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The impact of Covid-19 on Market Risks: an application of VaR

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A mia zia Francesca

It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so.

(Mark Twain)

Summary

ABSTRACT

2020 was a year marked by a worldwide event, the spread of Coronavirus Sars-CoV-2. From the first contagions in China, the virus spread rapidly across the planet. The first real measure to deal with this crisis was a general lockdown. Italy was the first country to adopt this drastic solution, but soon it was followed by many other European countries, the U.S.A., and then the rest of the world. The almost total lockdown of commercial activities for almost 2 months had drastic effects on the world economy. The main stock exchanges have collapsed, many companies have gone bankrupt and unemployment figures have reached very high levels. Between May and June, there was a general partial reopening, as prolonging the closures would have been economically unsustainable for many commercial activities. After a few months, the situation was not the same in various countries. In Italy, one of the areas initially most affected, the number of contagions was stable, while in other European countries such as France or Spain the figures were even worse than the March-April peak. In general, each area of the world was faced with a different situation in terms of contagions and decisions to be taken, which made even more difficult any medium-long term planning in terms of cooperation. Since September, with the end of the summer period, in Europe the situation has worsened again giving way to a real second wave, while in the rest of the world, again, each country has found itself facing very different situations from case to case (generally more critical in poorer countries). Towards the end of the year, the first vaccines appeared, but they need a very wide diffusion before showing their effects. The purpose of this paper is to determine the overall effect that Sars-Cov-2 has had on the economy of the G10 countries. To do this, the Value at Risk is used, a measure that highlights the risk of loss with a certain level of probability over a given time horizon. The VAR is applied to the main stock market indices of the G10 member countries and, after an analysis of the robustness of the historical series from 2010 to 2019, the comparison is made between 2019 and 2020. The calculation is performed with 2 different methods: parametric and non-parametric. Also the Monte-Carlo simulation will be introduced for completeness, but will not be used for the analytical part. In the conclusions were searched for possible correlations between the financial data and those strictly related to the spread of the virus.

CHAPTER 1

Coronavirus, VaR, Stock Markets

Coronavirus

Sars-Cov-2, a virus belonging to the Coronavirus family (and so commonly called) appeared between 2019 and 2020 in Hubei Province, China. The first cases of human contagion probably date back to November, although they were only released in January 2020. The species jump may have occurred in some outdoor markets in the city of Wuhan. The animal that hosted the virus before the first human infection was probably a bat, although to date a unanimous thesis on the actual origin of the virus has not yet been found. It is not even certain that the first human cases were actually in China because, precisely because of the abundant presence of bats, some neighboring regions have high probability of being the place of the first contagion. The virus has shown to be not particularly aggressive but very contagious from the beginning, which is why despite the drastic measures taken by China which, although belatedly and after underestimating the danger of spread, has quarantined the 11 million inhabitants of the city of Wuhan, its spread to the rest of the world was inevitable. The main problem, in the initial phase, was to underestimate the role of asymptomatic positives. In fact, most of the infected subjects did not present any symptoms, so the measures taken in airports around the world (measuring body temperature and isolating only subjects with obvious symptoms) proved to be completely ineffective. Already in February the infections, although still very limited in number, actually affected the whole world. In Europe the most critical situation, at least initially, was that of Italy, although it is likely that the high number of infections compared to other European countries was mainly related to the higher number of swabs carried out. In little more than a month the exponential growth of positives has forced almost the whole world to opt for a general lockdown. Although with different rules and timing depending on the area, the everyday life of each person has been disrupted. Countries such as Sweden and the U.K., which were against the lockdown, recorded such a high number of positives that they were forced to adapt to decisions taken by other countries. Symbols of this phase were images of large, almost deserted cities or entire fleets of aircraft that had been on the ground for weeks.

FIG 1.1 New York deserted during lockdown

FIG 1.2 American Airlines fleet grounded due to flight blockade

While it is true that the rules introduced following the dictates of the World Health Organization (such as often sanitizing hands, wearing masks indoors or respecting the interpersonal distance of 1.5 m) have slowed down the infection, the growth of new positives has been extremely high. At the end of April the official cases worldwide were about 3 million, at the end of September about 33, at the end of the year (INSERT CIFF).

What the lockdown allowed to do was to slow down the hospital pressure. Since the first weeks, in fact, the main problems were two: the physical condition of the most affected people (who often developed severe pneumonia) and the high number of patients that had practically filled the hospitals in the areas with more cases. The already mentioned (high) contagiousness of the virus meant that hospitals were not able to meet every demand. The Italian case in this sense was emblematic. In fact, between March and April, when the peak of positives was reached, hospitals in Lombardy, the region most affected, were collapsing. Moving patients to other regions was logistically difficult and it is plausible that many people, judged not to be serious, were unable to receive medical assistance. At the beginning of the epidemic in Italy there were 5179 places available between public and private healthcare. Gradually they were increased, also in anticipation of a possible second wave, and were increased to about 9000. That of overfilled hospitals was an issue that has in fact affected almost every country. In addition to the confinement measures and general rules dictated by the WHO, many countries have sought in technology an aid in the fight against Covid. In fact, several tracking applications have been developed, such as "Immuni" in Italy or "StopCovid" in France, with the aim of reporting to users any contact with people found positive to Covid, while protecting the privacy of everyone. However, the results were not very satisfactory because such applications work well only if they are used by at least 80% of the population, which is far from the percentage actually achieved.

Another widely used precautionary measure was to prohibit access to people from specific countries. In turn, during the various months there have been areas affected more severely than others that were on the "black list" of the various countries. In economic terms, these choices, although logical and aimed at slowing down the spread of the virus, have further worsened the situation of some sectors, such as aviation or tourism, among the most affected.

Another relevant issue, which has already begun to be discussed during the early stages of the pandemic was the vaccine. Despite some speculation that they wanted a vaccine available in a few months, the scientific community has never had doubts in indicating how 2021, however, in the second half, as the date on which this could have been ready. In fact, the protocols provide for 3 different stages on which the possibility of speeding up the actions is quite limited, due to the fact that they are necessary observations of entire months on volunteers. The two aspects in which you could instead greatly reduce the time are those related to the production and distribution of vaccine. In economic terms the vaccine is of great importance because only when this will be produced and distributed on a large scale there will be a high probability of returning to a life almost equal to the pre-Covid. The first country to develop it will also have a significant strategic advantage, which is why the U.S. and Russia are investing heavily to be the first, as are the EU countries. As far as therapies are

concerned, again there has been a very different choice between the various countries. In turn they have tried to take different paths, even if they have never reached a common agreement, on a scientific level, on which was the best option. This is a further reason why the vaccine, recognized instead as the only option to fight the virus effectively and above all permanently, is of vital importance and at the center of daily debates.

Value at Risk

Value at risk (or more simply VaR) is a risk measure applied to financial investments. It indicates the potential loss of an investment position with a certain level of confidence and over a given time horizon. It was created in investment banks to measure the market risk of assets in the portfolio (it was invented by some interns at JP Morgan), but has many other applications. The main advantage is its applicability to all types of investments, including equity, bond, derivatives and currency markets.

$$VAR = VM_i * \sigma_i * \alpha * \sqrt{t}$$

FIG 1.3 Generic formula of VaR

The most important parameters, in its general form, are:

- the holding period, i.e. the length of time the asset is held in the portfolio. There is no standard length. In commercial banks it tends to be only one day, but even 10 days or one year are commonly used holding periods
- the confidence interval. In fact, each estimate is made on a precise percentage, commonly 99% or 95%. A 99% confidence interval means that the VaR will indicate the maximum potential loss considering 99 out of 100 possible scenarios
- the exposure (with your own currency) of the position with the possible exchange rate (not present in the image shown)
- volatility

VaR is an instrument that can be calculated in several methods. It should be specified that, in the same portfolio, using different methods could lead to very different results. Underlying this is the fact that the best method is determined both by the position for which the metric is calculated and by the available data. Each type of calculation has its own characteristics, advantages and limitations. In the elaboration will be analyzed three of them, that are among the most diffused: the approach Variances-Covariances (or parametric approach); the approach with historical simulation (or NON-parametric approach); the approach with Monte Carlo simulation.

Variance-Covariance or parametric approach

Parametric VaR is one of the most popular calculation methods because of its simplicity. The model, also known as the variance-covariance approach, is based on the assumption that the losses or profits of the portfolio follow the Normal (or Gauss) distribution. What is calculated is therefore the percentile of the loss distribution that corresponds to the confidence level. The latter, as well as the time horizon, must be decided a priori and be known.

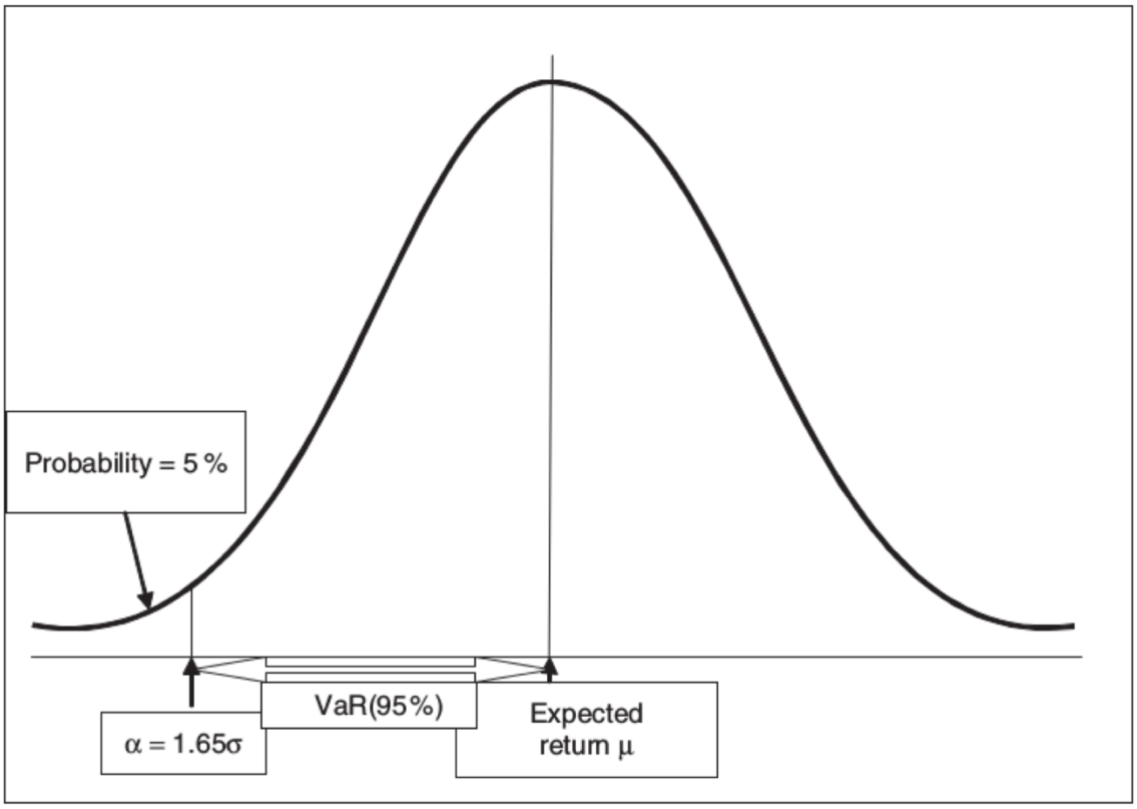


FIG 1.4 Normal distribution of parametric VaR

In the graph, we can assume that on the abscissae there are the potential profits or losses, while on the ordered ones there are their frequencies (i.e. how many times such returns have occurred). You then get the classic Gaussian curve with a bell shape. This result means that the maximum distribution of the yields is on the zero yield, while on both sides the curve goes down, thus indicating a smaller number of distributions detected. In the graph of the example the VAR will therefore correspond to a portion of the area of the curve considered. It will correspond to the area delimited the bottom by a yield variation and at the top by the portion of the curve that joins the corresponding frequencies. This area should have a probability equal to the difference between 100% probability and confidence level, so if the latter was 95% (as in the example) the VAR should correspond to a 5% probability for the expected event. Finally it should be specified that the shape of the distribution is not properly the normal one but it is leptokurtic. From definition the kurtosis is a departure from the distributive normality, concerning which a greater elongation is found in the case of leptokurtic distribution (a greater

flattening can also occur but it is not the case examined). However for simplicity of calculation we assume a classic normal distribution.

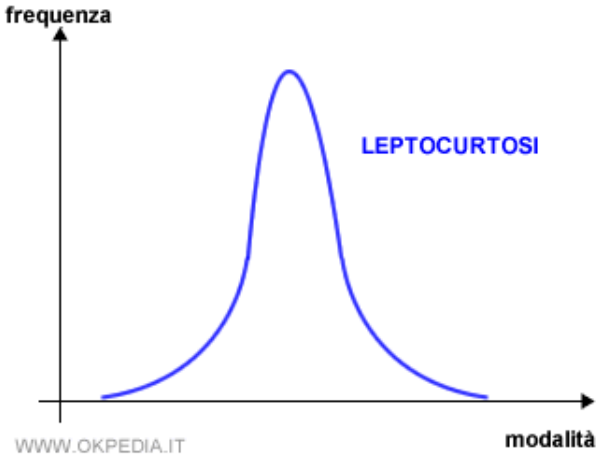


FIG 1.5 Graphic representation of leptocurtosis

It has been said that the parametric VaR has the great advantage of being, in terms of calculations, very simple. However this simplicity is compensated by some defects. The most important and noteworthy is the fact that assuming a normal distribution does not allow to identify some aspects names like fat tails and skewness.

The skewness of a distribution indicates its asymmetry. If it is positive the distribution is shifted to the right. Similarly, if negative the distribution is shifted to the left. As far as fat tails are concerned you risk to underestimate the probable losses. For this reason in some cases different distributions are used, especially in tails. The most used alternative approach is the t distribution of Student. Another limitation of the parametric approach is that the hypothesis of linear dependence between risk factors is verified only if they have very small variations.

Approach with historical simulation

Because of the limits of the parametric approach, simulation models have also been developed to calculate the VaR. The basic assumption is that the past scenarios are sufficient to construct the possible scenarios of future yield. To difference of the parametric approach does not come therefore hypothesized no distribution, but it proceeds generating an elevated number of scenarios of market from which to obtain potential profits and losses. The VaR in this case is then calculated on an empirical basis. From an analytical point of view there are 4 steps to follow:

- We collect market data for a specific period of time. Between the various periods possible profits or losses are determined. A large number of market scenarios are then obtained.
- The position of the current portfolio is re-evaluated considering the historical returns
- A (estimated) distribution of the development of the risk factors is obtained. Unlike analytical models, the distribution is not forced in any way, which is therefore empirical.
- The VaR is derived from the distribution obtained.

Compared to the parametric approach, the most important difference is that it is not necessary to estimate the distribution of returns a priori. And precisely because future returns are considered estimable on the basis of past returns, fat tails and skeweness do not create problems. The calculated VaR is also stable with respect to market variations, unless there are more substantial variations than the maximum present in the historical series considered. The limits lie instead in the computational effort, certainly greater than the parametric method, and in the fact that the hypothesis of temporal stability of the distribution may not always be verified, for example in the case of very particular historical events, such as the spread of Covid-Sars-19, which mark the beginning of an economic crisis. Another element to consider is that there can be, in no case, a greater loss than that present in the historical series. Finally, the available historical series are limited, and increasing the sample data as much as possible would affect the hypothesis of distribution stability.

Monte-Carlo approach

One of the main problems related to the approach with historical simulation concerns the scarcity of the present data. In order to overcome it, it is possible to resort to the simulation Monte-Carlo. The characteristic of this approach is that the historical series are used only in order to determine the main parameters like average, volatility or correlations and, starting from these parameters, allows to obtain an elevated number of scenarios. The difference with the historical simulation is in the fact that in this case distribution of probability of the factors of risk must be estimated, just in base to the parameters obtained. The analytical phases to follow for a correct calculation are the following:

- Collection of the data of market to carry out the simulation
- Simulation of various scenarios. In this phase the scenarios are constructed based on the chosen distribution (determined in turn by the parameters obtained).
- Flipping the scenarios on the portfolio of which the VaR is calculated. The number of values obtained is equal to that of the scenarios calculated in the previous point
- Comparison of the values obtained with the current value, which allows obtaining several potential returns always equal to the number of scenarios calculated

The various returns are then distributed and the value obtained is linked to the chosen probability. It is evident how this approach, even if more precise than the historical simulations and not influenced by the little availability of historical series, is more complex at calculation level and is strongly influenced by the distribution chosen a priori.

In conclusion it can be concluded that there is not a better method than another to determine the VaR. Each of the three just proposed has some advantages and some limits, so based on the available data, the accuracy of calculation required and the computational capacity you can opt for the approach considered best.

Stock Exchanges and stock indices

The modern economy has a very strong link with the financial world. Each crisis can be described in terms of percentage points lost on the Stock Exchange, as well as a period that sees the Stock Exchanges in continuous rise is seen as particularly positive and capable of having much more "pragmatic" effects for what is defined in jargon as "real economy". It is good therefore to clarify what is a stock exchange and what are the stock indices.

A stock exchange is a regulated financial market where securities and foreign currencies are traded. It is a secondary market (i.e. a market where securities arrive after being issued and placed on the primary market) and is regulated because it meets 3 requirements:

- Regularity of operation: the exchanges take place according to predefined modalities for each mechanism such as payment or price determination.
- Approval by the supervisory authority of the rules relating to the conditions of access and the mode of operation.
- Compliance with transparency obligations

FIG 1.6 Photos from inside the New York Exchange Stock (NYSE)

A stock index is the set of securities used to measure the performance of a sector, a trading venue or an economy. It tends to be composed of a predefined number of shares of a certain square (the most important ones). There are 4 types according to the different weighting that is attributed to the securities that determines it:

- Index equally weighted: every Stock has the same weight as the others, so there is not a real weighting. The capitalization of the various companies does not therefore have importance.
- Price weighted index: the weighting, and therefore the relative weight in the index, vary according to the price. This means, however, that the more "expensive" securities have a greater weight than the others regardless of the number of shares in the company.

- Value weighted index: unlike the previous types, the weight of the various securities in these indices is proportional to the market capitalization. The adjustment also follows operations such as groupings, splits or divisions, so that the index is much less approximate than the others.
- Sustainability index: This is a more modern type, so that each security is weighted according to alternative principles to the classic economic criteria. It is spreading more and more.

To date, the most widespread type is value-weighted, even some important indices such as the Dow Jones (USA) are still price-weighted indices. What almost all indices have in common is that the "price indexes" are used to calculate them. This generates distortions because what is evaluated is only capital gain. The remuneration for the shareholders also includes dividends, but when these are detached, the securities are depreciated, which leads to falls. What is a positive event is actually recorded as a negative event. For this reason, the total return indices, which also take into account possible dividend detachments, are gaining ground.

CHAPTER 2

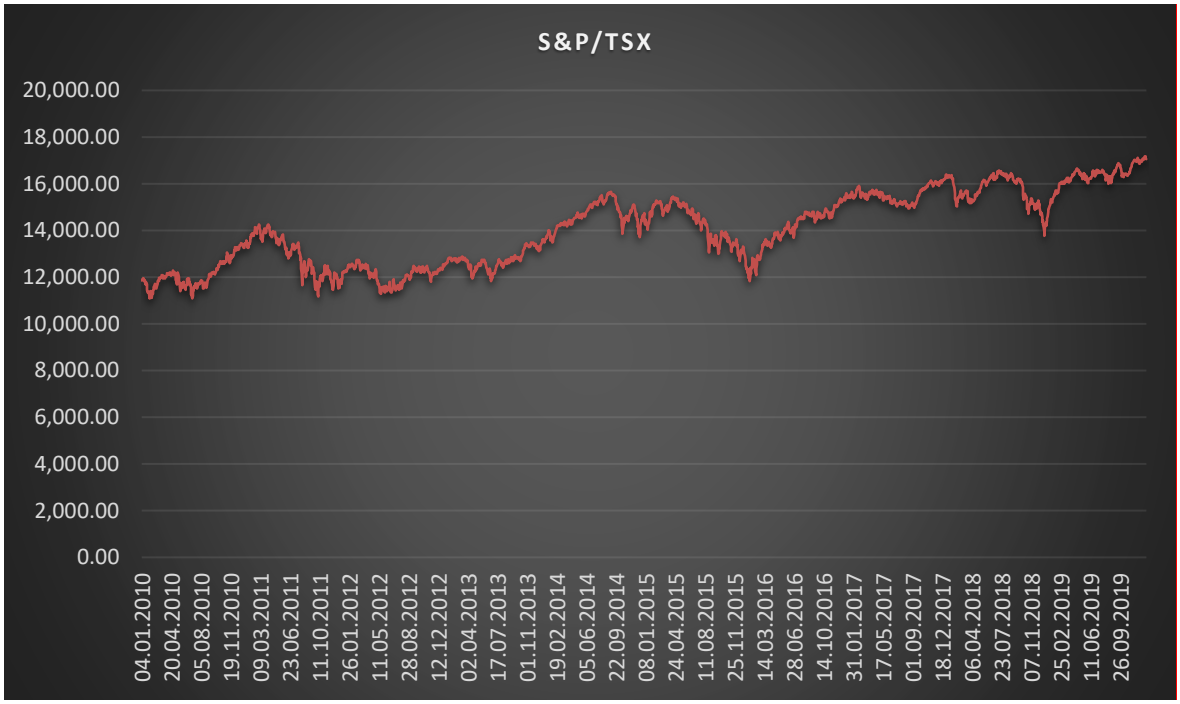
Stock indexes

The effects of Sars-CoV-2 will only be fully visible in many years. Never in recent history has such an event occurred, especially in terms of its magnitude. In turn the whole world has been in lockdown, and the blockage of many activities (whether production or service) will probably lead to heavy consequences in the medium to long term. Paradoxically, in the short term, containing the effects has been easier because of the huge "lockdown" manoeuvres of many EU and US countries (through the FED). In general, a large amount of liquidity was injected into the market, a lot of bonuses were granted and many payments were suspended or postponed. In the long term, but probably already as early as the first quarter of 2021, the consequences of these choices will have to be faced. Many sectors will enter, or have already entered, a crisis from which they will not be able to emerge. Others will undergo a major transformation. Still others will be able to emerge from this situation under better conditions than those of entry (recent history is full of successful entrepreneurial stories born during periods of crisis, such as Airbnb in 2008). Therefore, an exhaustive view of the consequences of this pandemic will only take place from 2022, when the entire first "post-Covid" year will presumably be over. However, it is of course possible to start already now to make quantitative analyses that have value. In this sense, the elaboration proposes to do so by means of the VaR analysis on the main G10 country indices. Given that there are 11 indices in question because the "G10" nomenclature has never been changed since Switzerland joined in 1964, this choice meets two requirements: geographical and quantitative. The geographical reason is linked to the fact that the choice of G10 countries makes it possible to cover several continents, countries that are very different from each other (also socially, culturally and economically) and also include the most relevant in economic terms. The quantitative reason lies in the fact that by choosing, for each country, the main index, many companies are considered simultaneously, including almost all the most strategic ones. The following is a list of the main indices with a brief description and the trend, graphic, of the period from 2010 to 2019.

