Original Article

Historical VaR method and Cornish-Fisher Approximation: Efficacy Against Unlikely Risks in Financial Engineering; The case of Covid-19 in Moroccan Financial Market

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Abstract - Covid-19 hit the global economy, its impact on global supply chains and financial operations was clear, and it showed the importance of managing unlikely risks. To manage the impact of such risks, analytical tools are needed. These tools can provide decision-makers with ways to confront these risks[1]. This article assesses the impact of Covid-19, a concrete example of unlikely risks: it's a sanitary risk on the Moroccan stock market. This evaluation consists first of choosing optimal investments that minimize the risk of loss for expected returns, based on the Markowitz model, which was awarded the Nobel Prize in Economics in 1990. This choice was made at the beginning of the covid-19 pandemic in Morocco. Then estimate the maximum loss for these investments, which should not exceed using the Historical VaR and Cornish-Ficher VaR calculation methods. Finally, it compared real losses with estimated losses to highlight the need to consider unlikely risks during financial engineering and risk management. The two methods: Historical VaR and Cornish-Fisher VaR, are chosen because they don't impose the normality assumption on return distributions. The Cornish-Fisher VaR approximation is generally used for crisis management. Its novelty consists of testing these methods' efficiency against unlikely risks and precisely against the sanitary risk. Existing researches suggest risking managers use Cornish Fisher VaR in time of crisis. This work demonstrates that the Cornish Fisher VaR overestimates losses and that more research is needed to estimate them better using the Extreme value theory.

Keywords - Unlikely risks, Extreme value theory, Financial engineering, Markowitz model, Value at Risk.

1. Introduction

In recent years, a respiratory disease that has come to be known as covid-19 has clearly demonstrated the deficiencies of financial engineering.

The virus is highly contagious and has caused the death of several thousand people around the world. The World Health Organization declared a state of emergency in January 2020 after the severe situation in some countries like China and South Korea. Then, Covid-19 has officially declared a global pandemic.

To control the spread of the virus, governments have taken measures like isolation, social distancing and closure of non-essential activities that have imposed immense economic costs, such as trading, tourism, medical supplies, consumer electronics, energy and the food sector...[1]

A significant economic impact has occurred due to these measures taken by governments. The choice is either total safety and despair or facing this challenge, which is considered unlikely in risk management [1].

Nowadays, the main problem regarding risk managers is being aware of the importance of considering and managing unlikely risks that this pandemic has clearly shown. Regarding human resources, Morocco has reported more than 1.000.000 cases, including more than 15.617 deaths. Morocco's economic situation decreased by almost 7% in 2020.

This work envisages testing methods used in financial engineering and risk management when facing sanitary risks. In this context, it presents a study on the impacts of Covid-19, a practical case of sanitary risk, on the Moroccan stock market.

2. Literature Review and Hypothesis Development

Since 1980, several studies have been conducted in the domain of risk management. The paper will try to present a short state of risk measurement in which some lacunae are found.

2.1. The Problem of Measuring Unlikely Risks

The degree of risk (R) depends on its probability of occurrence (P) and its severity (G). These two parameters are difficult to predict [4].

$$R = P \times G \qquad (1)$$

Risks with a low probability of occurrence and low severity are risks that will have limited impacts. Risk managers generally ignore them [4].

Risks that have a high probability of occurrence but low severity are called operational risks. Risk managers generally master them [4].

Risks, where the probability of occurrence and severity are high are risks that push risk managers to review their entire vision and sometimes abandon their strategies [4].

Finally, they are risks with a low probability of occurrence but high severity. These are risks that have little chance of occurring. They are difficult to predict and anticipate. Some of these risks can be natural risks, geopolitical risks (e.g., political decisions, conflicts ...), industrial risks, terrorist risks (e.g., the Argana attack in 2011), the so-called economic risks (e.g., stock market crashes) and sanitary risks (e.g., Covid-19).

They are catastrophic risks, but risk managers often neglect them because of their low probability and measurement difficulty [4].

The current pandemic has clearly shown that tools related to pandemic planning are required.

2.2 Portfolio Management in Financial Engineering: Preliminaries

In order to manage financial risks, the decision-maker uses a set of indicators, concepts and methods like the choice of the optimal portfolio and the VaR (Value at Risk).

VaR is the main element of the Basel 2 regulation. It estimates the maximum losses in a given time horizon with a probability [5].

Statistical methods do the calculation of VaR. This work will study the impact of sanitary risk (the case of covid-19) on stock markets and compare it to the maximum losses estimated by these statistical methods.

2.2.1. Concept of Optimal Portfolio Selection

The choice of a rational investor, as proposed by Markowitz, is based on the expected return and the risk of the portfolio[6].

Consider R_P as the return on a portfolio of n stocks with returns r_1, r_2,..., r_n, and standard deviations σ_1, σ_2,..., σ_n. The stocks in the portfolio have proportions such as

$: \sum_{i=1}^{n} p_i = 1.$

Therefore, the expected return of the portfolio is:

$$E(R_P) = \sum_{i=1}^{n} p_i E(r_i) \qquad (2)$$

And its risk is:

$$\sigma^2(R_P) = \sum_{i=1}^{n} p_i^2 \sigma_i^2 + 2 \sum_{i=1}^{n-1} \sum_{j=1+1}^{n} p_i p_j Cov(r_i, r_j) = \sum_{i=1}^{n} \sum_{j=1}^{n} p_i p_j Cov(r_i, r_j) \qquad (3)$$

