

DATA-DRIVEN OPTIMIZATION MODEL FOR FINANCIAL MARKET DYNAMICS ANALYSIS WITH SOCIAL INFORMATION RETRIEVAL PERSPECTIVE

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ABSTRACT

Recent advances in financial research highlight the growing importance of data-driven approaches, particularly Social Information Retrieval (SIR) and Machine Learning perspectives, in understanding financial market behavior during periods of uncertainty. These approaches emphasize the role of information flows, investor perception, and market reactions derived from large-scale financial and digital data.

The production and consumption of building materials is a fundamental indicator in assessing the economic health of a country and can also be considered a sensitive indicator of macroeconomic fluctuations and crisis transmission in financial markets. In this context, we analyze the financial impacts of the COVID-19 pandemic on the Building and Construction Materials sector by focusing on a portfolio composed of four leading securities in Morocco. This selection enables a focused analysis of market behavior under extreme economic conditions.

A preliminary analysis revealed a decline in closing prices and traded volumes during the first and second lockdown periods of 2020, reflecting both fundamental economic shocks and shifts in market sentiment. From a methodological perspective, a data-driven optimization approach is adopted to quantify risk-return trade-offs under different crisis scenarios. Subsequently, Modern Portfolio Theory (mean-variance optimization) is used to estimate the portfolio's expected return in 2008 and 2020 over the same period, allowing for a comparison of optimal return and volatility between the two crises. This comparison provides insights into the structural differences between a financial crisis and a pandemic-induced shock.

The analysis is discussed from a Social Information Retrieval perspective, offering an informational interpretation of market reactions without modifying the underlying quantitative framework. All computations were performed using R.

Keywords: *Data-driven, Optimization, Social Information Retrieval; Markowitz Theory; Financial Markets; COVID-19; Economic Crisis*

1. INTRODUCTION

The analysis of financial market dynamics during economic crises has recently evolved with the emergence of new data sources, particularly digital and social platforms. These sources generate large volumes of unstructured data reflecting investor perceptions, reactions, and information dissemination processes. In this context, Social Information Retrieval (SIR) has emerged as an approach for extracting relevant insights from such data.

At the same time, Machine Learning and Deep Learning techniques, especially in Natural Language Processing, have been increasingly used to analyze these data, identify patterns, and better understand market behavior during periods of uncertainty.

In this context, the Coronavirus crisis has certainly had a strong impact on economic activity [1]. The Moroccan economy, like the world economy as a whole, has been impacted in a brutal and unforeseen way. According to the latest estimates of the IMF, the Moroccan economy, which should have a growth rate of 3.7% according to the forecasts of the 2020

finance law, will have to realize a decline, the GDP would fall by 3.7% with an increase in the unemployment rate which would rise to over 12.5%.

Several factors led to this drastic decrease in activity [2]. The absence of manpower being the main one. According to the profession, the latter voluntarily left the building sites as soon as the state of emergency was announced. Especially since the resumption of this workforce is now "problematic" because of the traffic restrictions imposed by the authorities in town.

It is learned that the construction sector would also have recorded a reduction of nearly 170,000 jobs during this period, i.e. 24% of the overall employment of this sector.

During the containment period, 52.4% of the enterprises partially reduced their activity, 29.6% totally but temporarily and 1.3% declared to have stopped their activity permanently. Three quarters of the exporting companies, on the other hand, stopped their activities partially or totally during the containment. The main sectors most affected by this stoppage are accommodation and catering, with 98% of companies at a standstill, the textile and leather industries and the metal and mechanical industries with 99% and 91%, respectively, and the construction sector with 93%.

After the stoppage observed during the containment and until the beginning of July, 84.6% of enterprises resumed their activity, of which 32.4% with a normal rhythm, 52.2% partially, while 15.4% were at a standstill. Two-thirds of exporting companies have resumed their activities, 18.6% of them normally

At the end of the second half of 2020, 83.7% of companies have maintained their activity, while 8.1% of companies are still on temporary lay-off, 6% have temporarily stopped their activity after a recovery and 2.2% have permanently stopped their activity. By branch of activity, the companies that are still finding it difficult to resume their activity normally are those in transport and storage (30.5% of companies on temporary lay-off), accommodation and catering (27%) and real estate activities (25%). On the other hand, the proportion of enterprises having declared a permanent stoppage amounts to 10% in the textile and leather industries and 7% in real estate activities. The results of the survey show that compared to the second half of 2019, 83% of companies reported a decrease in their activity while 12% experienced a stable level of activity and only 5% of companies recorded an increase during the second half of 2020.

While these data-driven approaches provide a behavioral and informational understanding of market dynamics, classical financial models remain essential for quantitative evaluation and optimization. In particular, the Modern Portfolio Theory offers a robust framework to assess risk and return trade-offs.

In this context, the modern portfolio theory, developed by Harry Markowitz in the 1950s, defines the process of selecting securities to create the most efficient portfolio possible, i.e. one that has the maximum return for the minimum level of risk. Based on this powerful theory, we will develop a study to compare the maximum expectation and volatility of a portfolio composed of major companies in the Building and Construction Materials sector between the year 2008 and 2020.

The concept of diversification is the basis of the theory. Indeed, Markowitz believes that the various securities making up a portfolio cannot be selected individually and must instead be chosen according to the correlation of their variations to those of the rest of the assets in the portfolio.

2. CLASSICAL APPROACHES TO PORTFOLIO OPTIMIZATION OF FINANCIAL ASSETS

Despite recent advances in data-driven analysis using Machine Learning and Social Information Retrieval, traditional portfolio optimization models remain fundamental tools for financial evaluation.

In order to optimize a portfolio of financial assets, several models have been developed maximizing either the return or minimizing the risk. Thus, we have presented the different approaches to optimize the portfolio of financial assets existing in the last decades, focusing on the Markowitz approach, and analyzing the different criticisms addressed to each of these approaches as well as their advantages and disadvantages.

2.1 Markowitz Approach (1952)

Let be the price of a share at the end of period t , the price change $(p_t - p_{t-1})$ denotes the gain, to which may be added the income is the dividend paid in period t .

The return on this stock in period t is defined as follows [3]:

$$r_t = \frac{(p_t - p_{t-1}) + d_t}{p_{t-1}}$$

Let P be a portfolio of stocks (A_1, \dots, A_n) represented by a vector $x = (x_1, \dots, x_n)$ where i

denotes the proportion of capital C invested in the stock characterized by its uncertain return r_i ($i=1, \dots, n$).

The return on this portfolio is defined as follows:

$$R(x) = \sum_{j=1}^n r_j x_j$$

The value and change in this portfolio are defined as follows:

$$VaL = \sum_{j=1}^n p_j x_j$$

$$\Delta V(x) = \sum_{j=1}^n \Delta p_j x_j$$

Harry Markowitz [3] was the first to come up with the idea of measuring the profitability of a portfolio by the expected return and the risk by its variance.

The Markowitz approach, also called mean-variance, consists in minimizing the risk of this portfolio by setting the minimum return expected by this investor or vice versa [4], i.e.: Maximize the expected return by setting the minimum risk desired by this investor.

