-ORIGINAL ARTICLE-

Intelligent Data Analysis of the Influence of COVID-19 on the Stock Market using Case Based Reasoning

Análisis Inteligente de los Datos de la Influencia de la COVID-19 sobre los Mercados de Valores

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Abstract

Starting with the differences between forecasting and prediction and going deeper into prediction, a knowledge-based model is presented. The evolution of the stocks markets are analyzed, as well as how the epidemics and pandemics prior to the stock markets have affected them and how it is currently being affected by covid-19. The defined model is applied to a use case using Case-Based Reasoning (CBR): it makes an analogy between the 2008 crisis with the covid-19 crisis in 2020 to predict whether the stock markets will take more or less time to recover.

Keywords: Forecast, Prediction, Covid-19, Stock Markets, Case-Based Reasonig (CBR), Analogy Learning.

Resumen

Comenzando con las diferencias entre el pronóstico y la predicción y profundizando en la predicción, se presenta un modelo basado en el conocimiento. Se analiza la evolución de las bolsas de valores, así como cómo les han afectado las epidemias y pandemias previas y cómo está siendo afectado actualmente por el covid-19. El modelo definido se aplica a un caso de uso utilizando Case-Based Reasoning (CBR): hace una analogía entre la crisis de 2008 con la crisis del covid-19 en 2020 para predecir si los mercados de valores tardarán más o menos en recuperarse.

Palabras claves: Pronóstico, Predicción, Covid-19, Mercados Bursátiles, Razonamiento Basado en Casos (CBR), Aprendizaje por Analogía.

1. Introduction

Usually, forecast and prediction are terms that are used interchangeably, but are not completely the same. Generally, *forecasting* is "to predict something from signs" and *predicting* is "to announce by revelation, founded knowledge, intuition or conjecture something that is going to happen". Following on the definitions:
- A forecast refers to a calculation or estimation that uses data from past events to obtain a result for future events. It is a technique that analyzes data from a time series and predicts the future value by following the trend. It is more accurate than forecasting because it extrapolates from current data.
- On the other hand, a prediction is an actual act of indicating that something will happen in the future by having only part of the information. The prediction is more inaccurate than the forecast because it is made in scenarios of uncertainty. The prediction is forecast and other factors that can change the trend.

Although in the literature both terms are ambiguously used, in general, *forecasting* is related to trend and *prediction* is trend plus additional knowledge which can break it. Selvin, S. et al. [1] indicate that forecasting can be defined as "predicting future events by analyzing historical data", using both concepts imprecisely. Minh et al. [2] speak literally of "predicting the trend of stock values", the terms "predict" and "trend" are initially undefined, but after an analysis of the paper, the author proposes a system based on historical data, financial news and sentimental analysis of the news, they add additional knowledge to trend analysis, thus actually is "predicting". Sezer et al. [3] review the literature from 2005 to 2019 for financial forecasting with deep learning and use the term "forecast" to refer to time

series analysis. Stuparu et al. [4] propose a model for flood forecasting in the event of a dam break. It uses weather forecasts and additional information such as dam resistance, flood extent, number of cubic meters of dammed water…, in this case, is "forecast". Ding et al. [5] defines a prediction model for forecasting electricity consumption in China, adding additional information in the form of weighable coefficients to the historical data, making a "prediction".

The prediction is oriented to the final result. All forecasts are predictions, but not all predictions are forecasts and both terms can be used depending on what you try to mean. For example, we speak of "forecasting" when we want to determine future oil prices on international markets based on past prices. While we speak of "prediction" if we wish to determine the number of barrels of oil to be bought keeping in mind the influence on the market of the reduction in the number of barrels that Iraq exports. The soccer match can be "forecasted", if you use the soccer data that each soccer team has won in the past, the goals you have scored and if they have played on your field or on the opponent's field ... but it is a "prediction" if you also consider that the players are more tired because 24 hours ago they played another match. The probability that the prediction will be fulfilled increases when the event is close to happening.

We usually talk about "forecast" with weather, economic and medical reports. In medicine, when we talk about "prudent prognosis", we mean the patient's evolution based on the results of the medical tests performed. On the contrary, when we speak of electoral processes or natural disasters, we speak of "predictions", because not only the projection of the historical data is enough to determine the result.

