Spread of the Corona virus Epidemic in Morocco, USA, France, Spain, Italy, Egypt, Lebanon and Tunis by the Heteroscedastic Model during the first wave

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***Abstract*— A novel coronavirus (2019-nCoV) pneumonia hit a China in the end of 2019, and subsequently reached other countries and regions. In this paper, we present scenarios for the spread of the coronavirus epidemic by defining a coefficient called DS= (date i / date i-1) that represents the daily spread of covid19.**

We have demonstrated, in the first wave, by Applying the ARCH Models that the spread of the coronavirus knew a calm period by the end of April and beginning of May. However, a variation in mid-May showed first the increase in infected people with new cases which our model showed with 95% of confidence, and this will be followed by a last but larger variation to appear on July 4, 2020 and followed by a decline in COVID-19 infection propagation in the following weeks.

Keywords—coronavirus, ARCH Models, daily spread coefficient

INTRODUCTION

Respiratory symptoms, Fever, flanked by cough mostly dry, gastrointestinal symptoms such as nausea, vomiting and diarrhoea and myalgia or fatigue appearing during the course of illness are mostly considered to confirm the infection with the COVID-19 [1], [2]. The totality of initial COVID-19 cases in morocco were associated to Moroccans coming from abroad especially from Europe, however, a growing number of cases due to person-to-person transmission have been reported. Since the first case detected in Morocco on March 06, 2020, several measures have been quickly adopted by the Government to slow down the spread of COVID-19; measures such as the suspension of international flights, closure of schools, universities, cultural and sporting places, cafes, restaurants, non-essential businesses and mosques to limit the displacement of the population as much as possible were taken. Morocco declared a state of health emergency on March 20, 2020.

1. Methodology

1) The diffusions are random functions, which are widely used in physics, chemistry, biology, statistics and finance. it captures instant dynamics tainted with uncertainty.

Their very nature makes them a great modelling tool: Well beyond their descriptive interest, they lend themselves to quantitative uses. In this paper, we propose to model the new effects following a geometric Brownian movement (most usually in finance to model the share price evolution).

An autoregressive process is a process in which each value is described as a linear combination of the previous values plus a random component called a "noise". The number of previous values considered is called noise of the process.

2) The classical Autoregressive Moving Average model, based on AR model, trying to model the conditional expectation, are fundamentally linear and are based on weak constraints (constant mean, unconditional variance and constant conditional variance), have chosen which restrict their application in fields where the series with certain dynamic characteristics or constant for the conditional variance.

3) The variance σ_t at time t *is connected to the value of the series $y_{t"1}$ at time $t-1$. A relatively large value of $y^{\$}_{t"1}$ gives a relatively large value of the variance at time t. This means that the value of y_t is less predictable at time $t-1$ than at times after a relatively small value of $y^{\$}_{t"1}$*

A GARCH (p, q) model (generalized autoregressive conditionally heteroscedastic) uses values of the past squared observations and past variances itself to model the variance at time t. We give the model by:

$$y_t = \sigma_t \varepsilon_t$$

$$\sigma_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i y^{2}_{t"i} + \sum_{i=1}^{p} \alpha_i \sigma_{t"i}$$

$(\varepsilon_t, t \in \mathbb{Z})$ distributed normally N (0, 1)

The choice of model and its validation are based on the skewness, the kurtosis and taking some tests [6]; Jarque-Bera test [7], Ljung-Box (portemanteau) test [8], heteroscedastic test [9].

2. Daily Spread Coefficient of Corona virus in the world after confinement

After two months of detecting the first case in Morocco, the number of patients increased exponentially. We have noticed, between the first day detected case and May 03, 2020, an average growth daily rate increase of 15% in Morocco (first day March 03), USA 14% per day (Jan 21), Spain 14% per day (Feb 01), Italy 13% per day (Jan 31), France 11% per day (Jan 25), while the world average is 10% per day (Dec 31, 1919), Egypt 12% per day (Feb 15), Lebanon 10% per day (Feb 15), Tunis 12% per day (March 03).

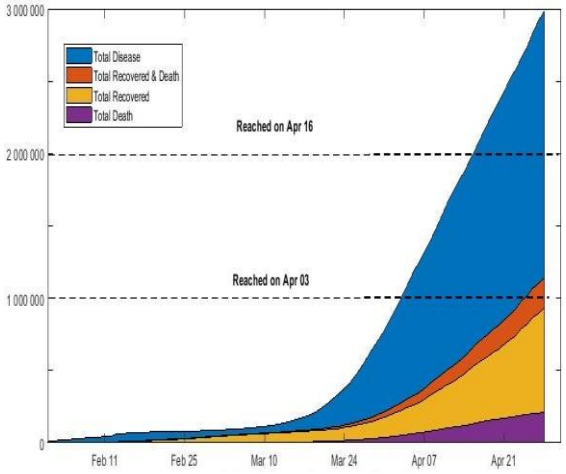


Fig 1. Global coronavirus cases in the world

Some viruses are highly contagious (spread easily), like measles, while other viruses do not spread as easily, the experts based on knowledge about other coronaviruses, believe that the virus is thought to spread mainly from person-to-person, between people who are in close contact with one another (within about 6 feet). Through respiratory droplets produced when an infected person coughs or sneezes. These droplets can land in the mouths or noses of people who are nearby or possibly be inhaled into the lungs. The spread might be possible before people show symptoms, but this is not thought to be the main way the virus spreads. while Patients are felt to be at highest risk of spreading the illness when they are most symptomatic [9]-[10].

