The Predictive Power of Financial Stress on the Financial Markets Dynamics: Hidden Markov Model

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Abstract
This study investigates the predictive power of the financial stress on the dynamic of the Middle East and North Africa (MENA) financial market returns from 2007 to 2021. Based on a Quantile Regression, we show that financial stress has highest predictive abilities at the lower quantiles when the market is bearish. Then, we propose a Hidden Markov Model (HMM) based on the transition matrix to understand the relationship between financial stress index and the MENA stock market dynamics. We find that the effect of financial stress on stock market return reveals the persistence of regimes: Bullish state exists and persists, and has the longest conditional expected duration for the majority of MENA markets, except Bahrain, Qatar and Jordan. However, the transition probability from the bullish to the calm regime is too low for the financial market of Bahrain, United Arab Emirates and Egypt. Besides, the estimated mean returns for each regime divulge that the bearish and calm states are more attractive destination for both portfolio managers and investors.

Keywords Financial Stress Index · Hidden Markov Model · Transition Probability Matrix · MENA region, COVID_19

1 Introduction

Following the succession of financial crises, stock market and oil crashes, the financial markets experienced a period of major financial shocks called “Financial Stress” which appears to be an important factor in determining the dynamics of stock prices during stressful periods. Indeed, setting the definition of financial stress is a daunting task. It is the same as financial instability (Borio and Lowe (2002), Bloom...
Moreover, on the financial markets, the stress index is a purely financial indicator with a double objective: to be an indicator of stress measurement and to be a leading indicator of economy, in order to predict macroeconomic trend reversals. Therefore, financial stress can be defined as “being the force exerted by uncertainty and the change in expectations of losses on the economic agents of markets and financial institutions” (Zayati and Gaaliche 2014). In fact, Sum and Brown (2014) focused on the relationship between financial stress and the performance of the US real estate market proxied by Real Estate Investment Trust returns. They conclude that, depending on the spike in financial stress, the response of returns on the CRSP Ziman REIT indices and sub-indices is negative in the first few months. Moreover, Apostolakis and Papadopoulos (2014) investigated financial stress co-movements and spillovers among the G7 economies for the period 1981–2009. They show a positive association of financial stress co-movements and spillovers with both financial crises and uncertainty and financial stress play an important role in the financial markets. Further, Das et al. (2018) focused on the relationship between stocks, crude oil, gold and financial stress during the period of 1993–2017. They have found evidence of a significant bi-directional causality in mean and variance of financial stress with gold and crude oil.

More specifically, over the past two decades, the stock markets have experienced various episodes of crises and crashes, such as the great global recession of (2007-2009), the political turmoil (2010-2011), the oil crisis (2014-2015), the Covid-19 pandemic (2019-2021). In fact, the outbreak of the COVID-19 pandemic has affected significantly the global financial markets (Al-Awadhi et al. 2020; He et al. 2020; Okorie and Lin 2021). Thus, the stock markets reacted more proactively to the increase of the confirmed COVID-19 cases as compared to the increase in the number of deaths. Further, Liu et al. (2020) indicate that the novel coronavirus had a significant negative impact on stock market returns across all affected countries, and the numbers of confirmed COVID-19 cases significantly hit the major stock indices performances, particularly in Asia, where they suffered a greater decline.

In this scenario, the proliferation of economic, financial, political, social, oil and health crises is referred to as a source of systematic risk and increases uncertainty on the financial markets, which will in turn increase the level of financial stress. As a result, this relationship prompts us to investigate the impact of financial stress regime change on stock market returns dynamics. To this end, we utilize the Hidden Markov Model (HMM), which is a probabilistic process that uses the current state to predict the next one and allow us to predict the state transition that depends on the current state and not on the past states. On the financial markets, the use of this model is becoming more and more important, especially in improving investment decisions.

In this context, the financial stress effect has been mainly studied in the literature, but so far, its impact on stock market dynamics has not been fully explored for the MENA financial markets. To our knowledge, this is the first study among the current literature that uses Hidden Markov Model to explore the predictive effect of financial stress on regime change of the financial market returns and implement further study on the financial effects of the Covid-19 outbreak on the MENA region. We considered three financial market states: bullish stress (S1), bearish stress (S2),
and calm stress (S3). We proposed a Hidden Markov Model based on the transition matrix to capture not only financial stress but also uncertainties in the MENA region.

The outline of the paper proceeds as follows: Section 2 reviews the relevant literature on the predictive effect of financial stress on stock market performance. The data and methodology will be described in section 3 and 4. Section 5 provides the research findings and discusses the possible implications of the findings. Finally, we conclude.

2 Literature review

In the recent past, analysts and investors have attempted to divide financial stock market fluctuations into two categories, namely negative and positive market phases, sometimes referred to as bearish and bullish market regimes. Nevertheless, the stock markets, the news and reality could be more complex and intricate than this dichotomous specification and the uncertainty about regime change can result in bad and wrong investment decisions. Due to the large fluctuations that occur, the negative market episode can be demonstrated by a rapid switching between different regimes, alternating regimes characterized by sharp declines in stock prices with regimes represented by sharp price increases. Particularly, investors might be interested in knowing which regime they are experiencing and which the most likely regime to occur next. This knowledge would make easy investment decisions during both bull and bear market phases.

