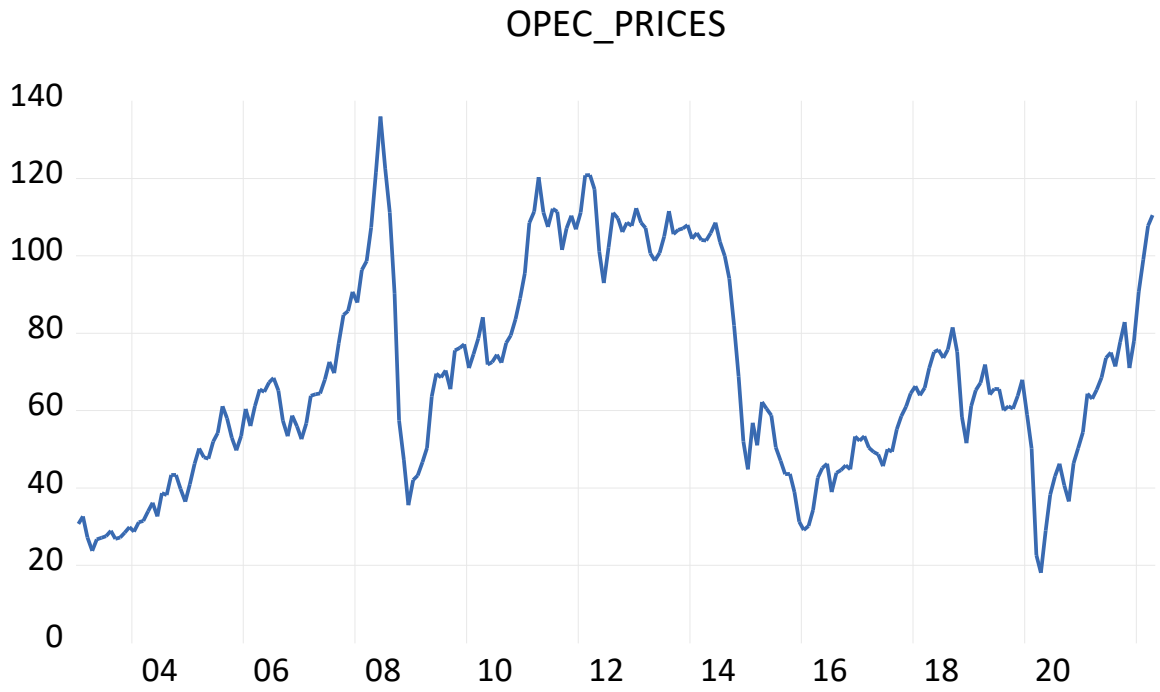
The second part as an additional analysis, we will study the relation between the GDP of Algeria and the OPEC Crude Oil prices, to see if major events impacting the oil prices can affect the Algerian economy and how it is dangerous for our economy to be dependent on assets who has the particularity that they are risky because of black Swan Events and how making decisions based on forecasting future in economic fields can be disastrous.

5.1- Main Results:

5.1.1- Graphical Analysis:

The graphic of the monthly OPEC Crude Oil prices from January 2003 to April 2022:

Figure 5.1: Graphic of The OPEC Crude Oil Prices Data (source: EViews 12 Output)



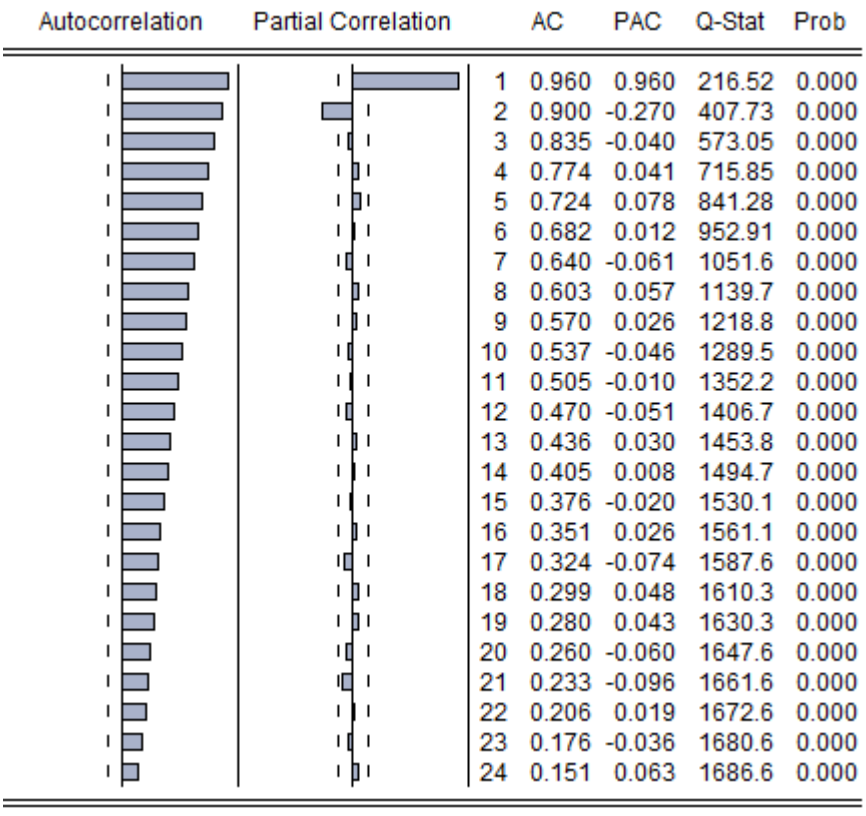
From the graphic, we can see the large raising period between January 2003 until June 2008, that period of a large fall between July 2008 until December 2008 coincides with the first Black Swan Event we will study, it is the subprime crises, the period between January 2009 until April 2011 we see a raising of the prices followed by a stable period with low volatility between May 2011 until June 2014, the second Black Swan Event began in that period with the collapse of Oil Market between July 2014 until January 2016 followed by a little raising of

prices until the third black swan event, the covid-19 crisis has begun on March 2020 with a very high fall of prices, the recovery of prices is until the current 2021, we finish with the fourth and last black swan event, the beginning of the Ukraine war was in February 2022 and he is qualified as an unpredictable event with major effect on the commodities market, especially the oil market.

5.1.2- Seasonality test:

For the preliminary analyses, we will try to detect if there is a seasonality represented in our monthly data, for doing that we will analyses the correlogram of the series named OPEC_PRICES with lags up to 24, the next figure will represent the correlogram of the series made by the econometric software EViews 12.

Figure 5.2: Correlogram of the monthly series OPEC_PRICES with 24 lags (source: EViews 12 Output)



	AC	PAC	Q-Stat	Prob
1	0.960	0.960	216.52	0.000
2	0.900	-0.270	407.73	0.000
3	0.835	-0.040	573.05	0.000
4	0.774	0.041	715.85	0.000
5	0.724	0.078	841.28	0.000
6	0.682	0.012	952.91	0.000
7	0.640	-0.061	1051.6	0.000
8	0.603	0.057	1139.7	0.000
9	0.570	0.026	1218.8	0.000
10	0.537	-0.046	1289.5	0.000
11	0.505	-0.010	1352.2	0.000
12	0.470	-0.051	1406.7	0.000
13	0.436	0.030	1453.8	0.000
14	0.405	0.008	1494.7	0.000
15	0.376	-0.020	1530.1	0.000
16	0.351	0.026	1561.1	0.000
17	0.324	-0.074	1587.6	0.000
18	0.299	0.048	1610.3	0.000
19	0.280	0.043	1630.3	0.000
20	0.260	-0.060	1647.6	0.000
21	0.233	-0.096	1661.6	0.000
22	0.206	0.019	1672.6	0.000
23	0.176	-0.036	1680.6	0.000
24	0.151	0.063	1686.6	0.000

Following the results of the Correlogram, we conclude that the monthly OPEC_PRICES series does not have a problem of seasonality, according to the autocorrelation function with decreasing values from the first lag until the last one.

