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MODELING THE VOLATILITY OF THE MOROCCAN ALL SHARES INDEX M.A.S.I WITH ARMA MODEL: WITHIN THE COVID-19 PANDEMIC

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Modeling the volatility of the Moroccan All Shares index M.A.S.I with ARMA Model: Within the covid-19 pandemic

Abstract

Since the appearance of the COVID-19 crisis in 2020, the whole world had been experienced economic and financial damage, and since it did not spare Morocco, the aim of this work is to examine if the volatility of the benchmark index of Casablanca Stock Exchange MASI was affected by the health crisis. To achieve this, we adopted a quantitative approach by using a model that will help us explaining the volatility. Indeed, the data collected will be examined using the Autoregressive–moving-average model (ARMA) under EViews. The results can conclude that the pandemic influenced negatively the volatility of the Moroccan All Shares Index.

Keywords: Covid-19, Stock Market, Volatility, ARMA
Paper type: Empirical research

1. Introduction

The Covid-19 pandemic impacted negatively many aspects such as the physical and mental health, and an economic shock, as the global economy was paralyzed gradually as the virus spread. which resulting considerable influences on the macroeconomic balance since 2020.
In the international view, the Global growth prospects are poor for 2020, with a regression at least as severe as during the global financial crisis (of 2008-2009), if not worse," said the IMF Managing Director Kristalina Georgieva. All affected countries quantified the effects of Covid-19'crisis on their economic crisis and recession and propose solutions which is manifested in analyzing the impact of the crisis and forecasting the future for optimal decisions.
In the national view, the Household consumption fell by more than 20% between 2019 and 2020, the rate of youth unemployment, already high before the pandemic, increased to 33%. Also, the freezeof economic activity in many sectors such as: accommodation and catering with 89% of businesses shut down, textile and leather industries and metal and mechanical industries with 76% and 73%, respectively, as well as the construction sector with nearly 60% of shutdown businesses.
The pandemic has had socio-economic consequences, prompting governments to take strong measures to try to mitigate the negative effects of the crisis on businesses and households. In this context, the Moroccan government sees that it is still necessary to extend the state of health emergency in order to further control the spread of the epidemic and to control the situation since the virus is still spreading. It should also be specified that all the measures taken by the government in this exceptional situation are mainly intended for the precarious categories, namely health, support, social and economic measures.
Like other vital sectors, the national financial market has not been exempted from Covid-19's repercussions, which is manifested in a decrease in the MASI Index (Moroccan All Shares Index) of 7.27% compared to 2019, then continued its upward trend started on March 18, 2020, and achieved a performance of 18.35% on 2021. Hoping for this to keep the same level of performance or better for 2022.
The Appropriate model to use is the ARMA model (Auto Regressive Moving Average) described by Peter Whittle [1951] and popularized in the 1970 by George E.P.Box and Gwilym Jenkins. This model is chosen as a tool to understand the volatility of the MASI stock market index and

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perhaps, predict future values in this series.
The main hypothesis of this paper is to investigate the impact of containment strategy during the Covid-19 pandemic on the performance of the stock market index MASI and expect the volatility of its return.
Using daily data over the period 01/01/2015 to 01/08/2022, we would like to consider the impact of covid-19 on MASI Index, so it's better to know MASI's performance before, during and after Covid-19's pandemic. Starting from 2015 to have robust parameters in the model.

The interest of the first section is to focus on the literature review of the MASI Stock index and ARMA model, then we will contribute to the methodology of our chosen model in the next section. Finally, we will present our results and discussions in the last section.

2. A zoom on MASI Index:

Like all modern financial centers, the Casablanca Stock Exchange has its own indices. These are calculated on a regular basis and according to standards that offer more readability and meaning to all users.

Thus, since the creation of the first general index in 1986, there has been an evolution in the number and quality of the indices distributed on the market:

Table 1: **History of the Casablanca Stock Exchange indices**

History of the Casablanca Stock Exchange indices	
1986	Creation of the IGB Index
2002	Creation of MASI, MADEX indices, their underlying and sector indices
2004	Adoption of floating capitalization in the calculation of indices
2012	Creation of the FTSE 15, FTSE All liquid MOROCCO indices

Source: Casablanca stock exchange website

The MASI or Moroccan All Shares Index MASI is a main index that measures the overall performance of the Casablanca Stock Exchange, i.e. the daily evolution of the floating market capitalization due to price variations. It therefore provides an overall idea of the Moroccan market performance.