Or also

$$\sigma^2(R_P) = p^T Cov(r_i, r_j) p \qquad (4)$$

With:

$$p = \begin{pmatrix} p_1 \\ p_2 \\ \vdots \\ \cdot \\ p_n \end{pmatrix}$$

And

$$Cov(r_i, r_j) = \begin{pmatrix} \sigma_1^2 & \cdot & \cdot & Cov(r_1, r_n) \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ Cov(r_n, r_1) & \cdot & \cdot & \sigma_n^2 \end{pmatrix}$$

The problem to solve to choose an efficient portfolio, according to Markowitz, is :

$$\begin{cases} Min: \text{ the portfolio's risk} \\ When: expected\ portfolio's\ return = Cte \\ And: \sum_{i=1}^{n} p_i = 1 \end{cases}$$

It means:

$$\begin{cases} Min: \ p^T Cov(r_i, r_j) p \\ E(R_P) = \sum_{i=1}^{n} p_i E(r_i) = Cte \\ \sum_{i=1}^{n} p_i = 1 \end{cases} \qquad (5)$$

2.2.2. VaR Calculation

Consider V_P as the value of the portfolio on the day of the VaR calculation, $E(R_P)$ as the expected return of the portfolio, Z_α as the quantile of the normal distribution, $p^T Cov(r_i, r_j) p$ as the portfolio's risk.

The calculation of the parametric VaR for one day, supposing the normality of the distribution of returns, is done using the following formula [5]:

$$VaR_{1d,\alpha} = \left(E(R_P) + Z_\alpha * \sqrt{p^T Cov(r_i, r_j) p} \right) * V_P \qquad (6)$$

If normality is not verified, we can use the Cornish-Fisher approximation [7].

Consider σ_i as the standard deviation for the stock i, W_α as the quantile of a distribution whose asymmetry and excess kurtosis are not null, Z_α as the quantile of the normal distribution, S as the skewness of the normal distribution, and K as the kurtosis of the normal distribution.

To use the Cornish-Fisher approximation for a stock, it is necessary that:

$$\frac{S^2}{9} - 4\left(\frac{K}{8} - \frac{S^2}{8}\right)\left(1 - \frac{K}{8} + \frac{5S^2}{36}\right) \leq 0 \qquad (7)$$

with :

$$W_\alpha = Z_\alpha + \frac{1}{6}(Z_\alpha^2 - 1)S + \frac{1}{24}(Z_\alpha^3 - 3Z_\alpha)K - \frac{1}{36}(2Z_\alpha^3 - 5Z_\alpha)S^2 \qquad (8)$$

The Cornish-Fisher VaR of a stock I is calculated with the following formula:

$$CF_i = W_\alpha \mathfrak{6}_i \qquad (9)$$

The Cornish-fisher VaR of a portfolio is calculated as follows:

$$CF_P = \sqrt{(CF_1 \quad \cdot \quad \cdot \quad CF_n)\begin{pmatrix} 1 & \varrho_{12} & \cdots & \varrho_{1n} \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \varrho_{n1} & \varrho_{n2} & \cdots & 1 \end{pmatrix}\begin{pmatrix} CF_1 \\ \cdot \\ \cdot \\ CF_n \end{pmatrix}}$$

$$(10)$$

With :

$$\begin{pmatrix} 1 & \varrho_{12} & \cdots & \varrho_{1n} \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \varrho_{n1} & \varrho_{n2} & \cdots & 1 \end{pmatrix}$$: The correlation matrix of the studied portfolio.

The historical VaR is calculated after getting the historical daily stock returns and calculating the historical daily portfolio value.

3.2. Developing Hypothesis

For the historical VaR, this work tests the null hypothesis H0: The historical VaR method is effective against unlikely risks versus the alternative hypothesis H1: The historical VaR method is ineffective against unlikely risks.

Also, for the Cornish-Fisher VaR, this work tests the null hypothesis H2: The Cornish-Fisher VaR method is effective against unlikely risks versus the alternative hypothesis H3: The Cornish-Fisher VaR method is not effective against unlikely risks.
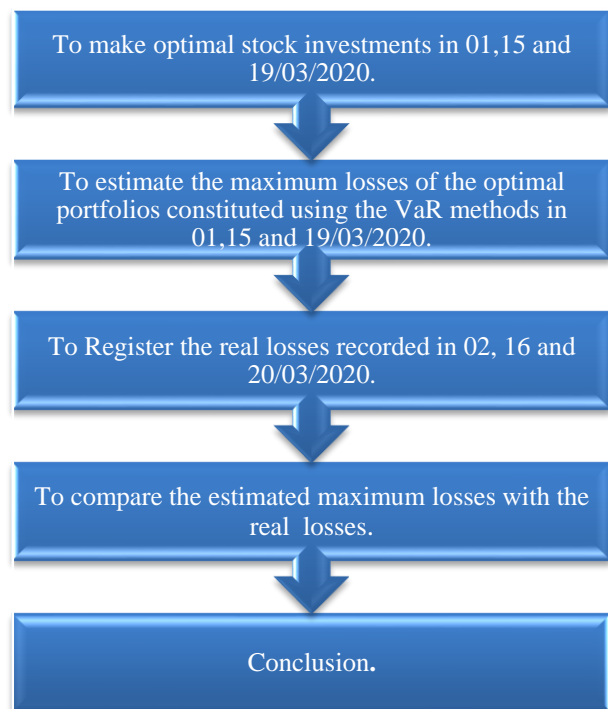
Efficacy in this article means that the real losses did not exceed the maximum losses estimated by the two methods.