5.1.3- Stationarity test:

For the stationarity test, as announced in the methodology chapter, we will refer to the ADF augmented Dickey Fuller test for the monthly prices of The OPEC Crude Oil, the results of the test are in the next table:

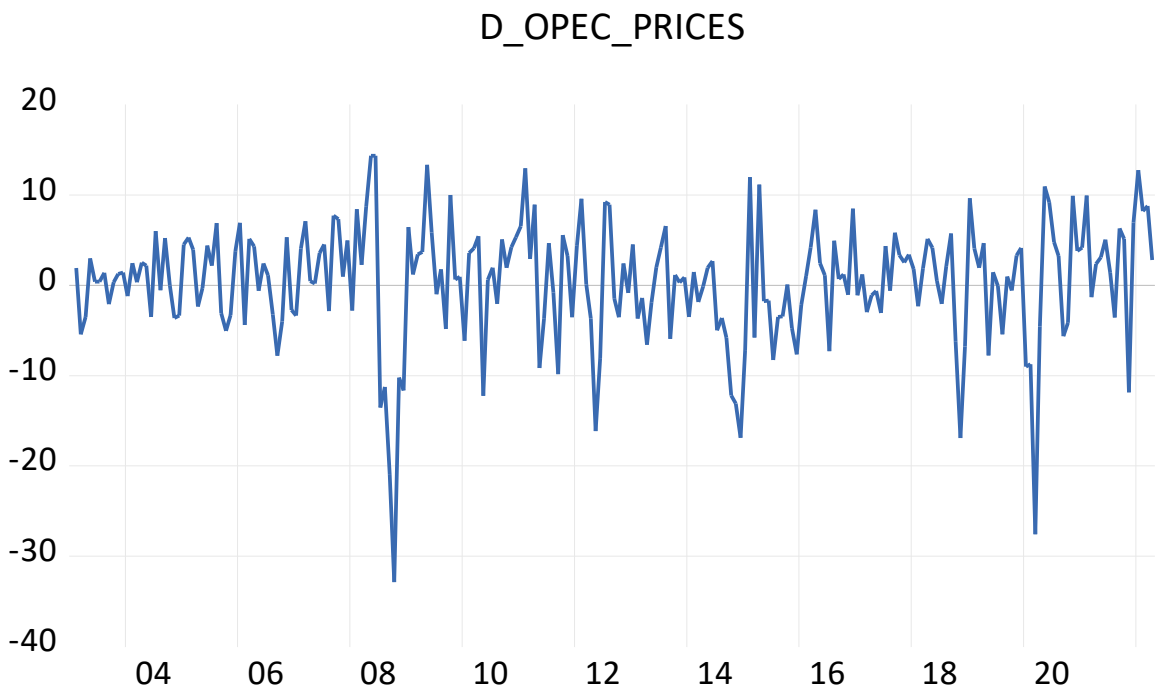
Table 5.1: ADF Stationarity with the model 4 – without trend or intercept

Variables	Level			First Difference			
	Test Statistics	Critical Value at 5%	ADF p-value	Test Statistics	Critical value at 5%	ADF p-value	Order of integration
OPEC_PRICES	-0.4334	1.9422	0.5257	-10,599	-1.9422	0.0000***	I (1)

Note: The stars (***), (**), (*) means the significance in 1%, 5%, 10% respectively.

After testing the model 6 of The ADF test, who contain a trend and intercept, we have concluded that the trend is not significant at 5% with an ADF probability of (0.2510 < 0.05), the model 5 of the ADF with an intercept is also not significant at 5% with an ADF probability of (0.0852 < 0.05), we go to the model 4 without intercept and trend, the results are represented in the Table 5.1, the OPEC_Prices series is stationary in the first difference without a trend and an intercept.

Figure 5.3: Graphic of the differenced stationary OPEC_P series (source: EViews 12 Output)



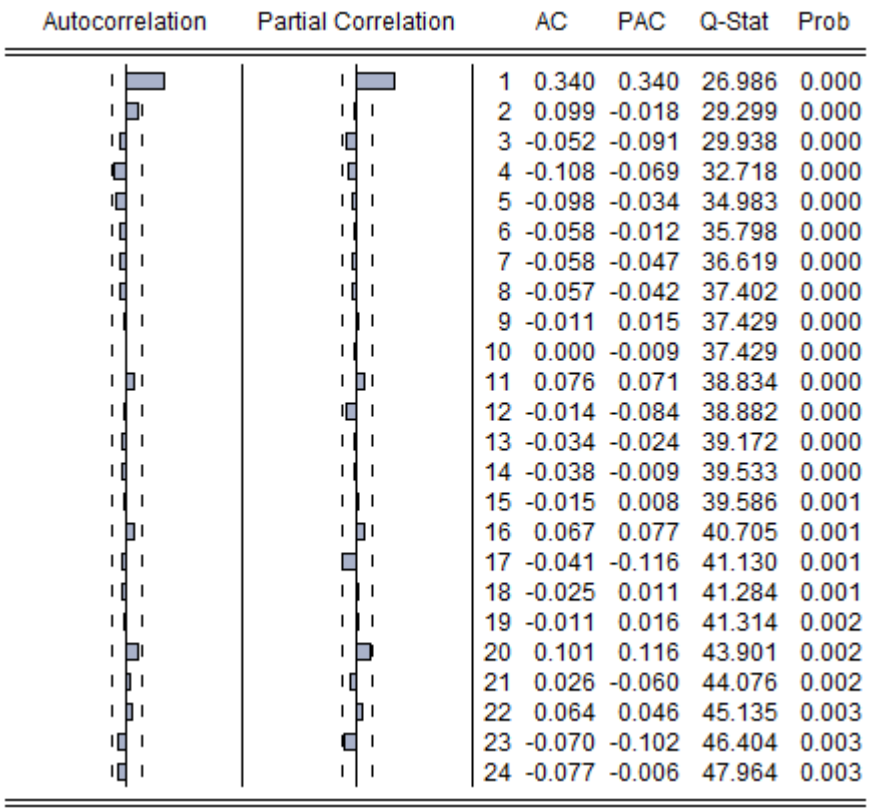
In this graphic, we see a stationary differenced series of the OPEC prices named D_OPEC_PRICES, the series revolves around its mean over time with a much better and stable variance compared to the normal series.

5.1.4- Estimating an ARMA (p, q) model:

With the stationary series (D_OPEC_PRICES) we can proceed to estimating an ARMA (p, q) model, as the first condition of the stationarity is satisfied.

The first step for estimating an ARMA (p, q) model is to refer to the correlogram of the stationary series, as the autocorrelation and the partial autocorrelation function for determining the (q) and (p) order of the ARMA (p, q) model.

Figure 5.4: Correlogram of the stationary series D_OPEC_PRICES (source: EViews 12 Output)



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.340	0.340	26.986	0.000
		2	0.099	-0.018	29.299	0.000
		3	-0.052	-0.091	29.938	0.000
		4	-0.108	-0.069	32.718	0.000
		5	-0.098	-0.034	34.983	0.000
		6	-0.058	-0.012	35.798	0.000
		7	-0.058	-0.047	36.619	0.000
		8	-0.057	-0.042	37.402	0.000
		9	-0.011	0.015	37.429	0.000
		10	0.000	-0.009	37.429	0.000
		11	0.076	0.071	38.834	0.000
		12	-0.014	-0.084	38.882	0.000
		13	-0.034	-0.024	39.172	0.000
		14	-0.038	-0.009	39.533	0.000
		15	-0.015	0.008	39.586	0.001
		16	0.067	0.077	40.705	0.001
		17	-0.041	-0.116	41.130	0.001
		18	-0.025	0.011	41.284	0.001
		19	-0.011	0.016	41.314	0.002
		20	0.101	0.116	43.901	0.002
		21	0.026	-0.060	44.076	0.002
		22	0.064	0.046	45.135	0.003
		23	-0.070	-0.102	46.404	0.003
		24	-0.077	-0.006	47.964	0.003

According to the results of the correlogram, with observing the Autocorrelation (AC) function we see an MA (1) and with Partial Autocorrelation (PAC) we see an AR (1), we conclude with a (max of lags = 3) that we have an ARMA (1, 1) process, we can estimate it and choose the significant model with a minimum of information criteria (AIC), (SC) and (HQ).