Many techniques have been developed to make predictions, generally based on statistics or machine learning, but few methods have been developed to make predictions based on knowledge. The prediction is complex because there are hidden variables that are not known at this time, as well as the hidden relationships between these variables.

The proposed knowledge-based model of ten steps allows us to predict whether the stock markets takes more or less time to recover their maximum values before the covid-19 crisis, comparing them with previous economic crises and taking into account how previous pandemics and epidemics have influenced them.

The stock exchange is an organization that allows its members negotiate the purchase and sale of shares. From the point of view of companies, the stock exchange is a way of financing with the objective of growth and expansion. For this purpose, they have the possibility of issuing shares. A share is the minimum part of the share capital into which a company is divided. The sale of shares will serve to make

improvements in the company: open new offices, employing more personnel and invest in research… From the point of view of investors, they can obtain profitability. Profitability is obtained by buying shares when they have a low price to sell them when they have a high price. The investor can also make a profit from dividends, which is the part of the profit that the company distributes to its shareholders.

Regarding the terminology of the covid-19, note that the virus is popularly called the "Wuhan coronavirus" or "coronavirus 2019". The scientific name of the virus is SARS-CoV-2 (pathogen) and the name of the disease is covid-19 [6].

1.1. Related works

The following references show different authors have studied how the SARS-CoV virus of 2003 and SARS-CoV-2 virus of 2019 affected the Asian economy and stock markets as well as the price of the barrel of oil.

Noy et al. [7] study the economic impact of the 2003 SARS-CoV, indicating that the supply chain in China was not affected, and the movement of goods at the border continued without major changes. The Hang Seng (Hong Kong) stock exchange index fell by -1.78% between March and April 2003, at a time when most people were infected and died from SARS. On the other hand, tourism was greatly affected, with fewer arrivals and cancelled flights. Pre-epidemic economic levels recovered by the end of July 2003.

Gormsen et al. [8] have studied aggregate stock market and futures market data on dividends to quantify how investor expectations of economic growth are evolving with the SARS-CoV-2 crisis. They concluded that as of 18 March 2020, the annual dividend growth forecast would fall by -28% in the US and -25% in the European Union (EU), and the GDP growth forecast has fallen by -2.6% in both the US and the EU.

Albulescu [9] relates the Covid-19 crisis to the price of oil and economic uncertainty. In the context of a severe fall in oil prices, the paper concluded that the exponential increase in new cases of infection risks freezing oil prices at a low level for a long period.

Fan et al. [10] did a study of the cost in the world economy of the covid-19 crisis. It determines that the cost of a moderately severe pandemic is 1% of global income and of a severe pandemic 4%-5%.

Minh et al. [2] try to predict the price of shares. It uses technical stock market analysis, which is generally good but does not take into account unexpected events. To improve it they use Natural Language Processing (NLP) of economic news. It complements the system by performing a "sentiment analysis" of each publication. The proposed method gives good results but the system needs a lot of training time as well as many computer resources.

1.2. Context

Nowadays the economy is very globalized. Countries' economies and stock market indexes develop in parallel. Several criteria can be used to determine the most important economies in the world: country G7 criterion, country GDP criterion [11]... Countries considered relevant on a global scale are: The United States (US), China, Japan, Germany, France, the United Kingdom, Italy... The most important stock exchange indexes in the world are [12]: the S&P500, Dow Jones and Nasdaq1000 in USA, Hang Seng in Hong Kong, Nikkei in Japan, DAX30 in Germany, CAC40 in France, FTSE100 in the UK and FTSE MIB in Italy. At the European level, the EuroStoxx50 index is important. One of the index reflecting the state of the world economy is the MSCI World Index, which is a stock market index containing the calculated average stock prices of companies from the most important countries in the world; in this index US companies account for 60% of the total weight.

At the end of the 20th century, and especially during the 21st century, trade agreements between countries allowed for a reduction of trade barriers. This created global economic interdependence, increasing the volume and variety of international transactions in goods and services as well as the flow of money.

Stock exchanges are influenced by a multitude of news or events, some planned (macroeconomic indicators, business results, publications of reference index, etc.) and others unplanned (natural disasters, trade relations, wars between countries, etc.):

- Planned events. These are macroeconomic indicators that are published periodically: GDP (Gross Domestic Product of a country that indicates the growth rate), interest rate of money (price paid for the inter-bank loan of money), inventories of crude oil, Industrial Production Index, Investor Confidence Index, Unemployment Level... when they do not have an expected value the stock markets have great variations.