BEL 20

The BEL 20 is the stock market reference index of Euronext Brussels. In general, the index is composed of a variable number of companies always between 10 and 20. However, since June 20, 2011, BEL20 has contained 20 quotations, with the exception of a one-month period in the period May-June 2018, when the Ablynx stock was removed following the acquisition by Sanofi, to be replaced in mid-June by arGEN-X. The composition of the BEL 20 index is revised every year, based on the closing prices of the last Friday of February. Any changes come into force after the third Friday in March. In addition to meeting a number of criteria that require a company to be "representative of the Belgian stock market", at least 15% of its shares must be considered floating in order to qualify for the index. A share is defined as floating if it can be freely traded on the secondary market. There are also minimum capitalization requirements. The free float must be at least 300,000 times the index price on the last trading day of December. The minimum requirement for an existing component to remain in the index is a market limit of 200000 times the index value. At each annual review, the weights of the companies in the index are limited to 15%, but afterwards may vary freely with the share price. BEL20 is a capitalization-weighted index. Its historical high is 4756.82 and was recorded on May 23, 2007.

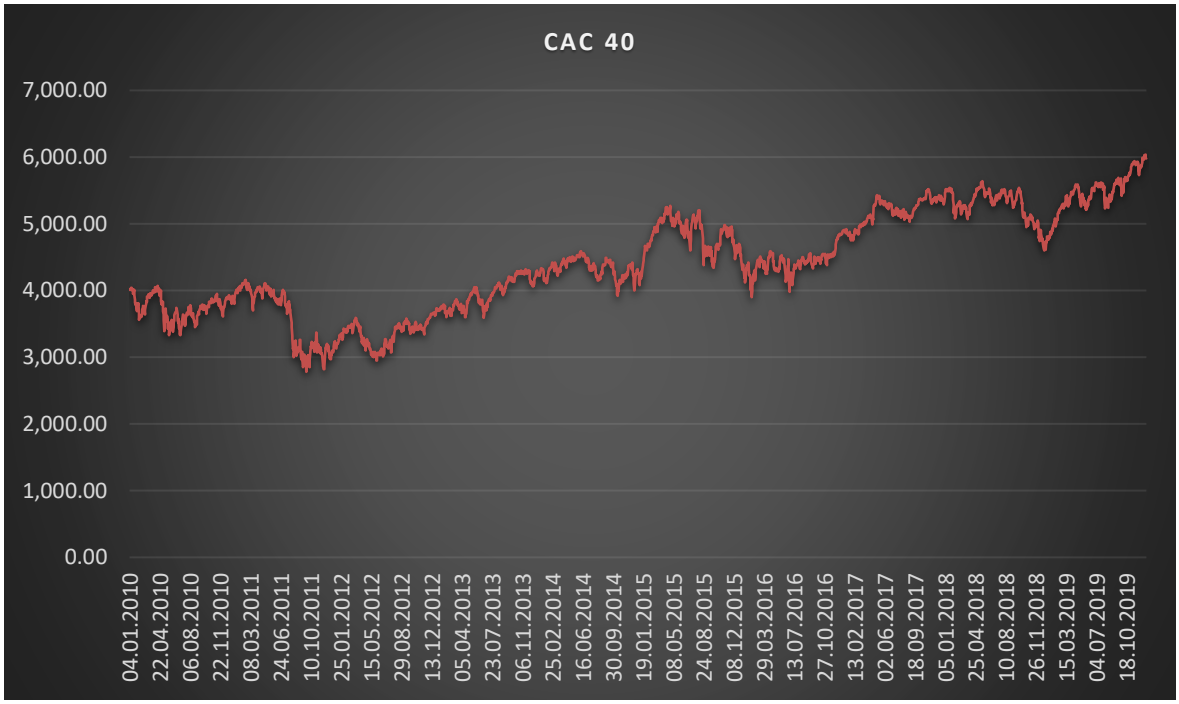
S&P/TSX



TSX is short for the Toronto Stock Exchange, Canada's leading stock exchange, and the ninth largest stock exchange in the world, based on the market capitalization of its companies. S&P stands for Standard & Poor's, the American financial services company that replaced the previous index, the TSE 300, which lasted from 1977 until S&P took over in 2002.

The S&P/TSX has three main functions: to provide an easily understandable snapshot of the performance of major public companies in terms of economic performance, to provide a benchmark against which fund managers can compare their results to assess their performance, and to provide a formalized structure that low-cost ETFs and index funds can follow (S&P earns a lot of money by licensing its indices for use in investment products). It comprises about 250 of the 1,500 or so companies represented on the Toronto Stock Exchange, but its companies account for about 70% of the entire market capitalization of the stock exchange, making it the most important index on the entire stock exchange. To be included, a company must account for at least 0.05 of the entire index, and those with the highest market capitalization are more weighted when determining increases or decreases. Membership is obviously not permanent; companies are added or excluded from the index based on parameters such as: their market capitalization; the trading volume of their shares; the amount of liquidity they hold. In 2015, for example, S&P/TSX added 16 new members and excluded even more companies (the number of companies present is therefore not fixed). Although the volume of trade has become less and less significant for natural resource companies, as Canada's activities diversify into areas that have nothing to do with the country's substantial oil reserves, the index is still significantly affected by possible fluctuations in oil prices.

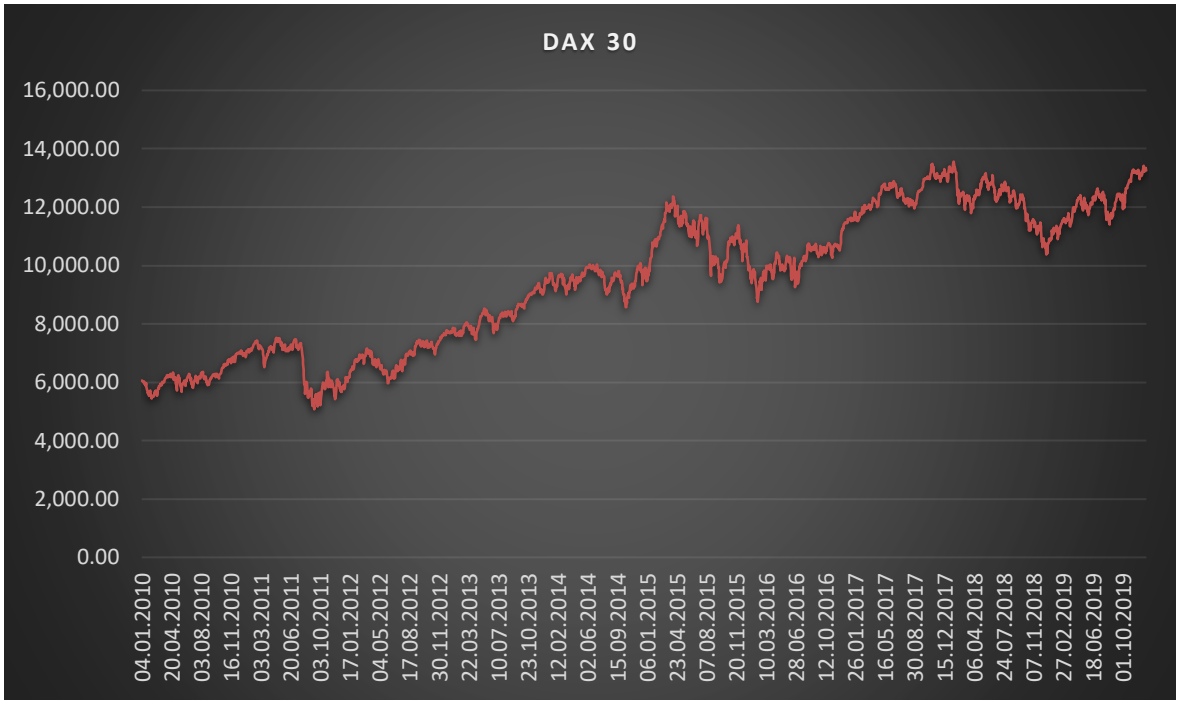
CAC 40



The CAC 40 (Cotation Assistée en Continu) is the reference index of the French stock market. The index represents a measure weighted by the capitalization of the 40 most significant shares among the 100 largest market capitalizations of Euronext Paris (formerly the Paris Stock Exchange). It is one of the leading national indices of the pan-European stock exchange group Euronext. Its name derives from the automation system of the Paris Stock Exchange Cotation Assistée en Continuos (Continuous Assisted Listing). Its base value of 1,000 was set at 31 December 1987. In common with many of the world's major stock markets, its historical high (6922.33 points) was reached at the height of the dot-com bubble in September 2000. On 1 December 2003, the index weighting system was changed from being dependent on total market capitalization to only the upper limit of the free float, in line with the other major indices. The composition of the CAC 40 index is updated every three months by an independent steering committee. At each review date, companies listed on Euronext Paris are ranked according to the market capitalization of the free float and the turnover of the shares over the previous 12 months. Since 2003, the index weights of the various companies have been set at 15%, but these then vary with the share price. Of the top 100 companies in this ranking, forty are chosen to enter CAC 40 so that it is "a relevant benchmark for portfolio management" and "an appropriate underlying asset for derivatives". Where a company has several classes of shares traded on an exchange, the index accepts the most actively traded class (usually common stock). The CAC 40 is almost exclusively composed of companies domiciled in France, but about 45% of its listed shares are owned by foreign investors (and among the European indices this represents a record). German, Japanese, American and British investors are among the most important holders of CAC 40 shares. This large percentage is due to the fact that CAC 40 companies are more

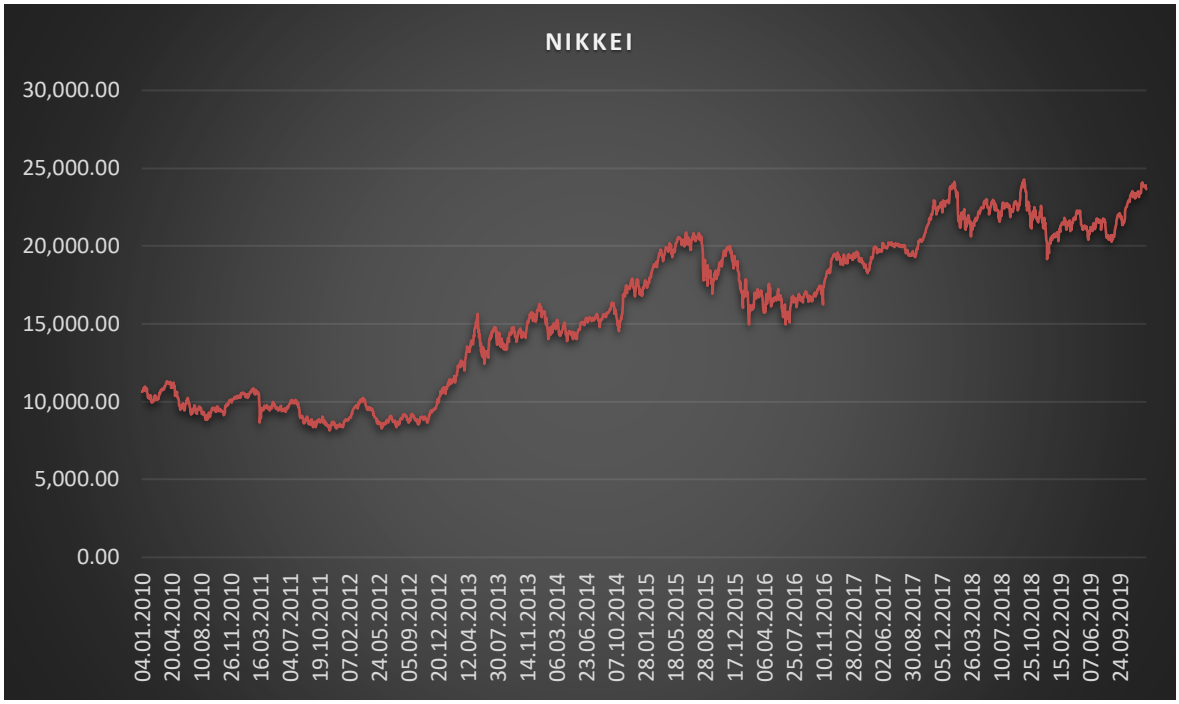
international, or multinational, than any other European market. In fact, CAC 40 companies carry out more than two thirds of their activity and employ more than two thirds of their workforce outside France.

DAX 30



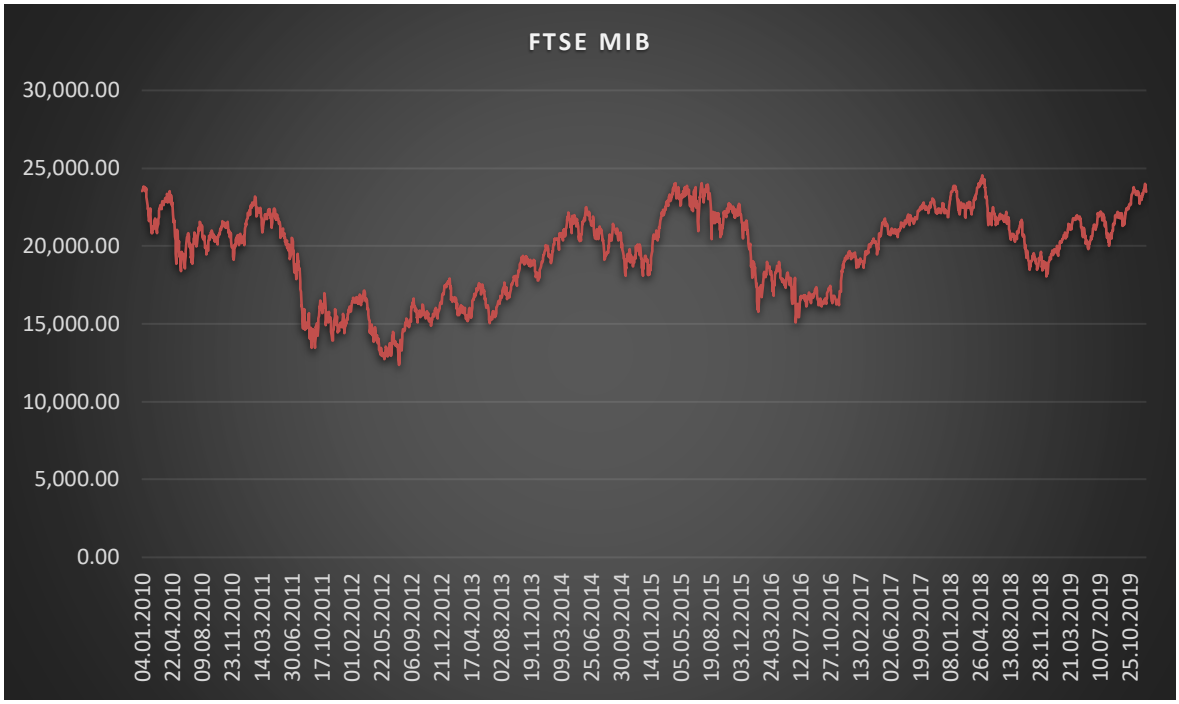
The DAX Deutscher Aktienindex (German stock index) is a blue chip stock market index consisting of the 30 leading German companies operating on the Frankfurt Stock Exchange. The expression "blue chip" simply means companies with high financial capitalization and is an expression derived from the game of Poker. Prices are taken from the Xetra trading venue. According to Deutsche Börse, the operator of Xetra, the DAX measures the performance of the 30 largest German Prime Standard companies in terms of order book volume and market capitalization. It is the equivalent of the FT 30 and the Dow Jones Industrial Average, and due to the very narrow selection it does not necessarily represent the economic situation as a whole. In addition, this index is not only calculated on price, but also includes dividends distributed in full, creating distortions. The parameters for a company to be included in the DAX-30 are: to be listed in the Prime Standard, continuously negotiated on Xetra and have at least a 10% free float (the limit was 5% until October 2008), have a registered office in Germany or focus on its commercial turnover on Frankfurt shares and a seat in the EU. The basis of the L-DAX index is the floor trading (Parketthandel) at the Frankfurt Stock Exchange, which is calculated daily. The base date for the DAX is December 30, 1987, and was started from a base value of 1,000. Xetra technology has been calculating the index every second since January 1, 2006.

NIKKEI



The Nikkei Stock Average is a stock market index of the Tokyo Stock Exchange (TSE). It has been calculated daily by the daily newspaper Nihon Keizai Shimbun (The Nikkei) since 1950. It is a price-weighted index, which operates in Japanese Yen (JP¥), and its components are reviewed once a year. The Nikkei consists of 225 large Japanese public companies from a wide range of industries. The Nikkei 225 began to be calculated on September 7, 1950, 70 years ago. However, with a retroactive calculation, its history begins on May 16, 1949. Since January 2010, the index is updated every 15 seconds during trading sessions. The average of the Nikkei has deviated significantly from the textbook model of stock averages, which grow at a constant exponential rate. The average peaked on 29 December 1989, during the peak of the Japanese asset price bubble, when it reached an intraday high of 38,957.44, before closing at 38,915.87, after having grown six times over the decade. Subsequently, it lost almost all of these gains, closing at 7,054.98 on March 10, 2009 - 81.9% below the peak of twenty years earlier. On March 15, 2011, the second working day after the massive earthquake in northeastern Japan, the index fell by more than 10% to 8605.15, a loss of 1,015 points. Japan's natural propensity for natural disasters means that the index is strongly influenced by them. Another element that characterizes the index is the strong interference of the Bank of Japan (BOJ). According to some analysts, the increase of the index in 2013 was artificial in nature and due to the BOJ purchases. From the period to 2013 to 2017, the BOJ took control of about 75% of the Japanese Exchange Trades Funds (ETF), and it is currently one of the top 10 shareholders of 90% of the securities that make up the Nikkei 225. Finally, the index is characterized by a reverse correlation with the Yen. This is due to the economic nature of the country, which exports large volumes of goods. A strong Yen makes Japanese products less competitive, while a weaker currency favors exports and consequently a positive trend for the index.

FTSE MIB



Ftse Mib stands for "Financial Times Stock Exchange Milan Stock Exchange Index". Previously, this stock was called COMIT 30 (name later changed to Mia 30) and included 30 companies. In 2003, a collaboration with the rating company Standard & Poor's began and the companies included became 40. The current name was created in 2009 following the merger with the London Stock Exchange. The 40 companies included today include about 80% of the Italian market capitalization. The index is derived from all the shares listed on the MTA (Mercato Telematico Azionario) and MIV (Mercato degli Investment Vehicles; the reference market for the listing of funds and corporate vehicles investing in Real Economy instruments). The parameters considered for admission to the index are the following:

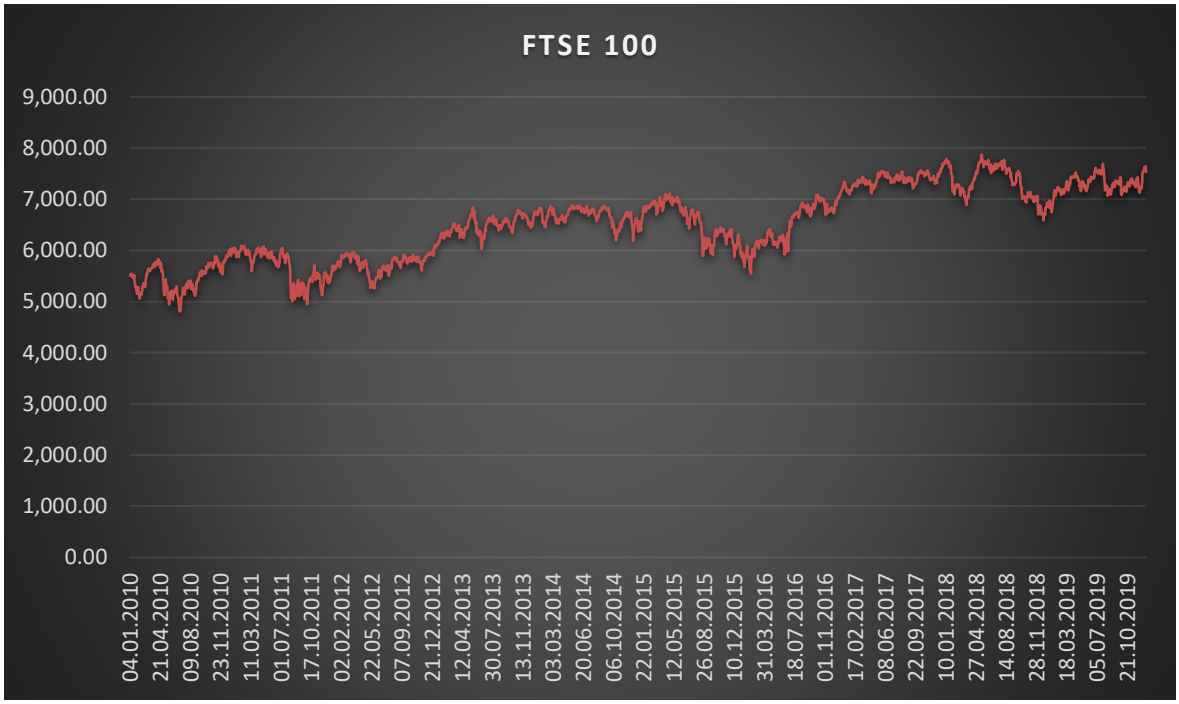
- Market capitalization on the basis of free float (the number of shares in circulation, issued by a company, not representing the part of the capital that constitutes a controlling interest) plus the weighting of investments
- Liquidity measured by the countervalue in Euro traded in the last six months on Borsa Italiana's electronic markets and by the number of trading days
- New quotations; the FTSE Italia Index Policy Committee generally observes the liquidity of the potential component for a period of at least three months before deciding whether to include it in the index.
- Outstanding Shares

The historical record of the index was reached during the session of March 7, 2000 when it reached 51 273 points, while the one on the closing price occurred the day before at 51 093 points.