4. Materials and Methods

The objective of this study is to measure the impact of the sanitary risk on the stock market at the level of the Casablanca Stock Exchange on the one hand and, on the other hand, to test if the calculation of the VaR has estimated this impact. For this purpose, investments considered optimal, according to the Markowitz model, were constituted during a period of time extending from 19/07/2016 (the date of introduction of the company SODEP -which is among the shares of the studied

portfolio- in the Moroccan stock exchange) to 19-03-2020.

Then, for this optimal investment that represents the minimum risk of loss, this work has calculated the maximum loss that the investments should not exceed with a 99% confidence level using the VaR model with both methods: historical and Cornish-Fisher. Finally, this study compared the estimated maximum loss with the real loss recorded on 02/03/2020, which is the date of the first case of covid-19 in Morocco, on 15 and 16/03/2020, the dates of the implementation of social distancing measures, and on 20/03/2020, the date of the implementation of isolation by the Moroccan health authorities to limit the effects of covid-19. The approach can be summarized as follows:

To make optimal stock investments in 01,15 and 19/03/2020.

To estimate the maximum losses of the optimal portfolios constituted using the VaR methods in 01,15 and 19/03/2020.

To Register the real losses recorded in 02, 16 and 20/03/2020.

To compare the estimated maximum losses with the real losses.

Conclusion.

The portfolios studied comprised 24 sectors operating on the Casablanca Stock Exchange. Figure 1 presents these sectors. Figure 2 shows the fluctuations in the returns of all the stocks in the portfolio during the considered period.

4.1. Descriptive Statistics
4.1.1. Normality Test

Testing the hypothesis H0: the distribution is normal against the hypothesis H1: the distribution is not normally using the Jarque Bera statistic that follows the χ^2 distribution with two degrees of freedom with the E-views software rejected hypothesis H0. The stock returns are not normally distributed. Figure 3 shows the test result for the stock AUTOHALL from 19/07/2016 to 01/03/2020. The test results are the same for the other stocks.

4.1.2. Stationarity Test

The test of the stationarity hypothesis using the Dickey-Fuller statistic with the E-views software showed that the series is stationary. Figure 3 shows the test result for the stock AUTOHALL from 19/07/2016 to 01/03/2020. The test results are the same for the other stocks.
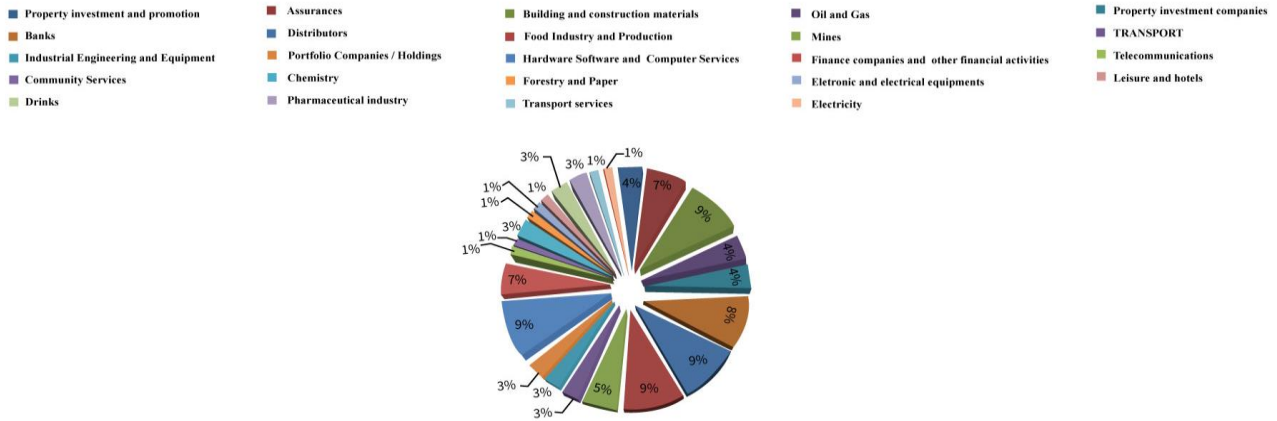
Property investment and promotion | Assurances | Building and construction materials | Oil and Gas | Property investment companies
Banks | Distributors | Food Industry and Production | Mines | TRANSPORT
Industrial Engineering and Equipment | Portfolio Companies / Holdings | Hardware Software and Computer Services | Finance companies and other financial activities | Telecommunications
Community Services | Chemistry | Forestry and Paper | Eletronic and electrical equipments | Leisure and hotels
Drinks | Pharmaceutical industry | Transport services | Electricity

Fig. 1 The sectors operating on the Casablanca Stock Exchange.

Fig. 2 Fluctuations of stock market returns from 07/19/2016 to 03/2020

Series: AUTOHALL
Sample 1 897
Observations 897
Mean	0.000561
Median	0.000000
Maximum	0.110957
Minimum	-0.090796
Std. Dev.	0.020795
Skewness	0.471585
Kurtosis	7.727174
Jarque-Bera	868.4360
Probability	0.000000
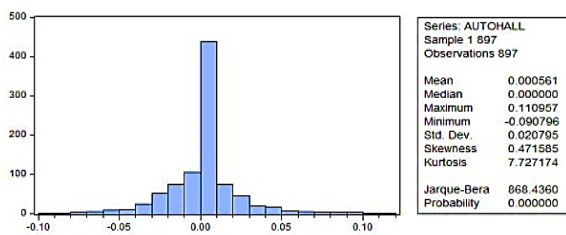
Null Hypothesis : AUTOHALL has a unit root
Exogenous : None
Lag Length : 3 (Automatic - based on SIC, maxlag=20)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-19.38853	0.0000
	1% level	-2.567554	
	5% level	-1.941178	
Test critical values:	10%	-1.616461	

Fig. 3 Results of the normality and the stationarity tests of the stock AUTOHALL from 19/07/2016 to 01/03/2020.