Table 5.2: The AR (1) Retained Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR (1)	0.340164	0.047601	7.146197	0.0000***
SIGMASQ	38.49959	2.767213	13.91277	0.0000***
R-squared	0.114152	Mean dependent var		0.345584
Adjusted R-squared	0.110284	Akaike info criterion		6.506373
S.E. of regression	6.231840	Schwarz criterion		6.536178
Sum squared resid	8893.406	Hannan-Quinn criterion.		6.518394
Log likelihood	-749.4861			

Note: The stars (***), (**), (*) means the significance in 1%, 5%, 10% respectively.

Table 5.3: The MA (1) Retained Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MA (1)	0.305215	0.053477	5.707395	0.0000***
SIGMASQ	39.01766	2.676391	14.57846	0.0000***
R-squared	0.102232	Mean dependent var		0.345584
Adjusted R-squared	0.098311	Akaike info criterion		6.519631
S.E. of regression	6.273630	Schwarz criterion		6.549435
Sum squared resid	9013.080	Hannan-Quinn criterion.		6.531652
Log likelihood	-751.0174			

Note: The stars (***), (**), (*) means the significance in 1%, 5%, 10% respectively.

After analyzing the results of the estimation, we conclude that the significant model to retain is an AR (1) without an intercept, because of the criterions, the AR (1) model have the lowest AKAIKE Criterion (AIC), SCHWARZ Criterion (SC) and Hanna-Quinn Criterion (HQ).

5.1.5- ARCH Effect Heteroskedasticity test:

After retaining the AR (1) model without intercept, we will do a heteroskedasticity test for determining if the model contain an ARCH Effect for estimating the GARCH model. The test reveals that we have an ARCH Effect with a probability of ($0.0273 < 0.05$), we can estimate a GARCH (1, 1) model, the coefficient of the residuals squared retarded by one period, is positive and significant.

Table 5.4: ARCH Heteroskedasticity Test

Panel A:

F-statistic	4.936085	Prob. F (1,228)	0.0273**
Obs*R-squared	4.873867	Prob. Chi-Square (1)	0.0273**

Note: The stars (***), (**), (*) means the significance in 1%, 5%, 10% respectively.

Panel B:

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	33.02356	5.605456	5.891326	0.0000***
RESID^2(-1)	0.145583	0.065527	2.221730	0.0273**

R-squared	0.021191	Mean dependent var	38.65281
Adjusted R-squared	0.016898	S.D. dependent var	76.47978
S.E. of regression	75.83086	Akaike info criterion	11.50355
Sum squared resid	1311073.	Schwarz criterion	11.53344
Log likelihood	-1320.908	Hannan-Quinn criter.	11.51560
F-statistic	4.936085	Durbin-Watson stat	2.064258
Prob(F-statistic)	0.027284		

Note: The stars (***), (**), (*) means the significance in 1%, 5%, 10% respectively.

5.1.5- Estimating a GARCH (1, 1) Model:

The results of the estimation of the GARCH (1, 1) model are represented in Table 5.5, with an AR (1) who is D_OPEC_PRICES (-1), the differenced series retarded by one period and an intercept. The Error Distribution is at **the normal law (gaussian)**.

Mean Equation: D_OPEC_PRICES = C + A*D_OPEC_PRICES (-1) + ε_t

Variance Equation: GARCH = C + B* ε_{t-1}^2 + D*GARCH (-1)

Table 5.5: The GARCH (1, 1) Estimated

Panel A:

Mean Equation

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.552745	0.335340	1.648314	0.0993*
D_OPEC_PRICES (-1)	0.134004	0.076302	1.756220	0.0791*

Note: The stars (***), (**), (*) means the significance in 1%, 5%, 10% respectively.

Panel B:

Variance Equation

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	5.546276	2.790753	1.987376	0.0469**
RESID (-1) ^2	0.440808	0.100290	4.395339	0.0000***
GARCH (-1)	0.477871	0.093788	5.095213	0.0000***

R-squared	0.071547	Mean dependent var	0.338739
Adjusted R-squared	0.067475	S.D. dependent var	6.620379
S.E. of regression	6.393124	Akaike info criterion	6.358070
Sum squared resid	9318.824	Schwarz criterion	6.432811
Log likelihood	-726.1780	Hannan-Quinn criter.	6.388219
Durbin-Watson stat	1.563123		

Note: The stars (***), (**), (*) means the significance in 1%, 5%, 10% respectively.

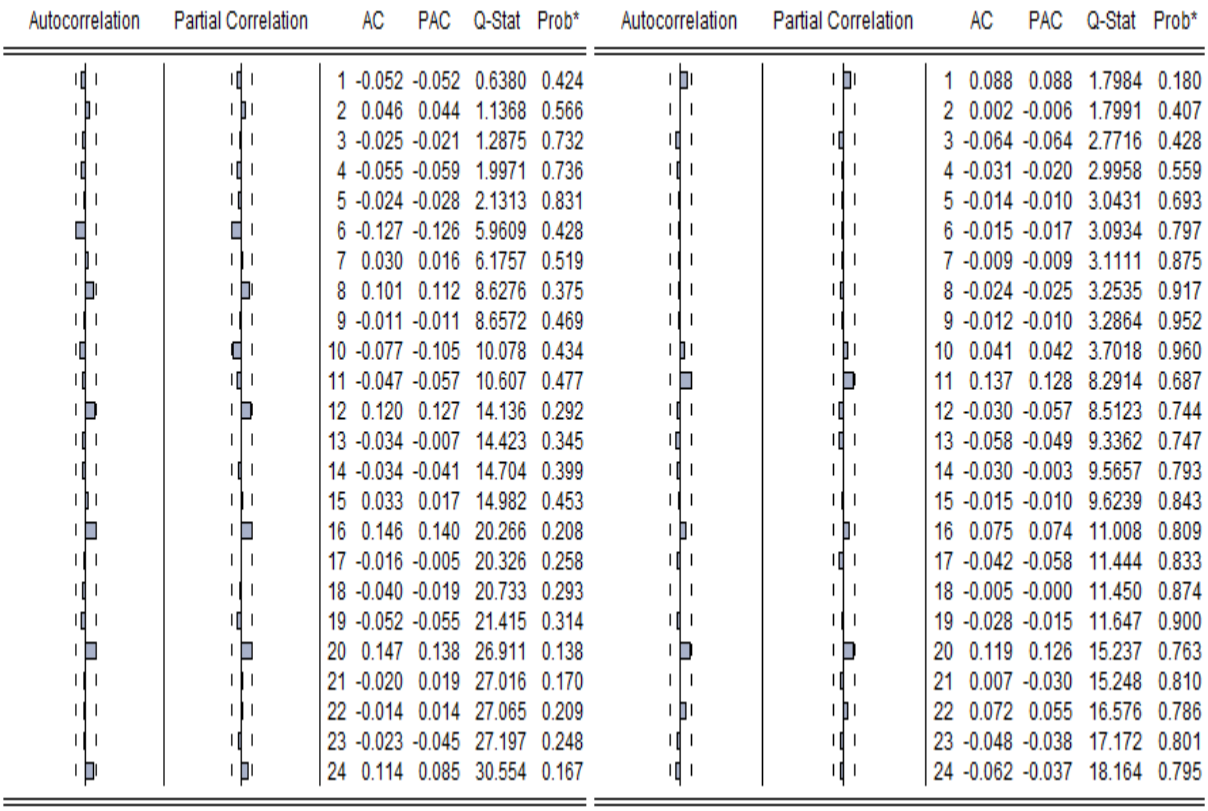
The results of the estimation output by EViews 12 are significant at 10% level of risk for the mean and the variance equation, the parameters of the both equations are globally significant with a probability less than (p value <0.10), we accept this model, we can make the series of the GARCH Variance for making an analysis about the volatility captured by the model concerning the oil prices. The R-squared and the Adjusted R-squared are very low at 7.15% and 6.74% respectively.