AEX

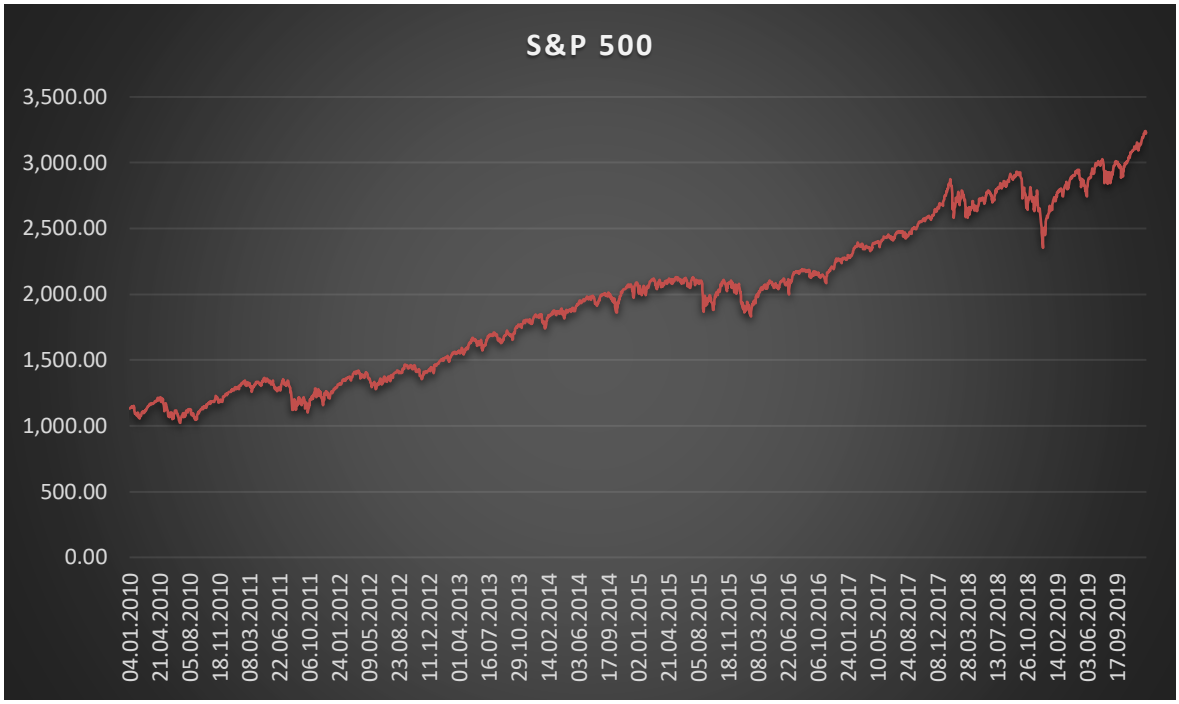
The AEX index, derived from the Amsterdam Stock Exchange index, is the main stock market index consisting of Dutch companies operating on the Euronext Amsterdam, formerly known as the Amsterdam Stock Exchange. Started in 1983, the index consists of up to 25 of the most frequently traded stocks on the stock exchange. The AEX started from a base level of 100 index points on January 3, 1983. The index peak to date is 703.18, reached on September 5, 2000 at the height of the dot-com bubble, as for many other European indices. It is no coincidence that the index value more than halved in the following three years before recovering in line with most global financial markets. As for the selection criteria, the composition of the AEX index is checked 4 times a year (one complete and 3 partial). At the main review in March, the 23 companies listed on the Euronext Amsterdam regulated market with the highest share turnover (in euros) compared to the previous year are admitted to the index. Of the companies ranked between 24th and 27th, i.e. the first 4 excluded from the initial selection, two others are selected with preference for the current components of the index. However, companies that have less than 25% of the shares considered to be floating on Euronext Amsterdam are not eligible for inclusion. Unlike some other European benchmark stock indices (such as the OMXS30), if a company has more than one class of shares traded on the stock exchange, only the most frequently traded shares will be accepted into the AEX. If one or more companies are removed from the index due to delisting, acquisition or other reasons, no substitutions are made until the next revision date. The AEX is a capitalization-weighted index. As in other indices, there is initially a limitation to 15%, but this can later vary depending on the price.

FTSE 100



The Financial Times Stock Exchange 100 Index (or shorter FTSE 100 Index) is a stock index of the 100 companies listed on the London Stock Exchange with the highest market capitalization. It is seen as an indicator of prosperity for companies regulated under British company law. The index is managed by the FTSE Group, a subsidiary of the London Stock Exchange Group, established as a joint venture between the Financial Times and the London Stock Exchange. It is calculated in real time and published every second. The index consists of the 100 most significant UK companies by market value. As with the main index of the French Stock Exchange, there are many international companies, so there is no very high correlation between the performance of the index and the real performance of the British economy. Another element of strong influence in this sense is the fact that the reference currency is the pound sterling, so the exchange rate plays a not insignificant factor. The FTSE 250, which includes many more non-international stocks, can be relied upon for the British economy only. Together, the two also form the FTSE 350 index. However, the FTSE 100 remains the most widely used, especially internationally, since it alone accounts for 81% of the market capitalization of the London Stock Exchange. The requirements set by the FTSE Group for companies in the index include full listing on the London Stock Exchange and some tests on free float, liquidity and nationality. The index was listed on 3 January 1984 at the base level of 1000. The maximum closing value of 7,877.45 was reached on 22 May 2018, while to date the maximum intraday value of 7,903.50 was reached on 22 May 2018.

S&P 500



The S&P 500 is a stock market index that measures the equity performance of 500 large listed companies in the US. It is a capitalisation-weighted index and the top 10 companies in the index account for 26% of the index's market capitalisation, which is below the average for major European indices. The top 10 companies in the index, in order of weighting, are Apple Inc., Microsoft, Amazon.com, Alphabet Inc., Facebook, Johnson & Johnson, Berkshire Hathaway, Visa Inc., Procter & Gamble and JPMorgan Chase, all of which are known worldwide and among the most important companies in their sectors. The index, unlike others, includes only companies listed in the United States. However, on average, only 71% of their revenue is attentive in the U.S.A. due to their strong international character. The index value is updated every 15 seconds, or 1,559 times for each trading day.

The S&P 500 is operated by S&P Dow Jones Indices, a majority-owned joint venture of S&P Global, and its members are selected by a committee. In assessing the suitability of a new addition, the committee assesses the company's merit using eight primary criteria: market capitalization, liquidity, domicile, public float, Global Industry Classification Standard and industry representation in the U.S. economy, financial sustainability, public trading duration and stock exchange. From a quantitative point of view we have that:

-Market capitalization must be at least USD 8.2 billion.

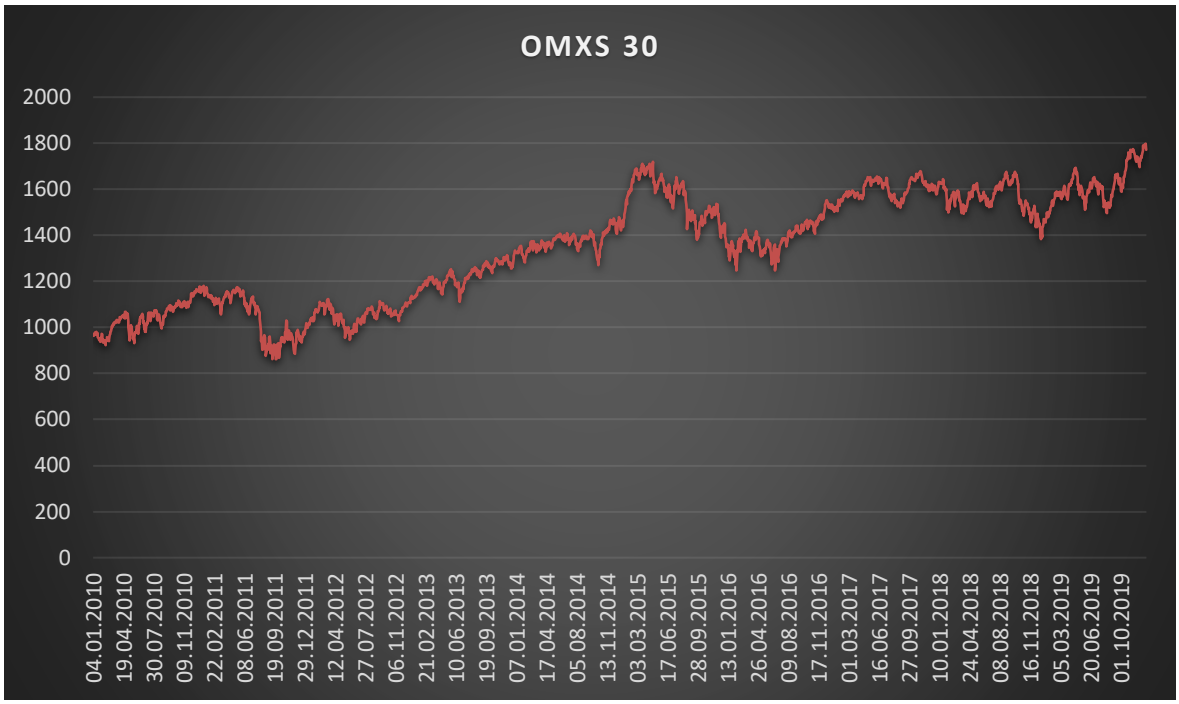
- The annual value of the dollar traded with the correct market capitalization for the free float is higher than 1.0

- Minimum monthly trading volume of 250,000 shares in each of the six months preceding the valuation date

- The company must be publicly traded on the New York Stock Exchange (including NYSE Arca or NYSE American) or NASDAQ (NASDAQ Global Select Market, NASDAQ Select Market or NASDAQ Capital Market).

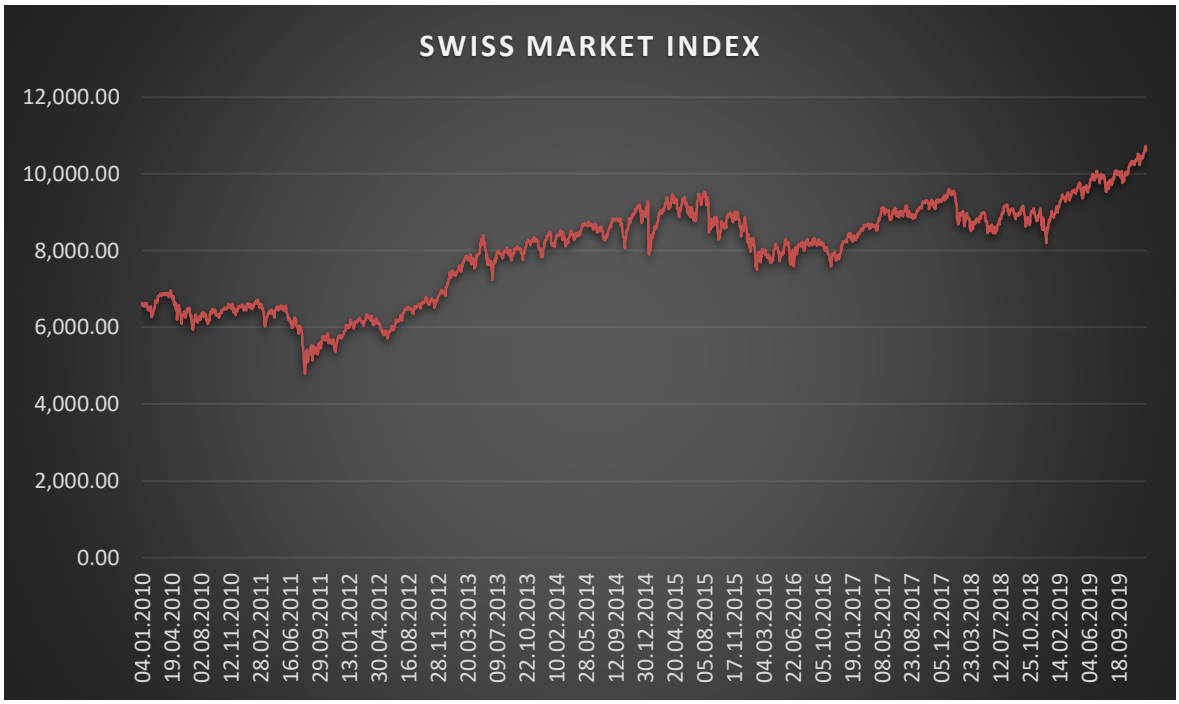
Checks on the included companies are carried out on a quarterly basis. Finally, a security may increase in value when added to the index, as the funds in the index have to buy that security to continue to follow the index.

OMXS 30



The OMXS30 is an index that includes the 30 securities with the highest trading volume on the Stockholm Stock Exchange. OMXS30 is considered Sweden's benchmark stock index and the limited number of constituents means that the underlying stocks have very good liquidity. The index, owned by the NASDAQ, is designed to accurately represent the overall performance of its constituents. NASDAQ Inc., the parent company, has granted the Stockholm Stock Exchange the right to use the OMXS30 in the clearing of index-based derivatives. The index is relatively recent in how much the launch has happened 30 September 1986 with a base value of 500.Il 27 April 1998 the index has been subject to a split 1:4, that has therefore brought the base value from 125. A split consists in splitting the existing shares into several shares with a lower value (in a proportionate way of course). Among the various reasons why you opt for a split the main one is the lowering of the price in order to make the shares in question more attractive for purchase. The index initially has been exchanged laterally (that is between two figures that make from support and resistance), but it has recorded strong oscillations between 1992 and 1994. Before the new millennium the index underwent a new period of contrasted trading, which brought the index to an all-time high (adjusted for the split) of about 2400 in December 1997, followed by a strong thud to about 600 in January 1998. Subsequently, the index advanced again, exceeding 1270 in May 2007, before pressure from the global financial crisis dragged the index just above 600 in January 2009. The index has recovered since then and was trading above 1700 in November 2019.

SWISS MARKET INDEX



The Swiss Market Index (SMI) is the most important Swiss stock market index in the country. It consists of 20 of the largest and most liquid equities in the Swiss Performance Index (SPI). As a price index, the SMI is not adjusted for dividends. The SMI was introduced on 30 June 1988 with a base value of 1,500 points. On 2 July 2019 it closed for the first time above the purely symbolic level of 10,000 points. The control of the composition is carried out annually. Currently, it contains 19 large cap and one mid cap, for a total of 20 quotations (previously there were 25). A large cap is defined as the shares of companies with market capitalization in excess of 8.8 billion Euros, while a mid cap is between 8.8 and 1.8 billion. The calculation takes place in real time and the index is updated once per second. The SMI is calculated in Swiss francs, the currency of the Swiss Confederation. The securities contained in the SMI currently account for around 80% of the entire capitalisation of the Swiss equity market and 85-90% of the total trading turnover of Swiss and Liechtenstein equities listed on the SIX Swiss Exchange. As the SMI is considered the mirror of the entire Swiss equity market, it is used as a benchmark for numerous mutual funds, index funds and ETFs and as the underlying index for numerous derivative financial instruments such as options, futures and structured products. This element is not secondary as there are several indices which, due to their composition including many international companies, are not a valid benchmark for the "real" economy of the country they represent.

As for the acceptance criteria, it should be specified that the indices in the SMI are all contained in the largest basket of the SPI. There are requirements on liquidity and market capitalization. Specifically, liquidity must represent at least 50% of the average liquidity of the SPI's constituent issues. On the other hand, the minimum free-floating capitalization must be equal to or greater than 0.45% of the SPI's entire capitalization. Therefore, trading volume and capitalization are the determining factors in the quarterly rankings. Due to the fact that

three large companies such as Nestlé, Roche and Novartis accounted for around 60% of the index capitalization, the upper weighting limit was set at 18% in 2017. This may vary, but if the value is above 20% at the end of the quarter, it is automatically reduced to 18%. There is also an index, the SPI 20, which indexes the 20 components of the SMI without such limits, to give a more realistic feedback.

CHAPTER 3

Efficient Market Theory and Random Walk Theory

Theory of efficient markets

The hypothesis of efficient markets (EMH) is an economic theory born in the late 1960s. First of all, it is necessary to understand what is meant by efficient market. To date, efficiency is considered on the basis of four different scenarios:

- **allocative efficiency**, which occurs when the correct allocation of financial resources from those in surplus to those in deficit occurs, under the assumption of the same marginal productivity of capital. This would occur only if all operators acted rationally, looking for investment (or financing) opportunities that would maximize their expected utility.
- **valuation efficiency**, which occurs when the available information is used in a correct way to determine the real value of a company, through correct pricing.
- **technical-operational efficiency**, that is the set of organizations and procedures with which the market performs its functions; it is evaluated on the observation of thickness, amplitude and market elasticity.
- **Information efficiency**, which concerns the relationship between prices and information. In general, a market is efficient, from the information point of view, if prices reflect all available information. Information efficiency can in turn be distinguished in three different cases:
    1. **Efficiency in a weak form**, which occurs when prices observed on the market reflect all the information present in the historical series. In practical terms, it is not possible for arbitrage situations to occur using only technical analysis, i.e. the forecasting of future prices based on past price trends.
    2. **Efficiency in a semi-strong form**, which occurs under the same conditions as efficiency in a weak form while also integrating information in the public domain. Again, if this efficiency is verified, it is not possible to formulate a trading strategy with an expected return higher than the market using only publicly available information.
    3. **Efficiency in a strong form**, which adds knowledge of any private information to the previous two cases. This efficiency makes it impossible to formulate a trading strategy with an expected return higher than the market based on any insider information.

As can be easily observed, efficiency in semi-strength form includes efficiency in the weak form, while the strong form includes efficiency in the semi-strength form. Studies on market efficiency date back to the 1950s, but were only formalized between 1965 and 1970 by Eugene Fama, then a Boston university student. In 1965 his doctoral thesis was published, which 9 months later was published in the Financial Analyst Journal under the

title "Random Walks in Stock Market Prices". According to Fama, in general a generic analyst had a 50% chance of beating the market, without having the opportunity to do so regularly. In fact, if all investors had portfolios formed by stock indices, the brightest traders could find profit situations. This trend would lead investors to move towards new opportunities, thus rendering the advantage null and void. In any case, Fama's work was not particularly innovative, to the extent that it was mainly to put together different theories from the 25 years before him, confirming some conclusions. His final thesis was, however, to consider markets efficient, at least in a weak form, in three different cases of economic agents:

1. The actors are all rational and evaluate prices based on fundamentals (e.g. net present value).
2. A numerically irrelevant part of the actors behaves in an irrational way. However, because of the dispersion of the strategies, these are annulled in average and the equilibrium price is not modified.
3. The greater part of the actors has an irrational behavior; however the stochastic disturbances caused by their activity do not affect the few rational investors that guarantee therefore a correct evaluation of the price.

The theory of Fame has received a lot of criticism over the years. Among the most widespread arguments, four are worthy of note. First of all, according to the theory of efficient markets, market bubbles and financial crises should not occur. Looking at even just the last 20 years, the reality of the facts would seem to state the opposite. Bearing in mind that a speculative bubble occurs when the price of an asset rises well above fair value, resulting in a sudden market correction that causes the price to fall rapidly, it is easy to think of the sub-prime mortgage crisis of 2008, linked to the real estate bubble. In this regard Fama said that the 2008 crisis was due to an impending recession and was not a real bubble. But both subsequent studies and the fact that some insiders were able to predict the events (and were in fact greatly enriched) seem to demonstrate the groundlessness of his thesis. Another element of criticism is related to market anomalies. These represent the situations in which there is no convergence between the real trajectory of the prices of the shares and that fixed by the theory of efficient markets. As an example we can cite the January effect, which sees a constant average price increase during this period of the year, without a concrete motivation (theoretical or factual). In an efficient market, by definition, anomalies like this should not occur. There are also some criticisms related to behavioral economics. The basic assumption about the rationality of those who participate in market trading is questioned because of studies related to trading psychology. Among the various behaviors that have occurred among traders, it is worth mentioning imitative behavior, which is a perfect example of how decisions are often made in a completely different way from the theory, i.e. rational and based on available information. Finally, we could mention those traders who have systematically achieved much higher returns than the average stock market returns such as Warren Buffet. However, since these are extremely limited and very particular cases, this last point is certainly the least important to challenge the theory of efficient markets.

Random Walk theory

Having ascertained that an efficient market, at least in a weak form, can be defined as such if it incorporates all the information (of all kinds) available to it by reflecting it on prices, it can also be said that a market is efficient if price variations are independent of each other. If we were also in the presence of the hypothesis of identical distribution of the same prices, we would have the two main hypotheses of the Random Walk Theory. While agreeing on the impossibility of systematically beating the market, these two theoretical models present a substantial difference: if according to the EMH the market cannot be beaten because the price incorporates by default any information, the Random Walk theory comes to the same conclusion citing as cause a completely random market trend. The random walk thoery, as we know it today, is the result of the work of more academics. The first to initiate studies in this field was, in 1863, a French mathematician named Jules Regnault, who published a book entitled "The Study of Chance and the Philosophy of Exchange". His work was very important especially for later scholars who inherited the results. Among them was in fact Louis Bachelier, also French, who published a paper entitled "Theory of speculation". Again, his work was later resumed, in this case by an American named Paul Cootner. He was an economist and in 1964 he published what today is considered one of the most important works on the Random Walk theory, "The Random character of Stock Market Prices". Among the subsequent academics who have based their work on this publication is also Eugene Fama, mentioned above for the part relating to the theory of efficient markets.The Random Walk model, as also suggested by the name, assumes that the market follows a random trend and that therefore historical data cannot be used to predict the trend. This is because, the continuous new information that the market incorporates and uses in the formation of prices, are also irregular. A practical consequence is therefore that the technical analysis is ineffective. In fact, technical analysis studies price trends over time in order to predict future trends. It is clear that a theory that denies any historical correlation between prices can only criticize such an instrument. An analogous discourse can be made then for the fundamental analysis, even if in this case there is a difference. While respecting the Random Walk Market it is possible to find under-quoted or over-quoted securities, if the analysis has been made on the basis of information that, although theoretically available, have not been assimilated correctly of the market. In essence, the investor, or observer, must interpret the information available in a better way than the average market. This is certainly very difficult but not impossible for the best investors. Finally, to better understand the implications of random walk can be useful a simple in-depth examination of the mathematical aspect of the same. In a market where this theory is verified, very simply a generic price of a security follows this model:

$$Yt = Yt\text{-}1 + ut$$

"Yt" represents the value at instant t, "Yt-1" is the value at instant t-1 and finally "ut" indicates the difference first between the two time periods. This allows us to understand how to be random, in the Random Walk model,

are not the values themselves, which in our case represent the prices, but their first differences. The verification of the Random Walk and the efficiency of the market in some ways coincide, as the assumptions of the first theory are more restrictive than those of the second. Therefore, determining whether in one of the historical series considered the Random Walk theory is verified allows to establish that that same series respects at least the weak efficiency.