The transmission of COVID-19 It may be possible through contaminated surfaces or fomites with subsequent contact with the eyes, nose, or mouth may also occur [2], [10], [11]. The COVID-19 seems spread easily and sustainably in people have been infected with the virus in an area, including some who are not sure how or where they became infected.

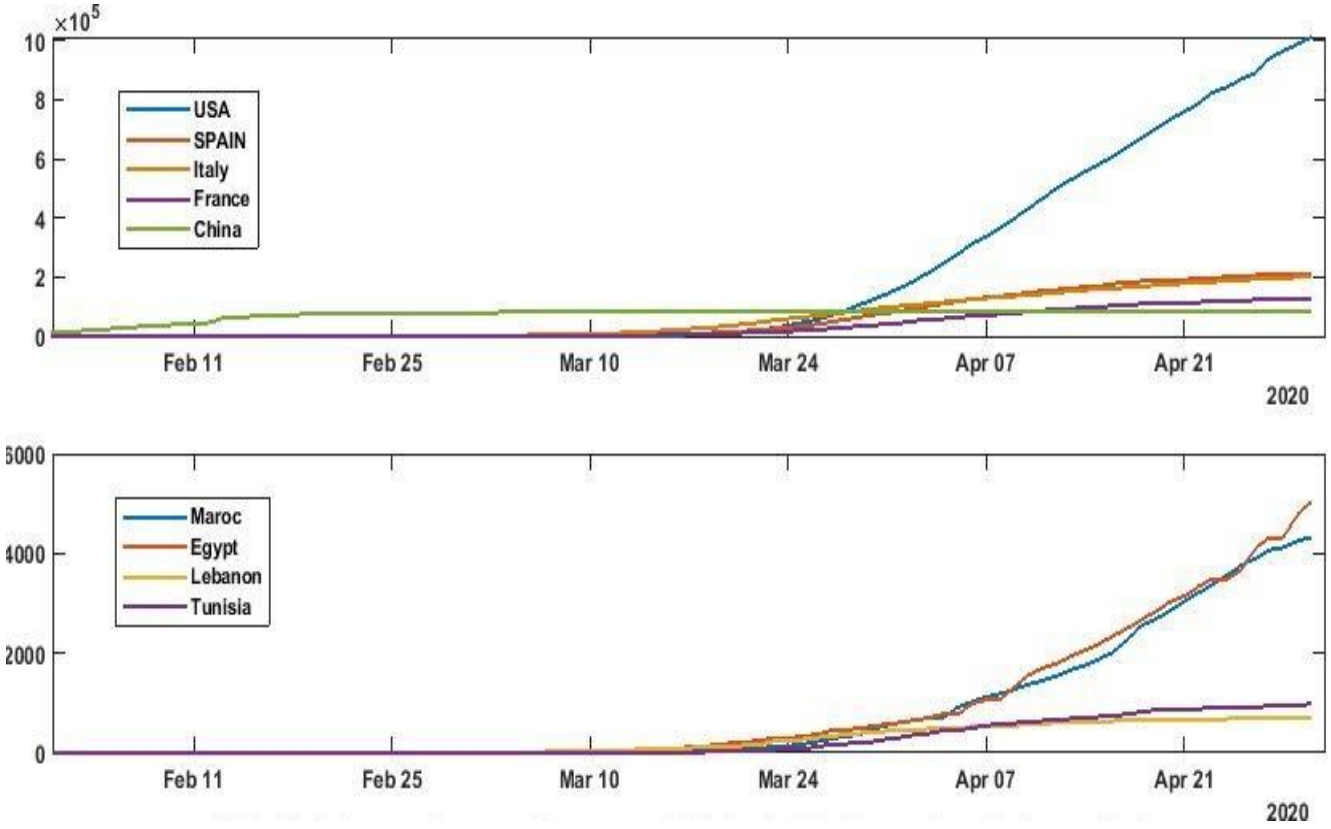
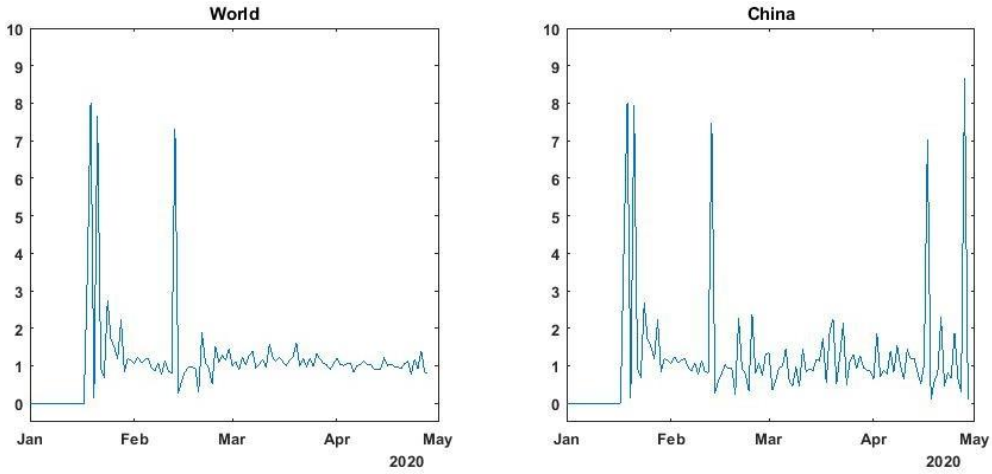
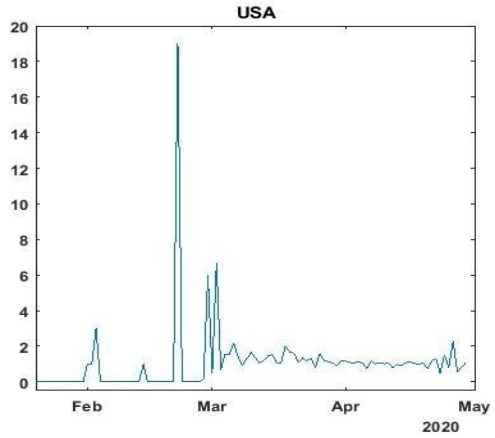
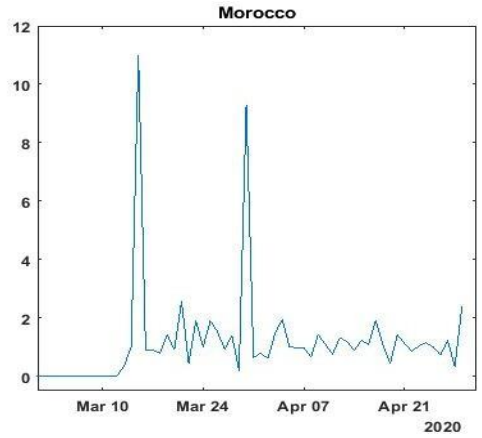