The portfolio return is a random variable whose expectation is given by :

$$E[R(x)] = E[\sum_{j=1}^n r_j x_j] = \sum_{j=1}^n E[r_j] x_j$$

Therefore :

$$E[R(x)] = \sum_{j=1}^n \bar{r}_j x_j$$

The variance of the portfolio return is given by :

$$\sigma^2[R(x)] = E[R(x) - E[R(x)]]^2 = E[\sum_{j=1}^n r_j x_j - \sum_{j=1}^n \bar{r}_j x_j]^2$$

$$= E[\sum_{j=1}^n (r_j - \bar{r}_j) x_j]^2$$

$$= \sum_{i=1}^n x_i^2 \sigma_i^2 + \sum_{i=1}^n \sum_{j=1}^n x_i x_j \sigma_{ij}$$

$$= \sum_{i=1}^n \sum_{j=1}^n x_i x_j cov(r_i, r_j)$$

This implies that :

$$\sigma^2[R(x)] = \sum_{i=1}^n \sum_{j=1}^n x_i x_j \sigma_{ij}$$

The resulting Markowitz optimization algorithm is written as follows:

$$\text{Min } \{ \sum_{i=1}^n \sum_{j=1}^n x_i x_j \sigma_{ij} \}$$

Under the constraints:

$$\sum_{j=1}^n E[r_j] x_j \geq \rho$$

$$\sum_{j=1}^n x_j = 1 \quad (\text{with } x_j \geq 0 \quad j = 1..n)$$

This is a quadratic programming problem that generates a feasible mean-variance combination. The set of possible combinations of the mean-variance portfolios is said to be efficient if, among all the portfolios with the same expected return, there is no strictly lower risk.

In the case where, $j=1, \dots, n$ is arbitrary, i.e., open outcry is allowed and the constraint on the minimum expected return to the investor is equal to ρ , the Lagrangian multiplier technique is used to compute the optimal solution. The Lagrangian function used is given by :

$$L(x_1, x_2, \dots, x_n, \lambda_1, \lambda_2) = \sum_{i=1}^n \sum_{j=1}^n x_i x_j \sigma_{ij} + \lambda_1 (\sum_{j=1}^n \bar{R}_j x_j - \rho) + \lambda_2 (\sum_{j=1}^n x_j - 1)$$

It follows that:

$$\frac{dL}{dx_1} = 2 \sum_{j=1}^n x_j \sigma_{1j} + \lambda_1 \bar{R}_1 + \lambda_2$$

$$\frac{dL}{d\lambda_1} = \sum_{j=1}^n \bar{R}_j x_j - \rho$$

$$\frac{dL}{d\lambda_2} = \sum_{j=1}^n x_j - 1$$

It follows that :

$$Cx = K \quad \text{so } x = c^{-1}K$$

Suppose we have a capital that we wish to allocate between n equities (risky assets) and a risk-free asset characterized by a fixed return a zero variance ($\sigma_{n+1}^2 = 0$) and a zero covariance of its return with the other returns of the risky assets ($\sigma_{i,n+1}^2 = 0$ for $i=1 \dots n$).

Let x_i be the proportion of capital C invested in asset i ($i=1, \dots, n$) and by the percentage of capital invested in the risk-free asset. We have:

$$\sigma^2[R(x)] = \sigma^2[\sum_{j=1}^n R_j x_j + x_{n+1} r_0] = \sigma^2[\sum_{j=1}^n R_j x_j] = \sum_{i=1}^n \sum_{j=1}^n x_i x_j \sigma_{ij}$$

Then the constraints on expected return and capital become:

$$\sum_{j=1}^n \bar{R}_j x_j + x_{n+1} r_0 = \rho.$$

$$\sum_{j=1}^{n+1} x_j = 1.$$

The Lagrangian function is given by :

$$L(x_1, x_2, \dots, x_{n+1}, \lambda_1, \lambda_2) = \sum_{i=1}^n \sum_{j=1}^n x_i x_j \sigma_{ij} + \lambda_1 (\sum_{j=1}^n \bar{R}_j x_j + x_{n+1} r_0 - \rho) + \lambda_2 (\sum_{j=1}^n x_j - 1).$$

It follows that:

$$\frac{dL}{dx_1} = 2 \sum_{j=1}^n x_j \sigma_{ij} + \lambda_1 \bar{R}_j + \lambda_2.$$

$$\frac{dL}{dx_{n+1}} = \lambda_1 r_0 + \lambda_2.$$

$$\frac{dL}{d\lambda_1} = \sum_{j=1}^n \bar{R}_j x_j + x_{n+1} r_0 - \rho.$$

$$\frac{dL}{d\lambda_2} = \sum_{j=1}^n x_j - 1 = 0$$

It follows that :

$$Cx = K \text{ so } x = c^{-1}K.$$

The mean-variance approach proposed by Markowitz is still usable in practice because of several limitations which are :

- ✓ The computational complexity: the optimization process requires the computation of $\frac{n(n+1)}{2}$ covariances, so it is clear that at the time, this optimization program required covariance, so it is clear that at the time, this optimization program required significant resources in terms of computer hardware.
- ✓ The non-linear (quadratic) nature of the risk measure used by Markowitz is very sensitive to the size of the optimization program used for optimal portfolio determination.
- ✓ The investor's perception of risk is not symmetrical with respect to the mean, whereas the variance takes into account variations below and above the expected return in the same way.
- ✓ The return distribution: Markowitz assumes that the return on assets follows the normal distribution, however several studies have shown that this result is not always verified in reality.
- ✓ Transaction costs: Transaction costs are not taken into account in the Markowitz approach, so they are uncontrollable in reality.
- ✓ The risk measure introduced by Markowitz does not explicitly measure the potential loss that the investor may incur.

It is interesting to note that each of these criticisms of this approach has led to attempts to modify the approach to accommodate these criticisms on one point or another.

2.2 Sharpe's Approach (1963-1964)

In order to simplify the model proposed by Markowitz, Sharpe [5] was the first to develop models based on a synthetic index, in order to simplify the variance-covariance matrix to reduce the calculations proposed by Markowitz.