Therefore, in order to verify the two theories on the indices taken into consideration, two different tests were carried out using statistical tools. Below are their descriptions, related to the results obtained, which, for simplicity of presentation, have been summarized in tables.

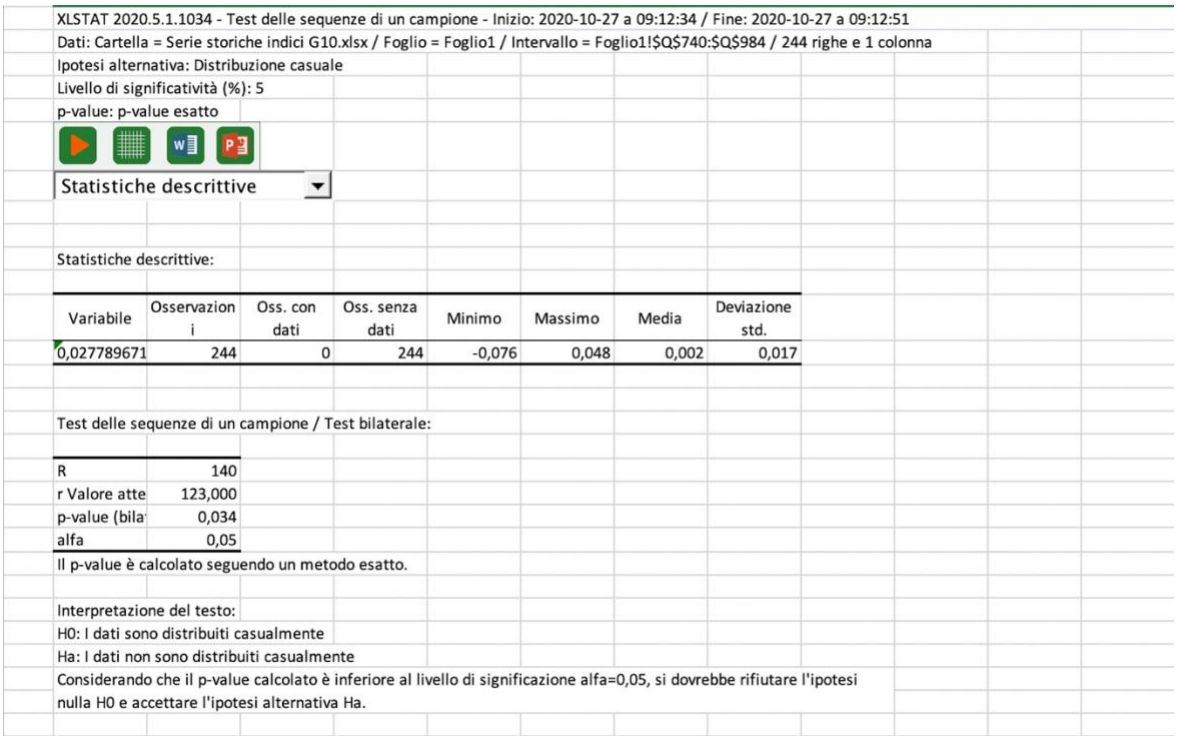
Run Test

The Wald-Wolfwitz test, more commonly known as run or sequence test, is a non-parametric hypothesis test. The fact that the test is not parametric means that the data distributions on which it can be performed are distribution-free or, more simply, have unspecified parameters. The objective of the test is to verify the randomness of the data distribution by checking the various runs. A run is defined as a sequence of price variations (in our specific case) preceded and followed by variations of opposite sign. The null hypothesis provides that the data are distributed randomly, while the alternative hypothesis that they are not distributed randomly. Under the hypothesis that the sample has a number higher than 20, which in our case is widely exceeded since for each year there are always more than 200 observations, the run test follows the behavior of a random variable with normal distribution. Therefore the number of runs will be distributed, normally, with the following mean and standard deviation values:

$$\frac{\mu = N(N+1) - \sum_{i=1}^{3} n_1^2}{N}$$

$$\sigma_\mu = \left(\frac{\sum_{i=1}^{3} \left(\sum_{i=1}^{3} n_1^2 + N(N+1) \right) - 2N(\sum_{i=1}^{3} n_1^3 - N^3)}{N^2(N-1)} \right)^{0,5}$$

In the two formulas N represents the number of observations and n_1^2 the number of price changes, i.e. the yield, for each group. In the elaboration the run test was performed, in the years 2010 to 2019, for each year and for each of the eleven different indices. For the data collected, the yield logs were calculated and the test was performed using the XLStatPro application. The level of significance α chosen was the standard 5%, so the limit value of the p-value for the two hypotheses was 0.05. So for values below 0.05 the null hypothesis that the data follow a random path was rejected, accepting the alternative that the data is not randomly distributed. For higher values the null hypothesis could not be rejected. In the image shown as an example a p-value lower than 0.05 can be observed, so the test, in the observation in question, was not passed.



XLSTAT 2020.5.1.1034 - Test delle sequenze di un campione - Inizio: 2020-10-27 a 09:12:34 / Fine: 2020-10-27 a 09:12:51

Dati: Cartella = Serie storiche indici G10.xlsx / Foglio = Foglio1 / Intervallo = Foglio1!$Q$740:$Q$984 / 244 righe e 1 colonna

Ipotesi alternativa: Distribuzione casuale

Livello di significatività (%): 5

p-value: p-value esatto

Statistiche descrittive

Statistiche descrittive:

Variabile	Osservazioni	Oss. con dati	Oss. senza dati	Minimo	Massimo	Media	Deviazione std.
0,027789671	244	0	244	-0,076	0,048	0,002	0,017

Test delle sequenze di un campione / Test bilaterale:

R	140
r Valore atte	123,000
p-value (bila	0,034
alfa	0,05

Il p-value è calcolato seguendo un metodo esatto.

Interpretazione del testo:

H0: I dati sono distribuiti casualmente

Ha: I dati non sono distribuiti casualmente

Considerando che il p-value calcolato è inferiore al livello di significazione alfa=0,05, si dovrebbe rifiutare l'ipotesi nulla H0 e accettare l'ipotesi alternativa Ha.

FIG 3.1: Example of output of a Run Test performed with XLStatPro

In the table below, the results of the Run Test carried out on the yield logs taken into consideration have been reported in graphic form. The green boxes represent the tests that gave a p-value higher than 0.05. In red are instead the p-value values lower than this threshold. Specifically, they refer to the French and Japanese index in 2013 and the Canadian index in 2019. Then, in orange, those p-values that passed the test (i.e. above 0.05) but by very little have been highlighted. Since it is a fairly weak test as it does not consider the variations on average but looks only at the number of positive or negative variations, to say not to reject the null hypothesis and therefore verify the Random Walk Theory is at least risky. Highlighting the combinations of index and year that are in a limit solution is a more conservative choice. You could therefore conclude that the Random Walk is definitely verified in the "index-year" pairs corresponding to the green color, while for the others there is a distinction between those for which it could be verified (orange color) and those for which it is definitely not verified (red color). Finally, it should be specified that at this stage each consideration was made according to the local currency and also the execution of the tests followed this rule. In the next chapter, that of the actual VaR calculation, we will also make considerations based on the exchange rate between the different currencies and the Euro.

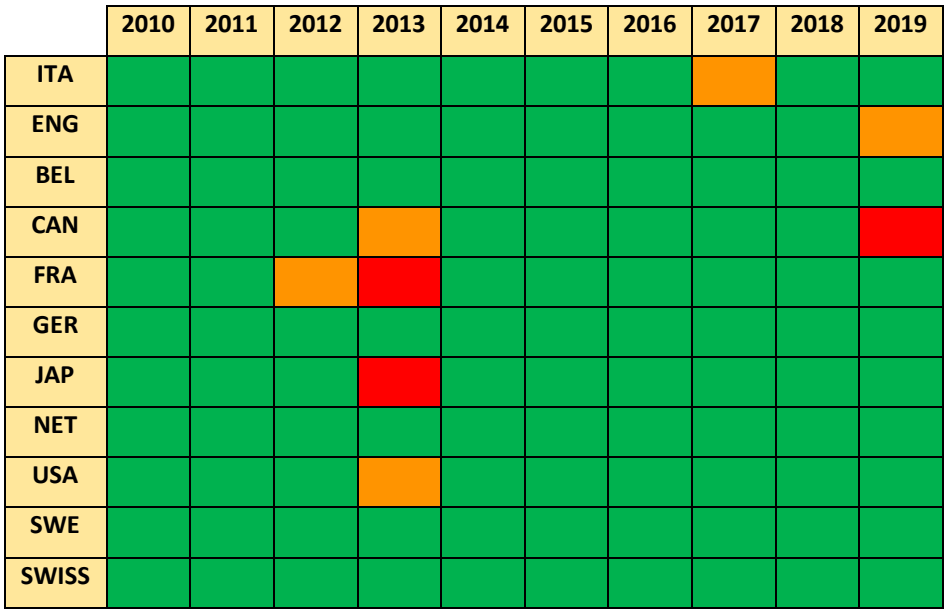


FIG 3.2: infographic of the Run Test on the indexes of the different countries

Autocorrelation Test

A second test useful to understand if the series considered follow a Random Walk is that of autocorrelation. Autocorrelation is a mathematical representation of the degree of similarity between a given time series and a postponed version of itself over successive time intervals. Autocorrelation can also be called delayed correlation or serial correlation, since it measures the relationship between the current value of a variable and its past values. When autocorrelation is calculated, the resulting output can vary from 1 to -1, in line with traditional correlation statistics. An autocorrelation of +1 represents a perfect positive correlation (an increase seen in one time series leads to a proportional increase in the other time series). An autocorrelation of - 1, instead, represents a perfect negative correlation (an increase seen in one time series leads to a proportional decrease in the other time series). It measures linear relationships and even if slightly different from zero, it can indicate a non-linear relationship between a time series and its postponed version. The assumption behind the test used is that if a value is influenced by that of the instant of time immediately preceding and influences that of the instant of time following, there is autocorrelation. If, on the other hand, this is null or very low (within the parameters used by the specific test) the history series, with the significance of the test adopted, would have a random trend. The autocorrelation can be verified with different tests. The Ljung-Box test has been used in the elaboration, which provides the null hypothesis or that the data are distributed independently and the alternative hypothesis that they are not and there is correlation within the series. The statistics used are as follows:

$$Q = n(n+2)\sum_{k=1}^{h} \frac{\hat{p}_k^2}{n-k}$$

Where n is the sample size, $\hat{p}_k^2$ is the sample autocorrelation at lag k and h is the number of lags being tested. In this case, a different application, NumXL, was used, an example of which is shown below.

White-Noise Test					
Lag	Score	C.V.	P-Value	Pass?	5,0%
1	0,15	3,84	70,3%	VERO	
2	0,16	5,99	92,5%	VERO	
3	0,16	7,81	98,4%	VERO	
4	11,62	9,49	2,0%	FALSO	
5	11,71	11,07	3,9%	FALSO	
6	13,59	12,59	3,5%	FALSO	
7	14,27	14,07	4,7%	FALSO	

FIG 3.3: Example of output of a White-Noise test performed with XLStatPro

Below are the results of the autocorrelation test in table form. For each country are reported the 7 time lags used for each year. The result " TRUE", in green, shows a p-value higher than 5%, a very low autocorrelation index, while " FALSE" is the output relative to p-values lower than the 5% threshold. The first result therefore indicates a weakly efficient market and, with good approximation, a random walk, while the second denies this hypothesis.

Belgium

LAG	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE
2	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
4	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
5	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
6	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
7	TRUE	TRUE	FALSE	FALSE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE

Canada

LAG	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	TRUE	TRUE	FALSE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE
2	TRUE	TRUE	FALSE	TRUE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
3	TRUE	TRUE	FALSE	TRUE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
4	TRUE	TRUE	FALSE	TRUE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
5	TRUE	TRUE	FALSE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE
6	TRUE	TRUE	FALSE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE
7	TRUE	TRUE	FALSE	TRUE	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE

France

LAG	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
2	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
4	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
5	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
6	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
7	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE

Germany

LAG	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
2	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
4	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	FALSE	TRUE
5	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
6	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
7	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE

Japan

LAG	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
2	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
4	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	FALSE	TRUE
5	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
6	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
7	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE

Italy

LAG	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
2	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
3	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
4	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
5	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
6	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
7	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE

Holland

LAG	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
2	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
4	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	FALSE	TRUE
5	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
6	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
7	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE

United Kingdom

LAG	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE
2	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
4	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
5	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	FALSE
6	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	FALSE
7	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE

USA

LAG	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
2	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
4	TRUE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE
5	TRUE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE
6	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
7	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

Sweden

LAG	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
2	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
4	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
5	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
6	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
7	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE

Switzerland

LAG	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
2	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
4	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
5	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
6	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE
7	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

First of all, it should be remembered that, in this case too, the log yields were calculated with the reference currencies. The results of this test give us more detailed information than the previous one. What stands out is that only in very rare cases there are "index-year" pairs in which the test is not passed for all 7 time lags considered (Italy 2014, Canada 2012 and 2015). In all other cases, even if there are particular years in which some indexes failed the test for 6 out of 7 lags, there is at least one result that would seem to confirm the random walk theory. Another element supporting this thesis is that there is no correspondence between the "index-year" pairs that failed the sequence test and those that did not pass the autocorrelation test. Therefore it cannot be asserted that there is a specific index that, in a given year, does not respect the random walk theory according to the results of both tests. In conclusion, it can be said that, as widely predictable, the main indices of G10 countries follow, with good approximation, a random walk theory. This element is very important for the final objective of the study. Although in the next chapter the focus on the calculation of VaR will shift to just two years 2019 and 2020, it is very important to verify the "goodness" of the data used for this purpose in previous years as well. The analysis following the next chapter will in fact be corroborated by these results, and any variations, even significant, of the VaR between 2019 and 2020 will not be attributable to the inefficiency of the market precisely because of the results of the tests in the period from 2010 to 2019.

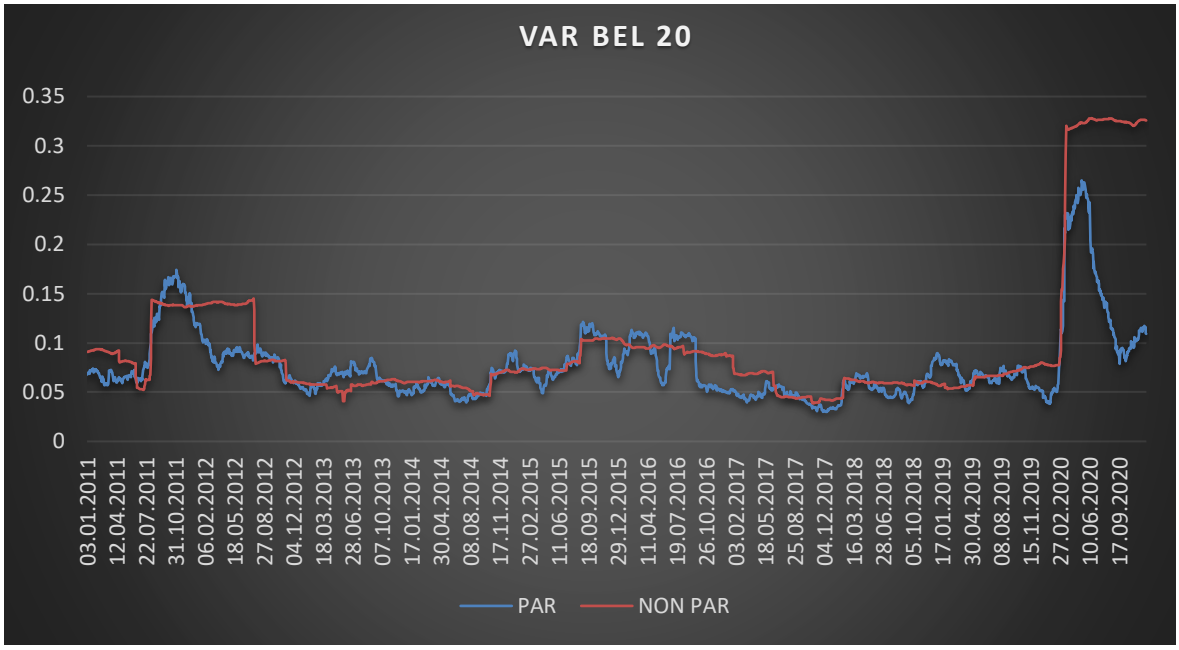
CHAPTER 4

Calculation of VaR

This chapter presents the results of the VaR calculations on the indices taken into consideration. For each index, the Value at Risk was calculated using both the parametric and non-parametric methods. Given the high number of indices and the long time span considered (2011-2020), the Monte-Carlo simulation was not used. The calculations were obtained through the Excel application. For both types of calculations, the values for the year 2010 were kept out of the results because the first data were used to determine the standard deviation. In both methodologies, a 99% confidence interval was considered. Furthermore, for the parametric VaR, in accordance with Basel regulations, the Holding Period was considered to be 10 days. Finally, in order to be able to better compare the two results on a graphical level, the non-parametric VaR was always considered in absolute value, in order to have only positive values.

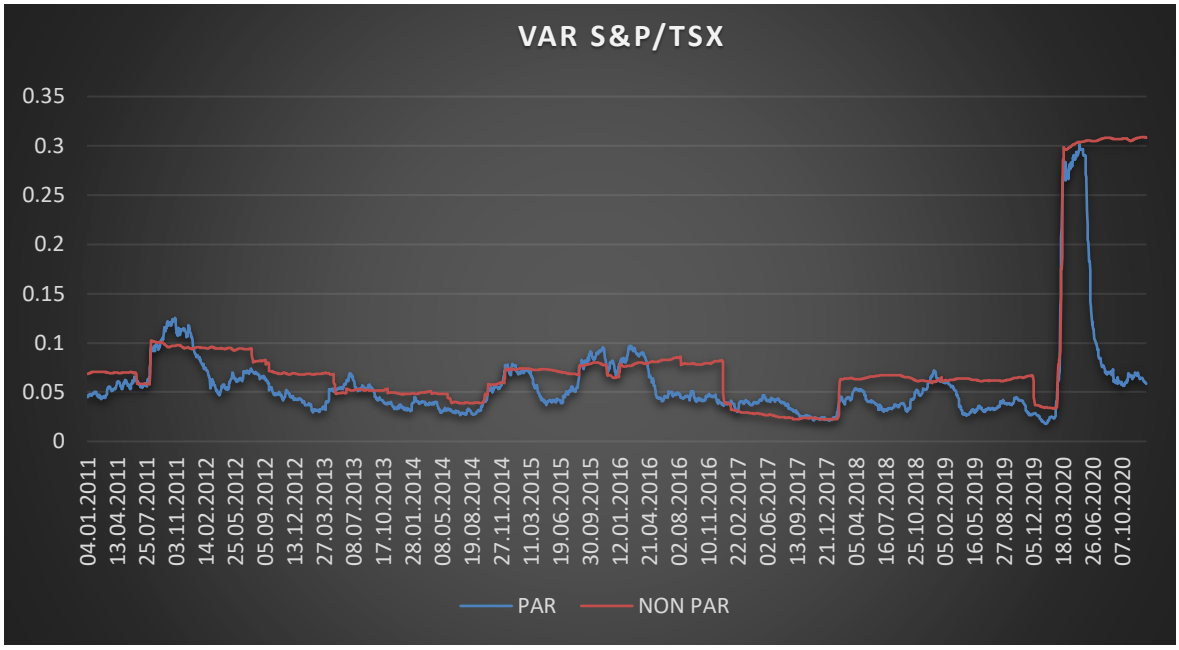
Please note that the theoretical basis of the calculations presented (parametric approach, non-parametric approach and for completeness Monte-Carlo simulation) has been introduced in chapter 1.