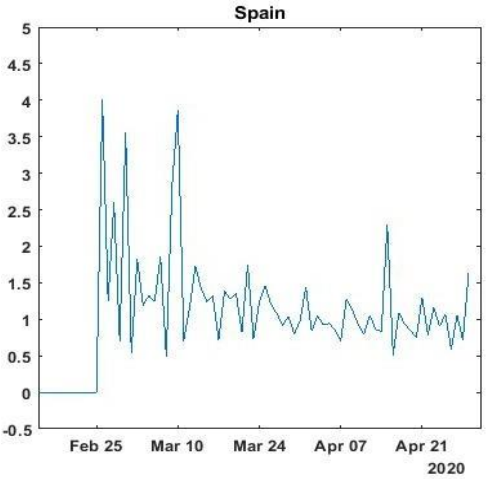
Fig 2. Global coronavirus cases in Morocco, USA, France, Spain, Italy, Egypt, Lebanon, Tunis, China.

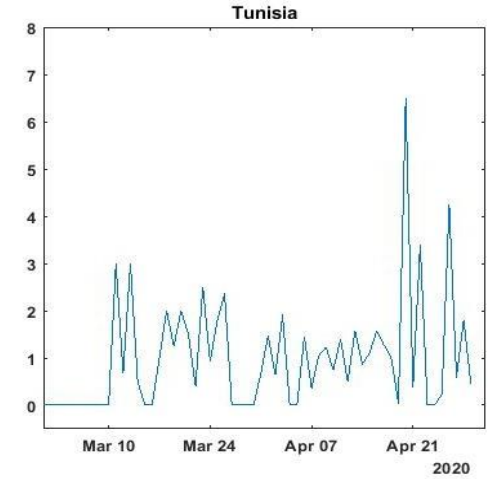
We consider that a chronological series (Xt) results in the spread of COVID-19 in the different countries studied, we have defined the coefficient DS = (date i / date i-1) represents the daily propagation or the daily spread of covid19 in the studied series, It reflects the "average" behaviour of each series. Fig 3. Shows The modelling of the daily proportion rate given by DS which can give a prediction of case, the figures show the existence of two waves of propagation, the first wave in the 1st 10 days, followed by a very important second wave in a month after the first.