The MASI Index includes 75 companies, the table below presents the top 10 companies in MASI in 2022 according to their capitalizations, the Figures are in billions of MAD

Table 2: top 10 companies in MASI 2022

	Company	**Sector**	**Capitalization**
1	Maroc Telecom	Telecommunications	104.56
2	Attijariwafa Bank	Banks	86,82
3	BCP	Banks	50.8

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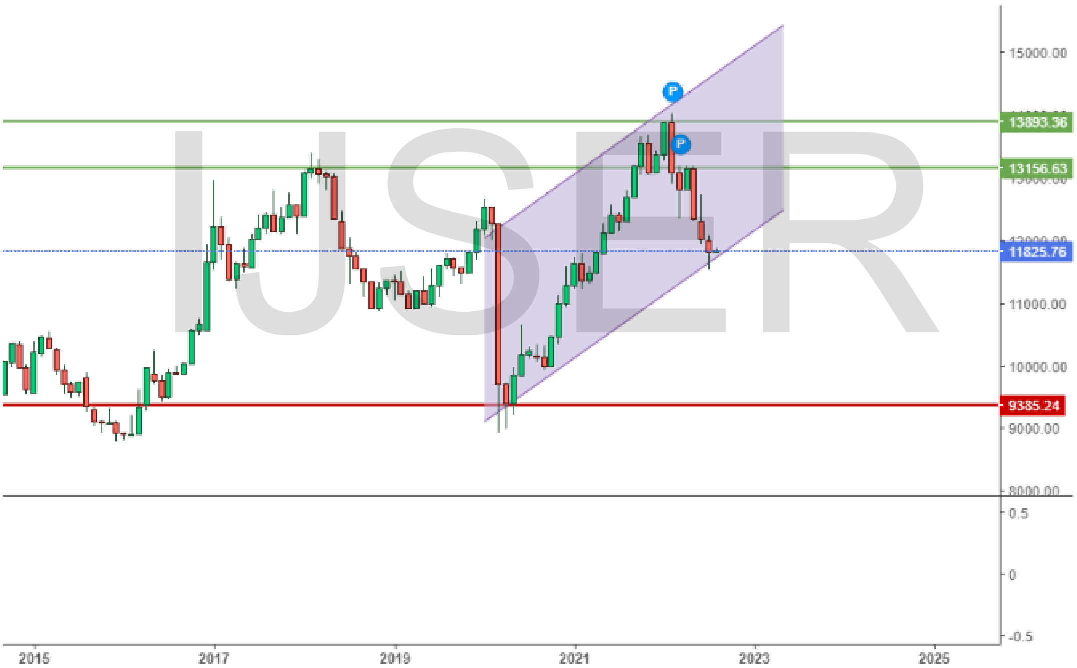
4	Lafarge Maroc	Construction	39.36
5	BMCE Bank	Banks	37.42
6	TAQA Morocco	Energy	25.95
7	Ciments du Maroc	Construction	23.31
8	Compagnie Sucrerie Marocaine	Consumer staples	20.30
9	Societe d'Exploitation des Ports	Industrial	19.01
10	Managem SA	Materials	18.68

Source: Casablanca stock exchange website

One of the repercussions of Covid-19 on the Moroccan financial market is that the MASI index decreased by 7.27% in 2020 compared to the previous year. This chart shows what was mentioned:

Figure 1: chart illustrating Covid-1's effect on MASI



Source: Investing.com

We see, as shown, that starting from 2020, the year when covid-19 declared as a pandemic, a huge drop in MASI's value from 12531.90 to 9400.70, which is expected during crises such as all historical financial market crashes due to the fact that it has a plausible effect on investors behavior which consists in demand, supply and the virtual non-existence of exchanges of shares.

In the first quarter of the year, the quarantine policy, the collapse of the global market in general, and the failure of some Moroccan small businesses in particular caused chock in the Moroccan stock market. But soon, it recovered it vitality from April 2020 until 2022 we witness a decrease to 11834.22 because Investors seem to have been negatively impacted by macroeconomic elements mainly due to the central bank of the Kingdom of Morocco (Bank Al-Maghreb)'s announcement of a small stagflation for 2022 with growth of 0.7% and inflation of 4.7%. In addition, the war in Ukraine is still weighs on investor's sentiment because the rise in the price of oil and wheat is likely