4.2. Results and Discussion

On 02/03/2020, the first case of covid-19 was detected in Morocco. An optimal and diversified portfolio was constituted to compare the estimated losses with the real losses on that day, containing a representative stock of each sector operating on the Stock Exchange of Casablanca. For a time extending from 19/07/2016 (the date of introduction of the company SODEP -which is among the shares of the studied portfolio- in the Moroccan stock exchange) to 01/03/2020, the obtained results are presented in Table 1 of the Annex.

The real loss recorded on 02/03/2020 did not exceed the maximum loss estimated by the historical Var method. The Cornish-Fisher approximation cannot be used for all of the mentioned portfolios because its condition for use is not respected.

For better clarification of THIS study, and because the Cornish-Fisher VaR can't be used for the portfolios mentioned before, a portfolio of stocks where the conditions for using this approximation are satisfied is constituted. The stocks in this example are AUTOHALL,

MANAGEM, DELATTRE, ZELLIDJA, IBMAROC, RISMA, LYDEC and TAQAMOROCO. The results are presented in Table 2 of the Annex.

Also, It can be seen that the real loss recorded on 02/03/2020 did not exceed the maximum loss estimated by the Cornish-Fisher Var method.

On 15/03/2020 and 16/03/2020, Morocco implemented social distancing measures to contain the propagation of the virus. Similarly, to compare the estimated losses with the real losses of 16/03/2020, an optimal and diversified portfolio containing a representative stock of each of the sectors operating on the Stock Exchange of Casablanca is constituted. Starting from 19/07/2016 (the date of introduction of the company SODEP -which is among the shares of the studied portfolio- in the Moroccan stock exchange) to 15/03/2020, the obtained results are presented in Table 3 of the Annex.

The losses recorded on 16/03/2020 were severe. For the historical VaR, the real loss on 16/03/2020 far exceeded the estimated maximum loss of the optimal portfolios.

For better clarification of this study, and because the Cornish-Fisher VaR can't also be used for the portfolios mentioned before, a portfolio of stocks where the conditions for using this approximation are satisfied is constituted. The stocks in this example are AUTOHALL, MANAGEM, DELATTRE, ZELLIDJA, IBMAROC, RISMA and TAQAMOROCO. The results are presented in Table 4 of the Annex.

Also, for these portfolios, the losses in 03/16/2020 were severe but did not exceed the maximum loss estimated by the Cornish-Fisher VaR. This approximation overestimated these losses.

Then for portfolios where the Cornish-Fisher approximation condition is respected, the estimated losses for 20/03/2020 (the date of the beginning of the confinement) are presented in Table 5 of the Annex.

On 20/03/2020, no losses were recorded for the optimal portfolios constructed. The estimated maximum losses have not been exceeded.

These results can be summarized in table 6 and figure 4,5 and 6 :

Table 6. Comparison between recorded losses and estimated losses

| Date	Losses(percentage of invested value)	Expected returns(percentage of invested value)					
		0,01%	0,02%	0,03%	0,04%	0,05%	MAX
02/03/2020	Estimated with Historical VaR :	5,92%	5,82%	5,66%	5,39%	5,33%	4,06%
	Estimated with Cornish-Fisher VaR	25,64%	25,64%	20,29%	18,40%	14,06%	9,18%
	Real losses(percentage of invested value)	0,75%	0,84%	1,05%	1,13%	1,12%	1,12%
16/03/2020	Estimated with Historical VaR	5,54%	5,45%	5,30%	5,17%	5,02%	5,45%
	Estimated with Cornish-Fisher VaR	25,29%	23,65%	19,60%	19,60%	19,60%	9,77%
	Real losses(percentage of invested value)	7,95%	8,15%	8,11%	8,10%	7,59%	5,88%
20/03/2020	Estimated with Historical VaR	7,19%	7,12%	7,06%	6,98%	6,64%	6,11%
	Estimated with Cornish-Fisher VaR	18,71%	18,71%	18,71%	16,71%	16,71%	9,74%
	Real losses(percentage of invested value)	0%	0%	0%	0%	0%	0%