Indeed, transaction costs and financial stress are among the factors that lead to the asymmetric effect. Aloui et al. (2012), for example, find an asymmetric impact of oil shocks on 25 emerging market returns. Several studies have been conducted to study the effect of financial stress on the performance of the financial market. Berger and Pukthuanthong (2016) show that indicators of increased probability do not necessarily imply lower average stock returns. They offer a measure of risk that specifically predicts falling stocks on a monthly basis. Risk measurement is based on capturing stress and fragility. They have shown that an increase in their risk measure predicts low monthly market returns, as well as large minimum monthly returns. The results are robust for several constraint specifications. Moreover, in order to construct financial stress indices for emerging economies, Stolbov and Shchepeleva (2016) have proposed an extension to the methodology introduced by Balakrishnan et al. (2011). They found that it has an adverse effect of the financial stress on economic activity in nine countries. Mezghani and Boujelbène-Abbes (2021) have found that the correlation between the oil and stock-bond markets tends to be stable in non-shock periods, but it evolves during oil and financial shocks at lower frequencies, as well as they found that the oil market and financial stress are the main transmitters of risks.

More recently, the outbreak of COVID-19 presents a source of systemic risk (Sharif et al. 2020) and previous evidence shows that extreme events can lead to downward pressure on financial markets and alter systematic adjustments to risk and return expectations (Heo et al. 2021). In fact, Salisu and Vo (2020) investigate the impact of COVID-19 cases and deaths on stock returns and find a negative impact.
Furthermore, Chatjuthamard et al. (2021) found that an increase in the growth rate of the number of confirmed cases increases volatility and jumps while reducing return.

None of these articles, nevertheless, focuses on the Covid-19 pandemic effects for the MENA region. Therefore, the present study would fill this gap and analyze the predictive effect of financial stress on the dynamics of financial market returns.

3 Empirical methodology

In our study, we use the Quantile Regression to investigate the effect of monthly financial stress scores on stock market returns across lower-upper quantiles. Then, we employ the Hidden Markov Model (HMM) which helps in separating the financial stress state from the market and making it possible to determine the probability of transition when the regime changes.

3.1 Quantile Regression

Quantile Regressions are statistical tools that describe the impact of explanatory variables on a variable of interest. They provide a more detailed picture than classic linear regression, as they focus on the entire conditional distribution of the dependent variable, not only on its mean. They are also more suited to some kind of data such as truncated and censored dependent variable, outcomes with fat-tailed distributions, nonlinear models...(D’haultfœuille and Givord (2014)). We utilize the Quantile Regression model developed by ((Koenker and d’Orey (1987)). This model is illustrated as follows:

\[
Y_i = X_i \alpha_k + V_{ki}
\]

(1)

With

\[
\text{Quantile}_k(Y_i/X_i) = X_i \alpha_k
\]

(2)

Note that (i = 1, ..., p). It should be noted that ”/” denotes the term “knowing that”. In the first eq. (1), \(\alpha_k \) and \(X_i \) are (Jx 1) vectors and \(X_{ij} \) is roughly equal to1. In addition, the expression \(\text{Quantile}_k(Y_i/X_i) \) denotes the \(k^{th}\) conditional quantile of \(Y\) given by \(X\).

3.2 Hidden Markov Model (HMM)

The Hidden Markov Model is a signal detection model that was introduced in 1966 by Baum and Petrie (Baum and Petrie 1966). It is an institutional change model that assumes that the sequence of observations that are viewed as a series of observations is hidden by Regime (or State), (Nguyen (2017)) in order to study the financial
stress ability to predict stock market returns. Given the time series of financial stress index and stock index returns, we use a Hidden Markov Chain to capture the relationship between these variables based on the transition probability matrix (TPM).

We explore the stock market states by using the estimated transition probability matrix. In our research, we assume that the number of hidden states is discrete and limited and the movement of the relationship, stress-return from one state to another depends on hazard.

### 3.2.1 Financial stress states

For clarity, we have defined the following attributes for each stock market through adopting the methodology used by Trichilli et al. (2020):

- $\text{FS}_t$: Financial stress index during month $t$
- $\text{RET}_t$: Stock market return during month $t$
- $\sigma_t$: Stock market volatility during month $t$
- $O_j$: The series of returns for the stock market index (Sequence of observations)
- $S_t$: Hidden states (Bullish, Bearish, Calm) = States of financial stress
- $a_{ij}$: Probability of transition from state $i$ to state $j$
- $b_{ij}$: Probability of emission from observation $i$ to observation $j$

Therefore, the purpose of HMM estimation is to provide a framework for modeling the relationship between the state (financial stress state) and the observed parameters (stock market returns).