Table 5.6: Heteroskedasticity Test with ARCH-LM

F-statistic	0.626571	Prob. F (1,227)	0.4294
Obs*R-squared	0.630351	Prob. Chi-Square (1)	0.4272

The heteroskedasticity test of the GARCH (1, 1) model reveals that the model is homoscedastic, we accept the Null Hypothesis H0 with absence of Heteroskedasticity.

Figure 5.5: Correlogram of the residuals and squared residuals of the GARCH (1, 1) model (source: EViews 12 Output)

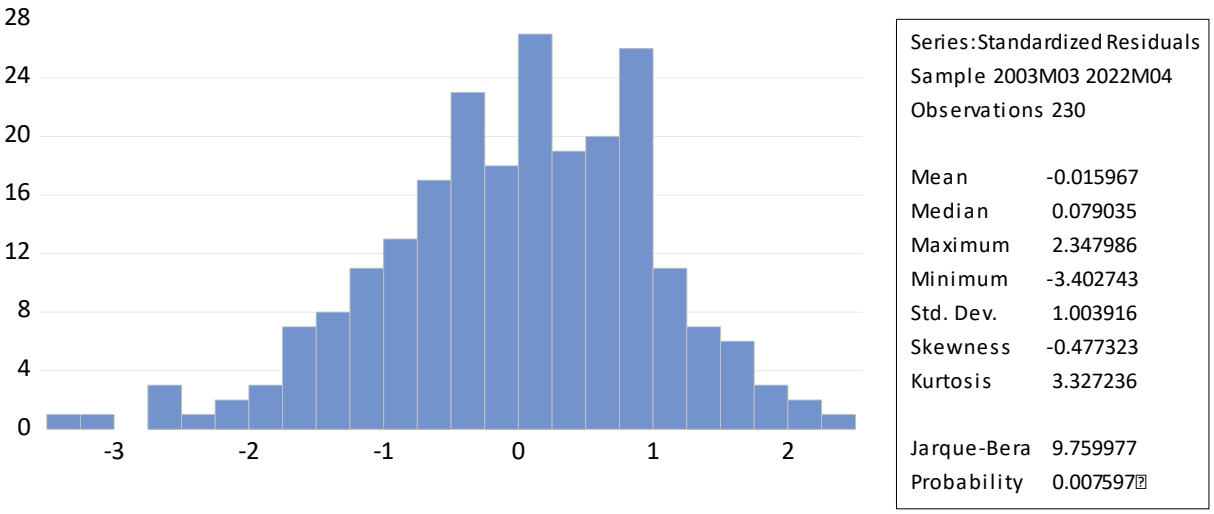


Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.052	-0.052	0.6380	0.424
		2	0.046	0.044	1.1368	0.566
		3	-0.025	-0.021	1.2875	0.732
		4	-0.055	-0.059	1.9971	0.736
		5	-0.024	-0.028	2.1313	0.831
		6	-0.127	-0.126	5.9609	0.428
		7	0.030	0.016	6.1757	0.519
		8	0.101	0.112	8.6276	0.375
		9	-0.011	-0.011	8.6572	0.469
		10	-0.077	-0.105	10.078	0.434
		11	-0.047	-0.057	10.607	0.477
		12	0.120	0.127	14.136	0.292
		13	-0.034	-0.007	14.423	0.345
		14	-0.034	-0.041	14.704	0.399
		15	0.033	0.017	14.982	0.453
		16	0.146	0.140	20.266	0.208
		17	-0.016	-0.005	20.326	0.258
		18	-0.040	-0.019	20.733	0.293
		19	-0.052	-0.055	21.415	0.314
		20	0.147	0.138	26.911	0.138
		21	-0.020	0.019	27.016	0.170
		22	-0.014	0.014	27.065	0.209
		23	-0.023	-0.045	27.197	0.248
		24	0.114	0.085	30.554	0.167

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.088	0.088	1.7984	0.180
		2	0.002	-0.006	1.7991	0.407
		3	-0.064	-0.064	2.7716	0.428
		4	-0.031	-0.020	2.9958	0.559
		5	-0.014	-0.010	3.0431	0.693
		6	-0.015	-0.017	3.0934	0.797
		7	-0.009	-0.009	3.1111	0.875
		8	-0.024	-0.025	3.2535	0.917
		9	-0.012	-0.010	3.2864	0.952
		10	0.041	0.042	3.7018	0.960
		11	0.137	0.128	8.2914	0.687
		12	-0.030	-0.057	8.5123	0.744
		13	-0.058	-0.049	9.3362	0.747
		14	-0.030	-0.003	9.5657	0.793
		15	-0.015	-0.010	9.6239	0.843
		16	0.075	0.074	11.008	0.809
		17	-0.042	-0.058	11.444	0.833
		18	-0.005	-0.000	11.450	0.874
		19	-0.028	-0.015	11.647	0.900
		20	0.119	0.126	15.237	0.763
		21	0.007	-0.030	15.248	0.810
		22	0.072	0.055	16.576	0.786
		23	-0.048	-0.038	17.172	0.801
		24	-0.062	-0.037	18.164	0.795

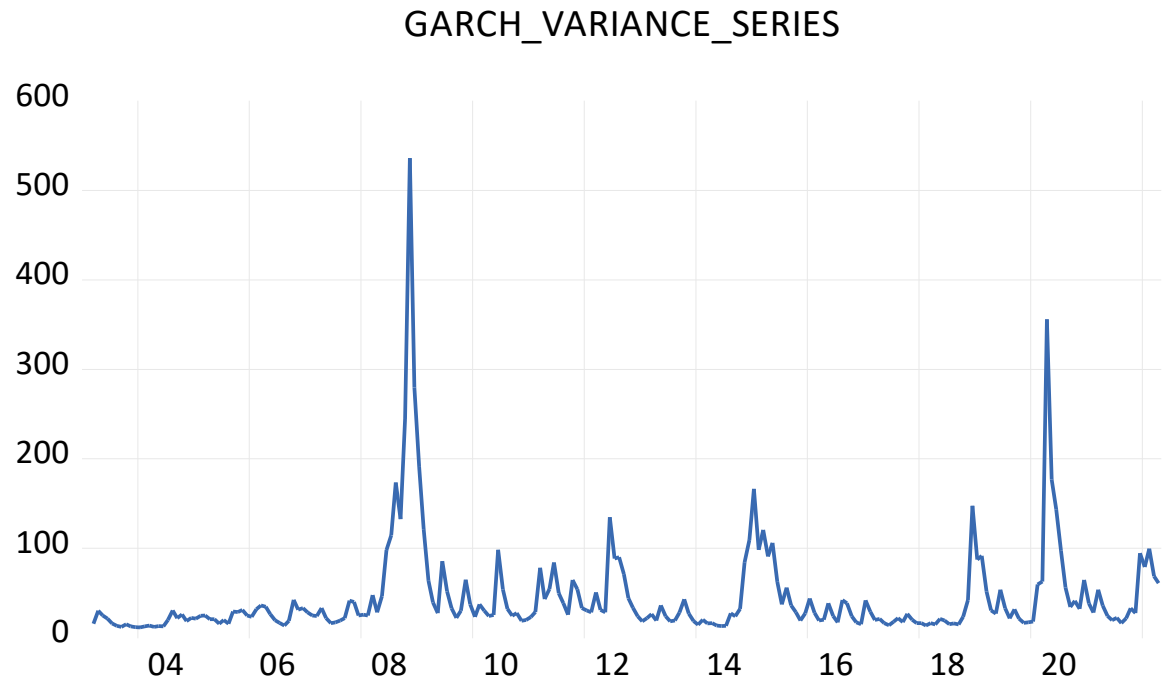
For the both correlograms, we can see that the p-values are not significant and greater than 5% level, we accept the Null Hypothesis H0 of the absence of autocorrelation in residuals.

Figure 5.6: The Histogram of the GARCH (1, 1) model (source: EViews 12 Output)



The histogram and the Jarque-Bera Value with p-value (0.007597 < 0.05) means that the model doesn't follow a normal law distribution, the hypothesis of the normality of the residuals is rejected.