Source: Author treatment methods.
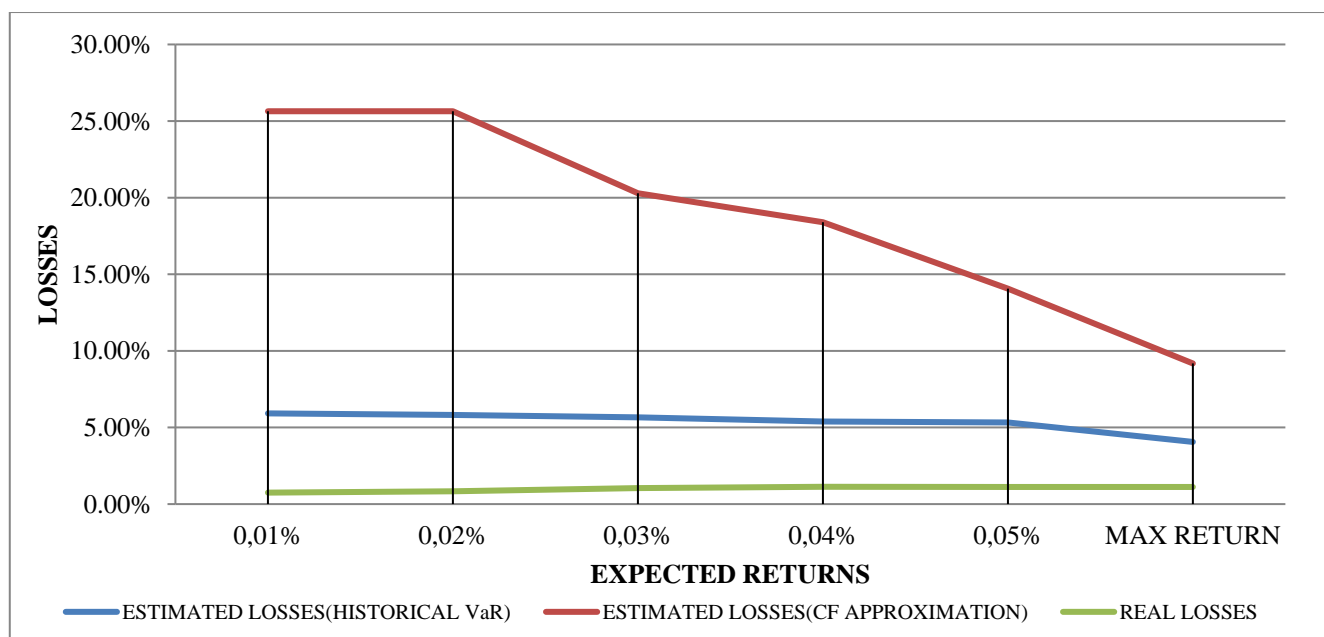
Fig. 4 Comparison between recorded losses and estimated losses on 02/03/2020
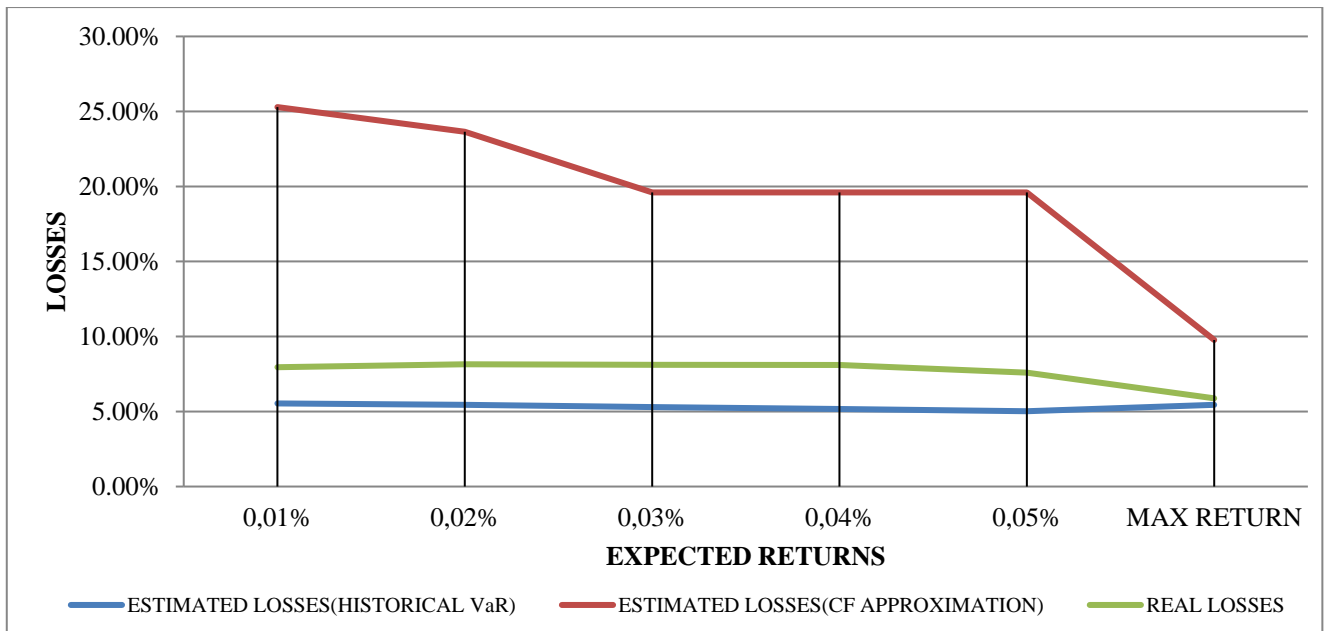
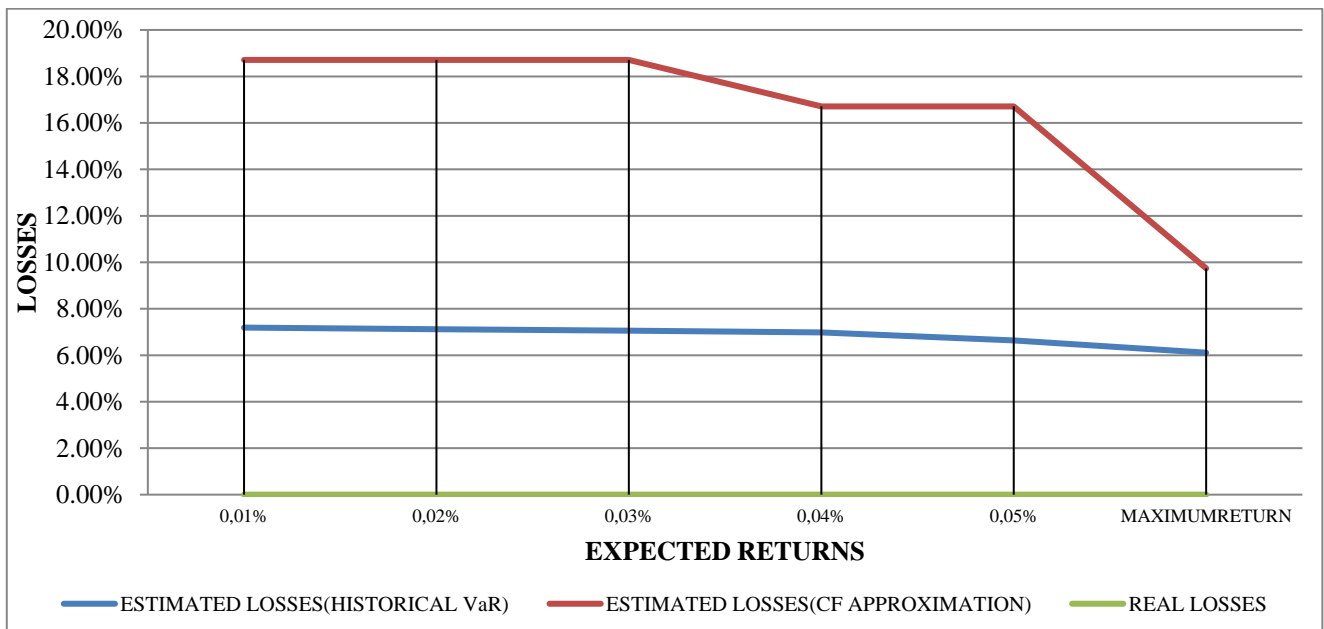**Fig. 5 Comparison between recorded losses and estimated losses on 16/03/2020.**