BELGIUM



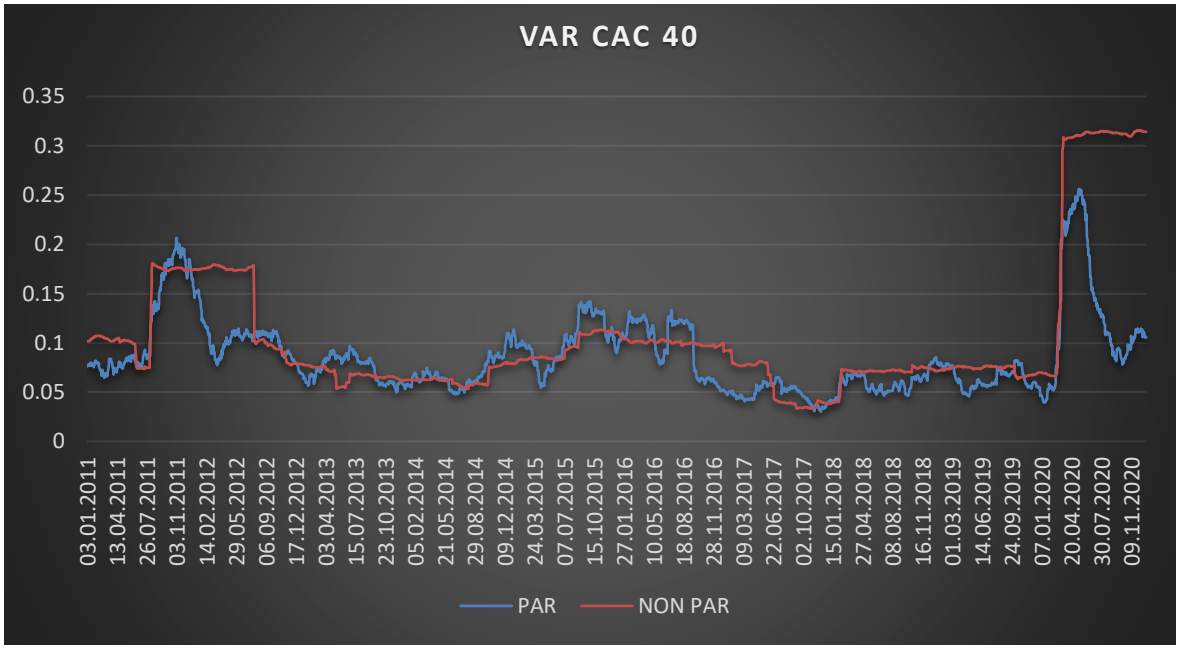
	Parametric		Non Parametric	
	AVG	MAX	AVG	MAX
2019	6,69%	8,95%	6,54%	7,99%
2020	13,83%	26,49%	27,67%	32,81%
Variation	7,13%	17,54%	21,13%	24,82%

CANADA



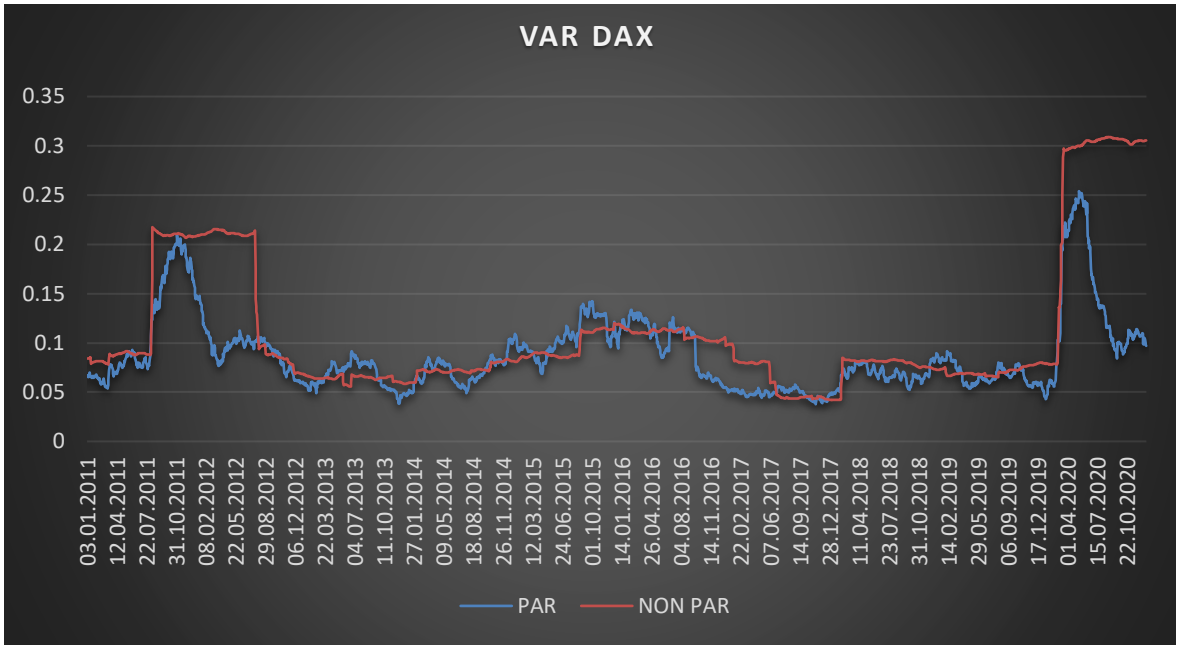
	Parametric		Non Parametric	
	AVG	MAX	AVG	MAX
2019	3,95%	7,17%	6,15%	6,72%
2020	11,97%	30,15%	25,15%	30,87%
Variation	8,01%	22,98%	19,00%	24,15%

FRANCE



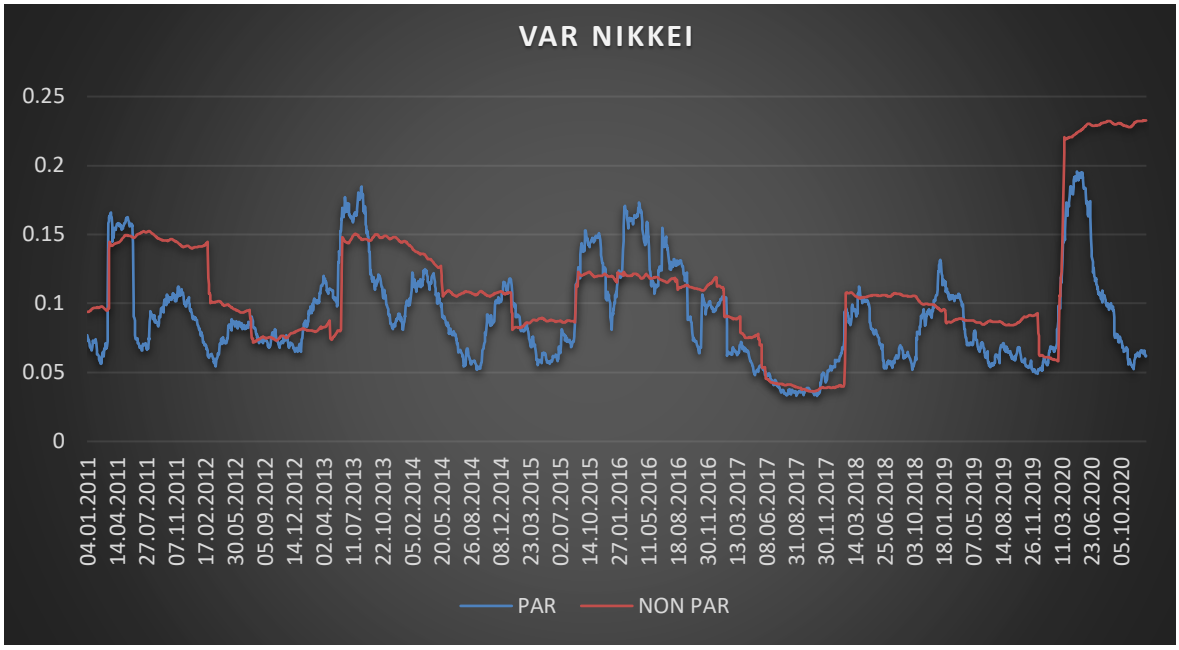
	Parametric		Non Parametric	
	AVG	MAX	AVG	MAX
2019	6,49%	8,56%	7,29%	7,68%
2020	13,29%	25,64%	26,48%	31,58%
Variation	6,80%	17,08%	19,19%	23,91%

GERMANY



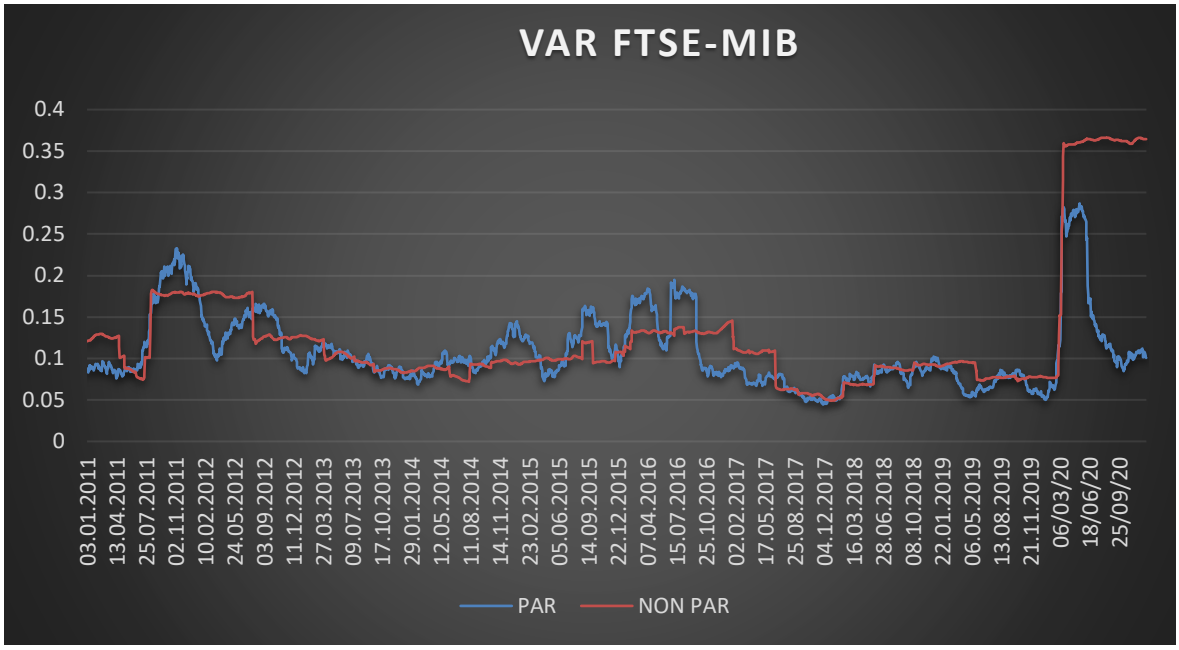
	Parametric		Non Parametric	
	AVG	MAX	AVG	MAX
2019	6,88%	9,16%	7,09%	8,01%
2020	13,67%	25,40%	25,98%	30,90%
Variation	6,79%	16,23%	18,89%	22,89%

JAPAN



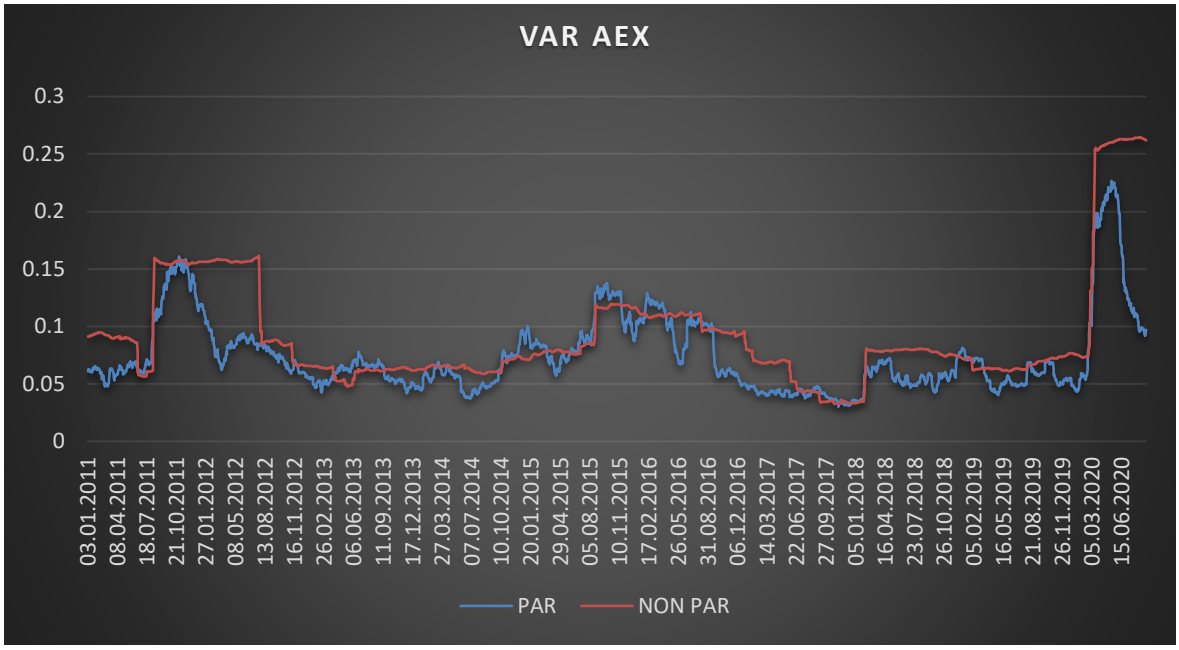
	Parametric		Non Parametric	
	AVG	MAX	AVG	MAX
2019	7,37%	13,18%	8,69%	9,60%
2020	10,72%	19,57%	19,71%	23,27%
Variation	3,35%	6,39%	11,02%	13,66%

ITALY



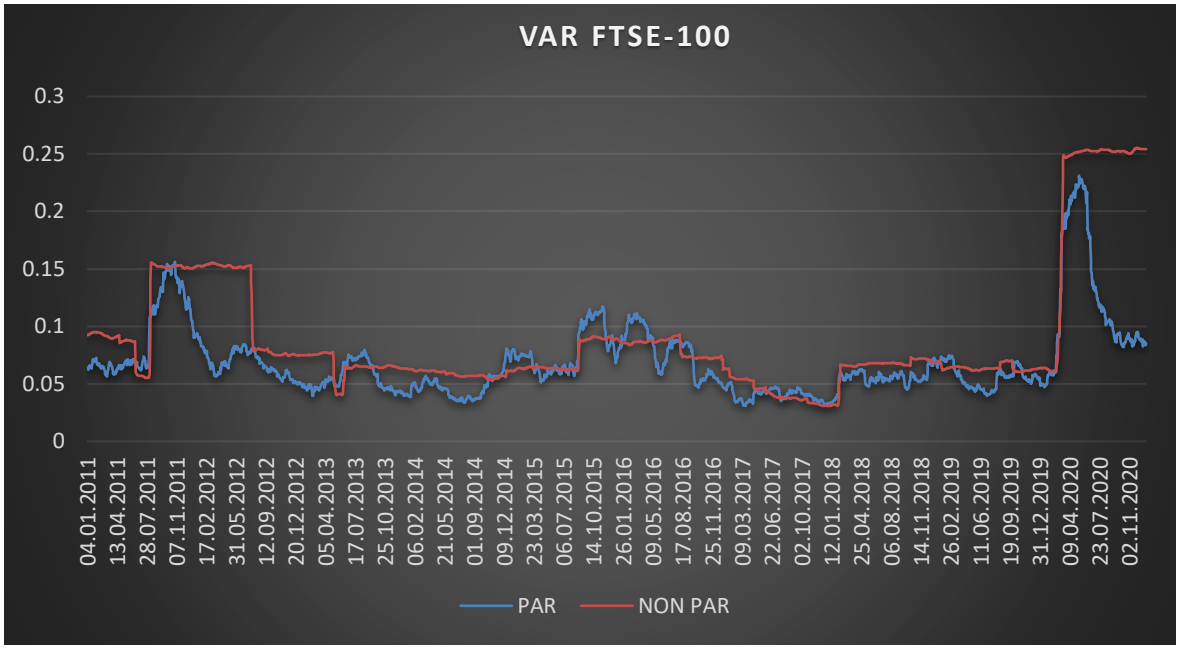
	Parametric		Non Parametric	
	AVG	MAX	AVG	MAX
2019	7,27%	10,04%	8,33%	9,68%
2020	14,53%	28,69%	30,68%	36,62%
Variation	7,27%	18,64%	22,35%	26,95%

HOLLANDE



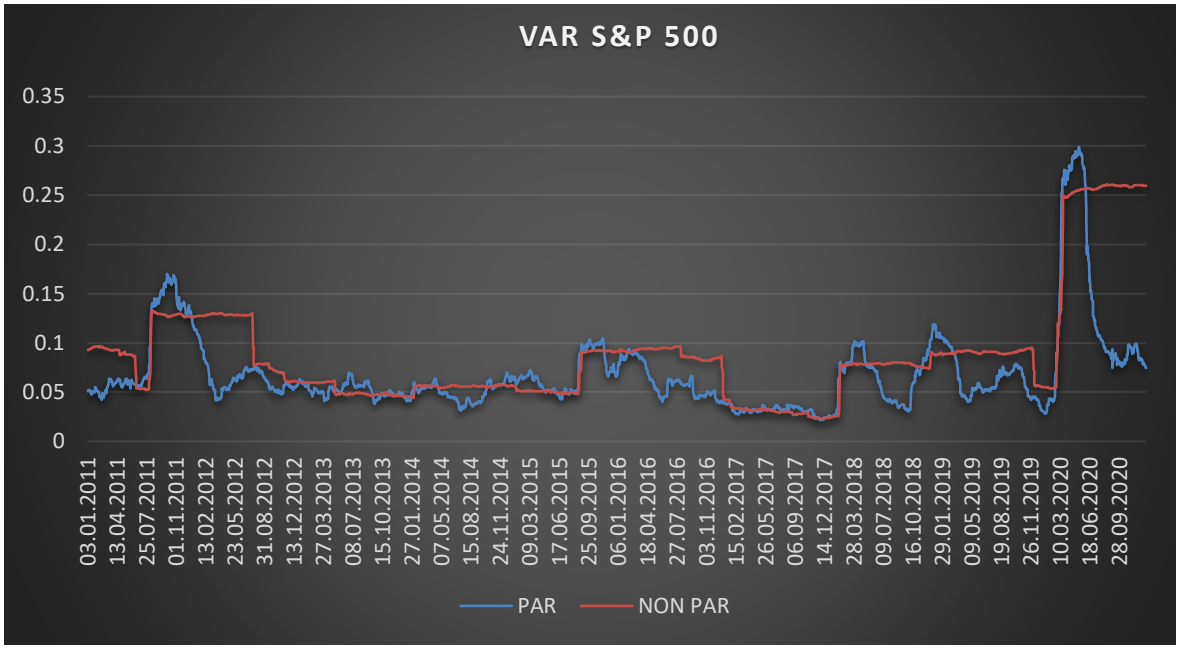
	Parametric		Non Parametric	
	AVG	MAX	AVG	MAX
2019	5,80%	8,10%	6,70%	7,70%
2020	11,77%	22,66%	22,56%	26,45%
Variation	5,97%	14,55%	15,86%	18,75%

UNITED KINGDOM



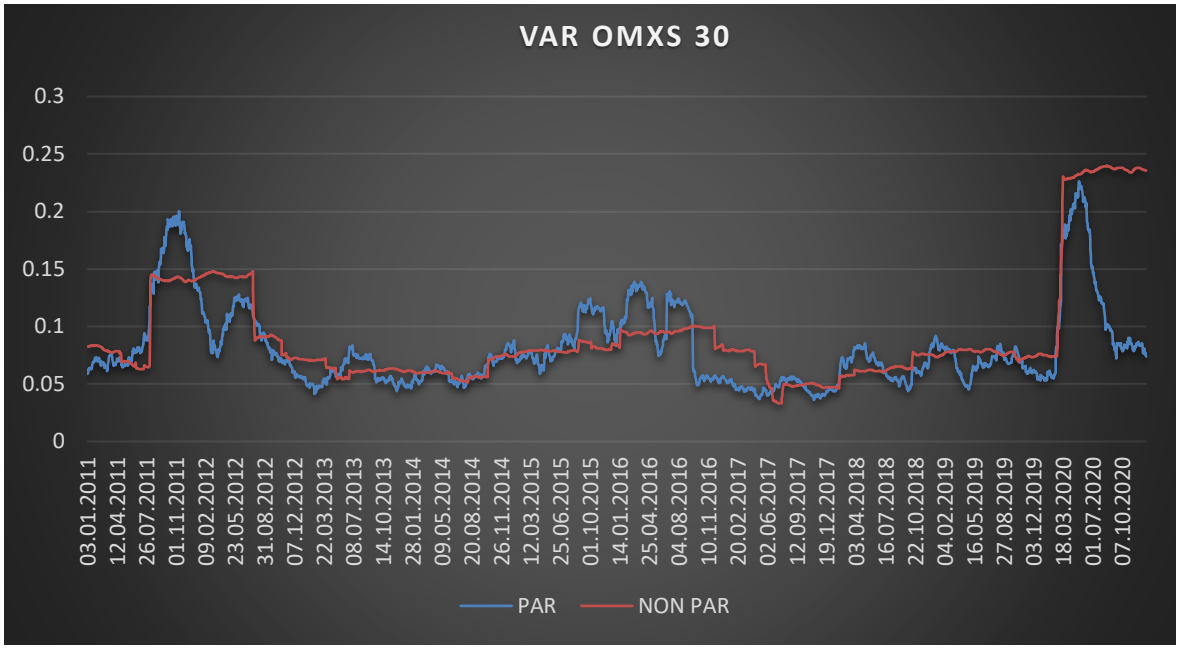
	Parametric		Non Parametric	
	AVG	MAX	AVG	MAX
2019	5,65%	7,48%	6,40%	7,04%
2020	12,26%	23,11%	21,48%	25,53%
Variation	6,61%	15,63%	15,08%	18,50%

USA



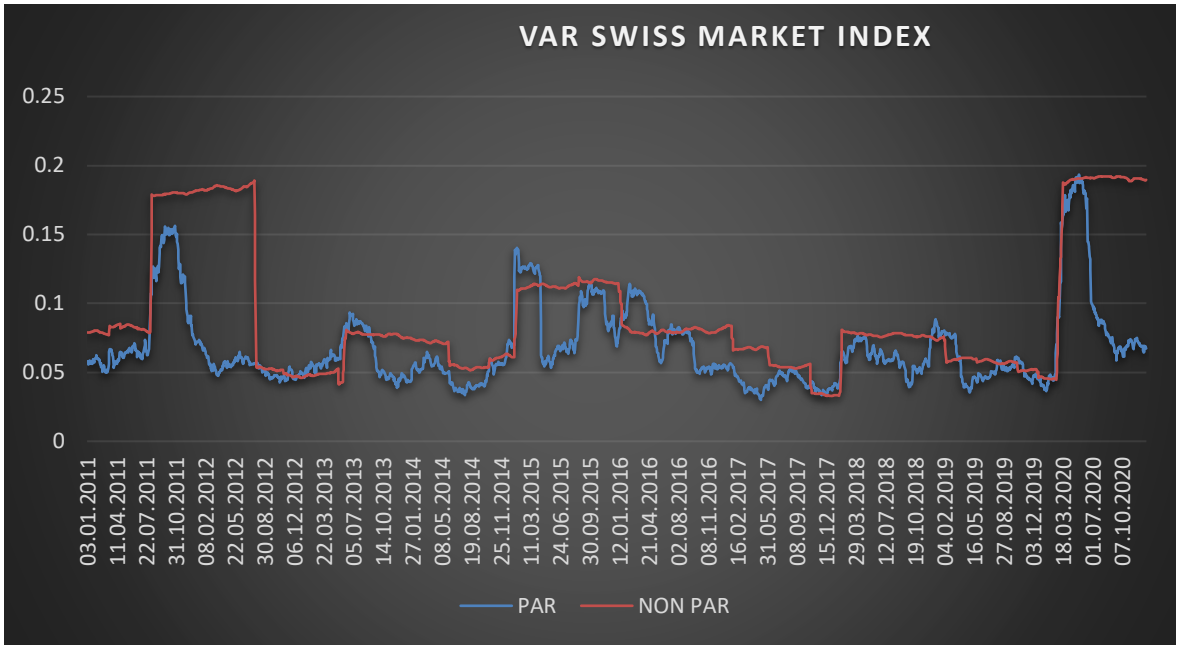
	Parametric		Non Parametric	
	AVG	MAX	AVG	MAX
2019	6,67%	11,87%	8,86%	9,53%
2020	13,38%	29,89%	21,81%	26,05%
Variation	6,71%	18,02%	12,94%	16,52%