Sharpe diagonalized the variance-covariance matrix, based on a model constructed from a single index. The assumption of this model is that fluctuations in stock returns can be modeled by a linear regression model. So,

$$r_i = a_i + b_i R_i + \varepsilon_i \text{ Pour } i = 1..n$$

In other words:

R : is the return on the
 ε_i : is a random variable (white noise) that verifies the following assumptions:

The following assumptions are made:

$$\begin{aligned} \forall i = 1..n & \quad E[\varepsilon_i] = 0 \text{ and } \sigma_{\varepsilon_i}^2 = 0 \\ \forall i \neq j & \quad \sigma_{\varepsilon_i, \varepsilon_j} = \text{cov}(\varepsilon_i, \varepsilon_j) = 0 \\ \forall i = 1..n & \quad \sigma_{\varepsilon_i, R_i} = \text{Cov}(\varepsilon_i, R_i) = 0 \end{aligned}$$

The portfolio return becomes:

$$R(x) = \sum_{i=1}^n x_i r_i = \sum_{i=1}^n x_i a_i + R_i (\sum_{i=1}^n x_i b_i) + \sum_{i=1}^n x_i \varepsilon_i.$$

$$\text{Let } x_{n+1} = \sum_{i=1}^n b_i x_i.$$

This results in :

$$R(x) = \sum_{i=1}^n x_i r_i = \sum_{i=1}^n x_i a_i + x_{n+1} R_i + \sum_{i=1}^n x_i \varepsilon_i.$$

The expected return is given by:

$$R(x) = \sum_{i=1}^n x_i r_i = \sum_{i=1}^n x_i a_i + x_{n+1} E[R_i].$$

The variance of the return is:

$$\sigma_p^2 = \sum_{i=1}^n x_i^2 \sigma_{\varepsilon_i}^2 + x_{n+1}^2 \sigma_i^2.$$

The Sharpe model [6] proposes to estimate only (n+1) terms to be estimated instead of $\frac{n(n+1)}{2}$ variance and covariance (for the Markowitz approach, which gives an advantage to the Sharpe model in terms of minimizing the number of estimated parameters.

Comparing the two approaches, we see that the Markowitz approach relies on diversification to reduce the risk associated with the portfolio. On the other hand, despite the increase in the size of the stocks in a portfolio, we cannot reduce the risk to zero.

Otherwise the Sharpe model decomposes the risk of any portfolio into two parts:

- ✓ Diversifiable risk (or unsystematic risk).
- ✓ Non-diversifiable risk (or market risk).

2.3 The Speranza Model (1993)

Esperanza's model [7] proposes to combine the absolute deviation below the mean and the absolute deviation above the mean as a linear function. In order to propose an improvement on the model of Konno and Yamazaki. The measure of this risk is defined as follows:

$$S(x) = \alpha E[-\min(0, \sum_{j=1}^n R_j x_j - E[\sum_{j=1}^n R_j x_j])] + \beta E[\max(0, \sum_{j=1}^n R_j x_j - E[\sum_{j=1}^n R_j x_j])].$$

Where α and β are the weights of the risk function, which measure the degree of risk aversion of investors.

Depending on the values that the parameters α and β . The model can be written in different ways. Esperanza [8] chose the values $\alpha = 1$ and $\beta = 0$, in order to improve the efficiency of the model, in this case the risk measure:

$$S(x) = E[-\min(0, \sum_{j=1}^n R_j x_j - E[\sum_{j=1}^n R_j x_j])].$$

Then the optimization algorithm is as follows:

$$\frac{1}{T-1} \sum_{t=1}^T \{-\alpha \min(0, \sum_{j=1}^n (r_{jt} - r_j) x_j)\}.$$

Under the constraints :

$$\sum_{j=1}^n r_j x_j \geq \rho, \sum_{j=1}^n x_j = 1 \text{ with } x_j \geq 0 \quad j = 1 \dots n.$$

This algorithm is equivalent to the following algorithm:

$$\text{Min} \left\{ \frac{1}{T-1} \sum_{t=1}^T u_t \right\}$$

Under the following constraints:

$$u_t - \sum_{j=1}^n (r_{jt} - r_j) x_j \geq 0$$

$$\sum_{j=1}^n r_j x_j \geq \rho$$

$$\sum_{j=1}^n x_j = 1 \text{ with } x_j \geq 0, \quad j = 1 \dots n.$$

3. IMPACT OF THE CONTAINMENT PERIODS ON THE AVERAGE CLOSING PRICES AND THE NUMBER OF SHARES TRADED ON THE SELECTED PORTFOLIO

In this part, we analyze a portfolio composed of four stocks from the Casablanca Stock Exchange between the period 20.1.2020 and 20.5.2020, focusing on their financial evolution during the crisis period. This analysis is conducted with the perspective of integrating dimensions related to market behavior and investor sentiment within the framework of Social Information Retrieval, in order to enable a more comprehensive comparative study of financial dynamics during economic crises. The selected companies are: LafargeHolcim, Ciment du Maroc, Aluminium SA, Sonasid. These companies are the leaders in the building and construction sector in Morocco. All data are from the official website of the Casablanca Stock Exchange.

3.1 Analysis by average closing prices during the containment periods

For the first quarter of 2020, LafargeHolcim Morocco's consolidated sales were down by 6.8% compared to a year earlier. This decrease is explained by the drop in national cement demand due to the impact of the health crisis linked to the coronavirus pandemic. For its part, the Board of Directors of LafargeHolcim Morocco has decided to reduce the remuneration of its shareholders.

At the end of fiscal year 2020, Ciments du Maroc posted revenues of MAD 3.68 billion, down 7.1% compared to 2019. Despite the voluntary program to reduce operating costs, the gross operating surplus is down 9.9% compared to the previous period and stands at MAD 1.75 billion. For its part, the net income of the year 2020 was down by 33.8% to MAD 716 million following the drop in activity, to which is added an operation of depreciation on financial assets and the exceptional contribution to the special fund Covid-19. In a first degree, the analysis of the average closing prices and the securities traded marked a recession during the periods of the confinement declared in Morocco. The figure shows the evolution of the average closing price between 20.1.2020 and 20.5.2020.

Figure 2 shows the evolution of the average closing prices during the periods of confinement, of "LafargeHolcim" and "Ciment du Maroc" shares.

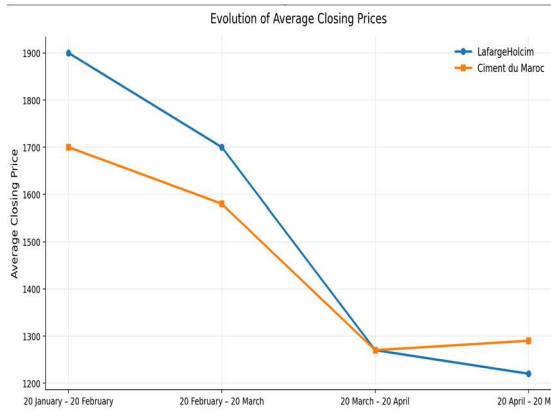


Figure 1: Evolution of the average monthly closing prices of the companies Ciment du Maroc and Lafarge Holcim between 20.01.2020 and 20.05.2020

In general, the average closing prices of the stocks have decreased considerably between 20.1.2020 and 20.5.2020. 20.3.2020 average closing prices of "LafargeHolcim" and "Ciment du Maroc" recorded a decrease of 25.67% and 19.63% respectively.

The recession of the average closing prices continued during the second period of confinement : the average

prices went from 1271.67 to 1221.95 and from 1266.05 to 1293.32 respectively for "LafargeHolcim" and "Ciment du Maroc". In order to carry out a more detailed comparison, Figure 3 presents the evolution of the average closing prices of "Aluminium SA" and "Sonasid".