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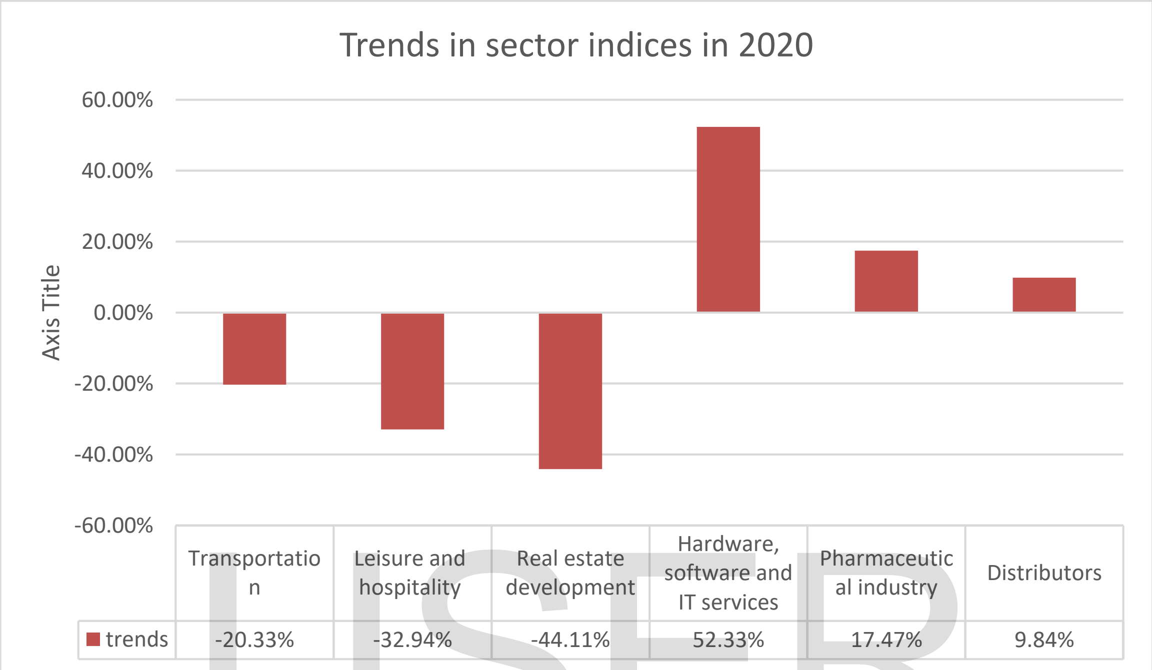
to influence public finance.

The sectors that are impacted by Covid-19 are listed below, we can see that despite all the damage caused, it affected some sectors positively:

Graph 1: Trends in sector indices in 2020



Source: Annual report of the Moroccan Capital Market Authority.

The crisis came suddenly, therefore, many sectors such as Transportation, Leisure and hotels and the real estate promotion has been heavily impacted by Covid-19.

However, there are sectors that have achieved performances never seen before, the companies that have been able to do so are those whose business has benefited from the crisis.

For the IT hardware, software and services sector, we can understand that it has taken advantage of the crisis and confinement due to digitalization. Teleworking, videoconference, and e-commerce.

At the second position, we notice that the increase of the pharmaceutical industry is as a consequence of a turnover of 1.28 billion DH achieved by the Moroccan biotech leader, associated with the clinical tests of the anti-Covid vaccine at the end of September 2020, up 4.4% compared to the same period of 2019.

The “Distributors” sector index shows an increase of 9,84%, driven by Label’Vie (+21.51%). The only retail group represented on the Casablanca Stock Exchange benefited in particular from the increase in demand during the confinement period.

3. ARMA Model:

It is it's defined by linear difference equations with constant coefficients that used for stationary time series, which means it requires the process to be in a state of “statistical equilibrium” and also use past values, as well as past errors to construct future estimations.

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to analyze return volatility, research has shown the importance of using autoregressive moving averages (ARMA) which was described in the 1951 thesis of Peter Whittle, then popularized in the 1970 book by George E. P. Box and Gwilym Jenkins.

Starting with the **Identification**, by using methods and procedures applied to a set of data to indicate the kind of model that is worthy of further investigation, the specific aim here is to obtain some idea of the values of p and q needed in ARMA model and to obtain initial estimates for the parameters.

The second step is the **estimation**, after that the parameters have been identified, several models are generally estimated using many tests, those tests are helping to validate the selected model, and to compare the performances between models.

Thereafter The model having been identified and the parameters estimated, **diagnostic checks** are then applied to the fitted model. One useful method of checking a model is to overfit, that is, to estimate the parameters in a model somewhat more general than that which we believe to be true. This method assumes that we can guess the direction in which the model is likely to be inadequate.

At the **forecasting** stage, several techniques were used to stationaries the generating process so that it could be identified in the class of ARMA processes.

4. Methodology

Our aim is to study the impact of COVID-19 on the MASI stock market by estimating the Auto Regressive–Moving-Average model applied to a daily series of MASI market index prices from 01/01/2015 to 01/08/2022.