- Unplanned events. They are unexpected events that have influence on the economy in a global way. They are called "black swans" (they are unexpected events of great impact). For example, the biggest falls that have occurred in the last 30 years in the S&P500 index are: the first Gulf War in 1991, in 2000 the bursting of the technology bubble, in 2001 the attack, in 2008 the subprime mortgage crisis and Britain's exit from the European Union in the Brexit referendum in 2016.

If the stock markets were to follow their established trend, they would, in general, always be rising or always be falling. Events, both planned and unplanned, create a turning point in stock markets by abruptly changing their trend. For example, the S&P500 had been on a bull market for 10 years, and on the occasion of covid-19 it has changed to bear market (in 20 days it has lost 30% of its value).

There are many statistical techniques to predict the value of the stock market, (time series, ARIMA algorithm, ARCH, GARCH...) as well as Machine Learning techniques (neural networks, neuro fuzzy networks...). Specific techniques for stock market forecasting based on the technical analysis of stock market charts are now described. Charles Dow defined three trends: increasing, decreasing and lateral. Knowing the trend and the change in trend is very important in the stock market.

To represent the price of a stock, you use charts called Japanese candlestick charts. The Japanese candlestick gives information about the opening, closing, high and low price that the security has obtained during the session (Fig.1). There are two types of candlestick: when a value closes positive with respect to the opening, the body of the candle is green or white. When a value closes negative with respect to the opening, the body of the candle is red or black.

Fig. 1. Types of Japanese candlesticks.

The objective of a technical analysis is the interpretation of the stock exchange charts. Through learning techniques by analogy, it applies what has happened in past situations to future situations. When this pattern is repeated, it is assumed that the stock market will behave in a similar way in the future. Without wishing to be exhaustive in terms of forecasting techniques, we will describe two types of situations in which a change in trend is determined: Shoulder-Head-Shoulder (change to bear market) and Reverse Shoulder-Head-Shoulder (change to bull market). In the other hand, Double Bottom (change to bull market) and Double Top (change to bear market) (Fig.2).

For these patterns there are many real examples where what the pattern indicates is not fulfilled. For example, in the following graph the Double Bottom pattern is a change from bear market to bull market, whereas in the following graph of the S&P500, a Double Bottom is shown that causes bear market (Fig.3):
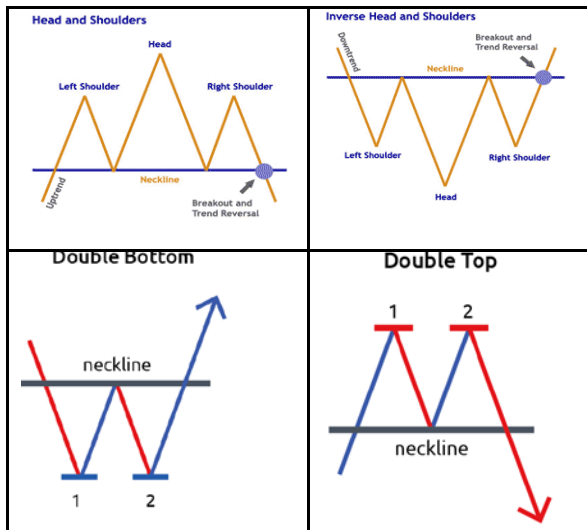
Fig. 2. Japanese trend-setting candlestick patterns.

Fig. 3. Double Bottom didn't follow in pattern. Source: https://forextraininggroup.com/learn-trade-profit-chart-pattern-failures/

In conclusion, the problem with the technical analysis is that it does not consider other exogenous factors that can change the trend of the stock markets. For example, in September 2019, the IBEX35 (Spain) was bull market. Technical analysis indicated that the upward trend would continue. The World Trade Organization (WTO) ruled that the European aeronautical company Airbus had illegally received aid from European countries [13]. The President of the United States announced taxes for products from the European countries. The main stock market indexes of these European countries collapsed, breaking the bull market.

In this work the relationship between stock indexes (i.e. S&P500) and the covid-19 pandemic is analyzed. Historical data will be examined from these two perspectives.