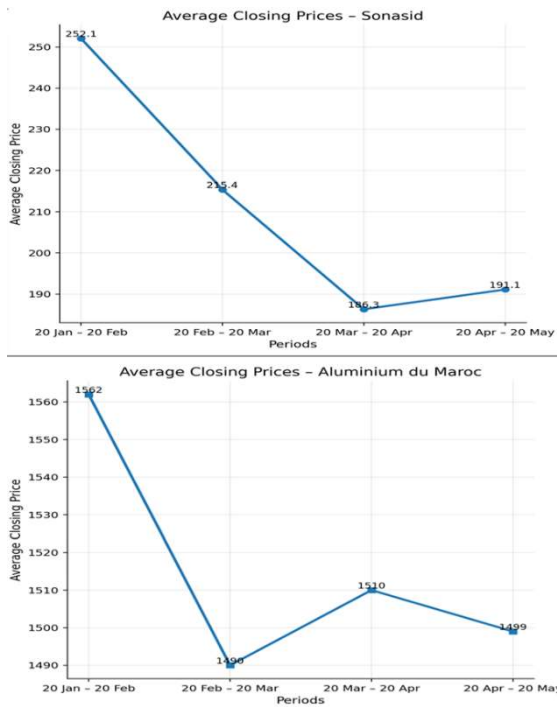


Figure 2: Evolution of average monthly closing prices of Sonasid and Aluminium SA between 20.01.2020 and 20.05.2020

Substantial decline in the construction market. This is the main finding through the latest results of the first half of 2020 of Sonasid. This situation is due to the exceptional circumstances due to the Covid-19 pandemic and especially to the containment period which has strongly impacted the pace of deliveries and construction activities. As a result, Sonasid's revenue declined by 34% at the end of June 2020 compared to the same period of the previous year, which will certainly have a significant impact on the company's results as at 30 June 2020.

Similarly, the turnover of the "Aluminium SA" group is down by 16% in 2020 at MAD 752.5 million. The group justifies the decrease by the effects of the pandemic and the containment. Earnings from operations fell by 28% to MAD 43.2 million. This drop is mainly due to the decrease in the group's activity in 2020. Aluminium du Maroc specifies that the impact "was contained thanks to the efforts undertaken to control structural charges while preserving employment".

Thus, Sonasid and Aluminium SA recorded decreases of 13.63% and 7.9% respectively during the first period of containment [9]. Subsequently during the second period of containment, the average fence prices recorded a slight decline of 2.53%, 2.57% during the second period of containment. Such variations may also reflect the impact of information dissemination and collective reactions observed through digital channels, which are typically explored in Social Information Retrieval approaches.

3.2 Analysis of securities traded during the lock-up period

The LafargeHolcim Morocco group unveils its achievements for the first half of 2020 in a context marked by a significant slowdown since mid-March 2020 of the entire construction sector.

On the other hand, cement sales continue to reduce their losses, gradually offsetting the shortfall in revenue experienced in the period due to total containment. After three months of almost total stoppage of construction sites, as evidenced by the 8.81% increase in cement sales last September, after a peak of 18.6% in August. Even though October sales show a 7.77% drop compared to 2019, volumes delivered reached 1,249,449 tonnes, slightly up on September which totalled 1,244,773 tonnes. For building materials professionals, the level of sales is stable compared to the previous month.

Consolidated revenues amounted to MAD3,185 million, down 18% year-on-year. This decline was due to the drop in domestic cement demand as a result of the impact of the health crisis linked to the coronavirus pandemic. Current operating income was down by 15% to MAD 1,411 million following the cost control efforts made during the first half of the year. In addition, net income fell by 55% to MAD 431 million, mainly impacted by the drop in demand and by the MAD 500 million contribution to the special fund for the management of the coronavirus pandemic.

The evolution of the securities traded had recessions during the periods of the confinement Declared in Morocco, the figure presents the evolution of the securities traded between 20.1.2020 and 20.5.2020.

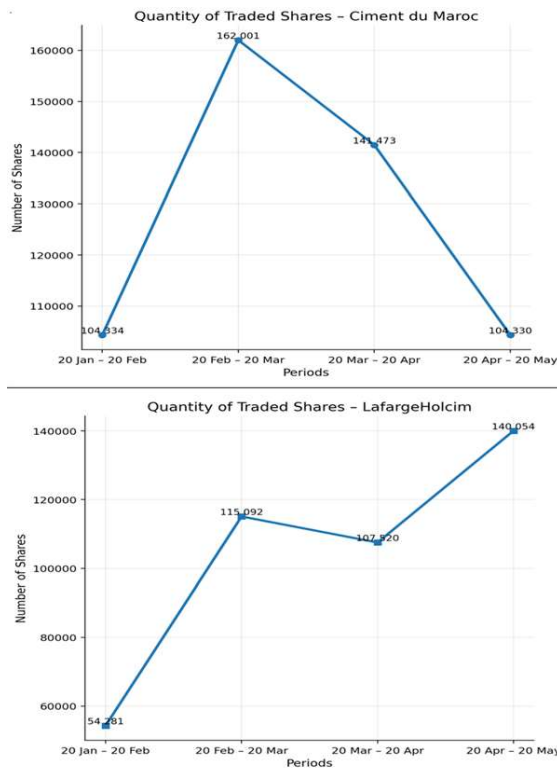


Figure 3: Evolution of the shares traded in Ciment du Maroc and Lafarge Holcim between 20.01.2020 and 20.05.2020

The traded shares of "Ciment du Maroc" and "Lafargeholcim" have increased from 104334/54281 to 162001/115092 respectively between 20.1.2020 and 20.3.2020. This increase is mainly due to the increase in demand for cement during the second quarter of the year 2020.

The observation of the traded securities of the year 2019 mentioned an increase on the demand of

cement during the third quarter. In this sense, the first period of confinement has decreased the traded stocks respectively by 12.67%, to 6.57% for "Ciment du Maroc", "Lafargeholcim". The second period of confinement has generated recessions of 26.25% on the traded stocks of "Ciment du Maroc". In spite of the decrease of the average closing prices, the traded stocks continued to fall .this decrease is caused by the stop of the activity of the sector of Building and Construction. Beyond quantitative indicators, these fluctuations can be linked to market sentiment and information flow dynamics, which can be further explored using Machine Learning techniques.