Figure 5.7: Graphic of the GARCH Variance series (source: EViews 12 Output)



The graphic of the GARCH Variance series made on the estimated GARCH model offer a large view concerning the predictability of Black Swan Events, when we see the huge variance of the Subprime Crisis during the period of 2008-2009, the Covid-19 crisis during the year of 2020 or the collapse of 2014 until 2016 in the Oil market like the OPEC Crude Oil, those events have the particularity that they are not predictable, no matter the sophisticated model that we will use, the problem is maybe we don't have all the information concerning the markets or else, we don't know the events that can come from other environments that are not contained in our variables and can affect the Oil Market.

5.1.6- Introduction of Dummy Variables on the GARCH (1, 1) model:

For examining the effect of the Black Swan Events that are contained on the series of the OPEC Prices, we will make a model using a dummy's variables, we have five dummy variables, the first one is the Subprime Crisis, the second is the Collapse of 2014 in oil prices, the third is the Covid-19, the fourth is the Ukraine War and the last one named Crisis who englobes all the fourth previous crises in one dummy variable.

After testing the significance of the dummy variables, the unique retained model is the variable CRISIS who englobes all the crisis in one dummy variable, the variable is significant only in the mean equation at 10% level of risk but not in the variance equation, we have deleted it from the variance equation, the estimation output is represented in the next table.

Table 5.7: GARCH (1, 1) Model with dummy CRISIS variable.

Panel A:

Mean Equation

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.660859	0.361240	1.829418	0.0673*
D_OPEC_PRICES (-1)	0.129453	0.077370	1.673176	0.0943*
CRISIS	-1.936549	0.937985	-2.064584	0.0390**

Note: The stars (***), (**), (*) means the significance in 1%, 5%, 10% respectively.

Panel B:

Variance Equation

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	4.686712	2.369594	1.977855	0.0479**
RESID (-1) ^2	0.396458	0.101282	3.914392	0.0001***
GARCH (-1)	0.535677	0.090228	5.936938	0.0000***

R-squared	0.098591	Mean dependent var	0.338739
Adjusted R-squared	0.090649	S.D. dependent var	6.620379
S.E. of regression	6.313186	Akaike info criterion	6.354602
Sum squared resid	9047.385	Schwarz criterion	6.444291
Log likelihood	-724.7792	Hannan-Quinn criter.	6.390781
Durbin-Watson stat	1.591282		

Note: The stars (***), (**), (*) means the significance in 1%, 5%, 10% respectively.

We conclude that the dummy variable of the four-crisis included in the series of the OPEC prices have a significance in the mean equation and not in the variance equation, that means that even if the including of this variable those events are not normal events that follows a gaussian normal law to predict them by using the past of the series, the deviation of those events is so huge to make predictions on those events and to understand clearly their effects on the oil prices.

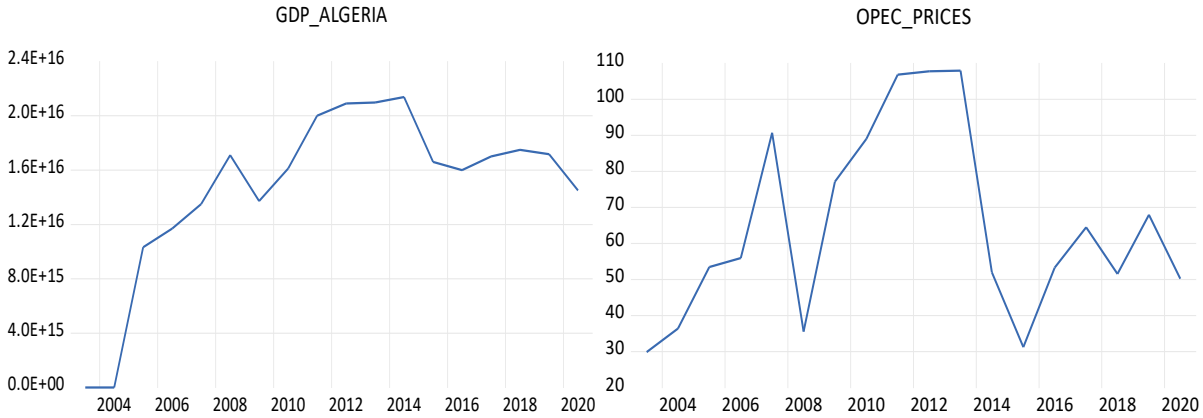
5.2- Additional Analysis:

To see if the variations of the OPEC Crude Oil prices have an impact on the economy of Algeria, we will analyze those two variables by making a VAR (p) model and seeing if there is a relation of causality between those two series. The two series of GDP of Algeria and the OPEC prices are annual series, with a period from 2003 to 2020.

5.2.1- Graphical Analysis:

The analyses of the graphic the annual series GDP of Algeria and OPEC prices:

Figure 5.8: Graphic of the GDP of Algeria and OPEC prices (source: EViews 12 Output)



The graphic of those normal series, as we see both graphics contain effects from Black Swan Events like the subprime crisis, the collapse of 2014 on oil market, the covid-19, we will search in this part of analyses to determine if huge variations of Black Swan Events in oil market can influence the GDP of Algeria, the economy of Algeria is hugely dependent on revenues made by the trade of oil.

5.2.2- Stationarity Test:

The stationarity test with an ADF method of the two variables is represented on the next table.

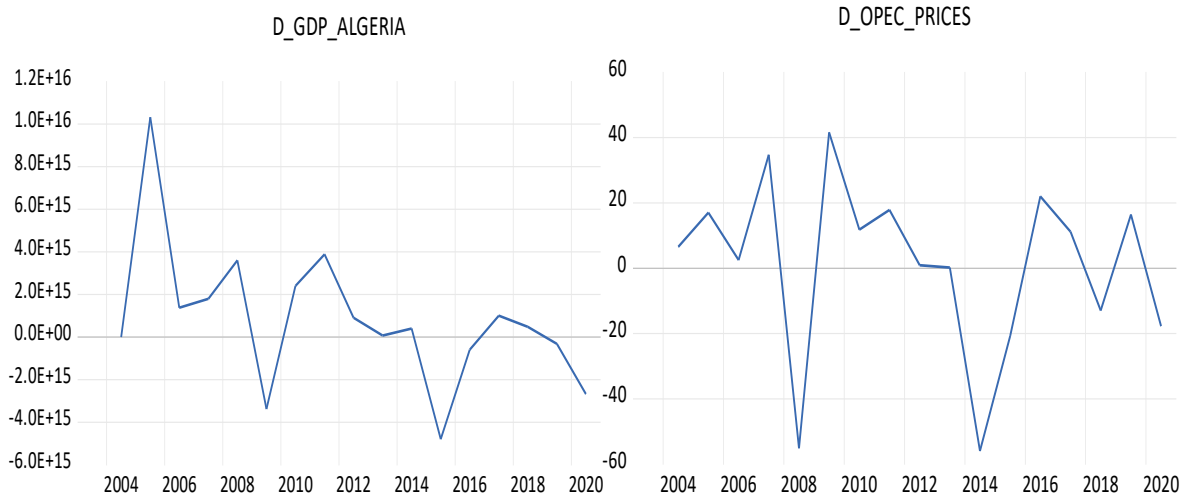
Tables 5.8: Stationarity test for the both of GDP Algeria and OPEC Prices

Variables	Level			First Difference			
	Test Statistics	Critical Value at 5%	ADF p-value	Test Statistics	Critical value at 5%	ADF p-value	Order of integration
OPEC_PRICES	-0,6496	-1,9628	0,4208	-4,9882	-1,9644	0.0001***	I (1)
GDP_ALGERIA	0,0457	-1,9628	0,6838	-3,4531	-1,9644	0,0019***	I (1)

Note: The stars (***), (**), (*) means the significance in 1%, 5%, 10% respectively.