The methodology chosen is based on the approach of Box and Jenkins, which consists in the systematic study of the chronological series from their characteristics in order to determine in the family Arima models, the most suitable to represent the phenomenon studied. The Box and Jenkins method is based on four main stages: (Bourbonnais, R., Terraza, M., 2008)

• Analysis of the characteristics of the series: notably stationarity;
• Identification: determination of orders P and q of the Arima process;
• Estimate: Estimation of the optimal model considering delays P and Q;
• Adequacy of the model: validation of the model

4.1. The Data

In this article, we analysis the effect of Covid-19 health crisis on a daily series of MASI market index prices between 01/01/2015 and 01/08/2022, i.e. 1902 observations, which covers three periods:

- Before pandemic.
- During pandemic.
- The situation now.

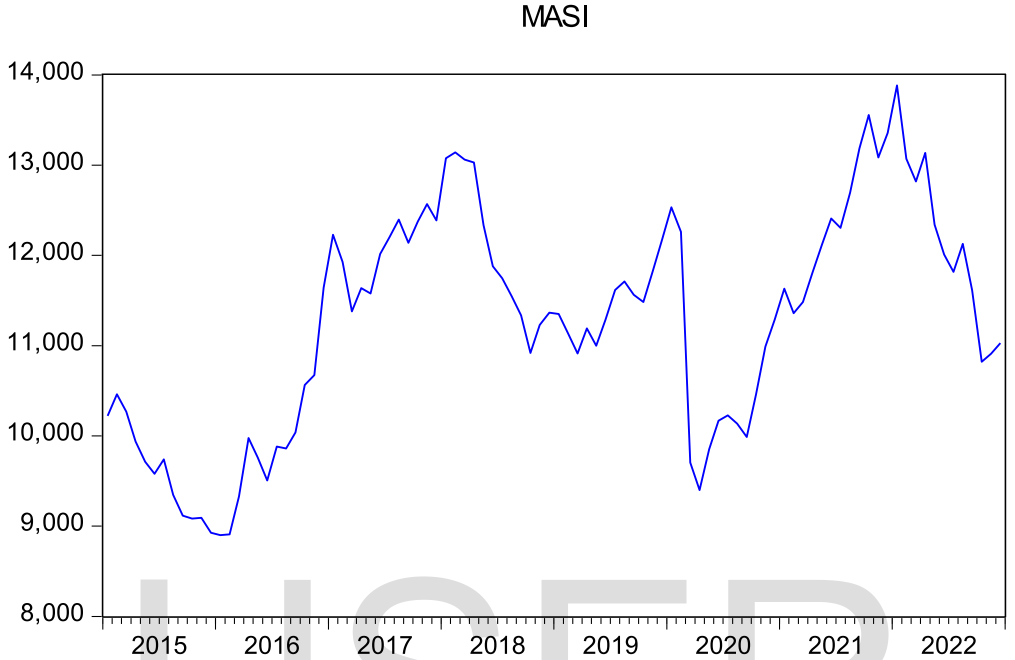
We consider only 1902 days as workdays instead of 2769 days since stock markets are closed on weekends and holidays,

The data of our study are taken from the following website: "https://cn.investing.com/indices/masi-historical-data".

5. Results and discussions

First and before performing the stationary tests, it is necessary to present the graph of the series which is the subject of our study:

Graph 2 : MASI series over the period 2015 to 2022



Most stock market series are not stationary, in which case the data must be transformed. (Lardic, S. and Mignon, V. 2002). According to the graph observed, we can see that the series is not stationary (preliminary observation), that is to say that its stochastic characteristics, namely the expectation and the variance, are modifiable over time.

5.1 The correlogram of the series:

Figure 2 : The correlogram of MASI

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.935	0.935	86.519	0.000
		2	0.847	-0.208	158.40	0.000
		3	0.778	0.131	219.67	0.000
		4	0.709	-0.096	271.13	0.000
		5	0.638	-0.026	313.19	0.000
		6	0.552	-0.175	345.00	0.000
		7	0.455	-0.093	366.93	0.000
		8	0.358	-0.091	380.67	0.000
		9	0.274	0.032	388.81	0.000
		10	0.200	-0.023	393.19	0.000
		11	0.128	-0.022	394.99	0.000
		12	0.059	-0.013	395.39	0.000
		13	-0.011	-0.091	395.40	0.000
		14	-0.074	0.010	396.03	0.000
		15	-0.122	-0.012	397.76	0.000
		16	-0.165	-0.033	400.97	0.000
		17	-0.198	0.032	405.63	0.000
		18	-0.226	-0.037	411.81	0.000
		19	-0.242	0.074	418.97	0.000
		20	-0.248	-0.021	426.60	0.000
		21	-0.251	-0.003	434.47	0.000
		22	-0.247	-0.008	442.22	0.000
		23	-0.245	-0.056	449.95	0.000
		24	-0.252	-0.116	458.24	0.000
		25	-0.260	-0.040	467.21	0.000
		26	-0.259	0.014	476.21	0.000
		27	-0.257	-0.060	485.25	0.000
		28	-0.255	0.034	494.22	0.000
		29	-0.247	0.010	502.79	0.000
		30	-0.220	0.187	509.67	0.000
		31	-0.204	-0.186	515.68	0.000
		32	-0.195	0.033	521.27	0.000
		33	-0.181	-0.043	526.17	0.000
		34	-0.161	0.045	530.12	0.000
		35	-0.127	0.080	532.61	0.000
		36	-0.088	0.041	533.83	0.000