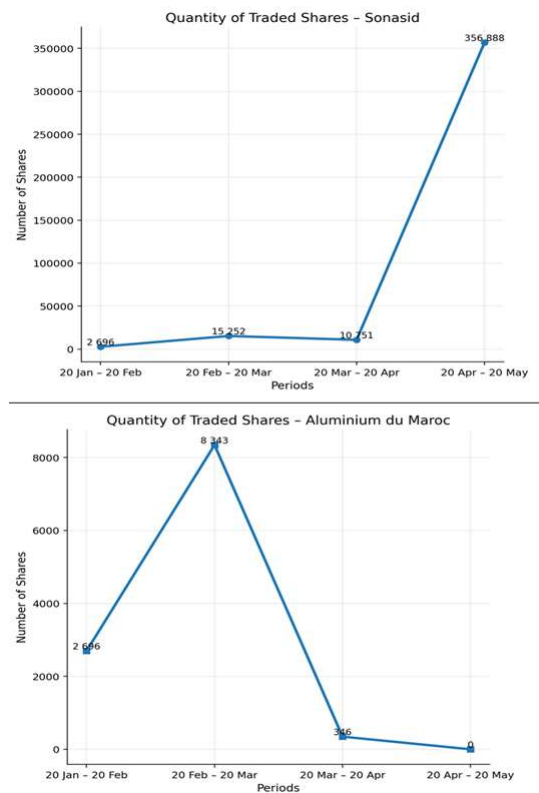


Figure 4: Changes in the trading volume of Sonasid and Aluminium SA shares between 20.01.2020 et 20.05.2020

The traded stocks of "Sonasid" and "Aluminium du Maroc" increased from 2696 each to 15252 and 8343 respectively between 20.1.2020 and 20.2.2020. This increase is mainly due to the rise in activity in the Building and Construction sector during this period. Thereafter, the first confinement period led to a decline in traded stocks for both companies.

4. COMPARISON BETWEEN THE COVID-19 PANDEMIC AND THE 2008 ECONOMIC CRISIS ON THE BUILDING AND CONSTRUCTION SECTOR IN MOROCCO

With its brutal impact on growth and markets, the economic crisis caused by the coronavirus is reminiscent of the one that plunged the world into the "great recession" in 2008, but the resemblance is deceptive. The 2008-2009 recession [10] had a financial origin: the collapse of the "subprimes", the real estate loans granted lightly by the American banks. The current crisis comes from an external shock affecting the real economy and is spreading as countries shut down. The shutdown of factories in China first affected supply by disrupting business supplies, but it is now spreading to demand, with consumers forced to stay at home, cancelling or postponing trips and purchases. The epicentre of the subprime crisis was in the United States, the world's largest economy. The coronavirus crisis originated in China and highlighted the weight of the world's second largest economy. In addition, the COVID-19 crisis has been characterized by an unprecedented level of real-time information exchange through digital platforms, reinforcing the relevance of approaches such as Social Information Retrieval and Machine Learning for understanding market reactions.

The aim of this part is to compare the cumulative deficits of the COVID-19 pandemic and the economic crisis of the year 2008-2009 [11] on the building and construction sector. The optimization of the portfolio by the application of the Modern Markowitz theory, between the 20th of March and the 20th of May of the years 2008 and 2020 has allowed to compare the optimal expectation and the volatility of the portfolio composed by 4 companies, coming from the Casablanca Stock Exchange.

4.1 Portfolio optimization

The optimization is done in the context of the mean-variance [12], we maximize the mean of the returns under the variance constraint, we then have the problem:

$$\begin{cases} \text{Max } E(R) \\ \text{Var}(R) = W^T \Sigma W \\ W^T U = 1 \end{cases}$$

$$E(R) = \sum_{i=1}^N W_i E(R_i), \text{Var}(R) = \sum_{i=1}^N \sum_{j=1}^N W_i W_j \text{Cov}(R_i, R_j) \text{ and } \sum_{i=1}^N W_i = 1.$$

$$L(W_i, \lambda) = \sum_{i=1}^N W_i E(R_i) - \sum_{i=1}^N \sum_{j=1}^N W_i W_j \text{Cov}(R_i, R_j) - \lambda \left(\sum_{i=1}^N W_i - 1 \right)$$

The first-order necessary conditions are:

$$\frac{dL_i}{dW_i} = 0, \text{ and } \frac{dL_i}{d\lambda} = 0 \text{ then:}$$

$$E(R_i) - 2 \sum_{j=1}^N W_j \text{Cov}(R_i, R_j) - \lambda = 0$$

$$\sum_{i=1}^N W_i = 1$$

The solution of the system is written in the matrix form:

$$\begin{pmatrix} 2\sigma_{12} & \dots & 2\sigma_{1n} & 1 \\ \vdots & \ddots & \vdots & \vdots \\ \vdots & \vdots & \vdots & 1 \\ 1 & 1 & \dots & 1 & 0 \end{pmatrix} \begin{pmatrix} W_1 \\ \vdots \\ W_N \\ \lambda \end{pmatrix} = \begin{pmatrix} E(R_1) \\ \vdots \\ E(R_N) \\ 1 \end{pmatrix}$$

4.2 Minimum variance portfolio

The portfolio of minimum variance [13] corresponds to the lowest level of risk. It is a question of optimizing the following quadratic program:

$$\begin{cases} \text{Min Var}(R) \\ W_1 + W_2 + W_3 + W_4 = 1 \end{cases}$$

$$L(W_i, \lambda) = \sum_{i=1}^N \sum_{j=1}^N W_i W_j \text{Cov}(R_i, R_j) - \lambda \left(\sum_{i=1}^N W_i - 1 \right)$$

Where λ is the Lagrange multiplier, The first-order necessary conditions:

$$\begin{aligned} \frac{dL_i}{dW_i} = 0: & \quad 2 \sum_{i=1}^N W_j \text{Cov}(R_i, R_j) - \lambda = 0 \\ \frac{dL_i}{d\lambda} = 0: & \quad \sum_{i=1}^N W_i = 1 \end{aligned}$$

We will first draw W in equation (4.1), after which we will replace it in equation (4.2) by its expression:

$$2 \sum_{i=1}^N W_j \text{Cov}(R_i, R_j) = \lambda, W^T U = 1, \text{ then: } \lambda = \frac{2}{U^T \Sigma^{-1} U}$$

We are going to put this last expression of λ in the expression of w, which will give:

$$W = \frac{\Sigma^{-1}U}{U^t \Sigma^{-1}U}$$

4.3 The Tangent Portfolio

For this portfolio [14], the reasoning is done by considering an additional asset, or the risk-free asset f. This asset yields the return R_f (a return that is very low compared to the expected return of a risky security). We note w_0 the proportion invested in the risk-free asset [15].