The both series are integrated (1) order, the both are tested in the model 4 of Augmented Dickey fuller, the trend and the intercept are insignificant therefore removed from the model 6 and 5 respectfully for the trend and the intercept. We have created a differenced series for both.

Figure 5.9: Graphic of the differenced series named D_GDP_ALGERIA and D_OPEC_PRICES (source: EViews 12 Output)



5.2.3- Estimating a VAR (p) Model:

The first step of estimating a VAR (p) model is to have a stationary series, passed this step we can estimating our model. The first thing is to determine how many (p) lags for the VAR model, we will refer to the information criterions AKAIKE Criterion (AIC), SCHWARZ Criterion (SC) and Hanna-Quinn Criterion (HQ), the model who minimize the criterion are retained.

Table 5.9: Criterion information of the VAR (p) Model with 4 Lags Max

Lag	AIC	SC	HQ
0	83.47748	83.56440	83.45962
1	82.92062*	83.18137*	82.86702*
2	83.35642	83.79100	83.26710
3	83.16105	83.76945	83.03599
4	83.14246	83.92470	82.98168

Note: The Star (*) means that the criterion is retained as the minimum.

As showed by the Table 5.8, the retained model with minimum of information criteria value is a VAR (1) with one lag period, the next step is to estimate it.

Table 5.10: Estimating a VAR (1) model

	D_GDP_ALGERIA	D_OPEC_PRICES
D_GDP_ALGERIA (-1)	0.000614	-7.33E-18
	(0.23673)	(2.3E-15)
	[0.00259]	[-0.00325]
D_OPEC_PRICES (-1)	7.11E+13	-0.264571
	(2.9E+13)	(0.27193)
	[2.49076] **	[-0.97296]
C	7.36E+14	1.500841
	(8.0E+14)	(7.64057)
	[0.91862]	[0.19643]
R-squared	0.323126	0.067903
Adj. R-squared	0.218992	-0.075497
F-statistic	3.102976	0.473521
Log likelihood	-591.4036	-74.85515
Akaike AIC	74.30046	9.731893
Schwarz SC	74.44532	9.876754
Log likelihood		-665.6360
Akaike information criterion		83.95450
Schwarz criterion		84.24423
Number of coefficients		6

Note: the stars (**) means that the coefficient is significant at 5% level of risk. The values between two parentheses are the standard deviation, those between two square brackets are the t-student values.

The VAR (1) model represented by two equations is explained here:

$$\mathbf{D\_GDP\_ALGERIA = C + A*D\_GDP\_ALGERIA\ (-1) + B*D\_OPEC\_PRICES\ (-1) + } \boldsymbol{\varepsilon_t}$$

$$\mathbf{D\_\ OPEC\_PRICES = C + H*D\_OPEC\_PRICES\ (-1) + Z*D\_GDP\_ALGERIA\ (-1) + } \boldsymbol{\varepsilon_t}$$

The parameters of the model for the most are not significant, except the parameter of the exogenous variable D_OPEC_PRICES (-1) in the equation of the endogenous variable D_GDP_ALGERIA.

5.2.4- Granger Causality test:

In this part we will make a Granger causality test for the two variables D_GDP_ALGEIA and D_OPEC_PRICES with one lag order as defined by the VAR (1) retained model.

Table 5.11: Granger Causality test for D_OPEC_PRICES and D_GDP_ALGERIA variables

Null Hypothesis	Obs	t-statistics	p-value
D_OPEC_PRICES does not Granger Cause D_GDP_ALGERIA	16	6.20388	0.0271**
D_GDP_ALGERIA does not Granger Cause D_OPEC_PRICES		1.1E-05	0.9975

Note: The stars (**) means that the value is significant at 5% level of Risk

According to the granger test, the prices of OPEC Crude Oil can cause as the sense of Granger the GDP of Algeria, this reveals that the economy of Algeria have the same fluctuations as the variations of the OPEC Crude Oil Market, the present of the OPEC prices (t) can affect the future of the GDP of Algeria (t+1), that means only one thing, the Algerian Economy is dependent on the OPEC Crude Oil Market especially the SAHARA BLEND, who is the name of the Algerian Oil traded in the world market of the commodities.

5.2.5- Modeling with OLS Method:

In the VAR (1) model with the equation of the GDP of Algeria we have seen the parameter of the OPEC prices retarded by one period significant at 5% level, the Granger Causality Test reveals a unilateral causality relation between the series of OPEC Crude Oil prices and the GDP of Algeria, we can make a last model for expressing this relation as correcting the VAR (1) model by deleting all non-significant parameters.

Table 5.12: Modeling with OLS Method

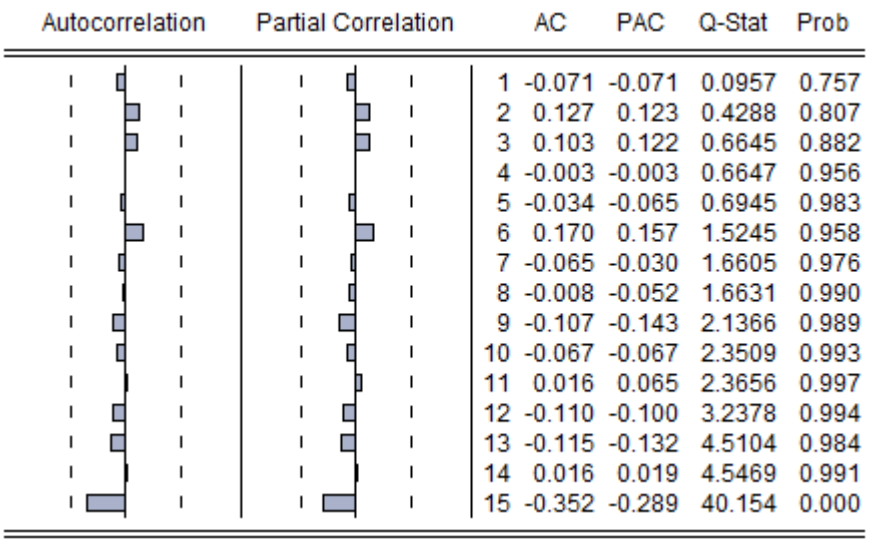
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D_OPEC_PRICES (-1)	7.35E+13	2.74E+13	2.684712	0.0170**
R-squared	0.274243	Akaike info criterion		74.12019
Adjusted R-squared	0.274243	Schwarz criterion		74.16847
Log likelihood	-591.9615	Hannan-Quinn criter.		74.12266
Durbin-Watson stat	1.184292			

Note: The stars (**) means that the parameter is significant in 5% level of risk

The Model is globally significant at 5% level, the R^2 and the adjusted R^2 represent 27% who is very low, the goal is only to represent the relation between the GDP of Algeria and the OPEC Crude Oil retarded by one period, this model can testify the huge influence of the Oil Prices on the economy of Algeria. The positive coefficient of the D_OPEC_PRICES(-1) explains that the recent past of the Opec prices can affect the GDP of Algeria in the present.