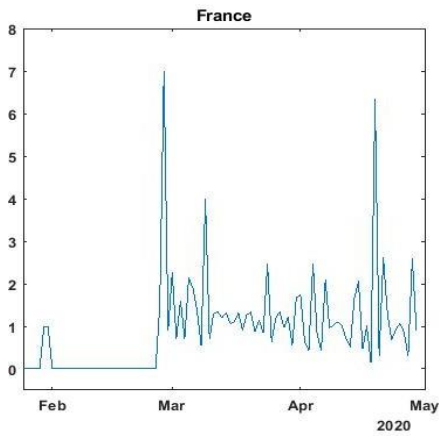


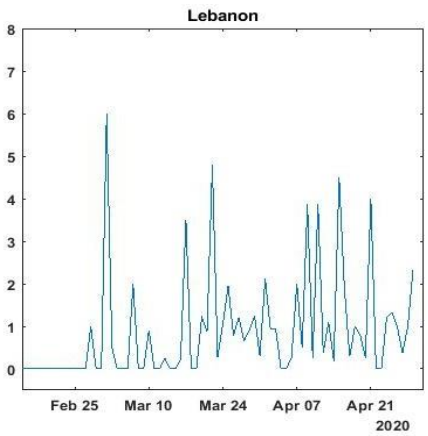












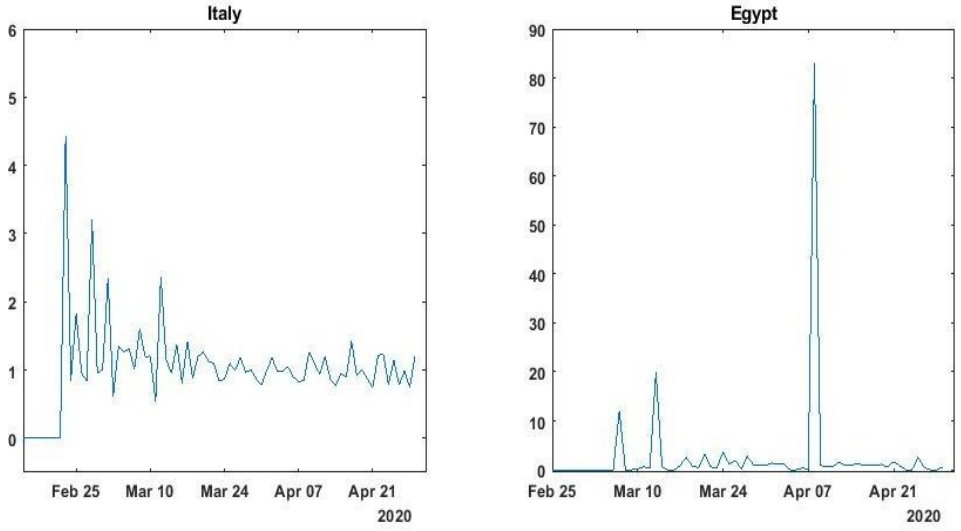


Fig 3. The modelling of the daily spread rate (DS) in the World, Morocco, USA, France, Spain, Italy, Egypt, Lebanon, Tunis and China.

3. 3. Scenarios for the Spread of the Corona virus epidemic in the USA, Morocco, Italy, France, Spain, Egypt, Lebanon and Tunis.

3.1 Ljung-Box Q-Test

By this test, we search that any of a group of autocorrelations of a time series are different from zero;

Null Hypothesis: The first autocorrelations of DS are

3.2 Engle's ARCH Test

In this test, we seek the non-attendance of homoscedasticity (contraire of Heteroscedasticity);
Null Hypothesis: The series exhibits no ARCH Effects.
We present results when the Null Hypothesis rejected is true.

jointly 0.

We present results when the Null Hypothesis rejected is true.

Tab1. Ljung-Box Q-Test
Tab2. Engle's ARCH Test

p+q give us the parameters of the model We will present two best GARCH model for that p+q using Akaike Information Criterion AIC and Bayesian information criterion in one hand and considering that the values follow a Gaussian or t distribution

Country	Test Statistic	Critical Value	Lags	DOF	Significance Level
Morocco	18.1654	16.919	15	9	5%
Tunis	25.2452	3.8415	1	1	5%
Egypt	4.5413	3.8415	14	1	5%
Lebanon	22.7886	3.8415	1	1	5%
Italy	5.6798	3.8415	3	1	5%
France	25.544	3.8415	1	1	5%
Spain	8.3383	3.8415	1	1	5%
USA	6.0391	3.8415	7	1	5%
World	7.597	3.8415	2	1	5%

Country	Test Statistic	Critical Value	p+q	Significance Level
Morocco	27.9811	24.9958	15	5%
Tunis	13.9744	3.8415	1	5%
Egypt	13.7833	11.0705	5	5%
Lebanon	9.3811	3.8415	1	5%
Italy	15.4012	9.4877	4	5%
France	36.5176	3.8415	1	5%
Spain	6.7769	3.8415	1	5%
USA	69.9164	33.9244	22	5%
World	20.4776	5.9915	2	5%

3.3 Models :

a- Gaussian distribution based maximum-likelihood estimation:

Tab 3. Model estimated parameter using Gaussian distribution

Parameter	Morocco	Tunis	Egypt	Lebanon	Italy	France	Spain	USA	World
Constant	0.070184	1.9538	0.15473	2.4592	0.0025836	0.43967	0.08569	0.1768	0.00016272
GARCH{1}					0.82001		0.96933		0.89252
GARCH{3}	0.0031843								
GARCH{4}	0.0019962								
ARCH{1}		0.51403		0.41506		1			0.088364
ARCH{2}			0.48639		0.075852			0.86879	
ARCH{3}	0.068107		0.51361						
ARCH{4}								0.0010096	
GARCH{5}	0.1069								
ARCH{7}								0.1302	
ARCH{10}	0.88792								
Offset	0.10636	0.16841	0.85848	0.23457	1.0037	0.14991	0.04082	1.5017	1.0428
AIC	151.2633	215.6739	182.3509	273.5607	62.424	303.2073	89.7999	356.2572	189.4955
BIC	162.2352	221.5277	190.3802	280.0373	71.3604	310.9314	96.414	II. 368.5289	200.2974

b- t-distribution based maximum likelihood estimation:

tab 4. Model estimated parameter using t-distribution:

Parameter	Morocco	Tunis	Egypt	Lebanon	Italy	France	Spain	USA	World
Constant	2e-07	1.5242	0.5522	2.5586	0.0069823	0.22314	0.097588	0.019949	0.02617
GARCH{1}					0.79627				0.66599
GARCH{3}	0.82225							0.0047325	
GARCH{4}								0.0053119	
ARCH{1}		0.94583		1		1	0.86752	0.77358	0.11768
ARCH{2}			0.10931		0.076946			0.0067106	
ARCH{3}			0.89069					0.0048603	
ARCH{4}								0.0033048	
ARCH{5}	0.0096237								
ARCH{6}	0.040208							0.0010572	

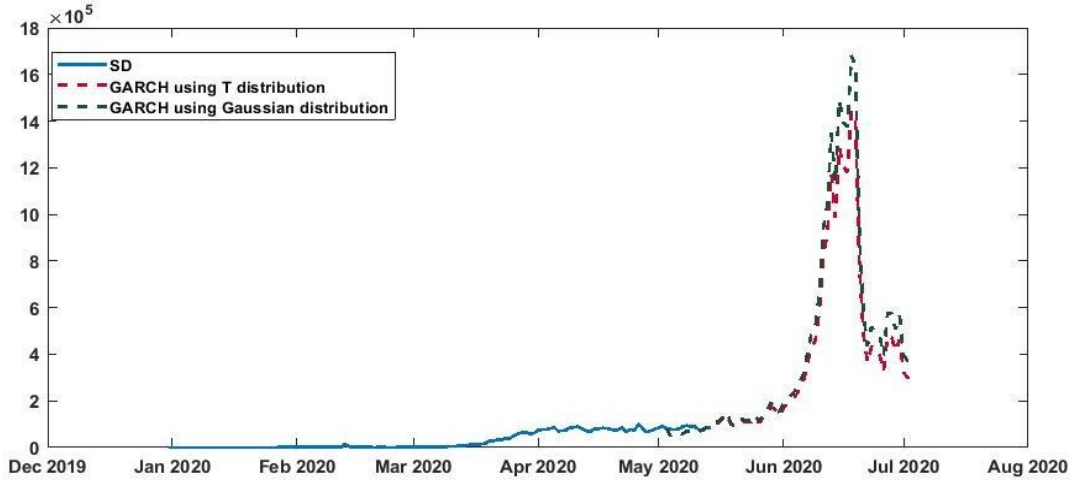
ARCH{7}								0.062467	
ARCH{9}								0.059231	
ARCH{13}								0.0045191	
ARCH{17}								0.0015503	
ARCH{18}								0.072671	
DoF	2.208	3.7866	2.6615	2.7503	3.2057	2.7173	6.2549	3.1191	2.357
Offset	1.119	0.024345	0.79681	-0.0072848	0.99098	-0.017817	0.037495	1.0586	1.0526
AIC	111.8716	209.169	153.3543	264.7403	33.2396	259.2154	89.9538	189.5156	49.7467
BIC	123.3437	216.974	163.391	273.3759	44.4101	269.5143	98.7726	224.2779	63.2491

3.4 prevision for the spread of the coronavirus epidemic:

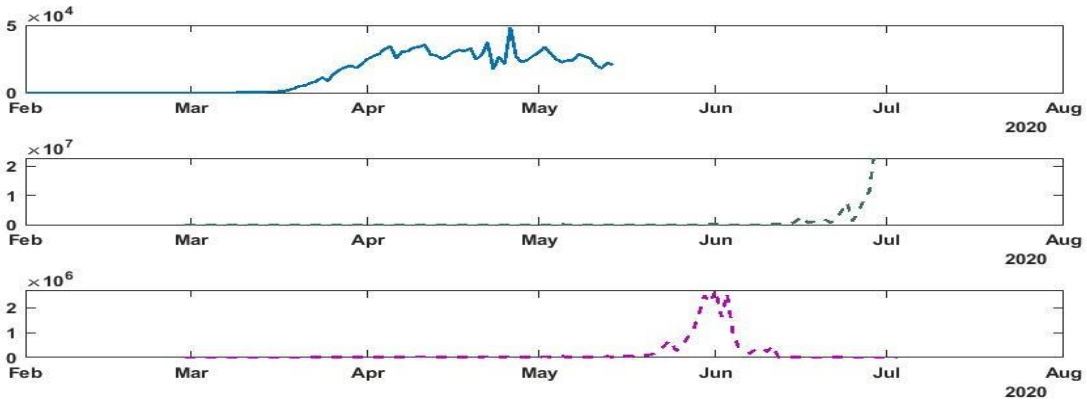
By Applying the GARCH(p,q) Conditional Variance Model with Offset with Gaussian distribution and t-distribution. Fig.4 present the graphs which show the evolution of the new cases until May 14, 2020 and the prevision of the studied countries using both of model estimated since May 03, 2020. We can notice, based on the two models, and although some countries, which in the Covid-19 spread tend to be extinguished,