SWEDEN



	Parametric		Non Parametric	
	AVG	MAX	AVG	MAX
2019	6,89%	9,18%	7,67%	8,05%
2020	11,96%	22,63%	20,41%	23,96%
Variation	5,08%	13,45%	12,73%	15,91%

SWITZERLAND



	Parametric		Non Parametric	
	AVG	MAX	AVG	MAX
2019	5,54%	8,84%	5,84%	7,59%
2020	9,89%	19,34%	16,36%	19,22%
Variation	4,35%	10,50%	10,52%	11,63%

The graphs just presented show VaR performance from 2011 to 2019 (parametric in blue and non-parametric in orange). From the summary tables we can see the countries that in terms of VaR have performed better and worse. Considering the Parametric VaR, Japan was the country that showed the smallest increase in average and maximum value between 2019 and 2020 (+ 3.35% in average value and + 6.39% in maximum value). On the other hand, the worst was Canada, with an average increase of 8.01% and a maximum of 22.98%. On the other hand, analyzing the non-parametric VaR, the worst index is the Italian one, with an increase in the average value of 22.35% and the maximum of 26.95%. Switzerland, on the other hand, shows the smallest increase between 2019 and 2020, with an increase of 10.52% in the average value and 11.63% in the maximum value. From both the tables and the graphs it is possible to see a big difference between the two calculation methods, namely that parametric VaR is much faster in reacting to market changes. In each of the 11 graphs it can be seen that, after the peak reached between April and May 2020, the values have dropped dramatically. The non-parametric calculation, on the other hand, takes a much longer time horizon to return to values prior to the shock caused by the coronavirus. The reason is obviously in the different calculation methodology. The parametric Value-at-Risk was calculated on a daily basis with data that, taking into account the standard deviation, reach a maximum of 3 months before. On the other hand, the non-parametric calculation "embraces" values up to a year earlier, so much so that in the analysis, all the data from 2010 were used only to initialize the first value of 2011. Further evidence of this difference between the two approaches, on a graphical level, can be seen in the period between 2011 and 2012. The American sub-prime mortgage crisis of 2007 had in fact had very heavy repercussions in the Eurozone, due to a very high increase in the debt of the main countries (and consequently in the ratio of debt to GDP). Therefore, in 2010, what was later renamed the "European Sovereign Debt Crisis" began for all intents and purposes. As with the American crisis of 2007, this also had significant consequences on many other countries. On a graphical level, only Canada, among the member countries of the G11, shows only a moderate increase in VaR in those years. Once again, for the other countries, the trend between the parametric and non-parametric approach followed the same logic highlighted in 2020. This difference between the two models cannot and must not lead to judgments on the goodness of one method to the detriment of the other. The VaR is essentially a statistical indicator and as such is strongly influenced by the starting hypotheses made. For this reason the two values have been considered exactly equal and every consideration has been repeated for each of the two models.

CHAPTER 5

Analysis of the relationship between VaR and Covid-19

In the previous chapters, the three different players in this study were introduced: the Covid-19, the stock market indices of the G10 countries and the Value at Risk. Subsequently, after an analysis of the robustness and goodness of the data used for the calculations, the values of the VaR, parametric and non-parametric, of the countries considered were reported. The difference in values, both in average and maximum terms, between the years 2019 and 2020, was evident. In this fifth and final chapter, the goal is to go on to determine the relationship between this variation and Coronavirus. To do so, the number of positives and deaths officially linked to the virus and the values on unemployment, one of the economic parameters most affected by pandemic effects, were taken into account. Before illustrating the results of the analysis, the concepts of "Correlation and Causality" and "Coefficient of Determinations R Framework", both central to the analysis of the chapter, will be introduced.

Correlation and randomness

Correlation and randomness are two statistical concepts that are often mistakenly confused or approximated with each other. In reality they indicate quite distinct things.

Correlation refers to the relationship between two (or more) variables that change together, and can be either negative or positive.

A positive correlation is when, if one variable increases, so does the other. An example might be an increase in temperature that correlates with increased use of air conditioners. A correlation is instead negative if as one variable increases, the other decreases. Net of price elasticity considerations, we can think of the case where the price of a good increases and its consumption, i.e. the number of goods sold, decreases.

Randomness refers to a relationship between two or more variables in which one variable causes the other. In order to speak of causality, three different requirements must be met:

- The variables must be related to each other
- In the case of two variables, one variable must precede the other.
- It must be demonstrated that a third variable is not in turn modifying the two variables of interest.

The first requirement shows how correlation and randomness are two distinct characteristics, as the correlation between two variables is a necessary condition for randomness to occur. Equally important is the third requirement, which excludes the so-called "spurious correlation". This concept was introduced in 1926 by George Udny Yule, who in a study noted the positive linear correlation between percentage of marriages and mortality rate, two events obviously not linked in any way. Based on subsequent studies, including those of the 2003 Nobel Prize winner for economics Clive W. J. Granger, it can be said that even if two phenomena are correlated from a statistical point of view, it cannot be said that there is a cause-effect relationship. The correlation could be random (or spurious), and depend on a third element. A curious and at the same time intuitive example of spurious correlation is the relationship between marriages and number of swallows in the sky. Obviously there is no direct link between the two phenomena, but in some countries swallows tend to migrate more in spring and autumn, two seasons in which, for socio-cultural reasons, more marriages are celebrated. In the light of what has been said, it must be specified that in this paper we will only look for a correlation between the reported parameters, which will then be analyzed also in the light of the "R Framework" parameter. The different types of counting of deaths and positives and the fact that the Stock Exchange Indices (and therefore the VaR) were strongly influenced by an event of unprecedented magnitude make the scenario absolutely distant, in statistical terms, from the "controlled experiment" conditions necessary to identify an effective causality between two variables. It should also be remembered that the Value at Risk values chosen, although calculated correctly, are strongly influenced by arbitrarily chosen parameters. First of

all, the confidence interval, always chosen as 99%, when it could have been 90%, 95% or 97.5%. The same applies to the Holding Period of 10 days, although chosen in accordance with the Basel regulations, it could have been different. More generally, the choice of comparing the epidemiological and unemployment data with the parametric and non-parametric VaR, and not, for example, with the VaR calculated with the Monte-Carlo simulation, was also arbitrary. That is why talking about an "absolute" relationship or causality between the change in Value at Risk between 2019 and 2020 and certain parameters would be incorrect. However, even just analyzing the correlation between these parameters provides very useful information for an initial analysis of the effects that Covid has had on the global economy.

Coefficient of determination R

The coefficient of determination, in statistics, is the ratio between the variability of the data of a statistical model and its correctness. It can take values between 0 and 1, and indicates, in practical terms, how well the linear regression line used can explain the data of a given model. A value of 0 indicates that there is no relationship between two linear variables. On the contrary, R Quadro equal to 1 represents a perfect linear relationship between the two variables under examination. It is calculated according to the formula

$$R^2 = \frac{ESS}{TSS}$$

with

$$ESS = \sum_{i=1}^{n} (\hat{y}_i - \overline{y})^2$$

that represents the Explained Sum of Squares

and

$$TSS = \sum_{i=1}^{n} (y_i - \overline{y})^2$$

that represents the Total Sum of Squares.

Around the coefficient of determination there are many misconceptions. Chief among them are those that based on the value it is possible to determine whether the most appropriate set of regressors was chosen or whether the variables considered are statistically significant. The value of the R square only indicates the percentage of the data explained by the model. It is also not entirely correct to use static ranges to indicate the threshold values for which the coefficient is valid or not, such as between 0 and 0.3 R null, between 0.3 and 0.7 R medium or above 0.7 R high. Influencing this parameter is first the field of study, followed immediately by the goodness of fit of the data. As already reported, all Coronavirus-related data are calculated differently by each country. Trivially, a consideration of the simple number of positive swabs is influenced by the number of swabs performed, which in turn can be molecular or rapid, i.e., two tests with different sensitivity. In addition, a swab may sometimes provide a borderline value, which different operators might interpret differently. This is just an example, but it allows to understand that in the present discussion it is not legitimate to expect high R values.

Another important consideration is that in order to understand "how big R should be", one must take into account the precision required for the estimate in question. In this discussion, the main objective is to quantify the impact of Covid on the world economy. Considering a statistical value such as VaR is in fact already a major limitation. It is unthinkable that a single parameter can perfectly explain all the

impacts that Covid has had on the economy, even if it is correlated to data whose quality has already been discussed. In conclusion, even low R values could be accepted in demonstrating a correlation, however weak, between the increase in VaR in the 2019-2020 biennium and the parameters chosen (positivity rate, mortality rate, unemployment rate).

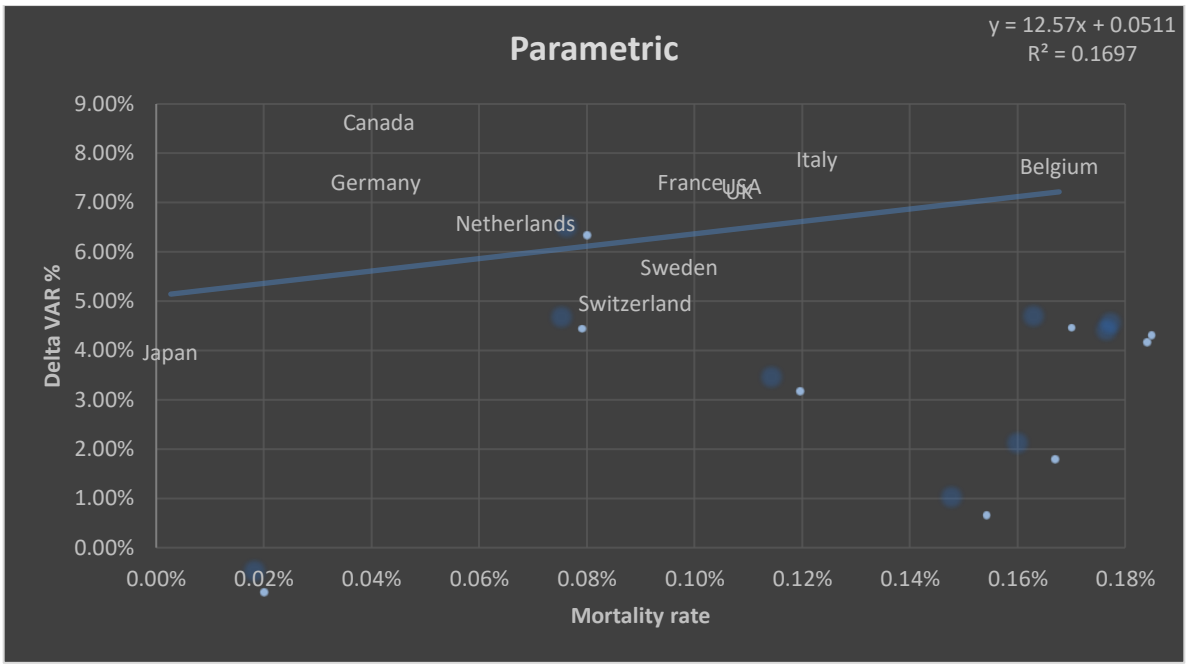
Mortality rate

One of the problems related to information about Coronavirus, worldwide, has been from the beginning the use of scientific terms in an inappropriate way. For example, in many countries, during the first wave of 2020, comparisons were made with past influences (e.g. Spanish flu) in terms of mortality or lethality. These two terms have repeatedly been used as synonyms, when in fact they represent two very different things.

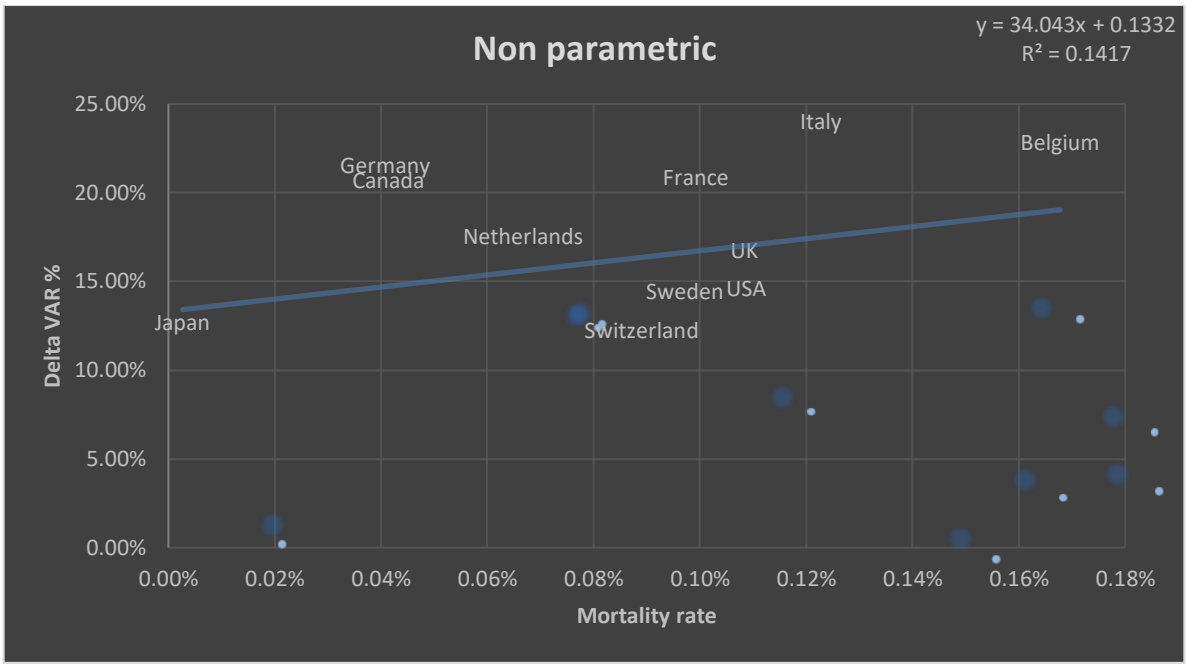
The lethality rate is the ratio between the number of people who died of a disease and the total number of sick people.

The mortality rate, on the other hand, is given by dividing the number of people who died from a disease by the total number of people exposed.

In this paper, mortality was considered for each of the G10 member countries. This means that the rates obtained were calculated from the ratio of the number of deaths for each country to its population. The number was then considered as a percentage value to make it possible to compare the 11 countries. Because of the different sizes of the various countries, considering absolute numbers would have led to enormous distortions, since it is obvious that, all things being equal, a country with a population double or triple that of another tends to have a greater number of deaths. There is then to consider the fact that, in the dissemination of official data, each country has followed its own logic, and there was no control by higher organizations (such as WHO) on the goodness of the data. This does not necessarily imply that some data have been manipulated or are "more correct" than others, but only that they compare data taken in a different way. Italy has been an example of very rigorous counting both for positivity and for the number of deaths. Other countries, such as Sweden, at least initially have followed different logics. Unquestionable proof of these different operations is given by the different amount of swabs carried out. In any case, considering the very large time sample, i.e., all of 2020, and the fact that with the beginning of the second wave, even the countries that were initially less careful have raised the threshold of attention, it is possible to make a comparison between the various countries, trying to highlight a possible correlation between the mortality rate and the increase in the average Value at Risk between 2019 and 2020.



The graph shows the correlation between the percentage of deaths and the difference in parametric VaR between 2019 and 2020. Some positive linear correlation can be seen. The value of the coefficient of determination is about 17%. This is not a particularly high value but, in this case, not very low. It can be seen that some countries have performed particularly better or worse than others. Japan, which had a very low mortality rate, according to the model should have had an increase in VaR of about 2 percentage points more. Countries such as Germany, Italy and especially Canada should have performed better. In reality, mortality, just like the number of positives, has seen a strong influence of external factors. The average age of the population and the level and accessibility of medical care have in fact played a central role, providing some surprising results. This is the case when comparing the USA, whose largely private healthcare is often spoken of in a negative light, with Italy, which guarantees every citizen free healthcare. In percentage terms, Italy has suffered greater losses. Undoubtedly the higher average age and the fact that Italy was one of the first countries to be affected after China have had a major impact on the Italian situation.

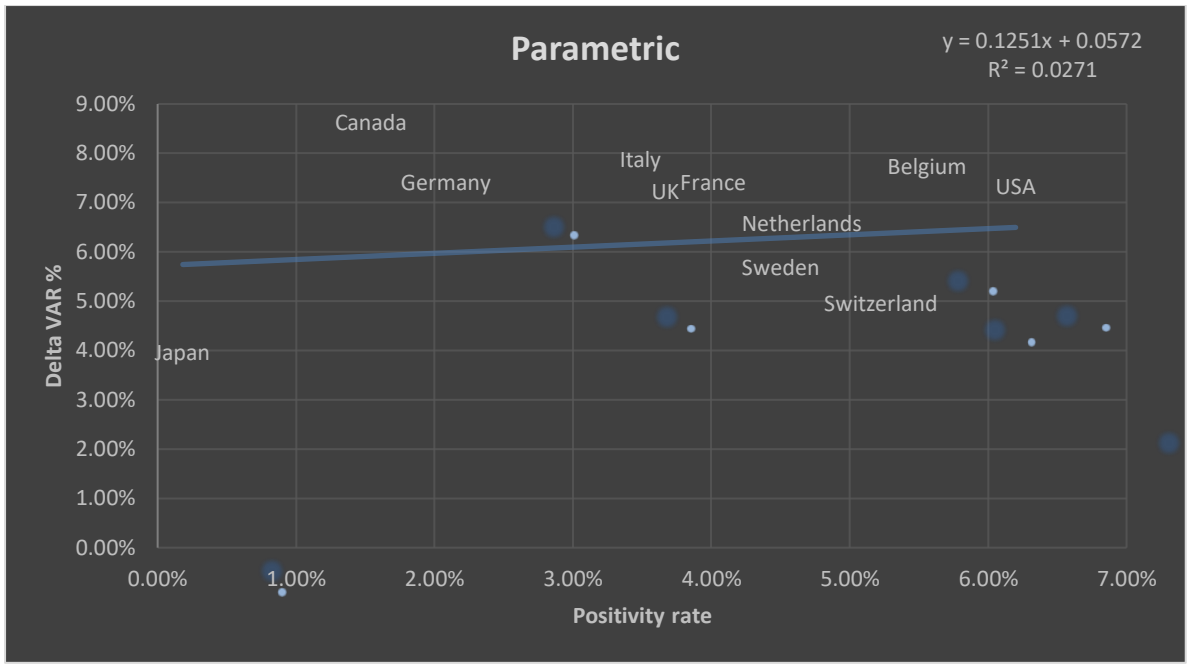


The correlation between the mortality rate and the average change in nonparametric VaR has a similar pattern to the previous case, so we can also speak of a slight positive linear correlation in this case. The coefficient of determination is slightly lower, and is just over 14%. The lower value can easily be explained by the fact that, in the analysis in question, the parametric model was more suitable for calculation. In fact, between the two methodologies, the parametric VaR is much faster in reacting to variations, a fundamental characteristic in the case under examination in which, due to the coronavirus, the values of the Stock Exchange indices analyzed had significant variations in a very limited time interval.

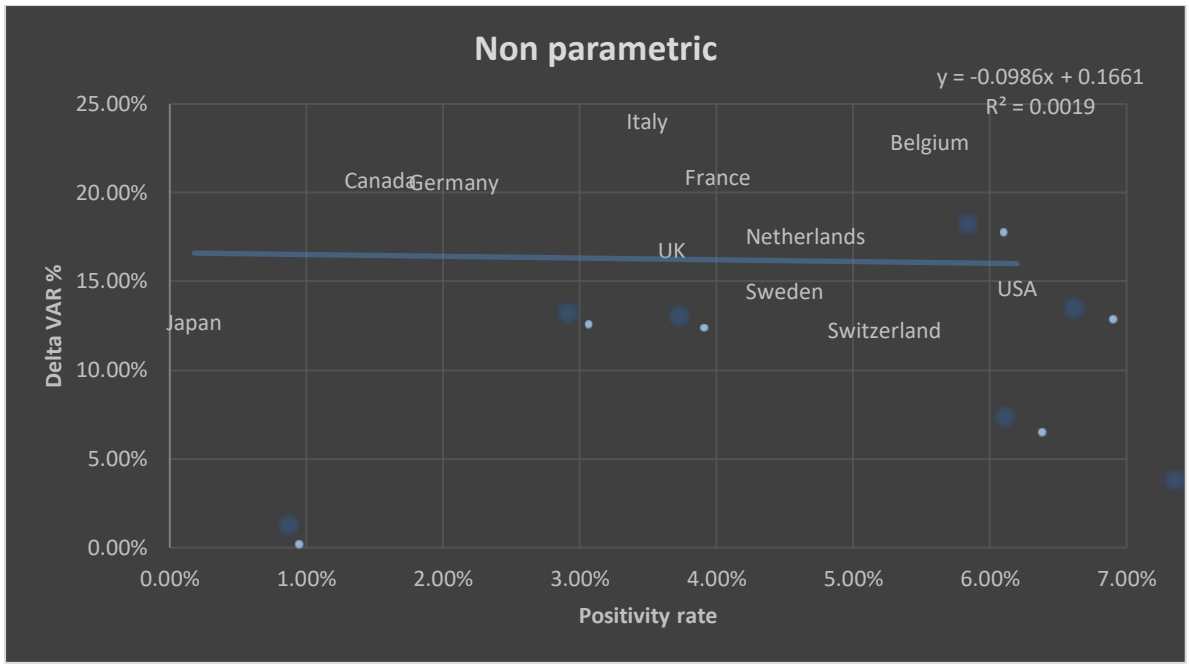
Positivity rate

The number of Coronavirus positives could appear to be a very useful data for making comparisons, as it can be obtained as a result of an instrument used by all on a large scale, namely the swab. In reality there are many aspects that make the rate of positivity a value with possible huge differences between different countries. First of all there are two different types of swabs, the molecular swab and the rapid swab. Both can give as a result either a false negative or a false positive. Generally the molecular swab is more reliable, but still subject to error.