When we test the heteroscedasticity and the autocorrelation of this model:

Figure 5.10: Correlogram of the OLS model (source: EViews 12 Output)



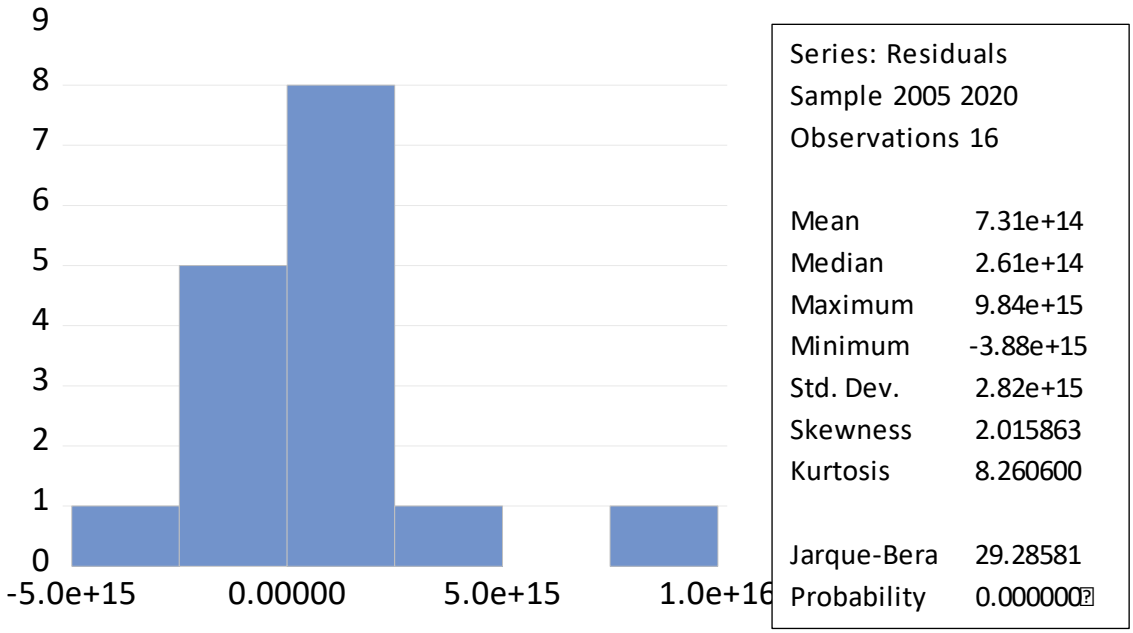
The Model does not have an autocorrelation problem, as we accept the null H0 hypothesis as the absence of the autocorrelation, with Probabilities (p-values > 0.05).

Table 5.13: White Heteroskedasticity Test

F-statistic	0.604129	Prob. F (1,14)	0.4499
Obs*R-squared	0.661872	Prob. Chi-Square (1)	0.4159
Scaled explained SS	2.458103	Prob. Chi-Square (1)	0.1169

The White Heteroskedasticity test reveals that the model is homoscedastic, we accept the Null Hypothesis H0, absence of heteroskedasticity.

Figure 5.11: Normality Test with Histogram (source: EViews 12 Output)



The test of normality with Jarque-Bera test reveals that the residuals does not follow a normal distribution law, we accept H1 with probability of Jarque-Bera lower than 5% level. The positive value of the skewness (2.015) traduce that the tail of the distribution is spreading on the right side with a higher mean than the median. The kurtosis value of 8.26 traduce a Leptokurtic with a very long and skinny tail of the distribution.

5.3- Discussing the results:

The results of this empirical part suggest that capturing Black Swan events by econometric models, such as GARCH, is not an easy task. This is because the markets for oil are highly volatile those of other risky asset are affected by several unpredictable events, which makes econometric models as inefficient too for forecasting. When econometrics is used to

forecast asset volatility, it need pay a careful attention to the potential effect of Black Swan events, which cannot easily be quantified or used in the modelling process.

Elmezouar *et al.* (2014) have shown in their study, that there is a bilateral relation of causality (Granger Causality) between the GDP of Algeria and the oil prices. In our case, there is uniquely a unilateral causality between OPEC prices and the GDP of Algeria, as the OPEC crude oil prices cannot be affected by the Algerian economy. Nevertheless, in another way, the oil prices are hugely affected by unpredictable events that affect negatively (decreasing prices) or positively (increasing prices) the Algerian economy.

This kind of dependence traduce a certain risk of instability in the Algerian economy, a fall in oil prices can create a recession, many sectors and private societies can be hugely affected, when we know that our economy is clearly not well diversified.

Summary and Conclusion

Econometrics is an incredible tool for analyzing economic data and understanding past tendencies, The problem of black swan event is its unpredictability. while the first objective of the econometrics is to forecast future for taking decisions, forecasting future with events that have huge deviations in variance is not an easy task. This because an unseen volatility affects the series distribution, making difficult for even the most sophisticated models to predict future.

In our thesis we have presented the limits of the econometric methods and models that are considered excellent in our field for forecasting the future, followed by empirical results, we have seen that the presence of event like Black Swans, can false all the work of forecasting, the risk increase followed by extreme variations like the event of Subprime crisis, in those situations the normal law is highly violated.

The empirical results traduce the danger of being tributary on extreme hazards and taking decisions based on forecasting unknown future, if an unfortunate Black Swan event should arrive, the effect for the one who didn't expect it should be very extreme, if it is a negative black swan event it will be a dramatical disaster as we have seen in the Covid-19 crisis.

The economy of Algeria is hugely dependent on the Oil Market as principal revenues, the black swan events that have occurred which are mentioned in our work, generally had negative impact, because of their direct correlation on the prices if Oil, what results recession in Algeria, PhD's Hicham Ayad says: *"Algeria as one of the oil exporting countries produces an average of 1.3 million barrels per day, and with more than 60% of total government revenues, it's clear that oil prices are the most important factor and key factor to be considered in the consideration of economic policy. After the collapse of oil prices in 2014, the Algerian economy entered a real crisis according to the large decline of its total income from 60 billion dollars in 2015 to 27.5 billion in 2016, and this is what eroded the foreign exchange reserves with a fall from 193 billion dollars in 2013 to 105 billion in 2017 and then to 50 billion in 2019. As a response to this collapse, the Algerian government pursued an austerity policy in 2016 by reducing its expenditures and increasing its taxes in addition to stopping many investments and projects which has led to an increase in the unemployment and poverty rates (from 9.5 to 12% for unemployment and from 9 to 11% for poverty between 2014 and 2018 respectively). This problem continued with the beginning of the year 2020 as the COVID-19 disease that struck*

China at the end of 2019 spread to all countries around the world, this is as a consequence reduced the global demand for oil when prices fell to 22 dollars in mid-March."[19]

Recommendation For Policy Makers:

The changing nature of the economic environment make it very complex for analyzing, for understanding and even for forecasting, our Algerian government never understood that depending on hazard makes things worse, taking decisions based on forecasting future is being the most catastrophic thing to do especially when Black Swan Events occurs.

In finance, the most exposed portfolio is the one who contain a lot of risks, following the modern portfolio theory, the Oil Market as the major revenues of the Government, in the recent war of Ukraine we have seen how the effect can be benefic for the states who are Oil producers and exporters, and dramatic for the importers, but it is the inverse when the prices go down like in Covid-19, in some countries like the United States the Crude Oil prices during the pandemic have reached negative prices, that traduce the dangerous situation of depending on risky assets like the commodities market, where a forecast is entirely useless and rare events occurs often.

Our Algerian government should be warned on the danger of this dependency that can include serious recessions in the future, the diversifying assets for our economy can be encouraged with more Research and Development departments, exporting scientific discoveries or future technologies can be very benefic when we know that Oil production has a limit to dry up one day like all material wealth.

The work of diversification by encouraging large investment of particular investors who are motivated with benefic projects, for earth and for the humanity, with reducing negative effects like pollution, can be a solution.

The objective for the Algerian economists is to study effects of the government policy and condemning those who are not good and creates automatically recessions and poverty, for a big African state who is considered as poor state who have a large oil production and large human resources with the wrong economic model.

[19] Hicham Ayad, M 2021, "Oil Prices and the Algerian Exchange Rate: is there any Difference with Hidden Co-Integration?", PhD Thesis, University center of Maghnia, Tlemcen, Algeria.

Limitations and suggestions for future researches:

The principle limit of our work is not being able to go far and provide real solutions, with studying the Risk Management and economic policies of growth that can be applicated to our country, but as Algerian economists we have to contribute in resolving big and fundamental questions and not to limit ourselves to forecasting the future, as what our science want us to do, preventing is a fundamental idea to face the future in term of recessions or other events with extreme Black Swan impacts but trying to forecast them is very wrong idea.

We see that the future of our science can be in considering the risk management for taking decisions by preventing things that can be those who can create severe recessions and solving them, also contributing on the development of the recent and new approach, the compartmental economy who can be a good alternative to understanding the humanity with a fundamental changing nature by psychological law and the interaction with markets especially during black swan events, that can help us to create solutions and resolving economic problems with taking into account the humanity, because of the purpose of our science as a social science.