The critical probabilities of this test are indicated αc = 0.000 < 0.05, so we refuse H0. Note the presence of a unit root, a non-stationary process. We first proceed to the study of the stationarity of the MASIt series by applying the strategy of augmented Dickey-Fuller tests (ADF), which aims to test the null hypothesis of the non-stationary process against the alternative hypothesis of stationary process. The Dickey-Fuller test is based on the least square's estimation of the following three models:

Model [3] with trend and intercept: Yt = c + bt + ϕ1yt-1 + εt

Model [2] with intercept and without trend: Yt = c + ϕ1yt-1 + εt

Model [1] without trend and without intercept: Yt = ϕ1yt-1 + εt

5.2. Stationarity analysis

Table 3 : Dickey-Fuller augmented test (ADF)

MASI	Model 3	Model 2	Model 1
T-Statistic	-2.378340	-2.156325	-0.010356
Critical value 5%	-3.458326	-2.892536	-1.944248

The application of the ADF (Augmented Dickey and Fuller) tests reveals the presence of a unit root in all the level series. We note according to the results of the various tests that T-statistic is largely higher, in all the cases and without exception, with the critical values. The table above leads to the conclusion that the MASIt series is a non-stationary process of the DS (Difference Stationary) type.
However, the identification of an ARIMA model (p, d, q) likely to explain the behavior of our series. To make the MASIt series stationary, just differentiate it once. The following transformation is thus performed :

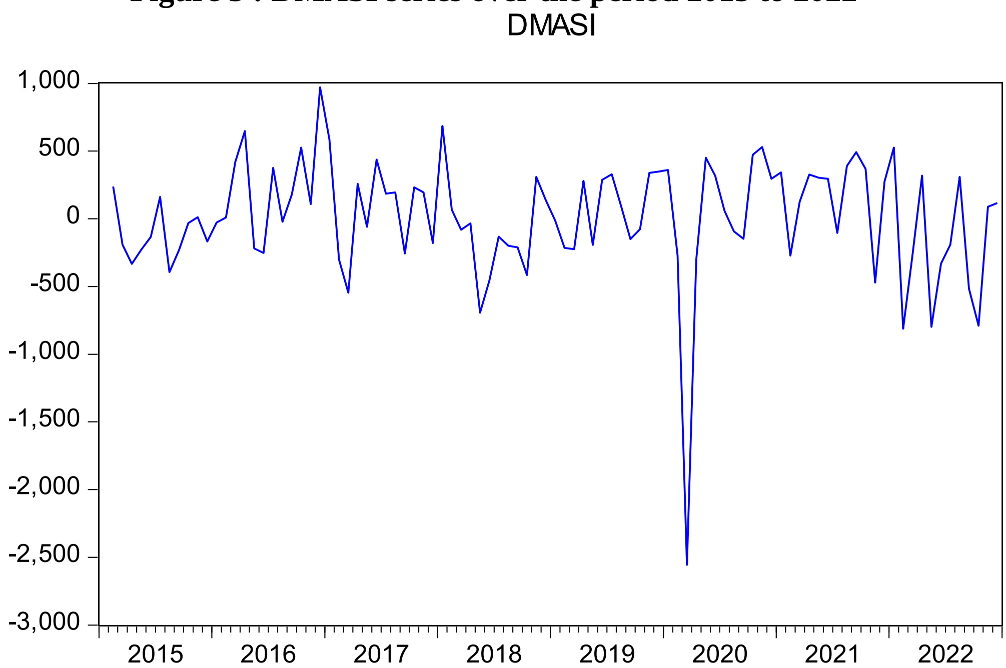
Differentiation:

This is to differentiate the log from the variable. The purpose of the application of the log is to smooth and reduce the trend while the differentiation stabilizes the process.

$$DMASIt = MASIt - MASIt{-}1$$

Curve of differentiation

Figure 3 : DMASI series over the period 2015 to 2022



The shape of the differentiation curve marks an oscillation around the zero mean, which shows its stationarity.