The model makes it possible to predict hidden state probability distributions from the known sequences of the observed parameters. In this context, the selection of the observation parameter is considered to be the most important part of a successful development of HMM. It should have a high degree of functional relationship with the unknown state parameter. Thus, the estimated financial stress index, $\text{FS}_t$, is classified in various stress states $S_t$. The series of returns considered for the analysis refers to the logarithm of the monthly ratio of $P_t$ with the previous month of $P_{t-1}$, is defined through:

$$
\text{RET}_t = \ln P_t - \ln P_{t-1}, \quad t = 2 \ldots W
$$

**Where:** $W$ indicates the number of months in the study period, $\text{RET}_t$ is the return on the stock market index for month $t$, $P_t$ and $P_{t-1}$ are the closing prices of the index, respectively, during month $t$ and $t-1$.

Let $\overline{\text{RET}}_w$ be the average of $(\text{RET}_t^w)$, for the month $W^{th}$ is defined as follows:

$$
\overline{\text{RET}}_w = \frac{1}{n_w} \sum_{t=1}^{n_w} \text{RET}_t^w, \quad w = t, \ldots, W
$$

And $\sigma^2_w$ presents the empirical variance of $(\text{RET}_t^w)$, for the month $W^{th}$ which is defined as follows:
We are supposed that stress market was symmetric around the center of the distribution of means. We discriminated the market stress into three categories, for month \((w + 1), w = t \ldots w - 1\),

\[\sigma_w^2 = \frac{1}{n_w - 1} \sum_{t=1}^{n_w} \left( \overline{RET}_t - \overline{RET}_w \right)^2 \tag{5}\]

The states cited above are named the Bullish state (S1), the Bearish state (S2) and the Calm state (S3), respectively. Figure 1 below represents a Hidden Markov graphical model that integrates financial stress to predict states.

3.2.2 Stochastic model for financial market stress

A stochastic transition matrix First, within the framework of estimating the stochastic transition matrix, we have classified the monthly financial stress in different states: S1, S2, and S3. In addition, specify the structure of monthly market stress so that recent market stress depends only on the construction of the current state, not on the past state.

We assume that for a log (Return) data \(\text{RET}_t = 2, \ldots, W\) (Eq. (3)), we have the monthly states of market stress obtained according to the classification rules (6). Then, the transition process between states can be presented by a stochastic transition matrix encompassing the different probabilities of transition from one state to another.

The states cited above are named the Bullish state (S1), the Bearish state (S2) and the Calm state (S3), respectively. Figure 1 below represents a Hidden Markov graphical model that integrates financial stress to predict states.

**Fig. 1** A Schematic visualization of Hidden Markov Model \((\text{RET}_t, \sigma_t, S_t)\)
Note that \( n_{ij} \) the number of transitions from a state \( i \) to a state \( j \) and let 
\[ \sum_{j=1}^{k} n_{ij} = n_i; i = 1, \ldots, k, \ j = 1, \ldots, k. \]
Let \( p_{ij} \) represent the probability of transitions from a state \( i \) to a state \( j \). Generally, 
\( p = (p_{ij}) \) is the transition probability matrix of the Markov chain which is presented 
as follows:
\[
P = (p_{ij}) = \begin{pmatrix} 
p_{11} & p_{12} & \cdots & p_{1k} 
p_{21} & p_{22} & \cdots & p_{2k} 
\vdots & \vdots & \ddots & \vdots 
p_{k1} & p_{k2} & \cdots & p_{kk} \end{pmatrix}
\]  

(7)

The transition accounts \( (n_{i1}, n_{i2}, \ldots, n_{iK}) \) can be presented as a sample of 
sizes \( n \) from a multinomial distribution with probabilities \( (p_{11}, p_{12}, \ldots, p_{ik}) \) such that 
\[ 0 < p_{ij} < 1, \ \sum_{j=1}^{k} p_{ij} = 1. \]

Then, we estimate the probability of transition by the following formula:
\[
\hat{p}_{ij} = \frac{n_{ij}}{n_i}, i,j = 1,2,\ldots,K
\]

(8)

**Steady state probabilities** After calculating the transition probabilities of the \( n^{th} \) step 
for a Markov Chain, the latter will show the characteristic of a stationary state. That is, 
if the value of \( n \) is large enough, each row of the matrix will be identical, that is, the 
probability that the process is in each state does not depend on its initial state. Consequently, the probability that the process will be in each state after a certain number of transitions is a probability of limitation which exists independently of the initial state. This can be explained by the fact that for an irreducible ergodic chain, the limits \( \pi_j = \lim_{n \to \infty} p_{ij}(n) \) exists such that \( \pi_j \geq 0, \ \sum_{j=1}^{k} \pi_j = 1 \) and the limits define a probability distribution \( \{\pi_j\} \) as identical to the stationary distribution of the given chain so that:
\[
\pi_i = \sum_{j=1}^{k} \pi_j p_{ji}, \ \sum_{i=1}^{k} \pi_i = 1, i = 1, \ldots, K
\]

(9)

Finally, the value of the recurrence time for state \( i \) is presented as follows:
\[
\tau_{ii} = \frac{1}{\pi_i}, i = 1,2,\ldots,K
\]

(10)

We can be noted that the Markov Chain is time homogeneous, ergodic and stationary.