References

Articles:

- Ada MARINESCU, “Human nature in the economic behavior based on the neoclassical economic model”, 2016, Volume XXIII, Theoretical and Applied Economics, No. 4(609), Winter, pp. 203-214.
- Bent E. S¿rensen, “Granger Causality”, ECONOMICS 7395, Spring, 2005.
- Daniel Kahneman and Amos Tversky, “Prospect Theory: An Analysis of Decision under Risk”, 2009, The Econometric Society, Econometrica, Vol. 47, No. 2 (Mar., 1979), pp. 263-291.
- Edward O. Thorp and Steven Mizusawa, “Optimal Capital Growth Versus Black Swan Insurance Part I: Mediocristan”, A Mathematician on Wall Street, Wilmott Magazine.
- Edward O. Thorp and Steven Mizusawa, “Optimal Capital Growth Versus Black Swan Insurance Part II: Extremistan”, A Mathematician on Wall Street, Wilmott Magazine.
- Elmezouar, Z.C., Mazri, A., Benzaire, M., Boudi, A. (2014). Test of Causality Between Oil Price and GDP Growth in Algeria. In: Ansari, A. (eds) Advances in Applied Mathematics. Springer Proceedings in Mathematics & Statistics, vol 87. Springer, Cham. https://doi.org/10.1007/978-3-319-06923-4_19.
- Graham Elliott and Allan Timmermann, “Economic Forecasting”, Journal of Economic Literature, Vol. 46, No. 1 (Mar., 2008), pp. 3-56.
- Ida Bell Shaw, “A History of the Development of Mathematics in the Field of Economics”, Mathematics News Letter, Vol. 8, No. 2 (Nov., 1933), pp. 31-37.
- J. PETER FERDERER, “Oil Price Volatility and the Macroeconomy”, Journal of Macroeconomics, Volume 18, Issue 1, Winter 1996, Pages 1-26
- M. W. Watson & J. H. Stock, “Time Series: Economic Forecasting”, 2001, Elsevier Science Ltd. International Encyclopedia of the Social & Behavioral Sciences, ISBN: 0-08-043076-7.
- Magda Osman, “Controlling Uncertainty: A Review of Human Behavior in Complex Dynamic Environments”, Article in Psychological Bulletin · December 2010, PubMed, DOI: 10.1037/a0017815.
- Pär Sjölander. A Stationary Unbiased Finite Sample ARCH-LM Test Procedure. Applied Economics, Taylor & Francis (Routledge), 2010, 43 (8), pp.1019 10.1080/00036840802600046. hal-00588680
- Philip Mirowski, “The When, the How and the Why of Mathematical Expression in the History of Economics Analysis”, The Journal of Economic Perspectives, Vol. 5, No. 1 (Winter, 1991), pp. 145-157.
- Robert Leonard, ““BETWEEN WORLDS,’’ OR AN IMAGINED REMINISCENCE BY OSKAR MORGENSTERN ABOUT EQUILIBRIUM ANDMATHEMATICS IN THE 1920s”, 2004, vole 26, Journal of the History of Economic Thought.
- Roberto Marchionatti, “On the application of mathematics to political economy’. The Edgeworth–Walras–Bortkievicz controversy, 1889–1891”, Cambridge Journal of Economics 2007, 31, 291–307.
- Saša Žiković, “Measuring risk of crude oil at extreme quantiles”, 2011, Proceedings of Rijeka School of Economics 29.

- Sofiane Aboura, “Is there any Black Swan hidden in the oil markets?”, 2012, Université de Paris-Dauphine, France.
- THOMAS A. BOYLAN & PASCAL F. O'GORMAN, “The critique of equilibrium theory in economic methodology: a constructive empiricist perspective”, International Studies In the Philosophy of Science, Vol. 5, No. 2, 1991.
- Wolfgang Polasek, “Nassim Nicholas Taleb: The black swan: the impact of the highly improbable”, Penguin, 2008, xiv + 400pp., 9.99GB£, 8.95e, ISBN: 978-0-141-03459-1.

Books:

- Adam Smith, “Wealth of Nations”, 1776, W. Strahan and T. Cadell, London.
- Benoit Malbranque, “Introduction a la methodologie économique”, 2013, Paris, Institut Coppet.
- François-Eric Racicot & Raymond Théoret, “TRAITÉ D’ECONOMETRIE FINANCIERE: MODÉLISATATION FINANCIÈRE.”, 2001, Presses de l’Université du Québec.
- Geoffrey M. Hodgson, “How economics forgot history, The problem of historical specificity in social sciences”, 2001, Routledge, Taylor and Francis e-Library edition.
- Joseph A. Schumpeter, “History of Economic Analysis”, 1954, Elizabeth Boody Schumpeter.
- Karl Marx, “Capital, A Critique of Political Economy”, 1887, volume one, Progress Publishers, Moscow, USSR.
- Nassim Nicholas Taleb, “The Black Swan: The Impact of the Highly Improbable”, Random House Trade Paperbacks, 2nd edition, 2010, p. xvii.
- Philippe Herlin, “Finance Le Nouveau Paradigme: Comprendre la finance et l’economie avec Manderlbrot, Taleb…”, 2010, Groupe EYROLLES, ISBN : 978-2-212-54657-6.
- Philippe Herlin, “REPENSER L’ECONOMIE: Manderlbrot, Pareto, cygnet noir, monnaie complementaire…, les nouveaux concepts pour sortir de la crise”, 2012, Groupe EYROLLES, ISBN: 978-2-212-55330-7.
- Régis Bourbonnais, “Econometrie”, 2018, 10e edition, Dunod, ISBN 978-2-10-077721-1.
- Richard Thaler, “Misbehaving. Les découvertes de l'économie comportementale”, 2019, Pocket Book.
- Thomas Sowell, “Classical Economics Reconsidered” Princeton University Press, Princeton, New Jersey.

Thesis:

- Adeleke Oluwole Adesanya, M 2014, “Strengths and Weaknesses of Anticipatory Failure Determination in Identifying Black Swan Type of Events.”, Master’s Thesis, Faculty of Science and Technology, University of Stavanger, Norwegian.
- Erik Forsman, M 2018, “Black swan: Synthesis and Future Research Directions”, Master’s Thesis in Strategic Business Development, UNIVERSITY OF VAASA

- Hicham Ayad, M 2021, “Oil Prices and the Algerian Exchange Rate: is there any Difference with Hidden Co-Integration?”, PhD Thesis, University center of Maghnia, Tlemcen, Algeria.
- Nicholas Kozeniauskas, Anna Orlik and Laura Veldkamp, “Black Swans and the Many Shades of Uncertainty” 2014, New York University and Federal Reserve Board.
- Othman Kadmiri, “Estimation et validation de modèles GARCH asymétriques en puissance multivariés à corrélations conditionnelles.”. Statistiques [math.ST]. Université Bourgogne Franche-Comté, 2018. Français. NNT: 2018UBFCD076. tel-02550853
- Philippe Herlin, “La remise en cause du modèle classique de la finance par Benoît Mandelbrot et la nécessité d’intégrer les lois de puissance dans la compréhension des phénomènes économiques”, Economies et finances, Conservatoire national des arts et metiers - CNAM, 2012. Français, NNT: 2012CNAM0830, tel-00787464**.** SCHOOL OF MANAGEMENT, Finland.
- Sina Beßlich, M 2020, “How Black Swan Events Reveal Known and Unknown Unknowns: The Case of COVID-19”, Master’s Thesis, Catolica Lisbon Business & Economics, Portugal.

Websites:

- KELLY SERVICK, “Stanford expert: 'Black swans' and 'perfect storms' become lame excuses for bad risk management”, Stanford Report, November 16, 2012, viewed in April 2022, Url: https://news.stanford.edu/news/2012/november/black-swan-risk-111612.html
- TAYLOR KUBOTA, “Stanford researchers develop a method for predicting unprecedented events”, Stanford Report, JULY 23, 2020, viewed in April 2022, Url: https://news.stanford.edu/2020/07/23/predicting-the-unpredictable/