The results of the test on the first differentiation variable (Masi) are summarized in the following table:

Table 2 : Dickey-Fuller augmented test (ADF)

Null Hypothesis: DMASI has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.954075	0.0000
Test critical values:	1% level	-2.589795	
	5% level	-1.944286	
	10% level	-1.614487	

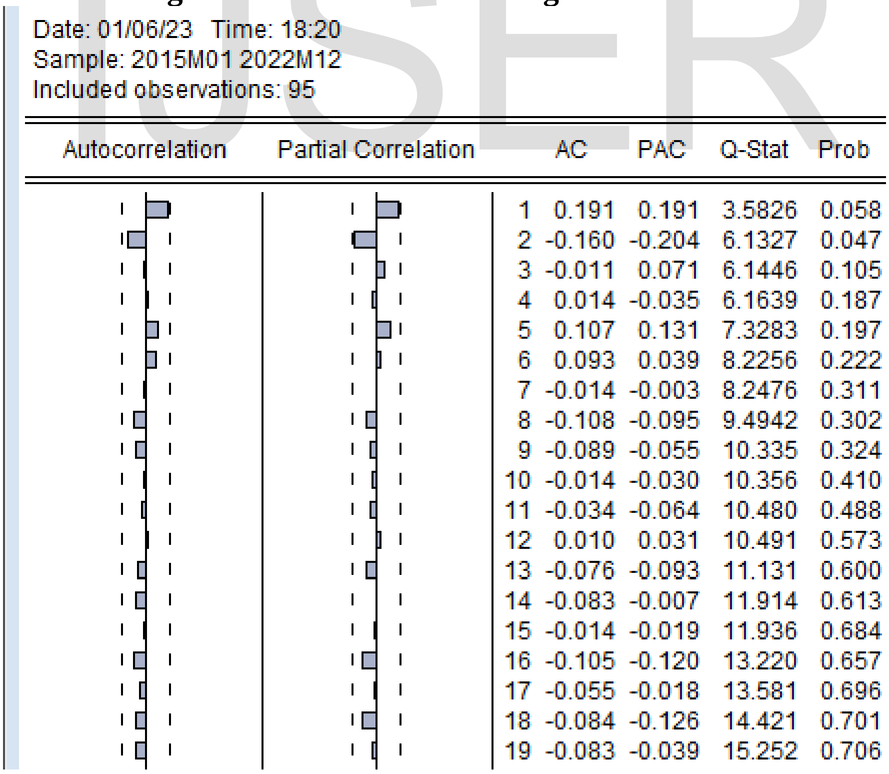
*MacKinnon (1996) one-sided p-values.

The p value being zero (< 0.05) We reject the basic hypothesis: the differentiated series is stationary.

5.3. Identification of the orders p and q of the ARIMA process:

Obtaining a stationary series DMASIt , we move on to the analysis of the autocorrelation function and the partial autocorrelation function through the correlogram to determine the parameters p, q of the model. The orders p and q respectively represent the number of delays to be introduced for an AR(p) and MA(q) model. (BARRAUD C. 2008)

Figure 4 : the DMASI correlogram



Date: 01/06/23 Time: 18:20
Sample: 2015M01 2022M12
Included observations: 95

	AC	PAC	Q-Stat	Prob
1	0.191	0.191	3.5826	0.058
2	-0.160	-0.204	6.1327	0.047
3	-0.011	0.071	6.1446	0.105
4	0.014	-0.035	6.1639	0.187
5	0.107	0.131	7.3283	0.197
6	0.093	0.039	8.2256	0.222
7	-0.014	-0.003	8.2476	0.311
8	-0.108	-0.095	9.4942	0.302
9	-0.089	-0.055	10.335	0.324
10	-0.014	-0.030	10.356	0.410
11	-0.034	-0.064	10.480	0.488
12	0.010	0.031	10.491	0.573
13	-0.076	-0.093	11.131	0.600
14	-0.083	-0.007	11.914	0.613
15	-0.014	-0.019	11.936	0.684
16	-0.105	-0.120	13.220	0.657
17	-0.055	-0.018	13.581	0.696
18	-0.084	-0.126	14.421	0.701
19	-0.083	-0.039	15.252	0.706

At first glance, the possible processes of the variation of the DMASI are AR(1), MA(1), AR(2), ARMA(1,1), ARMA(2,1) and ARMA(1,2).

The estimation of this process by the ordinary least square method is represented in the following table and justifies the choice of an MA(1) with a p value (0.0084) < 5%.