1.2.1. Analysis of historical stock market data

Financial markets are a complex and enormous future time machine: they reflect the consequences of the events before they happen. In the weeks previous to Brexit (Great Britain's exit from the European Union), European stock markets began to fall. With

the murder of the British Member of the Parlament Jo Cox, [14] the markets began to rise. Four days before the vote, polls indicated that Britain would not leave the EU. It was a great surprise that Brexit won on 24 June 2016 [15]. The panic in the European markets led to big falls in the world's major stock markets. The following conclusions can be drawn from an analysis of the historical performance values of the S&P500:

- In the US stock market, Mondays are the worst day of the week to invest, and Wednesday is the best. According to a study by LPL Financial [16] the return that would be obtained by investing only on Mondays in the S&P500 would result in a loss of approximately -20%. The biggest falls by the US market have been on Mondays, for example, on Monday, October 19, 1987, the Dow Jones fell by -22.6%. More recently, on Monday 9 March 2020 due to the exponential increase in the number of people infected with covid-19.
- The month of December is statistically a good month for the stock market. In the last 100 years, the S&P500 stock index has had positive returns in 76 months of December.

However, this historical information is not enough to say when there will be a significant drop in the stock market. For example: On Monday March 2, 2020 the S&P500 up +4.60%, and on Wednesday March 11, 2020 under -4.89%. In December 2018 the S&P500 fell -14.8%, breaking the historical trend.

1.2.2. Analysis of historical data from stock exchanges and epidemics and pandemics

Since 1980 there have been many epidemics and pandemics that have affected the world. The most important epidemics and pandemics in the last 30 years have been the ones shown in Fig.4.

Fig. 4. World epidemics and global stock market performance. Source: https://www.marketwatch.com/story/heres-how-the-stock-market-has-performed-during-past-viral-outbreaks-as-chinas-coronavirus-spreads-2020-01-22

The first weeks, when the epidemic is declared, the

stock market drops, but if the impact of these epidemics and pandemics on the stock market is analyzed at 1 month, 3 months and 6 months, it is observed that on average the MSCI World Index has risen by +3.08% in three months, and +8.50% in six months. In the specific case of 21st century epidemics, the S&P500 has taken 31 sessions to recover on average from the corrections caused by the last five pandemics.

2. Influence of COVID-19 on the stock market

2.1. Expert analysis of the current situation

In general, if we compare the epidemics and pandemics of the 21st century, two scenarios are observed (Table 1):

- Geographical areas of great influence in the world economy, but relatively few people infected: SARS of 2003 in China or the MERS of 2013 in Saudi Arabia.
- Geographical areas with no major influence on the global economy but with a high number of infected people: Ebola in 2014 in Guinea or Avian flu in 2006 in Indonesia.

Table 1. Epidemics and pandemics on the 21st century [17].

Year	Virus	Period	Countries	Infected	Dead
2003	SARS-Cov	2002-2003	China	8.000	800 (10%)
2006	Avian Flu (H5N1)	2005-2006	Malaysia, Indonesia, Singapore	200	100 (50%)
2013	MERS	2013-2014	Arabia Saudis, Qatar	2.000	700 (35%)
2014	Cholera	2014-2016	Congo, Guinea, Liberia	28.000	14.000 (50%)
2016	Zika	2015-2016	Brazil, Argentina, Colombia.	1.000.000	10.000 (10%)
2019	SARS-CoV-2	2019-2020	World	1,500,000*	80,000 (6%)*

*Update 01-06-2020

China, from the start of the covid-19 outbreak to the end of February 2020, accounted for 80% of those infected and 90% of deaths worldwide. By mid-March 2020, the number of cases and deaths in China had stabilized, with small increases, while in the rest of the world, the number of cases and deaths had grown exponentially. According to the WHO (World Health Organization) in April and May the outbreak has spread to Europe and the United States. On March 19, 2020, Italy will overtake China in terms of the number of deaths, considering that Italy has a much smaller population [18]. The University of Valencia (Spain) has carried out a study that projects the curve

of the number of people currently infected. On March 24, they indicated that the maximum in Spain would occur between May 20 and June 6, 2020, with 800,000 people infected [19]. On June 7, 2020 Spain has over 240,000 cases and 27,000 deaths. The forecast has not been fulfilled. The University of Valencia model only took into account historical data and does not consider other data, such as increasing the number of COVID-19 tests performed in the population or increasing the number of beds in the ICU. In June the highest number of cases and deaths is America, specifically, EEUU (1,920,000 cases and 109,000 death) and Brazil (675,000 cases and 35,000 deaths) and Great Brittan (286,000 cases and 40,000 deaths).