Thus, the budget constraint is written:

$${}^t w e + w_0 = 1 \quad \text{so} \quad w_0 = 1 - {}^t w e$$

The optimization program that any investor might write takes the following form:

$$\begin{cases} \text{Min}(w^t V w) \\ s/c \quad w^t E[R] + (1 - {}^t w e)R_f = E_0 \end{cases}$$

The optimization program that any investor writes as :

$$L(w, \lambda) = w^t V w + \lambda (E_0 - w^t E[R] - (1 - {}^t w e)R_f).$$

The Lagrangian of this optimization problem is written :

$$\text{Min } L(w, \lambda) = w^t V w + \lambda (E_0 - w^t E[R] - (1 - {}^t w e)R_f).$$

Where λ is the Lagrange multiplier. The necessary and sufficient first-order conditions for a global minimum are:

$$\begin{aligned} \frac{dL(w, \lambda_1, \lambda_2)}{dw} &= 2Vw - \lambda(E[R] - cR_f) = 0 \\ \frac{dL(w, \lambda_1, \lambda_2)}{d\lambda_2} &= E_0 - w^t E[R] - (1 - {}^t w e)R_f = 0 \end{aligned}$$

Then :

$$W = V^{-1}(E[R] - cR_f) \frac{E_0 - R_f}{(E[R] - cR_f)V^{-1}(E[R] - cR_f)}$$

And :

$$W = V^{-1}(E[R] - cR_f) \frac{E_0 - R_f}{(B - 2AR_f + cR_f^2)}.$$

The variance of the portfolio's profitability is written as :

$$\sigma^2(R_p) = {}^t w V w = \frac{(E_0 - R_f)^2}{(B - 2AR_f + cR_f^2)}$$

5. APPLICATION OF THE MODERN PORTFOLIO THEORY ON THE PORTFOLIO COMPOSED OF THE 4 COMPANIES

5.1 Application to Portfolio Optimization

The following analysis remains based on classical financial modeling, providing a quantitative complement to data-driven perspectives. In order to compare the impact of the COVID-19 pandemic with the economic crisis of the year 2008 between March 20 and May 20 of the years 2008 and 2020. We apply the Modern Portfolio Theory (3.1), in order to compare the optimal expectations. Thus the maximum expectation corresponds to the optimal portfolio.

The least risky portfolio will be the solution to the following program:

$$\begin{cases} \text{Max } E(R) \\ (S/c) \quad \text{Var}(R) = W^T \sum W \\ \sum_{i=1}^N W_i = 1 \end{cases}$$

We consider a portfolio of securities made up of three risky securities whose Correlation matrix is as follows:

According to part the vector of the proportions of the portfolio of minimum variance is written:

Table 1: The Correlation Table of the four Companies 2008

Companies	Aluminium SA	Sonasid	Lafarge	Ciment du Maroc
Aluminium	$2,0701537e^{-4}$	$-4,609883 e^{-6}$	$1,347577 e^{-4}$	$-3,393019 e^{-5}$
Sonasid	$-4,6098883 e^{-6}$	$2,773473 e^{-4}$	$-6,577896 e^{-6}$	$3,619608 e^{-5}$
Lafarge	$1,347577 e^{-4}$	$-6,577896 e^{-6}$	$2,943034 e^{-4}$	$2,706563 e^{-5}$
Ciment du Maroc	$-3,393019 e^{-5}$	$3,619608 e^{-5}$	$2,706563 e^{-5}$	$2,891129 e^{-4}$

Table 2: The Correlation Table of the four Companies 2020

Companies	Aluminium SA	Sonasis	Lafarge	Ciment du Maroc
Ciment	$8,483860 e^{-4}$	$2,246170 e^{-4}$	0,0005975660	$9,591299 e^{-5}$
Lafarge	$6,953172 e^{-4}$	$2,713794 e^{-4}$	0,0006127747	$1,219969 e^{-4}$
Sonasis	$5,975660 e^{-4}$	$3,193541 e^{-4}$	0,0009645590	$1,416443 e^{-4}$
Aluminium SA	$9,591299 e^{-5}$	$5,281034 e^{-5}$	0,0001416443	$6,089643 e^{-5}$

We are going to determine the least risky portfolio of this universe: For that, we start with the calculation of the covariance matrix Σ . The covariance matrix Σ is then given by the following product:

$$\sigma_{ij} = \rho_{ij}\sigma_i\sigma_j$$

According to part (3.1) the vector of the proportions of the portfolio of minimum variance is written:

$$\begin{pmatrix} \sigma_{12} & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ 1 & 1 & 1 & 1 & 0 \end{pmatrix} \begin{pmatrix} W_1 \\ \cdot \\ W_N \\ \lambda \end{pmatrix} = \begin{pmatrix} E(R_1) \\ \cdot \\ E(R_N) \\ 1 \end{pmatrix}$$

So:

$$W = \begin{pmatrix} W_1 \\ \cdot \\ W_N \\ \lambda \end{pmatrix}$$

$$A = \begin{pmatrix} \sigma_{12} & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ 1 & 1 & 1 & 1 & 0 \end{pmatrix}^{-1}$$

$$B = \begin{pmatrix} E(R_1) \\ \cdot \\ E(R_N) \\ 1 \end{pmatrix}$$

Then: $W = A * B$

So :

$$E(R) = \sum_{i=1}^N W_i E(R_i)$$

$$Var(R) = \sum_{i=1}^N \sum_{j=1}^N W_i W_j Cov(R_i, R_j)$$

The table shows the results of the optimal expectation and the volatility of the years 2020 and 2008 between March 20 and May 20.

Table 3: results of the optimal expectation and the volatility of the years 2020 and 2008 between March 20 and May 20

Year	Optimal expectancy
2008	0,1253
2020	0,01968

The optimal expectation of the Portfolio has decreased from 0.1253 to 0.01968 between 2008 and 2020, the growth rate of the optimal expectation has decreased by 84.29%. This proves that the shock caused by the Covid-19 pandemic is more severe than the economic crisis in 2008.

5.2 Application to Portfolio Minimization

We consider a portfolio of securities made up of three risky securities whose Correlation matrix is as follows:

$$\begin{cases} \text{Min Var}(R) \\ (S/C) \sum_{i=1}^N W_i = 1 \end{cases}$$

$$L(W_i, \lambda) = \sum_{i=1}^4 \sum_{j=1}^4 W_i W_j Cov(R_i, R_j) - \lambda (\sum_{i=1}^4 W_i - 1).$$

According to what is seen the vector of the proportions of the portfolio of minimum variance is written:

$$W = \frac{\Sigma^{-1}U}{U^t \Sigma^{-1}U}$$

Numerically in our case:

$$\frac{1}{U^t \Sigma^{-1}U} = 1.818957e - 05$$

And so we find the following vector of weights:

$$W = \begin{pmatrix} 0.980705922 \\ 0.064243189 \\ -0.041655854 \\ -0.041655854 \end{pmatrix}$$

Then:

$$\begin{aligned} \text{Var}(R)_{2008} &= W^T \Sigma W = 0,01 \\ \text{and } \text{Var}(R)_{2020} &= W^T \Sigma W = 0,04 \end{aligned}$$

The variance of the Portfolio has increased from 0,01 to 0.04 between 2008 and 2020, The increase in variance indicates higher market volatility during the Covid-19 period. This indicates that the shock caused by the Covid-19 pandemic is more severe than the economic crisis in 2008.

6. CONCLUSION

The COVID-19 pandemic is disrupting the world economy and strongly impacting the construction sector. Indeed, construction companies must adapt to the health challenges while ensuring the continuation of construction sites in order to safeguard the economic life of countries. In fact, the stoppage of ongoing construction sites is naturally not without consequences in the construction sector in every region of the world. However, some countries are more affected than others by this pandemic. Our quantitative analysis shows that the optimal expected return of the studied portfolio decreased from 12.53% in 2008 to 1.97% in 2020, while portfolio variance increased from 0.01 to 0.04, indicating higher market volatility during the COVID-19 period.