the month of June may have consequence on its spread. By the World, and with 95% of confidence an increasing data will be held on July 4, 2020 followed by the decrease of the virus. This variation may be different between countries depending on the strategies adopted and strict compliance (France,Spain, Morocco) and also depending on the size of country's population (Tunis Lebanon).

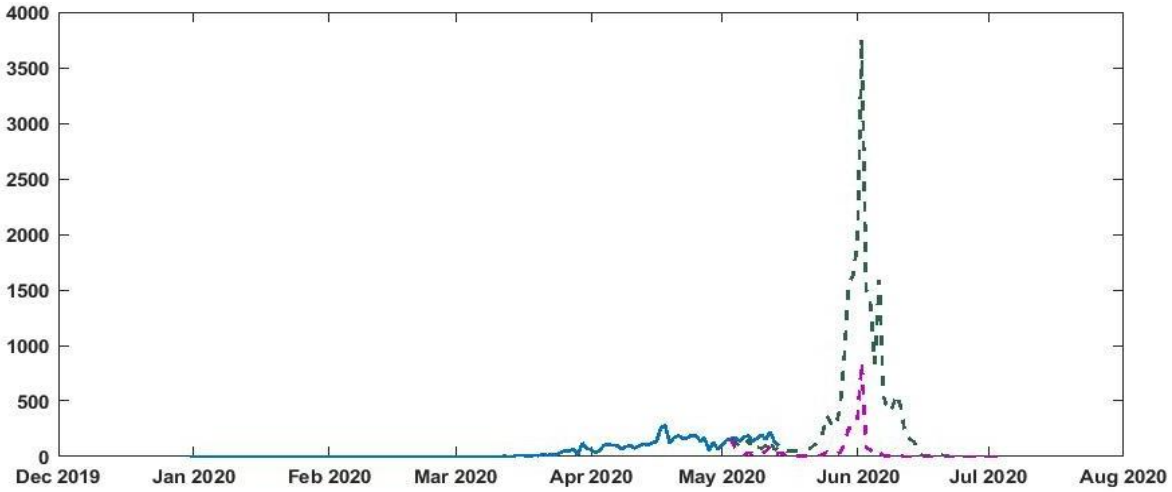
a- world



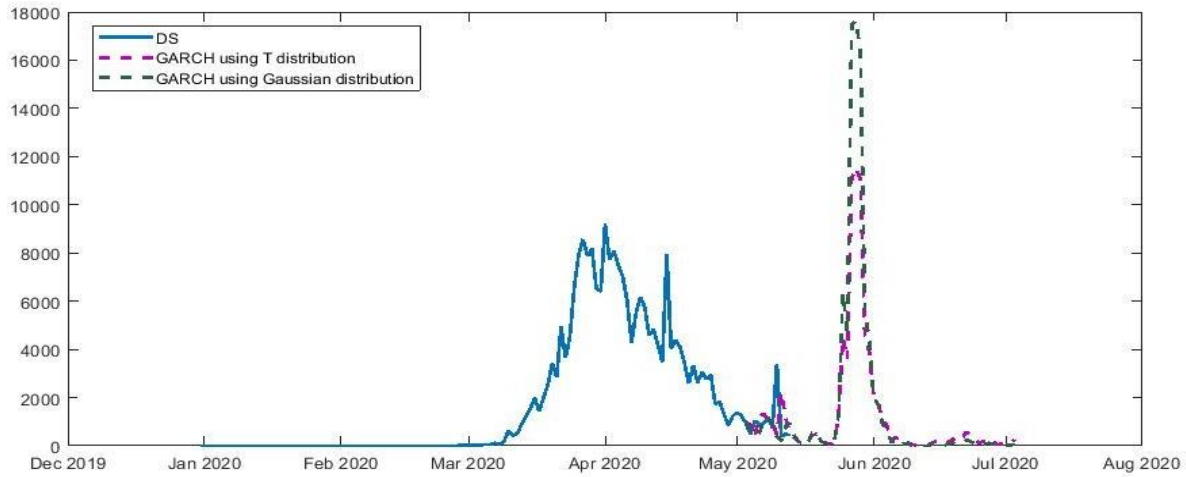
b- USA



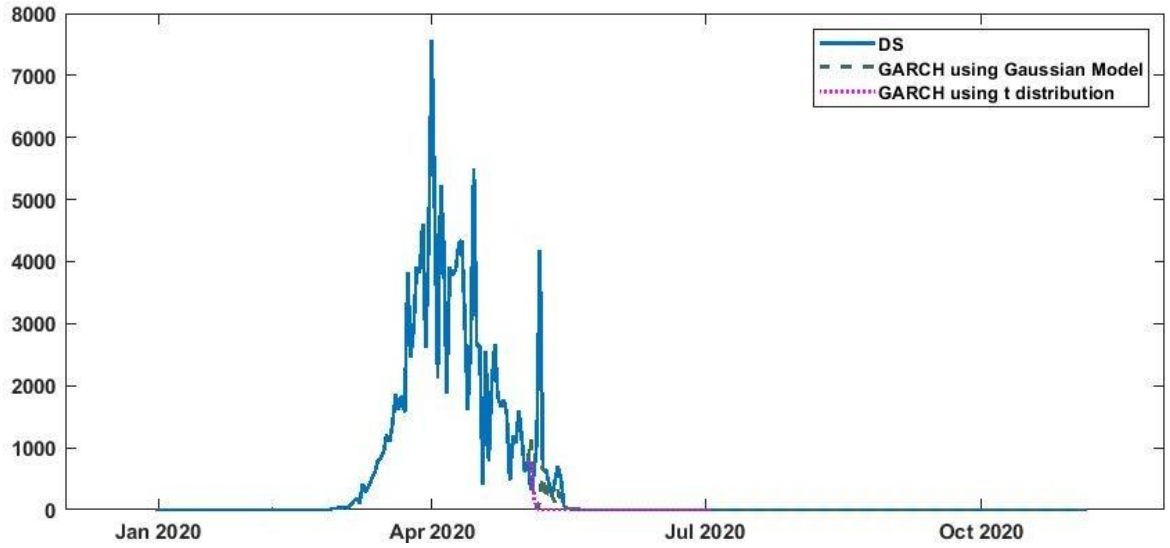
c- Morocco