**4 Data and variables analysis**

**4.1 Data**

Our data include the monthly financial stress index and stock market return for the 
following MENA countries (Egypt, Bahrain, Jordan, Morocco, Kuwait, Oman,
Qatar, Saudi Arabia and United Arab Emirates). The dataset used to construct Financial Stress Index (FSI) is based on observations retrieved from Datastream covering the period from January 2007 to December 2021. The study period is very sensitive and important. This period is marked by turbulent events such as: the global financial crisis (2007-2009), the Arab Spring, the Oil crisis and more recently, the COVID-19 health crisis.

4.2 Variables definition

4.2.1 Financial stress index

The construction of financial stress indices for MENA region has been done and introduced in a recent study (Soltani et al. 2021). Several major events in the economic history of the MENA region can be identified when analyzing the temporal evolution of this index. Indeed, Fig. 2 presents the evolution of the financial stress index for the MENA region during the period 2007-2021. We show that financial stress has been on an upward trend since the start of the Subprime crisis (2007–2009) for most countries and a remarkable decrease after this crisis for Egypt, Kuwait, Morocco, Qatar, Saudi Arabia and the United Arab Emirates. In exception, for Jordan, the stress index was very volatile during the period 2013-2016, which can be justified by the political instability experienced by this country. Another trend to consider is the Arab Spring, during this episode; the financial stress index has reached a high level in some countries. We notice another significant episode of financial stress, which coincides with the COVID-19 pandemic.

Fig. 2 Evolution of financial stress indices for MENA region

![Evolution of financial stress indices for MENA region](image-url)
4.2.2 Stock market return

Figure 3 depicts the monthly evolution of stock market returns. We note a decrease for most MENA stock market returns during the global financial crisis. In fact, during this crisis, the returns of most MENA stock markets fell sharply and peaked negatively, except Egypt. Moreover, another episode that needs to be taken into account which is the Arab Spring, the stock market index returns have been very volatile in Egypt, Morocco, Tunisia and Turkey. In addition, a decrease of the stock return index of Kuwait, Qatar, Saudi Arabia, and the United Arab Emirates was noted in 2015, which is justified by the crude oil prices drop. Further, a decrease of the stock return index of all MENA countries was noticed in the end of 2019, which can be explained by the COVID-19 pandemic.

4.2.3 Volatility

Figure 4 plots the volatility of stock market indices. During the subprime crisis 2007-2009, the graph illustrates high volatility, reaching a peak in all financial markets. This remarkable variation is an expected result that is automatically justified by the effect of contagion between the American market and the MENA markets. Moreover, there were moderate peaks of volatility around the end of 2010 and mid-2011, which can be explained by the uprising of the Arab Spring. It reveals also an increased volatility during the oil crisis of 2014-2015, particularly in Bahrain, Jordan, Kuwait, Qatar, Saudi Arabia and United Arab Emirates. In recent times, there were also high peaks in volatility around the end-2019, which can be attributed to the health crisis related to COVID-19.

In the bulk of the literature, it was indicated that the recurrence of financial crises and crashes would create market vulnerability and uncertainties. These uncertainties usually damage domestic and global economies (Salisu and Akanni 2020).
In previous work, researchers indicated that uncertainty was one of the important factors influencing investment decisions (Zhu et al. 2021). As a result, uncertainty needs to be incorporated in the decision making process.

5 Empirical results and interpretations

5.1 Quantile regression results

We employ the Quantile Regression to explore the effect of monthly financial stress indices on the stock market returns in the lower-upper quantiles. The following table shows the results of the Quantile Regression model, in which the stock market return is the dependent variable and the financial stress is the independent variable. Indeed, the estimation results show that the estimated coefficients differed according to the quantiles. As for the impact of the financial stress on stock market returns, our results show that it was significant and negative at the 1% level from the lower to upper quantiles for most MENA countries. Further, the financial stress has no impact on certain indices, no effect on the last two quantiles of Bahrain, the quantile90 for Qatar, the quantiles 80 and 90 for Saudi Arabia, Egypt and Turkey with the 70 also. Interestingly, regarding stock market returns, financial stress appears to have highest predictive abilities at the lower quantiles of 0.1 to 0.3 when the market is bearish. In the intermediate quantiles of 0.40 to 0.50, the financial stress again appears to cause stock market returns. This observation is in line with the findings of Soltani et al., (2021).
5.2 Transition matrix estimation for different MENA stock markets

Table 1 shows the monthly transition probability matrices for the stock market indices. Indeed, the probability of transition embodies the possibility that the return movement of the stock market index may remain in the original regime or move to another regime. These probabilities of movements during a certain period can be expressed in the form of a square transition probability matrix (P) (eq. (7)).