After the lockdown periods, the building materials sector is starting to show some signs of recovery, after three months of almost total stoppage of construction sites, as evidenced by the 8.81% increase in cement sales last September, after a peak of 18.6% in August. Even though October sales show a 7.77% drop compared to 2019, volumes delivered reached 1,249,449 tonnes, slightly up on September which totalled 1,244,773 tonnes. For building materials professionals, the level of sales is stable compared to the previous month.

Cumulatively, cement sales amounted to 9,932,843 tonnes at the end of the first ten months of the year. Thus, the cumulative fall since the beginning of the year has been reduced to -12% at the end of October instead of -18.5% at the end of June. By component, this evolution covered, at the end of September, an increase in sales at the level of the infrastructure segment (+17.7%) and decreases at the level of the ready-mixed concrete components (-18.2%), distribution (-12.2%), PREFAB concrete (-14.7%) and building (-25.6%). In spite of this situation, bank credits granted to real estate developers recorded an increase of 143 MDH at the end of September or +0.24% compared to the same period of the previous year. On the other hand,

credits allocated to housing increased by 4.745 MMDH at the end of September or 2.2% compared to 2019. For the operators of the sector, the indicators are reassuring, especially those relating to the public order, despite the lack of visibility. However, an unknown with regard to the revival of housing remains, in particular that social.

This research contributes a quantitative comparison between a financial crisis and a pandemic-induced shock on a focused sector portfolio.

This work illustrates the complementarity between classical financial approaches and emerging data-driven perspectives such as Social Information Retrieval and Machine Learning, which can enhance the interpretation of market dynamics without altering the underlying financial models.

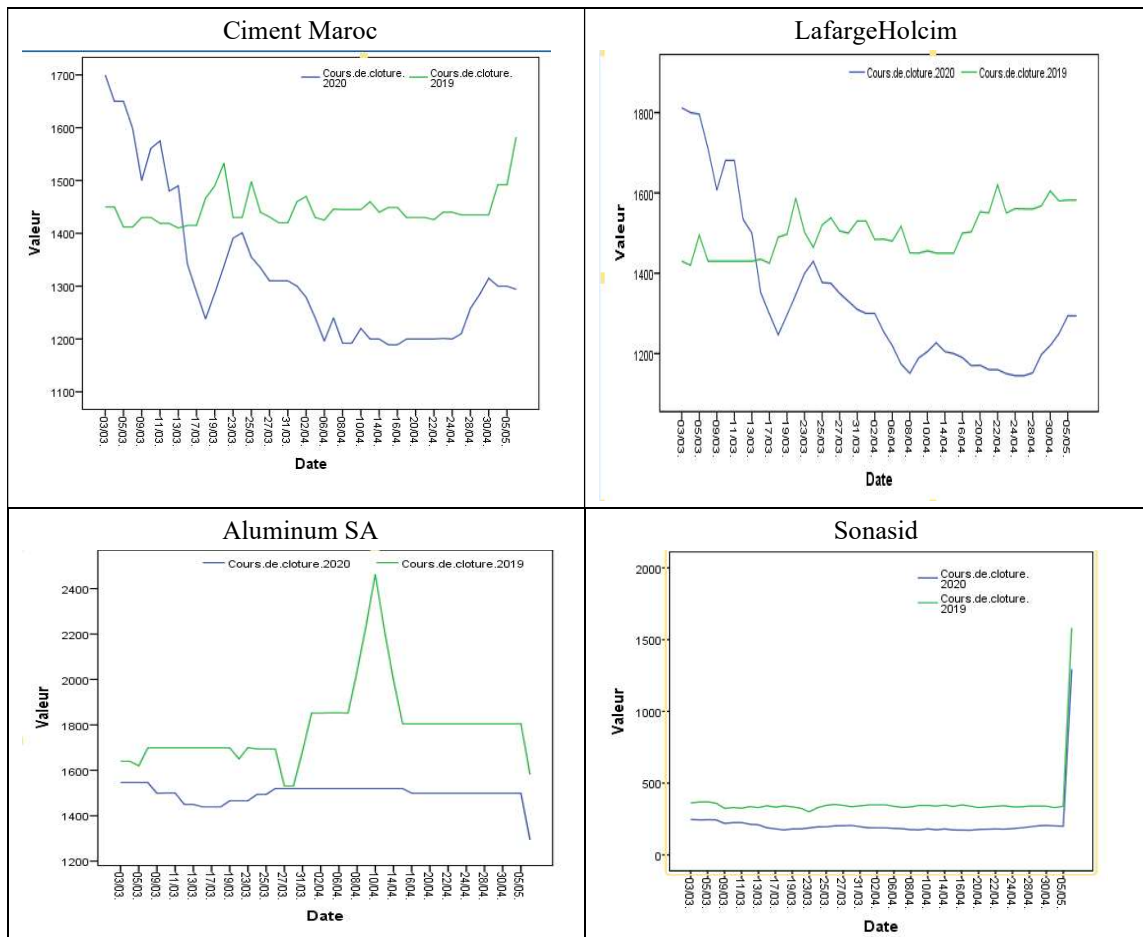
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APPENDIX:

1- The evolution of the closing prices of the years 2019 and 2020 between 3 March and 5 May :



2- The evolution of the returns of the companies of the building and construction sector between 04.03.2020 and 08.05.2020 :

Days	Return. CIMENT Maroc	Return. LAFARGEHOLCIM	Return. Sonasid	Return. Aluminium SA
08/05/2020	-0,039272727	-0,03961136	0	0
07/05/2020	0,018518519	0,029230769	-0,024512256	0
06/05/2020	0,038461538	0,004636785	-0,0005	0
05/05/2020	0	0,0352	-0,011369254	0
04/05/2020	-0,011406844	0,024590164	-0,016289813	0
30/04/2020	0,024143302	0,01836394	0,015555556	0
29/04/2020	0,020667727	0,039930556	0,038461538	0
28/04/2020	0,039669421	0,006113537	0,031746032	0
27/04/2020	0,008333333	0	0,032786885	0
24/04/2020	-0,000832639	-0,004347826	0,016666667	0
23/04/2020	0,000833333	-0,00862069	-0,005524862	0
22/04/2020	0	0	0,011173184	0
21/04/2020	0	-0,009393681	0,006466123	0
20/04/2020	0	0,000854701	0,0343123	0