Fig. 6 Comparison between recorded losses and estimated losses on 20/03/2020.

5. Conclusion

The first case of covid-19 was detected in Morocco on 02/03/2020. On that day, the maximum losses estimated by the historical method were not exceeded for the optimal portfolio constituted to minimize the risk. Therefore, hypothesis H0 is accepted for this date: The historical VaR was effective against sanitary risk on 02/03/2020.

For the same date, another portfolio was created, containing stocks permitting the use of the Cornish-Fisher VaR. Also, for that day, the maximum losses estimated by the Cornish-Fisher VaR were not exceeded for the optimal portfolio constituted to minimize the risk. Therefore, the hypothesis H2 is accepted for this date: The Cornish-Fisher VaR was effective against sanitary risk on 02/03/2020

On 16/03/2020, social distancing measures were implemented by the Moroccan health authorities. On that day, the real losses of the portfolio were significant. They varied between 1.30% and 10.50% of the portfolio value. The maximum losses estimated by the historical method were exceeded. Therefore, the H0 hypothesis is rejected for this date, and the H1 hypothesis is accepted: the historical VaR was ineffective against sanitary risk on 16/03/2020.

For the same date, another portfolio was built up, containing stocks permitting the use of the Cornish-Fisher VaR. The real losses were still severe. They exceeded the losses estimated by the historical VaR method, but the losses estimated by the Cornish-Fisher VaR method were

not exceeded. For this reason, hypothesis H2 is accepted for this date: The Cornish-Fisherl VaR was effective against sanitary risk on 16/03/2020.

The confinement started on 20/03/2020.In the meantime, no losses have been recorded for the portfolio. Consequently, the maximum estimated losses have not been exceeded. Therefore, for this date, the H0 and the H2 hypothesis are accepted, and the H1 and H3 hypotheses are rejected: the historical VaR and the Cornish-Fisher VaR were effective against sanitary risk on 20/03/2020.

For the three dates, the real losses never exceeded the losses estimated by the Cornish-Fisher VaR, but the estimation was far from reality. This method is based on the extreme value theory. For this reason, future research should focus on this theory to better estimate and manage unlikely risks.