The transition probabilities define the change in the stock market regime. The values on the diagonal represent the persistence of the state which is the probability of remaining in a particular market regime. Besides, we have transition probabilities for three states $p_{11}$, $p_{22}$ and $p_{33}$ with 1 expressing bullish stress (S1), 2 defining bearish stress (S2) and 3 identifying calm stress (S3).

The probabilities $\hat{p}_{ij}$ are calculated using the formula (eq. (8)) $\hat{p}_{ij} = \frac{\hat{\pi}_{ij}}{\hat{\pi}_{ii}}$, $i, j = 1, 2, \ldots, K$. For example, for the Bahrain stock market $\hat{p}_{12} = 0.077$, $\hat{p}_{22} = 0.206$ and $\hat{p}_{21} = 0.031$.

Given the matrix $\hat{p}_{ij}$, we can conclude from Table 2 that the three conditions of the Markov Chain are satisfied: the transition matrix is irreducible ($\hat{p}_{ij} > 0$ for all $i, j = 0, 1, 2, \ldots, K$), non-zero and aperiodic. Furthermore, using the definition of ergodicity, it follows that the Markov Chain transition probability matrix is ergodic.

The results show that the probability of transition from bearish to calm stress is essentially zero for the Oman financial market. In addition, the transition probability from the bullish to the calm regime is too small for the financial market of Bahrain, United Arab Emirates and Egypt. Also, findings show that in the majority of markets in the MENA region, the probability of going from a bullish state to a bearish state $p_{12}$ is generally higher than the probability of going from a bearish regime to a bullish regime $p_{21}$. Although, the results related to the transition matrix shows a persistence of a downward stress regime on all the economies of the MENA region. Indeed, the probabilities in the diagonal of the transition matrices for the stock market indices are 0.793 in Bahrain, 0.896 in Kuwait, 0.938 in Saudi Arabia, 0.923 in Egypt, 0.987 in Jordan and 0.757 in Tunisia.

While, there is an empirical literature like Prajogo (2011) which showed that the transition probability matrix could be used to determine the property of the regime changes behavior. We can conclude that the transition probability from calm to bullish is almost low for most of the financial markets of Bahrain, Kuwait and Egypt. Moreover, by applying two Markov-switching and one threshold vector autoregressive models, Duprey et al. (2017) concluded that information from the Country-Level Index of Financial Stress (CLIFS) are associated with industrial production to identify those episodes of financial market stress that are related with a substantial negative impact on the real economy.

In summary, the impact of financial stress on the prediction of return on stock market indices in the MENA region is conditional on the state of regime. This finding is consistent with previous studies (He et al. (2021), Zhang and Wang (2021)), showing that there are complex influences on stock market performance and financial market stress.
5.3 Steady state probabilities

From Table 3, we conclude that the effect of financial stress on stock market index returns in MENA countries is quite different when comparing the bull market and the bear market. Taking the example of Bahrain for which the expected conditional duration of this effect in state 1 (bullish stress) and in state 2 (bearish stress) is 0.077 and 0.207 months, respectively. Further, in Tunisia, the stock market return rebounded, in the state of bullish stress (S1) once in each 0.150 months and in the state of bearish stress (S2) once every 0.242 months and so on during the study period. Consequently, the expected durations provided in state 2, is 0.207 months in Bahrain, 0.103 months in Kuwait, 0.061 months in Saudi Arabia, 0.956 months in Saudi Arabia, 1 month in Oman, Qatar and United Arab Emirates, 0.076 months in Egypt, 0.012 months in Jordan, 0.242 months in Tunisia and 0.892 months in Turkey. For this reason, it means that the market operates under the same conditions in these markets. We also pointed out that the duration of the impact of financial stress on market returns is different. In addition, the expected duration of State 3 was 0.031 in Bahrain, 0.075 months in Kuwait, and 0.040 months in the United Arab Emirates, 0.931 months in Jordan, 0.913 months in Tunisia, and so on. Therefore, it may be useful to assess the expected duration of regimes to draw conclusions about the persistence of market regimes. In this context, we observed that state 1 has the longest duration for most Middle East and North Africa countries.

The conclusions drawn from the monthly expectations of the three states are as follows: Kuwait, Egypt, Morocco and Turkey (Bahrain and Qatar) financial markets have the highest duration for the bullish state (bearish state). Approximately, the impact of financial stress on the stock market return for Saudi Arabia, Jordan and Tunisia took longer time to go back to the calm stress state (S3). Intuitively, all these financial markets are characterized by a strong persistence of calm regime conditioned by the financial stress index.

5.4 Features of stock market conditions

Table 4 tabulates the evolution of the estimated mean returns and standard deviation for MENA region under three states. The graph of each regime is indicated in fig. 5. In fact, we can notice that the estimated returns are the highest in the bearish state and become the lowest in the bullish state for most countries, whereas, it becomes larger in the calm market.