17/04/2020	0,009251472	-0,016806723	-0,00778996	0
16/04/2020	0	-0,008333333	-0,003736706	-0,013815789
15/04/2020	-0,009166667	-0,004149378	-0,038950276	0
14/04/2020	0	-0,01792991	0,033990288	0
13/04/2020	-0,016393443	0,018257261	-0,035802809	0
10/04/2020	0,023489933	0,013456686	0,036540108	0
09/04/2020	0	0,03301477	-0,00341394	0
08/04/2020	-0,038709677	-0,019591141	-0,039617486	0
07/04/2020	0,036789298	-0,037704918	-0,010810811	0
06/04/2020	-0,035483871	-0,027888446	-0,021164021	0
03/04/2020	-0,030492572	-0,034615385	0	0
02/04/2020	-0,016153846	0	-0,000793021	0
01/04/2020	-0,007633588	-0,007633588	-0,039847716	0
31/03/2020	0	-0,015037594	-0,03902439	0
30/03/2020	0	-0,014814815	0,00761858	0
27/03/2020	-0,018726592	-0,018181818	0,002710695	0
26/03/2020	-0,014760148	-0,001452433	0,035732517	0,017402945
25/03/2020	-0,03283369	-0,037062937	0,000510725	0
24/03/2020	0,007189073	0,021428571	0,039278132	0,019099591
23/03/2020	0,03961136	0,039346696	0,039735099	0
20/03/2020	0,03962704	0,039351852	0	0
19/03/2020	0,039579968	0,039294306	0,039885222	0,01876303
18/03/2020	-0,039565555	-0,039291217	-0,039944904	0
17/03/2020	-0,039493294	-0,039940828	-0,039936525	0
16/03/2020	-0,099328859	-0,098666667	-0,099761905	-0,007586207
13/03/2020	0,006756757	-0,022164276	-0,016393443	0
12/03/2020	-0,06031746	-0,087447948	-0,053215078	-0,033333333
11/03/2020	0,008968861	0	0,001554519	0
10/03/2020	0,040666667	0,046048538	0,025039836	0,000667111
09/03/2020	-0,061913696	-0,060233918	-0,099795082	-0,030401035
06/03/2020	-0,030909091	-0,047884187	-0,004081633	0
05/03/2020	0	-0,002222222	0,004098361	0
04/03/2020	-0,029411765	-0,006622517	-0,012145749	0

3- Code R : Portfolio optimization

```
library(tidyquant) # To download the data
library(plotly) # To create interactive charts
library(timetk) # To manipulate the data series
log_ret_tidy <- price_data %>%
group_by(symbol) %>%
tq_transmute(select = adjusted,mutate_fun =
periodReturn, period = 'daily', col_rename = 'ret', type =
'log')
log_ret_xts <- log_ret_tidy %>%
spread(symbol, value = ret) %>% tk_xts()
mean_ret <- colMeans(log_ret_xts)
print(round(mean_ret, 5))

cov_mat <- cov(log_ret_xts) * 252

print(round(cov_mat,4))

wts <- runif(n = length(tick))
print(wts)

print(sum(wts))
```

```
wts <- wts/sum(wts)
print(wts)
sum(wts)

port_returns <- (sum(wts * mean_ret) + 1)^252 - 1

port_risk <- sqrt(t(wts) %*% (cov_mat %*% wts))
print(port_risk)

sharpe_ratio <- port_returns/port_risk
print(sharpe_ratio)

# Calculate the random weights
wts <- runif(n = length(tick))
wts <- wts/sum(wts)

# Calculate the portfolio returns
port_returns <- (sum(wts * mean_ret) + 1)^252 - 1

# Calculate the portfolio risk
port_risk <- sqrt(t(wts) %*% (cov_mat %*% wts))

# Calculate the Sharpe Ratio
sharpe_ratio <- port_returns/port_risk
```

```

print(wts)

print(port_returns)
## [1] 0.2396506
print(port_risk)
##      [,1]
## [1,] 0.1778445
print(sharpe_ratio)
##      [,1]
## [1,] 1.347529
We have everything we need to perform our optimization.
All we need now is to run this code on 5000 random
portfolios. For that we will use a for loop.

Before we do that, we need to create empty vectors and
matrix for storing our values.

num_port <- 5000

# Creating a matrix to store the weights

all_wts <- matrix(nrow = num_port,
                 ncol = length(tick))

# Creating an empty vector to store
# Portfolio returns

port_returns <- vector('numeric', length = num_port)

# Creating an empty vector to store
# Portfolio Standard deviation

port_risk <- vector('numeric', length = num_port)

# Creating an empty vector to store
# Portfolio Sharpe Ratio

sharpe_ratio <- vector('numeric', length = num_port)
Next lets run the for loop 5000 times.

for (i in seq_along(port_returns)) {

  wts <- runif(length(tick))
  wts <- wts/sum(wts)

  # Storing weight in the matrix
  all_wts[i,] <- wts

  # Portfolio returns

  port_ret <- sum(wts * mean_ret)
  port_ret <- ((port_ret + 1)^252) - 1

  # Storing Portfolio Returns values
  port_returns[i] <- port_ret

  # Creating and storing portfolio risk
  port_sd <- sqrt(t(wts) %*% (cov_mat %*% wts))
  port_risk[i] <- port_sd

  # Creating and storing Portfolio Sharpe Ratios
  # Assuming 0% Risk free rate

  sr <- port_ret/port_sd
  sharpe_ratio[i] <- sr
}
All the heavy lifting has been done and now we can
create a data table to store all the values together.

# Storing the values in the table
portfolio_values <- tibble(Return = port_returns,
                          Risk = port_risk,
                          SharpeRatio = sharpe_ratio)

# Converting matrix to a tibble and changing column
names
all_wts <- tk_tbl(all_wts)
## Warning in tk_tbl.data.frame(as.data.frame(data),
preserve_index,
## rename_index, : Warning: No index to preserve.
Object otherwise converted
## to tibble successfully.
colnames(all_wts) <- colnames(log_ret_xts)

# Combing all the values together
portfolio_values <- tk_tbl(cbind(all_wts,
portfolio_values))
## Warning in tk_tbl.data.frame(cbind(all_wts,
portfolio_values)): Warning: No
## index to preserve. Object otherwise converted to tibble
successfully.
Lets look at the first few values.

head(portfolio_values)

The minimum variance portfolio
The tangency portfolio (the portfolio with highest sharpe
ratio)
min_var <-
portfolio_values[which.min(portfolio_values$Risk),]
max_sr <-
portfolio_values[which.max(portfolio_values$SharpeRati
o),]
Lets plot the weights of each portfolio. First with the
minimum variance portfolio.

p <- min_var %>%
gather(AAPL:XOM, key = Asset,
value = Weights) %>%
mutate(Asset = as.factor(Asset)) %>%
ggplot(aes(x = fct_reorder(Asset,Weights), y = Weights,
fill = Asset)) +
geom_bar(stat = 'identity') +
theme_minimal() +
labs(x = 'Assets', y = 'Weights', title = "Minimum
Variance Portfolio Weights") +
scale_y_continuous(labels = scales::percent)

```

ggplotly(p)

```
p <- max_sr %>%  
  gather(AAPL:XOM, key = Asset,  
         value = Weights) %>%  
  mutate(Asset = as.factor(Asset)) %>%  
  ggplot(aes(x = fct_reorder(Asset, Weights), y = Weights,  
            fill = Asset)) +  
  geom_bar(stat = 'identity') +  
  theme_minimal() +  
  labs(x = 'Assets', y = 'Weights', title = "Tangency  
Portfolio Weights") +  
  scale_y_continuous(labels = scales::percent)
```

ggplotly(p)