From a health point of view, SARS-CoV-2 is a different virus from previous epidemics and pandemics: it has a high rate of infection and a low death rate [20]:

- Contagiousness. According to the scientific journal Lancet [21], covid-19 infects about three people for every one person infected. This rate of infection is one of the highest compared to previous viruses.
- Lethality. According to the WHO, the lethality of the Wuhan coronavirus has a mortality rate of 5%-6%. Other viruses, such as the 2012 MERS, had a mortality rate of 35% and Ebola of 50%.

At the beginning, the country most affected by covid-19 has been China, the second largest economy in the world. Currently, the Chinese economy influences almost all countries, because most of the world's production takes place in China. The economic effects of the Chinese economy on the rest of the world's economies are very high: China is the first link in the global production chain; millions of companies around the world manufacture in China or need the materials and components supplied by China. For example, in August 2015 [22] a lower than expected economic growth figure for China was published. This caused the stock markets to crash on Monday, August 24, 2015: The Shanghai Stock Exchange fell by -8%, the Japanese Nikkei by -4%, the Ibex35 by -5.01%, the EuroStoxx by -5.5%, the S&P500 by almost -4% and the Dow Jones by -3.57%. Because millions of Chinese have been isolated, to prevent the spread of covid-19, the country's production has stopped. The effects of the spread of the virus in the rest of the countries have meant the isolation of their citizens (movements have been limited, factories and companies have been closed, borders have been closed...) causing the stop of almost all the productive sectors in many countries.

2.1.1. The covid-19 and the stock exchanges

Until 22 February 2020 COVID-19 had been controlled in Asia (China, South Korea, Japan, Singapore, Thailand, Taiwan...), a date when the

stock markets in Western countries were clearly on an upward trend. From Monday 24th February 2020, Italy appears as the second most infected country in the world and a "Black Monday" is produced in the stock markets all over the world.

On Monday 9 March 2020 the number of infected cases in Europe and the USA increases exponentially, stock markets worldwide crash dramatically. On Thursday 12 March 2020, the measures announced by the President of the ECB are interpreted by the markets as insufficient to prevent the economic crisis. One of the biggest falls in the history of the stock markets takes place: S&P500: -9.51%, DOW JONES: -9.99%, NIKKEI: -4.41%, DAX30: -12.24%, FTSE MIB: -16.92% and Ibex35: -14.06% (Table 2).

Table 2. Accumulated sum (%) from Monday 24 February to 19 March 2020.

S&P500	Dow Jones	MCSI	Hang Seng	Nikkei	EuroStoxx	DAX	Ibex	FSTE MIB
-29%	-33	-33	-18	-34	-41	-37	-41	-43

2.1.2. Other factors influencing the stock markets: the fall in the price of oil

Due to the closure of many industries and companies, the reduced number of movements of citizens, Saudi Arabia proposes a cut in the production of the number of barrels which Russia refuses to do it. China, the second largest oil importer in the world, has significantly reduced its demand due to the decline in activity by the COVID-19 crisis [23]. In March 2020, the price of a barrel of Brent oil was around $23 when a couple of months ago it was around $80.

2.2. Make an extended prediction

The spread of COVID-19 in more than 180 countries around the world, the increase in the number of people infected and death outside China, and the declaration of a global pandemic by the WHO, has potentially increased the negative impact on financial market developments, corporate profits and employment, seriously affecting growth worldwide. The most affected sectors are: tourism, passenger transport, hotels and leisure. The OECD estimates highlight a significant slowdown in global GDP in the first half of 2020.

The fall in oil prices not only affects the stock markets and the shares of many companies, but also the foreign exchange market (the most important stock market in the world) because the barrel of oil is paid in dollars. The price of a barrel of Brent has fallen more than 70% from its lowest level at 2016 to its maximum in January 2020. The covid-19 is causing the first drop in demand since 2009.