Table 3 : Estimation of Ma(1) model

Dependent Variable: DMASI
Method: ARMA Maximum Likelihood (BFGS)
Date: 01/06/23 Time: 18:30
Sample: 2015M02 2022M12
Included observations: 95
Convergence achieved after 4 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MA(1)	0.303156	0.112527	2.694083	0.0084
SIGMASQ	179558.4	12280.36	14.62159	0.0000

R-squared	0.058545	Mean dependent var	8.479895
Adjusted R-squared	0.048422	S.D. dependent var	439.0369
S.E. of regression	428.2755	Akaike info criterion	14.97925
Sum squared resid	17058047	Schwarz criterion	15.03302
Log likelihood	-709.5145	Hannan-Quinn criter.	15.00098
Durbin-Watson stat	2.094752		

Inverted MA Roots -.30

After the estimation of the preceding model, the analysis of the significance of the coefficients leads us to keep only the MA(1) model above which gave satisfactory results. The following table contains the information criteria of AKAIKE and of SCHWARTZ and the MA(1) model R-squared:

Table 4 : the chosen model

model	Akaike info criterion (AIC)	Schwarz criterion (SC)	R-squared
MA(1) Model	14,97925	15,03302	0,058545

According to the table, we notice that the MA(1) model has the criteria AIC (14.97925) and SC (15.03302) and the R2 (0.058545), the ARIMA model (p=0, d =1, q=1) is therefore the most adequate to model the series.

5.4. The model validation:

The validation of our model is conditioned by the absence of autocorrelation of errors, the latter must have the character of white noise. The study of the existence or not of a white noise, is done through the correlogram of the residuals:

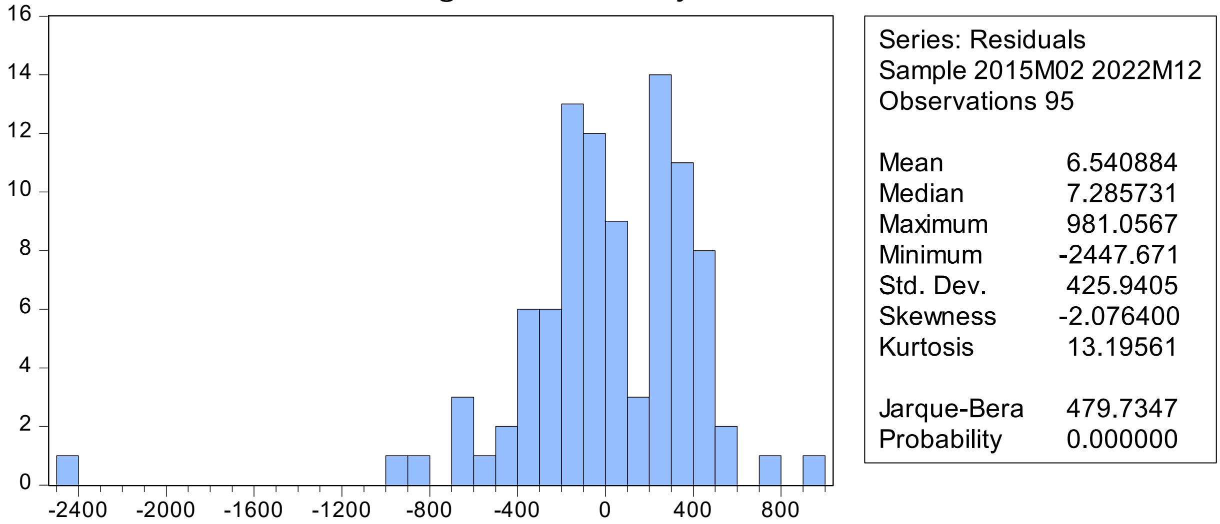
Figure 5 : Correlogram of residuals of the optimal model MA(1)

Date: 01/06/23 Time: 18:47
Sample: 2015M01 2022M12
Included observations: 95
Q-statistic probabilities adjusted for 1 ARMA term