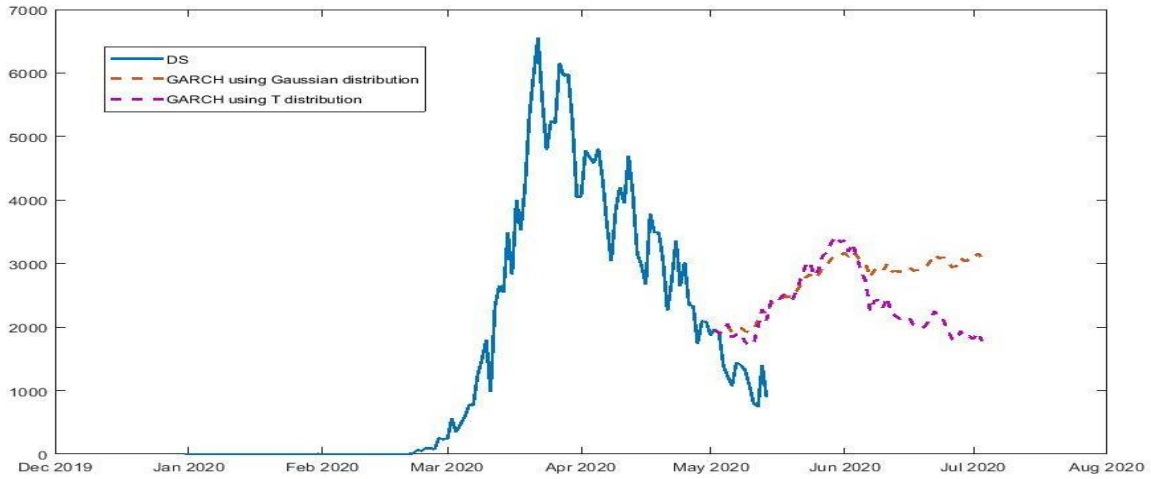
d- Spain



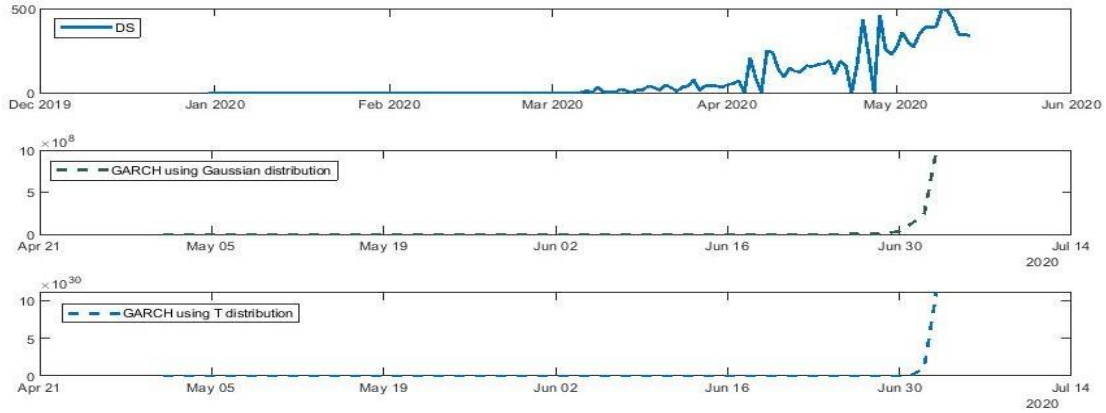
e- France



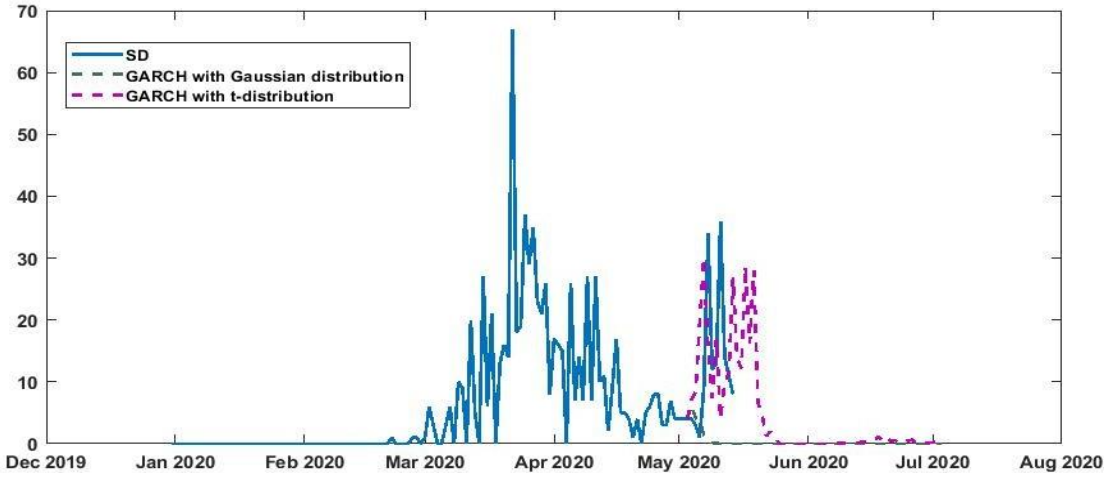
f- Italy



g- Egypt



h- Tunis



i- china

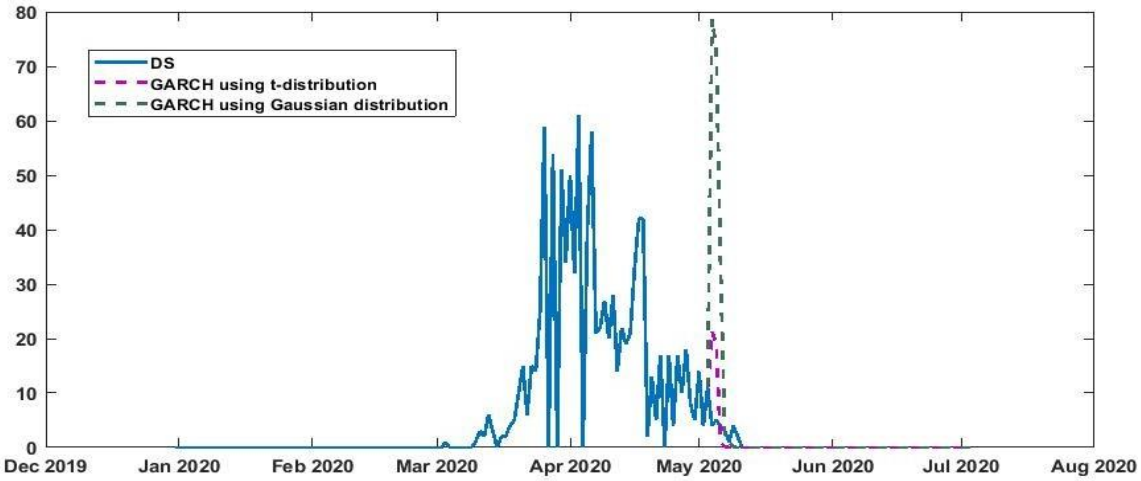


Fig 4. Scenarios for the spread of the coronavirus epidemic in the World, Morocco, USA, France, Spain, Italy, Egypt, Lebanon, Tunis and China.

CONCLUSION

Most of scenarios that try to model the COVID-19 evolution of new cases, are based on Gaussian distribution. We present in this study two scenarios of GARCH model using Gaussian and t- distribution. Both models anticipate an extinction of the new cases before the beginning of July provided strict respect of the measures taken (France, Spain, Morocco, and Tunis, Lebanon). However, global variation in countries like USA and Egypt need to take more severe measures to slowdown the spread of this virus. In fact, the failing in total extinction of the virus before the fall can cause a reactivation of this one especially if the measure of closing of the borders is lifted.

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