Indeed, as mentioned in the Table 4, in state 1, the mean return is positive for the majority of countries varying from 0.014 in Morocco to 0.095 in Oman. Interestingly, all MENA markets have been affected by the financial crisis 2007-2009. In line with this related occasion, we notice that Tunisia, Egypt, Morocco and Jordan were affected by 2010-2012 Arab revolutions. Moreover, the crude oil crisis affected all oil importing and exporting countries in the Middle East and North Africa (Saudi Arabia, Kuwait, Qatar and UAE) and more recently, the covid-19 pandemic, which dramatically slow down economic activity, increase uncertainty and consequently, affect conditions in financial markets. In fact, in a bearish financial stress (S2), the
mean return is negative for some countries. Whereof, during this regime, the Qatari investor can be considered as pessimistic and appears to sell and leave the market. Actually, these finding are explained by the fact that, the financial market dynamics is significantly affected during turbulent time (Nusair and Al-Khasawneh (2018) and Al-Maadid et al. (2020)).

Under the calm regime (S3), the mean return was positive for some countries. This signals proved that the returns were stable. For instance, the stock market of Qatar, Saudi Arabia, United Arab Emirates, Jordan, Morocco and Tunisia provides a negative return during this state. This sign can be justified by the sharp drop in oil price which is soared in all GCC countries in one hand and the COVID-19 pandemic in another hand.

Interestingly, bearish and calm states present the best investment opportunities as they enjoy effectively a positive mean return and they don’t have high probability for moving to the bullish state for most MENA countries. To conclude, our findings are of potential interest for portfolio management. In fact, detecting different stock market states can motivate investors to further enhance their investment decisions, especially predicting risk diversification.

The estimated mean returns trend for all MENA markets is plotted in Fig. 5 under three states. In a bearish market, the expected returns are higher, and in a bullish market, they are lower. As a result, the market stress and the predicted index returns have a nonlinear relationship. In fact, these findings explain why stock market returns have a negative association with positive financial stress as well as projected stock returns on the one hand, while a negative financial stress...
Table 1 The impact of financial stress on stock market returns

| Quantiles | GCC COUNTRIES | MENA EXCLUDING GCC |
|-----------|---------------|--------------------|
|           | BAHRAIN | KUWAIT | OMAN | QATAR | SAUDI ARABIA | UAE | EGYPT | JORDAN | MOROCCO | TUNISIA | TURKEY |
| Q 10 | −0.038865 | −0.069028 | −0.084181 | −0.111454 | −0.073095 | −0.138729 | −0.107862 | −0.035513 | −0.006213 | −0.048550 | −0.089450 |
|        | (0.0000)*** | (0.0000)*** | (0.0000)*** | (0.0000)*** | (0.0001)*** | (0.0000)*** | (0.0000)*** | (0.0000)*** | (0.0003)*** | (0.0000)*** | (0.0000)*** |
| Q 20 | −0.037490 | −0.063424 | −0.075685 | −0.092185 | −0.059663 | −0.091725 | −0.085894 | −0.031645 | −0.013004 | −0.042727 | −0.079380 |
|        | (0.0000)*** | (0.0000)*** | (0.0000)*** | (0.0000)*** | (0.0001)*** | (0.0000)*** | (0.0000)*** | (0.0000)*** | (0.4668) | (0.0000)*** | (0.0000)** |
| Q 30 | −0.032628 | −0.067557 | −0.058922 | −0.091135 | −0.054577 | −0.066968 | −0.077746 | −0.025266 | −0.012957 | −0.029266 | −0.072926 |
|        | (0.0063)*** | (0.0000)*** | (0.0000)*** | (0.0000)*** | (0.0001)*** | (0.0000)*** | (0.0000)*** | (0.0001)*** | (0.4953) | (0.0009)*** | (0.0001)*** |
| Q 40 | −0.026013 | −0.062235 | −0.053579 | −0.081249 | −0.045207 | −0.053470 | −0.073668 | −0.026632 | −0.012814 | −0.027699 | −0.069566 |
|        | (0.0266)* | (0.0000)*** | (0.0000)*** | (0.0000)*** | (0.0098)*** | (0.0113)*** | (0.0000)*** | (0.0001)*** | (0.6656)*** | (0.0090)*** | (0.0000)*** |
| Q 50 | −0.025424 | −0.061701 | −0.046972 | −0.063304 | −0.041128 | −0.051277 | −0.071511 | −0.024525 | −0.003505 | −0.023257 | −0.064353 |
|        | (0.0240)* | (0.0000)*** | (0.0000)*** | (0.0000)*** | (0.0192)*** | (0.0061)*** | (0.0000)*** | (0.0001)*** | (0.6656)*** | (0.0090)*** | (0.0000)*** |
| Q 60 | −0.018091 | −0.062407 | −0.044535 | −0.061539 | −0.051637 | −0.036331 | −0.072853 | −0.021141 | 0.000950 | −0.021953 | −0.056315 |
|        | (0.0280)** | (0.0000)*** | (0.0000)*** | (0.0000)*** | (0.0332)*** | (0.0344)*** | (0.0000)*** | (0.0002)*** | (0.5987) | (0.0152)** | (0.0016)** |
| Q 70 | −0.020826 | −0.054386 | −0.032810 | −0.060293 | −0.049897 | −0.048684 | −0.056050 | −0.020581 | 0.000225 | −0.019283 | −0.030345 |
|        | (0.0103)*** | (0.0001)*** | (0.0001)*** | (0.0000)*** | (0.0100)*** | (0.0150)** | (0.0005)*** | (0.0025)** | (0.9125) | (0.0113)** | (0.1832) |
| Q 80 | −0.022683 | −0.033693 | −0.035650 | −0.043303 | −0.030634 | −0.060319 | −0.040809 | −0.026747 | −0.000675 | −0.024595 | −0.026860 |
|        | (0.0064) | (0.0358)*** | (0.0015)*** | (0.0395)*** | (0.1083) | (0.0234)** | (0.3277) | (0.0002)*** | (0.7787) | (0.0016)*** | (0.1615) |
| Q 90 | −0.021229 | −0.039705 | −0.037217 | −0.025469 | −0.574E-05 | −0.082203 | 0.001410 | −0.036405 | −0.001597 | −0.028869 | −0.022924 |
|        | (0.1800) | (0.0263)** | (0.0000)*** | (0.3191) | (0.9989) | (0.0018)*** | (0.9568) | (0.0103)*** | (0.4183) | (0.0006)*** | (0.2220) |