Then, especially during the first wave, Covid was addressed worldwide with different timing and modalities. In March 2020, while in Italy the situation precipitated, many other European countries did not take the slightest precaution, paying the consequences of this delay later. In fact, Italy, during the first wave, was one of the countries that carried out more swabs, with logical consequences on the number of positives recorded. Considering then that asymptomatic people played a huge role in the spread of the virus, it is estimated that at the end of 2020 the number of people who were really positive was about 6/7 times the official count. Finally, in addition to the sensitivity and sensitivity errors of the swabs and the different volume of swabs taken, there is the issue of communication. It is inconceivable to think that all over the world, for more than a year, the data were always correctly communicated. We need only think of the Italian case in which, on an almost weekly basis, there were corrections or actual recounts. During the most acute phases of the emergency, it is plausible to suppose that in the 11 countries examined, errors may have been made and that the official data are, in fact, different from the real ones. In any case, as in the case of mortality, it is worth considering that over the course of the entire year the differences between the various countries have diminished, so it is worth considering this parameter. Even if we wanted to consider the number of positive persons with respect to the number of swabs carried out, that is, a value that is still approximate but already more significant, it would be impossible to proceed with the analysis, since the data on the swabs carried out in many countries are unobtainable or significantly different if different sources are considered, therefore unreliable. For the elaboration, the same source (certified) was used for the number of positive persons at the end of 2020. As with mortality, the value was then considered as a percentage to normalize the figure to the population.



In the case of parametric VaR, a weak positive linear correlation can be seen between the increase in value at risk and the positivity rate. Compared to the previously analyzed case of mortality, the coefficient of determination is just under 3%, a value that tends to be low. The countries that deviate most from the straight line that approximates the trend are Japan, Canada and Switzerland. It can be seen that Japan and Switzerland had a particularly positive performance, in terms of increase in VaR, while Canada, compared to the officially recorded rate of positivity, had a high average increase in VaR, being also the country with the worst data. In fact, it would be enough to remove Canada from the countries observed and the VaR would rise to around 17%, with an increase of 14 percentage points. This implies that the trend in the other countries was much more uniform.



The graph shows a correlation that is even weakly negative between the increase in value at risk and the percentage of positives recorded. This is quite counter-intuitive and the first "alarm bell" is in the coefficient of determination, which is even lower than 0.5% and therefore practically null. In the 6 cases analyzed, this is the lowest value recorded. An explanation lies in the fact that of the two calculation models used for VaR, the non-parametric method has not proved particularly suitable for analysis, or at least has proved to be less performing than the parametric model. In fact, the two models differ in their "historical memory". While the parametric VaR considers values up to 3 months prior to each measurement, the non-parametric VaR considers all the values of the previous year. In practical terms, this is a figure that has a historical memory as much as 4 times higher than the other. Since the Coronavirus has caused rapid and significant changes in the indices, it is clear that the parametric model, which is much faster in reacting to changes, has returned much more significant values. In fact, for all the indices analyzed, after the shock of the period March-May 2020, i.e. the one related to the first wave of Covid-19, there was a slow return to much lower values of VaR and not much higher than the average of the end of 2019. The non-parametric calculation, on the other hand, considers the entire year 2020 at very high values, precisely because it continues to take into account the sudden shock of the first wave. It is no coincidence that in all 3 cases under examination, i.e., mortality rate, positivity rate, and unemployment rate, the correlation associated with the parametric case performed more in line with expectations than the nonparametric case (generally with a higher coefficient of determination).

Unemployment rate

The first two parameters analyzed from a medical-health point of view were the most significant. However, due to the frequent lockdowns used throughout the world as a countermeasure to Covid, it was immediately evident that the consequences would be very heavy also in economic and social terms. In this sense, the unemployment rate offers very useful information to photograph the situation of each country. However, before analyzing the correlation between this data and the increase in VaR, it is appropriate to take a closer look at the concept of unemployment and how it is calculated.
The unemployment rate is calculated using the formula

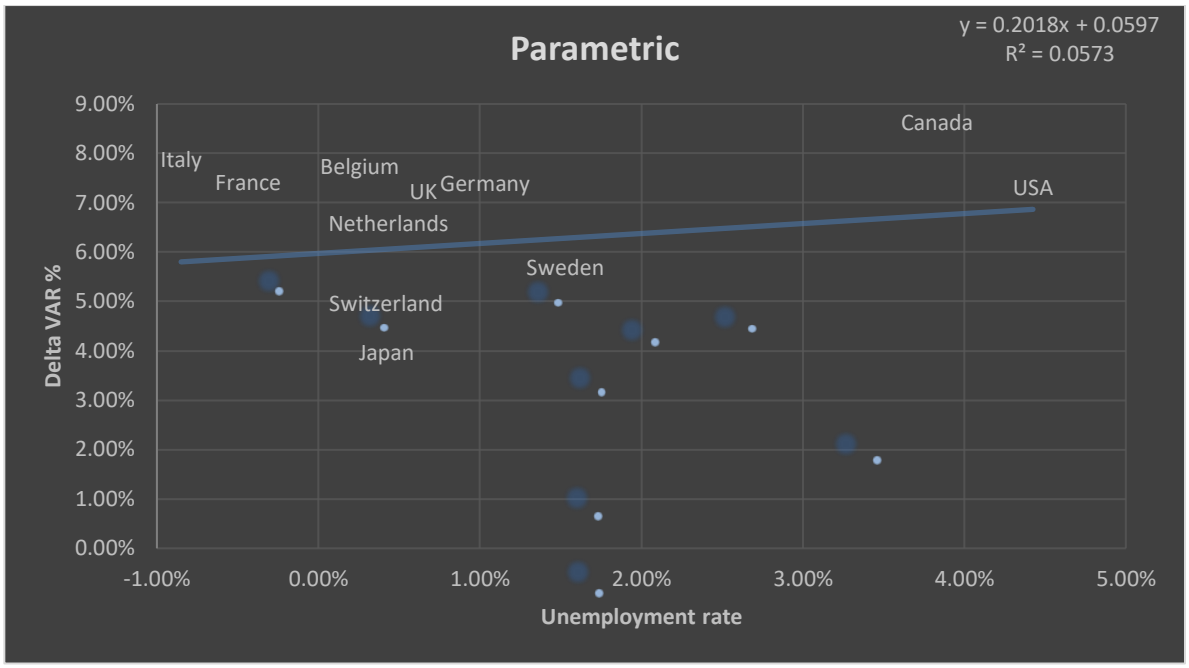
$$\frac{Unemployed\ rate}{Labor\ force}\ x\ 100$$

where "unemployed rate" represents people who are looking for work in the 15-64 age bracket, while "labor force" is the sum of the denominator value and the employed, i.e. all those who could potentially work. A person, according to European parameters, is defined as employed if in the reference period (often equal to one week), he or she verifies one of the following conditions:
- Has performed at least one hour of paid work
- Has performed at least one hour of work in a family member's business
- Has not done actual work but has maintained employment (this is the case with vacation, illness, or leave)

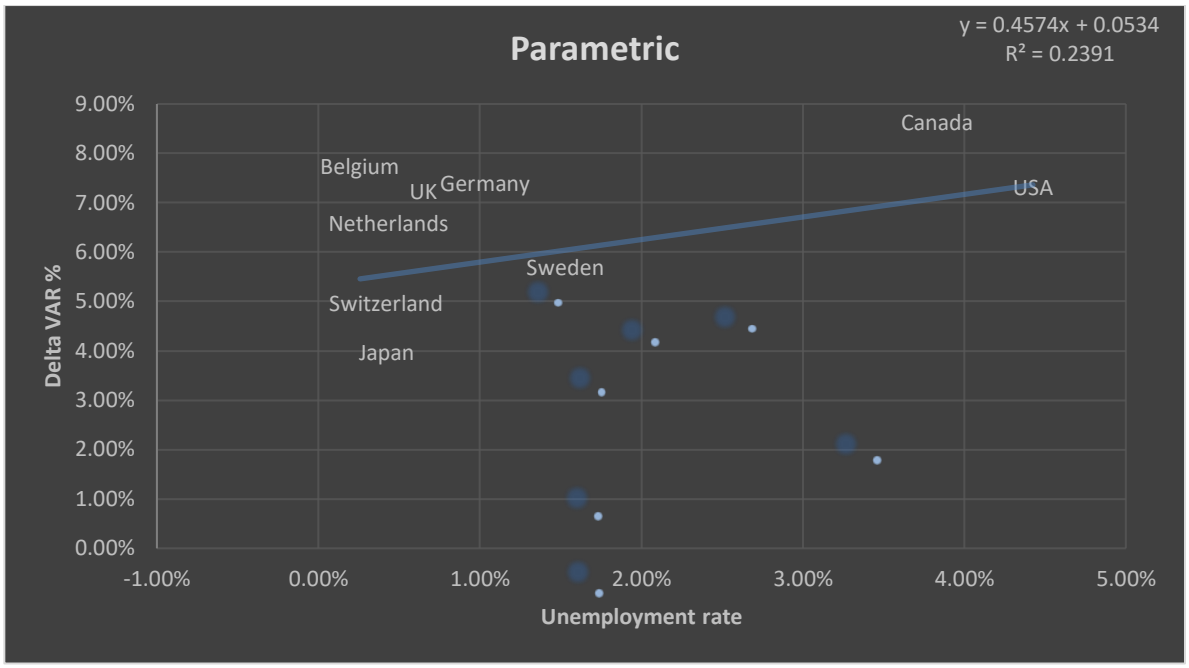
A person is defined as seeking employment if, again during the reference period, he or she meets at least one of these conditions:
- Has made at least one active job search in the previous 4 weeks
- He/she declares him/herself available for work for at least the next 2 weeks

The total labor force, consequently, is given by the sum of employed persons and job seekers. In general, the unemployment rate tends to underestimate the real value because considering a worker as paid only for a few hours of work (think for example of on-call contracts) tends to distort reality. Similarly, a distinction is made between unemployed and unemployable, where the latter term refers to a person who has never worked.
The unemployment rate is one of the most important parameters for a country's economy, as well as one of the most important in the media. For this reason, there are often real distortions of the real situation in order to highlight one aspect in favor of another. One example is comparisons between different countries. The unemployment rate, and more generally the labor market, are strongly conditioned by social (therefore also union) and cultural motivations. Considering the example of the USA and Italy, we have two completely different scenarios. For economic and political reasons, but also

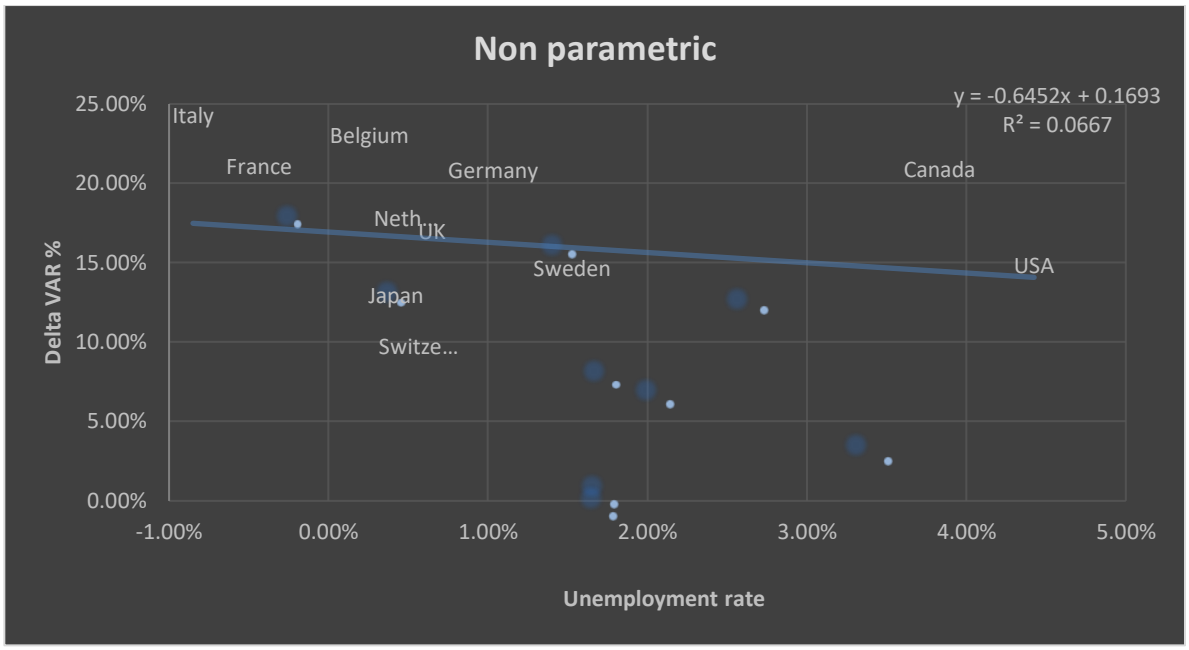
due to characteristics of their culture, people in the USA tend to change jobs a great deal, are very flexible and willing to move around geographically. In Italy, the opposite conditions occur, i.e. people tend to try to keep their jobs for as long as possible and moves are not well seen. In between these two extremes, there are many possible cases, all different from each other. But in general, it is the role played by unions that tips the scales. Such motivations have meant that the crisis related to Covid-19 has had very different influences from case to case. In the paper, monthly values, covering 2019 and 2020, were considered and averaged. Therefore, it has not been highlighted how in the USA, for example, the maximum peak of unemployment between April and June reached very high values, only to be lowered again with the first reopenings of last summer, precisely because of the aforementioned intrinsic flexibility of the working world. In Italy, to remain on the example given earlier, we have instead witnessed something very peculiar, namely the average unemployment rate that even, in the year of the pandemic, fell compared to 2019. In fact, the Italian government passed a layoff freeze as one of the measures to contain the effects of the Coronavirus. While it is true that from the spring of 2021 this freeze, unless extended, will expire, with possible very negative effects on those who have benefited from it, it is undeniable that in the most critical moment from an economic point of view, this support has been of great help to a great many employees.



The graph shows a positive linear correlation between the increase in unemployment and the increase in Value at Risk. It is certainly noticeable that two countries, Italy and France, have recorded a singular figure, that is, a decrease in the unemployment rate. This phenomenon, apparently almost counter-intuitive, is explained by precise choices made by the two governments to protect the employed class. Among the other countries, the USA has recorded the largest average increase in unemployment, although the enormous flexibility of its labor market has already been mentioned and it would not be surprising if in 2021 it were to return to perform particularly well as in the last four years. Japan, as well as the rate of positivity and mortality, registers a very positive value, showing itself as one of the best countries to know how to fight the Coronavirus. In this sense, according to many experts, the fact of always wearing surgical masks in crowded public places (such as subways) could have helped the eastern country, certainly more ready than others, from a cultural point of view, to face the challenge brought by Covid. For the rest, apart from Canada, which recorded values similar to those of the USA, the European bloc behaved similarly. In this case, it can be seen that the coefficient of determination is slightly less than 6%, but, eliminating France and Italy from the model, which recorded values that are, to say the least, unusual and therefore almost comparable to outliers, R would be equal to around 24%, with an even more marked positive linear trend (see graph below).



The graph, in which France and Italy have been removed, shows a very strong correlation between the increase in parametric Value at Risk and the increase in the unemployment rate in 9 of the 11 countries taken into consideration.



In the last graph analyzed, a negative linear correlation is shown between the increase in non-parametric VaR and the increase in unemployment. Again, as in the case of positivity (with non-parametric VaR), it is counter-intuitive to think that, as average unemployment increases, a country can perform better in terms of Value at Risks, thus recording lower values. The non-parametric model, as already highlighted, is very slow to react to changes in market risks, and records a delta, both in the average and in the maximum value, which is very significant compared to the parametric VaR. Therefore, in this case, despite having a greater coefficient of determination compared to the parametric case, equal to around 6.7%, the data is less significant.

CHAPTER 6

Conclusions

In the previous chapters, a great deal of data was analyzed for the decade 2010-2020, relating to the main stock market indices of the G10 member countries. Using this data, the Value at Risk was calculated, with a particular focus on the two-year period 2019-2020. On the basis of the evidence reported, it is possible to draw a series of conclusions that will be the central part of this sixth and final chapter.

Effects of Covid on VaR

The coronavirus has had enormous consequences on the daily lives of people around the world. Lockdowns have been of different types and durations, but still a measure used virtually everywhere. Immediately, in addition to the health risk, in any case of great magnitude, given the high number of deaths attributable to Covid, it was clear to all that there would be heavy consequences also in economic terms. It is likely to say that, to have a more precise idea of the real scope of the phenomenon, we will have to wait several years (because there will be many events that will be triggered in a chain from what happened in 2020) and it will be necessary a particularly in-depth study to capture all possible correlations, which are many. However, this paper has already highlighted a very important factor: in terms of Value at Risk, the pandemic crisis was enormously more significant than the European sovereign debt crisis. This crisis, which developed at the turn of the century between 2010 and 2012, was a direct consequence of the sub-prime mortgage crisis in the USA between 2007 and 2008. The effects on the social level were devastating and tangible (think of the Italian case where the technical government led by Mario Monti was set up and adopted a series of unpopular reforms, to say the least). Chapter 4 shows the graphical trends of VaR in the period between 2011 and 2020, i.e., a time span that covers both the sovereign debt crisis and the most acute phase of the Covid crisis (period March-June 2020). Already from the graphs it can be easily seen that the VaR surge, in the last year, has been clearly higher, both for the parametric and the non-parametric calculation. What has made it possible to buffer the situation until now is that the event has been of such a vast scale that the aid plan offered has been unprecedented. For example, the EU, which in recent years had imposed strict policies and enormous attention to public spending (think of the case of Italy, but also that of Ireland or Greece), has approved the "Next Generation EU", a fund with a record amount of 750 billion Euros, which will aim to stimulate economic recovery in the member countries of the union. Given that economics is not an exact science and that in order to evaluate the effects of this action, as well as many others, many years will be needed (the European fund foresees an investment plan that will end in 2027), it is evident that at an economic level the situation seems paradoxically better than that of a decade ago, despite the many activities forced to close or work "intermittently". And yet, the increase in VaR is not an indicator that can be disregarded, so a worsening of the economic situation, especially in the 2021-2022 biennium, should not

come as much of a surprise. The hope is that the funds made available will allow for a net recovery compared to 2020, and the most optimistic economists say that since this is an unprecedented event, making a predictive model of what will happen is very difficult. However, the situation still remains uncertain and even in the event that 2021 should be the year in which the vaccination campaign marks a sharp turnaround in the fight against Covid, it will remain premature to speak of overcoming the crisis. In addition to the aforementioned current labor protection policies in Italy, which will end in the current year, another notable example in this regard is inflation in the USA. The US printed a record amount of dollars in 2020, and many economists say they are concerned about the possible increase in inflation in the short to medium term. More generally, cutting rates and buying bonds is what the major central banks have done (see chart below).

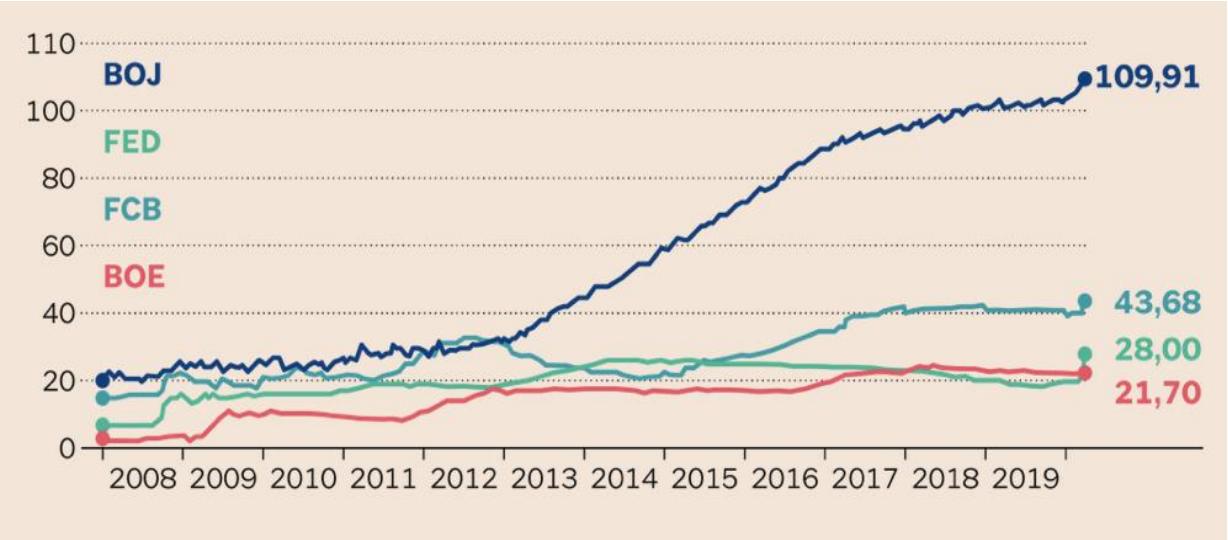


Fig 6.1 Portfolio of BOJ, FED, FCB and BOE

The main consequence of such policies is an increase in financial inflation, i.e. an unjustified rise in the prices of shares and bonds. Between 2021 and 2022, when the Covid emergency is over, central banks will be called upon to convince the markets to "turn back" by reducing their balance sheets. This is certainly a very complicated challenge.