Therefore, the COVID-19 crisis cannot be framed only as a health crisis, in the same way as previous pandemics; it is actually a bigger economic crisis than the subprime crisis of 2008. To see the economic dimensions of COVID-19 you can use the VIX (Volatility Index), which measures the volatility of the S&P500. When the VIX tends to 0, there is investor confidence in the US economy. When the VIX tends to 100, there is fear on the part of these same investors. The psychological threshold of the VIX index is 40 points, which has only been exceeded 7 times in the last 30 years. The highest value obtained was in the 2008 mortgage crisis with 79 points. Since 6 March 2020, the VIX has not fallen below 40 points, reaching its maximum on 16 March 2020 with over 82 points (Table 3).

Table 3. Evolution of the VIX since March 6, 2020.

06/3	09/3	10/3	11/3	12/3	13/3	16/3	17/3	18/3	19/3	20/3
41	54	47	53	75	57	82	75	76	72	67

The crisis generated by COVID-19 is an unprecedented health crisis and, by extension, has generated a global economic crisis. These health and economic crises will endure as long as the pandemic is not brought under control and the economic impact it will eventually have is unknown. Ignorance of the disease, along with its evolution and global spread, makes it unique. For the first time in this century, humanity is facing an unknown virus because no vaccine is available. Governments around the world are taking unprecedented measures both in the social field (on March 26, 2020, one third of humanity was confined [24]: closing borders, confining citizens to their homes, cancelling events with losses in the millions, stopping factory production, closing public administrations, closing schools, suspending flights,...) and in the economic field, the European Union estimates that the economic cost of the pandemic will be 5% of the EU budget.

Applying the technique based on Case Based Reasoning (CBR) we can establish a similarity between the economic crisis of 2008 and that of 2020. CBR is based on the use of available knowledge that is most relevant to the problem at hand. Its effectiveness is based on the mechanism of recall and allows us to learn characteristics that predict similar situations. This is done by applying the causes that determined the decisions taken, therefore, using knowledge that depends on the implicit model used. Retrieve. As of mid-March 2020, health authorities have indicated that the disease has not yet reached its maximum in Europe in terms of the number of infected and dead. In any case, if we look at the maximum values of the VIX index, the economic crisis generated by covid-19 is comparable to the mortgage crisis of 2008. In the 2008 crisis, the main economies affected were those of the United States

Table 4. Index stocks exchange, before and after crisis 2008, and before crisis 2020.

Index	Max before crisis 2008	Min after crisis 2008	Recovery crisis 2008	Recovery years	Max before crisis 2020	Min after min 2020
S&P500	OCT/2007 1.549 pts	MAR/2009 735 pts	MAR/2013 1.569 pts	4 years	FEB/2020 3.386 pts	MAR/2020 2.227 pts
MCSI Index	OCT/2007 1.682 pts	FEB/2009 750 pts	ABR/2014 1.687 pts	5 years	FEB/2020 2.358 pts	MAR/2020 1.650 pts
DAX30	DIC/2007 8.067 pts	FEB/2009 3.843 pts	MAY/2013 8.348 pts	4 years	FEB/2020 13.789 pts	MAR/2020 8.423 pts
Ibex35	OCT/2007 15.890 pts	MAY/2012 6.089 pts	-	-	FEB/2020 10.038 pts	MAR/2020 6.350 pts
Barrel Brent	JUN/2008 139$	ENE/2009 45,59$	ABR/2011 125$	2,2 years	ENE/2020 69$	MAR/2020 26$

and Europe, and in the 2020 crisis they are the main economies worldwide.

Reuse. In the 2020 crisis, the aim is to "frozen" the large productive sectors of the economy until the intensity of the outbreak decreases, at which point production should resume. During this period, governments around the world have announced the injection of large sums of capital to maintain the economy by preventing the destruction of enterprises and the rise in unemployment.

Although the 2008 crisis had an impact on China's economy, GDP was sustained: from 2008 to 2013 it grew on average by 9%. In contrast, the 2020 crisis has had a major impact on the Chinese economy. It is expected to grow only 2-3% of GDP. The global dependence on China and China's macroeconomic figures in the first two months of 2020 predicts a much worse scenario than that of the 2008 crisis:

- Domestic consumption. In the 2020 crisis, retail consumption in China has fallen by -20%. Before COVID-19 it was growing annually at 8%.
- Foreign investment. In March 2020, it in China fell by -26%.
- Industrial production has been growing for the last 20 years at 5%. However, in the first two months of the year, it has collapsed by -24.5% year-on-year.