Notes: Terms between parentheses represent the -t- student. ***, **, *, respectively represent the significance at the 1%, 5% and 10% level.
## Table 2  The monthly transition matrix for MENA stock markets

| GCC COUNTRIES | Bahrain | Kuwait | Oman | Qatar | Saudi Arabia | United Arab Emirates |
|---------------|---------|--------|------|-------|-------------|----------------------|
| **State1:** Bullish | 0.922 0.077 | 9.76E-10 | 0.684 | 0.076 | 0.239 | 1.64E-11 | 0.941 | 0.058 | 0.926 | 0.053 | 0.020 | 0.645 | 0.172 | 0.181 | 1.09E-16 |
| **State2:** Bearish | 2.10E-08 | 0.793 | 0.206 | 0.017 | 0.896 | 0.085 | 1.000 | 3.30E-34 | 0.000 | 1.000 | 3.95E-13 | 1.45E-10 | 0.061 | 0.938 | 1.54E-09 | 0.814 | 5.59E-17 | 0.185 |
| **State3:** Calm | 0.031 | 2.11E-11 | 0.968 | 0.030 | 0.044 | 0.924 | 0.060 | 7.23E-11 | 0.939 | 0.216 | 2.51E-11 | 0.783 | 1.000 | 1.7E-120 | 0.000 | 2.75E-12 | 0.959 |

| MENA EX GCC COUNTRIES | Egypt | Jordan | Morocco | Tunisia | Turkey |
|------------------------|-------|--------|---------|---------|--------|
| **State1:** Bullish | 0.813 | 0.186 | 2.11E-10 | 0.913 | 0.086 | 1.19E-09 | 0.517 | 0.222 | 0.260 | 0.850 | 0.025 | 0.124 | 1.87E-20 | 0.359 | 0.640 |
| **State2:** Bearish | 0.042 | 0.923 | 0.033 | 2.68E-25 | 0.987 | 0.012 | 0.151 | 0.606 | 0.151 | 0.152 | 0.757 | 0.090 | 0.891 | 0.108 | 1.14E-09 |
| **State3:** Calm | 0.034 | 0.092 | 0.872 | 0.581 | 0.350 | 0.068 | 0.126 | 0.215 | 0.658 | 0.356 | 0.556 | 0.087 | 0.297 | 0.628 | 0.074 |
Table 3  The steady state probabilities of financial stress of the stock market returns

| GCC COUNTRIES | Bahrain | Kuwait | Oman | Qatar | Saudi Arabia | UAE |
|---------------|---------|--------|------|-------|--------------|-----|
| State1: Bull-| 12.950  | 3.165  | 1.000| 1.000 | 1.000        | 1.000| 1.000 | 24.987 |
| ish          | 4.831   | 9.704  | 16.444| 13.598| 4.626        | 16.178| 1.000 | 1.000 | 1.000 |
| State2: Bear-| 32.173  | 13.313 | 0.060| 0.073 | 1.000        | 0.060| 0.216 | 0.061 |
| ish          |         |        |      |       |              |      |       |        | 1.000 |
| State3: Calm |         |        |      |       |              |      |       |        | 1.000 |
| π             | 0.077   | 0.031  | 0.075| 0.073 | 0.061        | 0.073| 1.000 | 0.216 | 0.354 | 0.040 |
| 1/π           | 0.077   | 0.031  | 0.075| 0.073 | 0.061        | 0.073| 1.000 | 0.216 | 0.354 | 0.040 |