Comparison between parametric and non-parametric VaR calculations

In chapter 4 it can be seen, from the graphs, how the parametric VaR was a much faster indicator in reacting to market variations than the non-parametric VaR. The reason that led to this difference has already been dealt with previously, namely the fact that the first VaR considers, for each measurement, values up to 3 months before, while the second model takes into consideration values up to one year before. In Chapter 5, in fact, one can see with a practical application the difference in performance between the two models. Only in the case of the mortality rate did the non-parametric VaR have a linearly correlated trend (positive), albeit with a lower coefficient of determination than the parametric case. On the other hand, as regards the positivity rate and the unemployment rate, net of the already discussed low quality of the data available, the model even showed a negative correlation between value at risk and the increase in the two values. In both cases, these are two results that have no significance. This is easily explained because the positivity rate and the unemployment rate during 2020 were strongly influenced by the trend of the virus spread. The parametric VaR, while taken at its mean value, followed exactly the same trend. The non-parametric VaR, on the other hand, immediately highlighted the increase in risk, without, however, returning to lower values in the periods in which the spread of the virus was very limited. In conclusion, the parametric calculation proved to be much better than the non-parametric one. However, this does not mean that the former model is necessarily always better than the latter. On the contrary, in general many analysts consider the historical simulation approach to be the best, since it does not require a priori assumptions about the trend in returns and because the correlation between risk factors is "captured" in an implicit way. However, one of the main problems is that the method loses a lot of efficiency in the case of significant structural changes in returns, i.e. exactly what happened due to an unpredictable and large event like the Covid. On the other hand, the parametric approach, although having the limitation of the assumption of normal distribution of the returns, which actually distribute according to a leptokurtic curve (see Chapter 1), allows to obtain discrete results in the case of sudden changes in the returns, as in the present case.

Effective correlation between VaR and parameters related to mortality, positivity and unemployment

The previous chapter focused on finding a correlation between the increase in VaR and the increase in 3 parameters directly or indirectly linked to Covid: mortality rate, positivity rate and unemployment rate. Because of the considerations made in chapter 5 and partly in the previous point of this chapter, it is worth focusing more on the results of the parametric calculation. To sum up, it can be seen that this correlation (positive linear) exists for mortality, is less evident for unemployment (unless one eliminates France and Italy from the model, obtaining an even greater coefficient of determination) and is almost nil with respect to the positivity rate. This should not be surprising because it is precisely in this order that the available data are most valid. Starting from mortality, it may be useful to analyze the Italian case, that is one of the countries with the highest percentage mortality in the world. Net of sterile controversy about the way deaths related to Covid are counted, several statistical studies have shown a significant increase in mortality, absolutely out of what can be the absolute error for a value calculated with a 95% confidence interval. In fact, at the end of 2020, there was a mortality rate that was about 6 to 7 times that of the average of the previous 5 years.

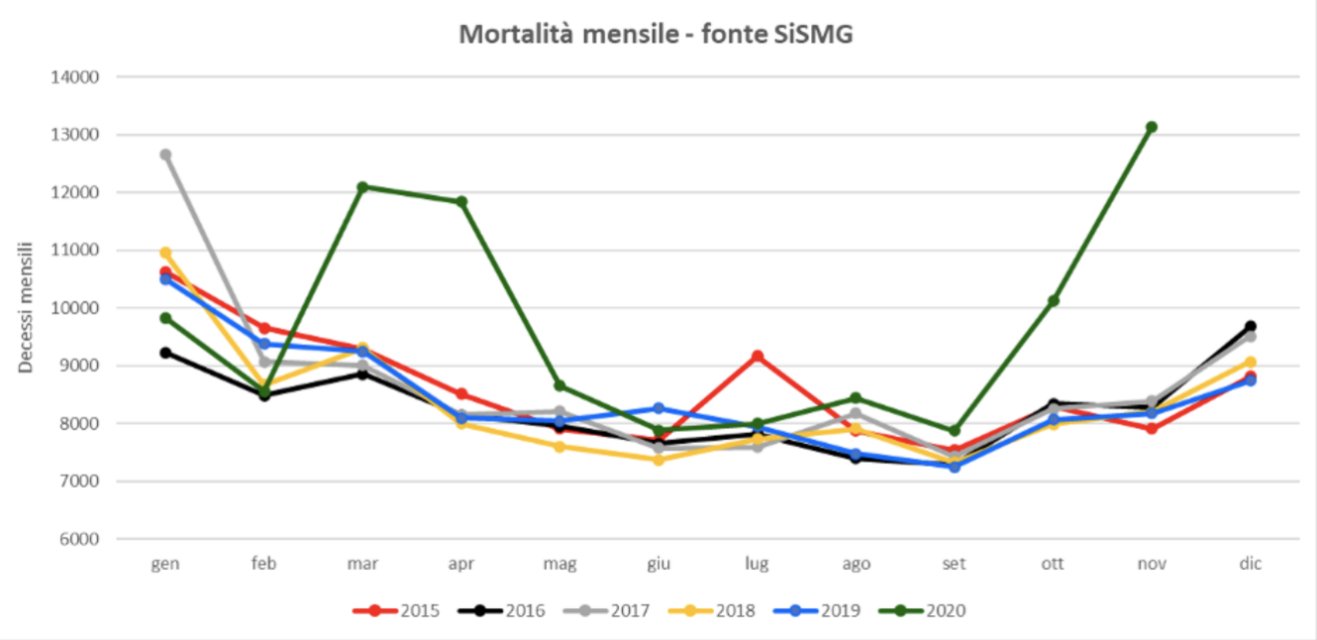


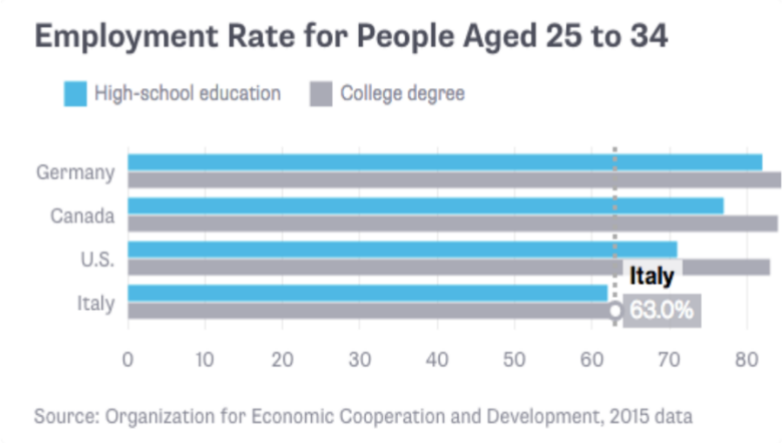
Fig 6.2 Mortality rate (monthly) in Italy in 2020

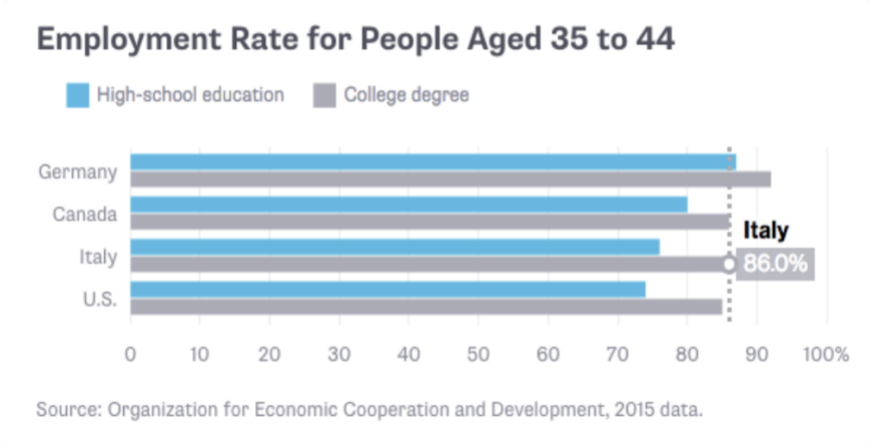
In the graph shown (with descriptions in Italian because of the source), the monthly cumulative mortality in Italy from 2015 to 2020 has been reported. In Green there are the values of the last year, and it is evident how during the first wave (March-April) and during the second (from September onwards) the values have reached much higher figures. Therefore, at least in the Italian case, there is a very high correspondence between the official deaths related to the virus and those presumed calculated as an increase over the average of previous years.

There is also a discourse linked to the psychology of investors. The market tends to move on the basis of what the future scenario will be, rather than on what the current scenario really is. Therefore, the countries that have recorded a higher mortality rate have certainly been those that have conveyed greater uncertainty and the image of a situation that is much more difficult to control. It is not surprising, therefore, that there is a certain correlation between the mortality recorded and the increase in VaR. It would not be possible to expect a stronger correlation, and therefore a higher coefficient of determination, because there are many factors that influence this parameter. One thinks of the average age, which in Italy, as already mentioned, has unfortunately played a central role. Also the population density, for a virus that is transmitted by air, has been fundamental, and also in this case it is a factor on which it was not possible to act at all.

As far as the unemployment rate is concerned, it was seen that the model could not explain very well the trend of all 11 countries. However, by removing Italy and France, which have behaved like veritable "Unicorns", registering an unemployment rate in 2020 that is even lower than in 2019, the R coefficient reaches a fairly high value and even at a graphical level the correlation appears clearer. The calculation of the unemployment rate is, by its nature, subject to possible interpretations and therefore to a certain

variability. As an example, recently on Bloomberg, a well known economic magazine, appeared an article that had the purpose of evaluating the goodness of the US labor market. The study was done by comparing the U.S. with an economy considered similar such as Canada, a very strong one such as Germany and a weak one such as Italy. An analysis was made considering different age groups and different levels of education, obtaining the results shown in the graphs below.





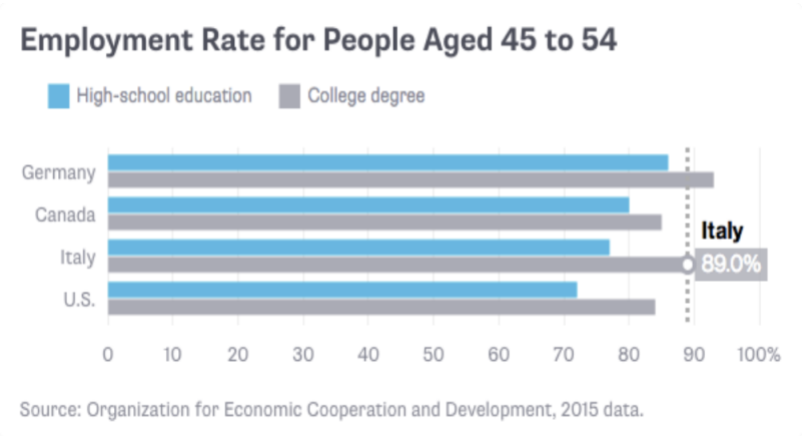


Fig 6.3 Comparison of employment rate between Germany, Canada, Usa and Italy

Given that this study does not relate to the period impacted by the Coronavirus, the objective of Narayana Kocherlakota, former governor of the Minneapolis Federal Reserve, was to demonstrate that compared to an economy considered weak, the USA has a better labor market only for younger segments of the population. However, no mention is made of the fact that in Italy the labor market is socially and culturally very different from those in the USA and that there is an enormous gap, both in terms of employment and above all in terms of wages, between young and old. Therefore, the fact that in the older age groups the situation is actually better than in countries such as the USA and Canada could be one of the main reasons why young people are in difficulty. Thi case is obviously only an example, even if it is quite accurate since it shows the cases of 4 countries dealt with in the paper, but it is, however, useful how, in general, considerations about labor markets are very difficult if the purpose is to compare countries that are very distant from each other, both geographically and economically. This is why a linear correlation can be expected, with respect to the delta of the VaR, which is slightly lower than the mortality rate.

Finally, there is the parameter on Covid positives. In general, it has already been said that this parameter was certainly the one most prone to be calculated subjectively. The main influencing factors were the following:

- Different choices of countries for the tracking campaigns, with volumes of swabs carried out absolutely not comparable
- Presence of different types of tests (molecular swab and rapid swab), used in different proportions and subject to different sensitivities and specificities
- Possibility of errors or manipulations in the communication of data: often the supply chain of swabs has been entrusted to local authorities that communicate data to higher structures; the more the number of intermediate steps increases, the more it is possible that there are errors or manipulations

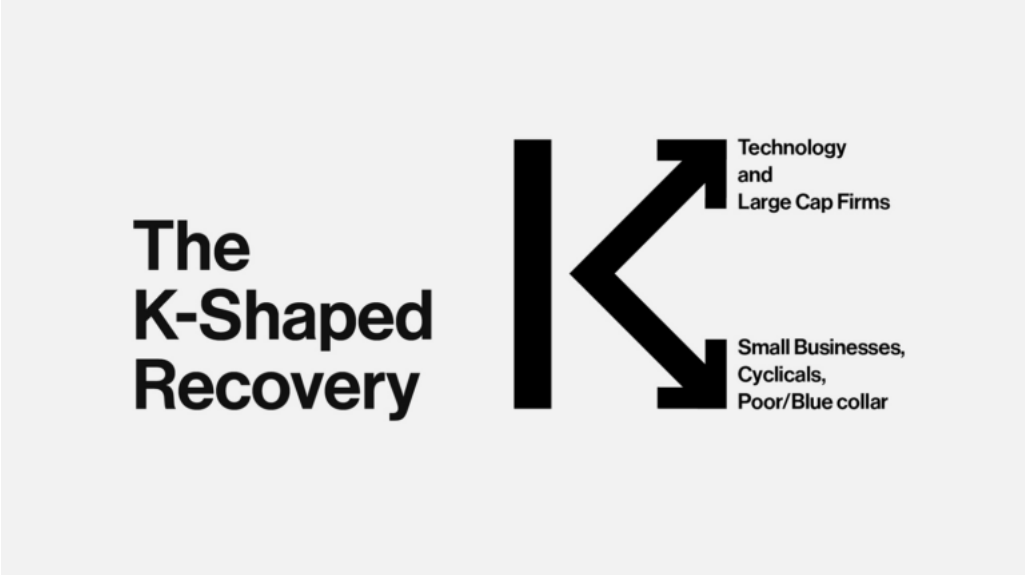
- Presence of many asymptomatic positives, which especially in the first wave were numerically underreported

Because of these factors, the number of people positive to Covid officially recognized is certainly lower, significantly, than the real number of positives. It is estimated that in Italy, at the end of 2020, the real number of positives could be about 6/7 times higher than the official figure, based on the first serological tests that indicate those who have developed antibodies (although perhaps never having tested positive for the virus). Ultimately, it is not surprising that there is no significant correlation between the variation of VaR and the number of positives recorded, precisely because this is a very partial parameter and subject to various types of error that are often difficult to avoid. In many situations, policy decisions have been made on the basis of the positivity rate. It is evident that this is a very short-sighted choice, precisely because it is based on substantially incorrect data. For example, already the hospitalization rate (standard and intensive care), is a parameter that gives a much more accurate picture of the Covid situation, which in the most advanced countries has often been a problem in terms of saturation of health facilities.

On the basis of this evidence, it can be expected that future studies will show that the countries most affected by Covid from an economic point of view will be those that have recorded a higher absolute and percentage mortality, while there may continue to be no significant correlation between the number of positives and the real economic impact.

Possible future scenarios

The coronavirus has already forced both the public and private sectors to rethink their models in order to face a very delicate period, that is, the one that will follow the end of the pandemic crisis and in which there will be a recovery. Quantifying economic recovery in the various sectors is something extremely complex due to the many interrelated factors in this crisis. Those who have tried to predict, using a model, what the recovery phase will be like is the American bank JP Morgan, which has recently proposed a K-Shaped curve to approximate the effects of recovery.



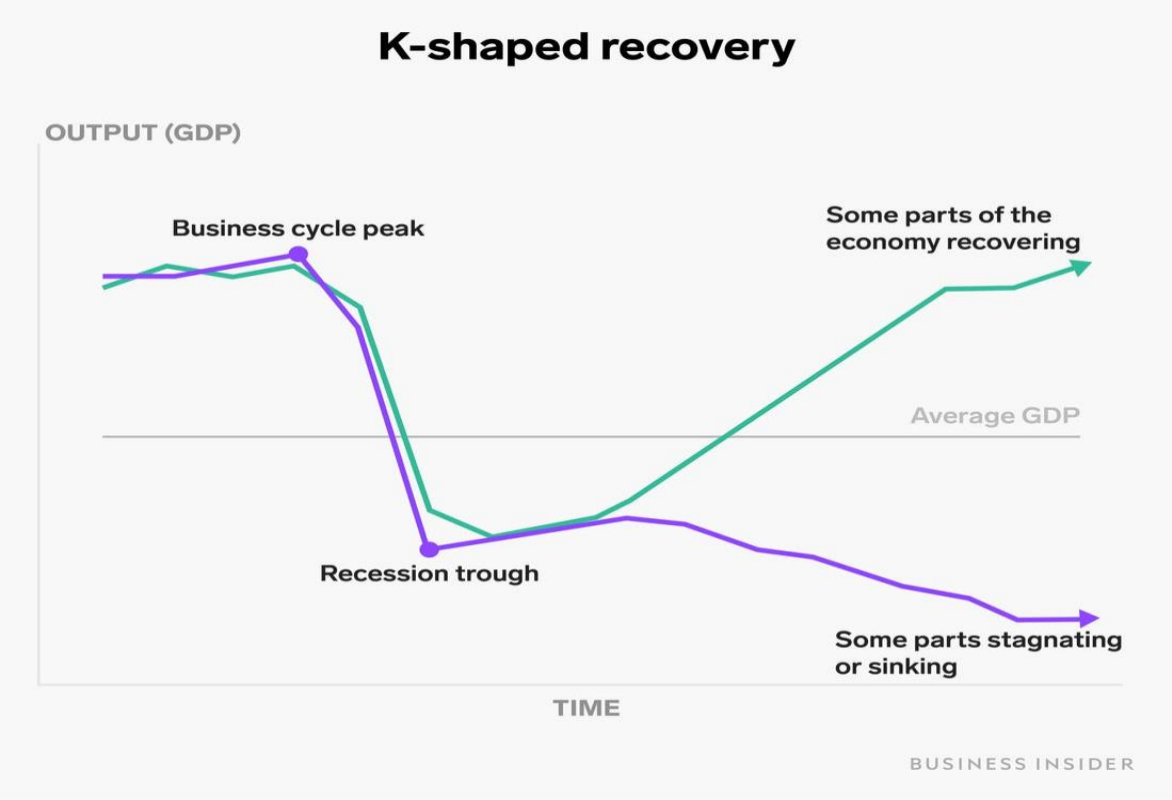


Fig 6.4 K-shape recovery curve

The first graph is a simple graphical representation of the k-shape curve, which predicts that after a period of crisis there are companies that manage to adapt and perform exactly as before, while for other sectors there is a decline that increases with time, without there being a real recovery phase. The second graph is a more quantitative model that puts time and GDP on the axes, and through two different colors indicates the two hypothetical trends predicted by the model. According to JP Morgan, as far as the US is concerned, large corporations and public sector institutions with direct access to government and central bank stimulus packages will make some areas of the economy recover quickly but will leave out others such as small and medium-sized enterprises (SMEs), the so-called "blue collar" and, in general, the middle class. Certainly one of the parameters to be monitored to determine which companies will be able to recover better than others is digitalization. By now, in a great many areas, the world is evolving towards a true digital revolution (this is, for example, one of the main items of expenditure of the Next Generation EU mentioned above), and the pandemic has abruptly accelerated this trend. But digitization will be the needle of the scales among sectors where this is possible. For others, precisely because of their structure, the possibility of a smarter approach is limited (think, for example, of the world of entertainment, concerts, discos, etc.). For these, the main hope is that the vaccination campaign will be efficient and rapid, so as to end 2021 with the main issues related to the coronavirus behind us.

Putting the elaborate focus on the 2019-2020 biennium, vaccination campaigns in almost every country in the world have started since early 2021. There is one noteworthy and hopeful case, and that is Israel. In Israel, in the first 3 months of 2021, many doses of the Pfizer vaccine were used. Not only has there been a marked slowdown in new positives and a drop in hospitalizations (and consequently in mortality), but the efficacy of the first dose has been greater than that declared by the pharmaceutical company itself (it should be remembered that the Pfizer vaccine works with a double administration a few weeks apart). The functioning of the vaccination campaign, which presents both logistical and contractual/legal problems in terms of supply of doses, will be one of the main drivers of the recovery because the countries that will reach first the herd immunity will have a strategic advantage (similar to that of the first mover) on the others, being able to return (almost) to normal with very positive consequences for the entire economic sector.

Another aspect related to this and central for the near future will be the public expenditure allocated to the health sector. In Italy, for example, Covid has revealed all the structural criticalities of the National Health System, lacking both in structures and in personnel. To make a comparison with Germany, the places of intensive care per 100,000 inhabitants are less than crica 4 times. As far as the number of physicians is concerned, according to various estimates, in 5 years time there will be a shortage of about 12,000 physicians throughout the country, due to the fact that the number of those who leave specialization schools each year is much lower than the number of those who retire in the same period of time. More generally, the Covid crisis has made the whole world realize how high the risk of a

pandemic, in such a globalized world, now is, and several scientific journals have speculated that similar phenomena, albeit of lesser magnitude, may be more frequent in the near future. When the pandemic and its consequent crisis are over, we will realize how, probably, the countries most affected by the virus were the same ones that had the most significant economic consequences. For this reason, over the next few years/decades, we can expect to see greater investment throughout the healthcare sector in every developed country. To return to the k-shaped curve, the healthcare sector could be one of those that will benefit most from the effects of the post-Covid recovery.

In conclusion, it is clear that with the spread of the virus still underway, a vaccination campaign still in its early stages and a situation that varies from country to country, photographing the economic impact caused by Covid is a possible operation but one that still leads to very partial results. In a few years, when the virus will disappear or become endemic, it will be possible to make more accurate analysis and fully understand how the world will have been changed by this virus. At the moment, the study has highlighted an extremely significant increase in Value at Risk in all G10 member countries, which represents a wake-up call that should not be ignored in purely economic terms. In terms of correlation with the main parameters linked to the virus, the VaR has shown a simple linear correlation with the mortality rate and with the increase in unemployment, while there is almost no correlation with the positivity rate, bearing witness to the enormous partiality of the official data regarding this parameter. The end of 2021, if vaccinations continue at the pace envisaged by the main countries, will be a very important date for evaluating the first effects of the measures aimed at stimulating economic recovery. However, it will be necessary to wait several years to observe the full effects of the main aid actions undertaken by States and Central Banks.

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