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>. |. |</td><td>. |. |</td><td>1</td><td>-0.049</td><td>-0.049</td><td>0.2362</td><td></td></tr>
<tr><td>.*|. |</td><td>.*|. |</td><td>2</td><td>-0.153</td><td>-0.156</td><td>2.5499</td><td>0.110</td></tr>
<tr><td>. |. |</td><td>. |. |</td><td>3</td><td>0.038</td><td>0.022</td><td>2.6926</td><td>0.260</td></tr>
<tr><td>. |. |</td><td>. |. |</td><td>4</td><td>-0.023</td><td>-0.044</td><td>2.7439</td><td>0.433</td></tr>
<tr><td>. |* |</td><td>. |* |</td><td>5</td><td>0.091</td><td>0.100</td><td>3.5942</td><td>0.464</td></tr>
<tr><td>. |. |</td><td>. |. |</td><td>6</td><td>0.068</td><td>0.069</td><td>4.0726</td><td>0.539</td></tr>
<tr><td>. |. |</td><td>. |. |</td><td>7</td><td>-0.010</td><td>0.031</td><td>4.0822</td><td>0.666</td></tr>
<tr><td>.*|. |</td><td>.*|. |</td><td>8</td><td>-0.084</td><td>-0.073</td><td>4.8366</td><td>0.680</td></tr>
<tr><td>.*|. |</td><td>.*|. |</td><td>9</td><td>-0.068</td><td>-0.077</td><td>5.3317</td><td>0.722</td></tr>
<tr><td>. |. |</td><td>. |. |</td><td>10</td><td>0.019</td><td>-0.022</td><td>5.3715</td><td>0.801</td></tr>
<tr><td>. |. |</td><td>.*|. |</td><td>11</td><td>-0.050</td><td>-0.083</td><td>5.6462</td><td>0.844</td></tr>
<tr><td>. |. |</td><td>. |. |</td><td>12</td><td>0.042</td><td>0.034</td><td>5.8406</td><td>0.884</td></tr>
<tr><td>. |. |</td><td>.*|. |</td><td>13</td><td>-0.065</td><td>-0.072</td><td>6.3084</td><td>0.900</td></tr>
<tr><td>.*|. |</td><td>. |. |</td><td>14</td><td>-0.074</td><td>-0.040</td><td>6.9282</td><td>0.906</td></tr>
<tr><td>. |. |</td><td>. |. |</td><td>15</td><td>0.038</td><td>0.015</td><td>7.0926</td><td>0.931</td></tr>
<tr><td>.*|. |</td><td>.*|. |</td><td>16</td><td>-0.111</td><td>-0.119</td><td>8.5184</td><td>0.901</td></tr>
<tr><td>. |. |</td><td>. |. |</td><td>17</td><td>-0.006</td><td>-0.020</td><td>8.5222</td><td>0.932</td></tr>
<tr><td>. |. |</td><td>.*|. |</td><td>18</td><td>-0.063</td><td>-0.113</td><td>8.9929</td><td>0.940</td></tr>
<tr><td>. |. |</td><td>. |. |</td><td>19</td><td>-0.062</td><td>-0.062</td><td>9.4588</td><td>0.948</td></tr>
<tr><td>. |. |</td><td>. |. |</td><td>20</td><td>-0.004</td><td>-0.051</td><td>9.4604</td><td>0.965</td></tr>
<tr><td>. |. |</td><td>. |. |</td><td>21</td><td>-0.019</td><td>-0.027</td><td>9.5065</td><td>0.976</td></tr>
<tr><td>. |. |</td><td>. |. |</td><td>22</td><td>-0.008</td><td>-0.028</td><td>9.5154</td><td>0.985</td></tr>
<tr><td>. |* |</td><td>. |* |</td><td>23</td><td>0.119</td><td>0.134</td><td>11.327</td><td>0.970</td></tr>
</table>

The graph of the autocorrelation function does not contain significant peaks. As a result, at the level of the two functions, there are no autocorrelations significantly different from 0. The residual is analyzed from its autocorrelation function. No term is outside the two confidence intervals and the Ljung-Box statistic (Q-Stat) has a critical probability (0.26) well above 5% for 3 lags. We then accept the white noise hypothesis, which proves the validity of our model.
We can test if the process follows a normal law through the Jarque-Bera test

Figure 6 : Normality of residuals



We note that the probability of the Jarque-Bera test is less than 5%, so our white noise does not follow a normal law, therefore it is a non-Gaussian white noise.
According to the results above, our model does not represent a random walk because it is not a superposition of independent random variables, (Gaussian white noise) since it does not follow a normal distribution .

6. Conclusion

The year 2020 which supposed to be a year of carrying out major projects and economic and social development for Morocco, has become a year of crisis and state interventions to save the life of its citizens.

The health crisis caused by COVID-19 has been considered the most serious in a century and has crossed the five continents by disturbing the functioning of the different sectors in almost all countries including Morocco, the level of stress and uncertainty about this epidemic explain the decline in equity markets that should remain volatile with sector disparities.

Regarding portfolio construction, several points remain essential. Diversification and investment horizon are part of it. Diversification (geographical, sectoral, etc.) makes it possible to spread the risks in the event of stock market fluctuations, each class of assets behaving differently from one another. This situation pushes us to ask ourselves the question of how Morocco could overcome the effects of the crisis on Moroccan stock market?

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