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Appendix 1

Table 1. Results of 02/03/2020

Stocks	EXPECTED RETURNS									
	0,01%	0,02%	0,03%	0,04%	0,05%	0,06%	0,07%	0,08%	0,09%	MAXIMUM RETURN
STOCK'S PROPORTIONS(OPTIMIZATION RESULT) (%)										
ADDOHA	0	0	0	0	0	0	0	0	0	0
AGMA	0,0373	0	0	0	0	0	0	0	0	0
ALUMINIUM DU MAROC	0,02	0,058	0,073	0,088	0,1026	0,1174	0,126	0,127	0,11486	0
AFRIQUIA-GAZ	0,0307	0,032	0,042	0,052	0,0622	0,0723	0,086	0,103	0,11695	0
BALIMA	0,6115	0,448	0,338	0,229	0,1186	0,0087	0	0	0	0
BP	0,0161	0,061	0,071	0,08	0,0897	0,0995	0,079	0,025	0	0
AUTOHALL	0,0155	0,039	0,048	0,058	0,0667	0,076	0,084	0,088	0,08751	0
CENTRAL DANON	0,0193	0,016	0,013	0,011	0,0082	0,0059	0	0	0	0
MANAGEM	0,0036	0,001	0,001	0,001	0	0	0	0	0	0
CTM	0,0122	0,029	0,037	0,045	0,0529	0,0607	0,067	0,071	0,06348	0
DELATTRE	0	0	0	0	0	0	0	0	0	0
ZELLIDJA	0	0	0	0	0	0	0	0	0	0
IBMAROC	0	0	0	0	0	0	0	0	0	0
EQDOM	0,0131	0,034	0,041	0,049	0,057	0,0648	0,064	0,057	0,03498	0
ITISSALAT-ALMAGHREB	0,0868	0,064	0,057	0,051	0,0451	0,0387	0	0	0	0
LYDEC	0	0	0	0	0	0	0	0	0	0
MAGHREB-OXYGENE	7E-05	1E-04	1E-04	1E-04	0,0002	0,0002	2E-04	2E-04	0,00015	0
MED PAPER	0,0025	0,002	0,002	0,002	0,003	0,0028	0	0	0	0
NEXANS	0,0138	0,011	0,01	0,008	0,0068	0,0051	0	0	0	0
OULMES	0,0022	0,019	0,022	0,024	0,0272	0,0299	0,011	0	0	0
RISMA	0,0027	0,012	0,013	0,014	0,0149	0,0158	0,011	3E-05	2,8E-05	0
SOTHEMA	0,0121	0,046	0,053	0,06	0,0676	0,0751	0,064	0,034	0	0
SODEP	0,0846	0,096	0,134	0,172	0,21	0,2482	0,322	0,413	0,52056	1
TAQA MOROCCO	0,0163	0,032	0,044	0,056	0,0673	0,0789	0,085	0,082	0,06148	0
Minimized portfolio risk with Markovitz's model.	0,27%	0,30%	0,30%	0,40%	0,46%	0,53%	0,60%	0,70%	0,80%	1,3%
Parametric VaR (H0 rejected)	0,63%	0,69%	0,82%	0,97%	1,13%	1,30%	1,49%	1,72%	2,00%	3,35%
Cornish-Fisher approximation	The condition of use is missing.									
HISTORICAL VaR	1,58%	0%	5,32%	5,21%	5,09%	4,98%	4,99%	4,96%	4,85%	3,75%
REAL LOSS ON 02/03/2020	0,50%	0,40%	0,40%	0,58%	0,67%	0,76%	0,81%	0,84%	0,88%	1,38%

Appendix 2

Table 2. Results of 02/03/2020 for a portfolio permitting the use of Cornish-Fisher VaR

	0,01%	0,02%	0,03%	0,04%	0,05%	0,06%
Stocks	STOCK'S PROPORTIONS(OPTIMIZATION RESULT) (%)					
AUTOHALL	0,1873	0,20149455	0,228828	0,2751	0,47727	1
MANAGEM	0,1008	0,102123855	0,096322	0,0728	0	0
DELATTRE	0,0356	0,008085168	0	0	0	0
ZELLIDJA	0,1157	0,10770697	0,069246	0	0	0
IBMAROC	0,0229	0,015253025	0	0	0	0
LYDEC	0,1226	0,124053544	0,114343	0,0813	0	0
RISMA	0,1179	0,126524834	0,1427	0,1669	0,15296	0
TAQA MOROCCO	0,2971	0,314758053	0,34856	0,4038	0,36977	0
Minimized portfolio risk with Markovitz's model.	0,0082	0,00848247	0,008898	0,0097	0,01185	0,02078
Parametric VaR (H0 rejected)	1,92%	2,00%	2,10%	2,30%	2,81%	4,90%
Cornish-Fisher approximation	25,64%	25,64%	20,29%	18,40%	14,06%	9,18%
HISTORICAL VaR	5,92%	5,82%	5,66%	5,39%	5,33%	4,06%
REAL LOSS ON 02/03/2020	0,75%	0,84%	1,05%	1,13%	1,12%	1,12%

Appendix 3

Table 3. Results of 16/03/2020

Stocks	EXPECTED RETURN									
	0,01%	0,02%	0,03%	0,04%	0,05%	0,06%	0,07%	0,08%	0,09%	MAXIMUM RETURN
STOCK'S PROPORTIONS(OPTIMIZATION RESULT) (%)										
ADDOHA	0	0	0	0	0	0	0	0	0	0
AGMA	0	0,00036974	0	0,00078757	0,00067257	0,00067159	0,00061544	0,00060816	0	0
ALUMINIUM DU MAROC	0,02654618	0,05031534	0,07962889	0,10047177	0,13203668	0,15836302	0,15129412	0,1268818	0	0
SAMIR	0,83476589	0,6735861	0,50508636	0,34695525	0,17559681	0,01321566	0	0	0	0
BALIMA	0	0	0	0	0	0	0	0	0	0
BP	0,00056085	0,00056285	0,00079247	0,00083003	0,00087314	0,00087198	0	0	0	0
AUTOHALL	0,02439952	0,04935465	0,07316709	0,09881229	0,12191275	0,14631228	0,1813983	0,21994878	0,21709111	0
CENTRAL DANON	0	0	0	0	0	0	0	0	0	0
MANAGEM	0	0	0	0	0	0	0	0	0	0
CTM	0,01101137	0,02323512	0,03306892	0,04738307	0,05511813	0,06693136	0,05585091	0,03135503	0	0
DELATTRE	0	0	0	0	0	0	0	0	0	0
ZELLIDJA	0	0	0	0	0	0	0	0	0	0
IBMAROC	0	0	0	0	0	0	0	0	0	0
EQDOM	0,0154683	0,03039496	0,04637065	0,0607556	0,07728657	0,09280183	0,06850662	0,02662265	0	0
ITISSALAT-ALMAGHREB	0	0	0	0	0	0	0	0	0	0
LYDEC	0	0	0	0	0	0	0	0	0	0
MAGHREB-OXYGENE	0	0	0	0	0	0	0	0	0	0
MED PAPER	0	0	0	0	0	0	0	0	0	0
NEXANS	0	0	0	0	0	0	0	0	0	0
OULMES	0,00238481	0,00270527	0,00729765	0,00536554	0,01215621	0,01212689	0	0	0	0
RISMA	0	0	0	0	0	0	0	0	0	0
SOTHEMA	0,01824486	0,03502806	0,05467179	0,06948152	0,09108242	0,10916286	0,06486925	0	0	0
SODEP	0,05633538	0,11334688	0,16896818	0,22621138	0,28162751	0,33802744	0,45893503	0,59458357	0,78290889	1
TAQA MOROCCO	0,01028283	0,02110162	0,03094801	0,0429458	0,05163721	0,06151509	0,01853033	0	0	0
Minimized portfolio risk (Markowitz)	0,117%	0,234%	0,351%	0,468%	0,585%	0,702%	0,839%	1,019%	1,249%	1,49%
PARAMETRIC VAR (H0 rejected)	0,28%	0,57%	0,85%	1,13%	1,41%	1,70%	2,03%	2,45%	3,00%	3,57%
CORNISH-FISHER APPROXIMATION	The condition of use is missing.									
HISTORICAL VaR	0,76%	1,50%	2,28%	3,01%	3,80%	4,54%	4,83%	4,94%	8,21%	8,62%
REAL LOSS ON 03/16/2020	1,13%	2,28%	3,38%	4,56%	5,64%	6,77%	7,48%	8,24%	9,50%	10,50%