Revise. The coincidences of the economic crisis of 2008 with the crisis of 2020 are: Stock market crash, fall in the price of oil, the injection of money by governments into their respective economies. However, the differences are as follows:

- In the 2008 crisis, the origin was known and could be solved by injecting money into the economy. In 2020 the solution is still not known, a vaccine is urgently needed.
- In the 2008 crisis, the aim was to relaunch the economy, activate investment and consumption, there was a problem of demand. In the 2020 crisis, the production chains of the world's major countries have come to a complete halt; the aim is to "unfrozen" the economy. There is a problem of supply.
- The stock markets and oil have collapsed in much less time. The 2008 crisis began in September 2008 and stock market lows were recorded in March 2009. In the 2020 crisis, the

big drop in the stock markets occurred on Monday 24 February 2020. In no other previous crisis economics had the stock market indices lost as much value in a short time.

- The contraction of the Chinese economy. Due to the slowdown in the Chinese economy, never had China's macroeconomic indicators fallen so much in such a short space of time.

The 2008 crisis occurred in the US with the fall of the Lehman Brothers investment fund in September 2008. Just before the 2008 crisis the S&P500 and Dow Jones indices were at their highest levels. In the first quarter of 2009 they had lost almost 50% of their value, and only at the beginning of 2013 did they reach the maximum values of the end of 2007 (Table 4).

Regarding the duration of the American bear markets, on average they have lasted 14 months since the Second World War. The shortest bear market for the S&P500 was in 1990, which lasted almost three months, falling by -20% in that period. In the specific case of the S&P500, the bear market is about 146 days, while the average bearish period for the Dow Jones is 206 days.

The medium-term economic impact of the virus will persist as long as the crisis sanitary lasts and is likely to depend on the length of time until the number of people infected stops growing and an effective vaccine is developed. The long-term impact will depend on how long there are enough people immunized, as with regular flu. Of the different economic scenarios of recovery (in "V", in "W", in "U", in "L"...), possibly the recovery of the stock markets will be in "W", that is to say, when the number of infected people stops growing and there is still no vaccine, then the markets will recover, as the governments will lift the containment measures, activating the economy. The number of people infected will decrease with the arrival of summer (the increase in temperature and ultraviolet radiation prevent the spread of the virus). But it will increase again with the arrival of autumn-winter, without a vaccine and without the containment measures, the number of people infected will increase again and the stock markets will fall again. It is estimated that a safe vaccine will take 12-18 months to develop. Due to the complexity of the economic crisis, recovery will be uneven across economic sectors and countries.

3. Conclusions

Current methods for forecasting are adequate when the trend is being followed, but inadequate when a trend-breaking event occurs. For example, published works in the second half of March that indicate the evolution of the number of infected people in Spain are "forecast" [25]. Some estimate 300,000, others 900,000, others 780,000 … all of them extrapolate the trend of those infected, the number of deaths, make surveys of how many people know they are infected, but do not consider future factors that may change this trend, for example, the effect of containment measures or the arrival of summer and its effect on the virus. At this point, we speak of "prediction", when knowledge is applied to historical data that produce a breaking point in the trend. In the specific case of the stock markets of the world's major economies, they were on an upward trend until mid-February 2020, and if the trend had been followed, the stock markets would not have collapsed by more than -30% in March 2020. At the end of 2019, an uncontrollable event (covid-19) occurred in China, which stopped world production and caused the stock markets and the world economy in general to collapse. This health crisis has generated a deep economic crisis. Applying Case Based Reasoning (CBR), the situation was similar to that which occurred in the 2008 mortgage crisis. The conclusion is that the covid-19 crisis, in addition to being a major health crisis, is a major economic crisis, much deeper than the previous ones because the adverse effects on world economies will be much greater than expected. Stock markets will take longer to recover than in the 2008 crisis. The recovery by sectors will be in this order: first the price of a barrel of Brent oil, second the stock markets, third the macroeconomic indicators, fourth the large companies and fifth the small companies and finally the household economy. By country, the first to recover will be China, the second the USA and the third the European countries. Within Europe, northern and central European countries will be able to recover on a par with the USA, while southern countries (Spain, Italy, Portugal and Greece) will take much longer complete recovery or not recover, as happened in the 2008 crisis.

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Authors' contribution

AL and JAO wrote the manuscript, conceived the idea, and analyzed the results; JAO revised the manuscript. All authors read and approved the final manuscript.

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