Appendix 4

Table 4. Results of 16/03/2020 for a portfolio permitting the use of Cornish-Fisher var

Stocks	EXPECTED RETURNS							
	0,01%	0,02%	0,03%	0,04%	0,05%	0,06%	0,07%	MAXIMUM RETURN
	STOCK'S PROPORTIONS(OPTIMIZATION RESULT) (%)							
ADDOHA	0	0	0	0	0	0	0	0
AGMA	0	0	0	0	0	0	0	0
ALUMINIUM DU MAROC	0	0	0	0	0	0	0	0
SAMIR	0	0	0	0	0	0	0	0
BALIMA	0	0	0	0	0	0	0	0
BP	0	0	0	0	0	0	0	0
AUTOHALL	0,24748	0,2671	0,31638	0,3749	0,4926	0,6561	0,85431	1
CENTRAL DANON	0	0	0	0	0	0	0	0
MANAGEM	0,11188	0,11244	0,09589	0,07158	0	0	0	0
CTM	0	0	0	0	0	0	0	0
DELATTRE	0,02638	0	0	0	0	0	0	0
ZELLIDJA	0,13434	0,12609	0,07114	0,00035	0	0	0	0
IBMAROC	0,02012	0,01181	0	0	0	0	0	0
EQDOM	0	0	0	0	0	0	0	0
ITISSALAT-ALMAGHREB	0	0	0	0	0	0	0	0
LYDEC	0	0	0	0	0	0	0	0
MAGHREB-OXYGENE	0	0	0	0	0	0	0	0
MED PAPER	0	0	0	0	0	0	0	0
NEXANS	0	0	0	0	0	0	0	0
OULMES	0	0	0	0	0	0	0	0
RISMA	0,11956	0,12501	0,12901	0,13168	0,094	0,0047	0	0
SOTHEMA	0	0	0	0	0	0	0	0
SODEP	0	0	0	0	0	0	0	0
TAQA MOROCCO	0,34022	0,35754	0,38758	0,4215	0,4134	0,3393	0,14569	0
Minimized portfolio risk (Markowitz)	0,00918	0,00954	0,01033	0,01113	0,0124	0,0149	0,01847	0,021564
Parametric VaR (H0 rejected)	2,15%	2,24%	2,38%	2,59%	2,94%	3,54%	4,37%	5,09%
Cornish-Fisher approximation	25,29%	23,65%	19,60%	19,60%	19,60%	19,60%	11,06%	9,77%
HISTORICAL VaR	5,54%	5,45%	5,30%	5,17%	5,02%	5,00%	5,26%	5,45%
REAL LOSS ON 03/16/2020	7,95%	8,15%	8,11%	8,10%	7,59%	6,97%	6,34%	5,88%

Appendix 5

Table 5. Results of 20/03/2020 for a portfolio permitting the use of Cornish-Fisher var

Stocks	EXPECTED RETURNS						
	0,01%	0,02%	0,03%	0,04%	0,05%	0,06%	MAXIMUM RETURN
	STOCK'S PROPORTIONS(OPTIMIZATION RESULT) (%)						
AUTOHALL	0,43693239	0,51499183	0,5930157	0,6719733	0,7771189	0,8902151	1
MANAGEM	0,18246999	0,16224853	0,14297	0,121733	0,0455737	0	0
DELATTRE	0	0	0	0	0	0	0
ZELLIDJA	0,18778729	0,12474593	0,0612804	0	0	0	0
IBMAROC	0	0	0	0	0	0	0
RISMA	0,19281033	0,1980137	0,2027339	0,2062936	0,1773073	0,1097849	0
Minimized portfolio risk (Markowitz)	0,01224274	0,01308713	0,0142168	0,01557	0,0172448	0,0193124	0,02161316
Parametric VaR (H0 rejected)	2,86%	3,07%	3,34%	3,67%	4,07%	4,56%	5,10%
Cornish-Fisher approximation	18,71%	18,71%	18,71%	16,71%	16,71%	13,40%	9,74%
HISTORICAL VaR	7,19%	7,12%	7,06%	6,98%	6,64%	6,34%	6,11%
REAL LOSS ON 20/03/2020	0%	0%	0%	0%	0%	0%	0%