| MENA EX GCC COUNTRIES | Egypt | Jordan | Morocco | Tunisia | Turkey |
|-----------------------|-------|--------|---------|---------|--------|
| State1: Bull-         | 5.373 | 11.526 | 3.296   | 6.691   | 1.095  |
| ish                   | 13.155| 78.720 | 2.928   | 4.125   | 1.000  |
| State2: Bear-         | 7.827 | 1.073  | 2.071   | 4.125   | 1.121  |
| ish                   |       |       |         |         |        |
| State3: Calm          | 11.526| 2.071  | 6.691   | 4.125   | 1.000  |
| π                      | 0.186 | 0.087  | 0.483   | 0.341   | 0.913  |
| 1/π                    | 0.076 | 0.012  | 0.031   | 0.031   | 0.892  |
|                        | 0.128 | 0.931  | 0.341   | 0.913   | 0.925  |
Table 4 The estimated mean return under three Markov State for MENA region

| Date | Bahrain | Kuwait | Oman | Qatar | Saudi Arabia | UAE | Egypt | Jordan | Morocco | Tunisia | Turkey |
|------|---------|--------|------|-------|-------------|-----|-------|--------|--------|--------|--------|
|      |         |        |      |       |             |     |       |        |        |        |        |
| BULLISH |         |        |      |       |             |     |       |        |        |        |        |
| 2007 | -0.444  | 0.218  | 0.128| -0.101| -0.034      | 0.347| 0.223 | 0.018  | 0.685  | 0.034  | 0.081  |
| 2008 | 0.154   | 0.272  | -0.002| -0.155| -0.254      | -0.558| -0.136| -0.375 | 0.578  | -0.233 | 0.028  |
| 2009 | -0.04   | -0.068 | 0.523| 0.538 | 0.543       | 0.117| 0.346 | -0.471 | -0.182 | -0.051 | 0.057  |
| 2010 | 0.02    | -0.036 | -0.09 | 0.039 | 0.143       | 0.32 | -0.047| 0.48   | -0.063 | 0.396  | 0.309  |
| 2011 | -0.095  | 0.146  | -0.183| -0.059| -0.06       | -0.433| -0.287| 0.309  | 0.082  | -0.129 | -0.342 |
| 2012 | 0.388   | -0.076 | 0.576| -0.011| -0.494      | 0.629| -0.096| 0.136  | 0.1     | -0.195 | -0.235 |
| 2013 | 0.467   | 0.252  | 0.087| 0.14  | -0.259      | -0.192| 0.338 | -0.144 | 0.061  | 0.489  | -0.289 |
| 2014 | 0.076   | 0.326  | 0.492| 0.188 | 0.479       | -0.038| 0.202 | 0.408  | 0.117  | 0.161  | -0.198 |
| 2015 | -0.596  | -0.59  | -0.252| -0.218| -0.103      | 0.369| 0.118 | 0.314  | -0.328 | -0.309 | 0.13   |
| 2016 | 0.482   | 0.308  | -0.054| -0.339| -0.465      | 0.082| 0.274 | -0.849 | -0.144 | -0.484 | 0.255  |
| 2017 | 0.174   | -0.143 | 0.115| -0.165| -0.22       | -0.123| -0.265| 0.111  | 0.14   | 0.34   | 0.209  |
| 2018 | -0.018  | -0.053 | 0.398| 0.557 | 0.006       | -0.035| -0.19 | 0.134  | -0.276 | 0.403  | -0.479 |
| 2019 | 0.262   | 0.045  | -0.159| -0.128| 0.238       | 0.023| 0.477 | 0.095  | -0.325 | 0.027  | 0.112  |
| 2020 | 0.375   | -0.23  | -0.195| 0.628 | -0.098      | -0.014| -0.167| 0.12   | -0.012 | -0.524 | 0.194  |
| 2021 | -0.159  | 0.457  | 0.034| 0.489 | 0.183       | 0.145| -0.596| 0.532  | -0.225 | -0.006 | -0.2   |
| Mean (2007_2021) | 0.07 | 0.055  | 0.095| 0.094 | -0.026      | 0.043| 0.013 | 0.055  | 0.014  | -0.009 | -0.024 |
| SDV  | 0.315   | 0.268  | 0.278| 0.317 | 0.304       | 0.307| 0.298 | 0.379  | 0.299  | 0.318  | 0.245  |
| BEARISH |         |        |      |       |             |     |       |        |        |        |        |
| 2007 | -0.148  | 0.592  | -0.41| -0.378| -0.427      | 0.784| 0.896 | 3.358  | -0.049 | 0.403  | 0.137  |
| 2008 | 0.547   | -0.893 | -0.31| -0.689| 2.663       | -0.611| 0.213 | 2.647  | 1.404  | -0.462 | 0.412  |
| 2009 | -0.941  | -0.421 | -0.746| 2.14  | 0.938       | 0.15 | -2.565| 2.834  | -1.014 | 0.506  | -0.061 |
| 2010 | 1291    | 2779   | 1152 | 1324  | -2.183      | -0.653| -0.287| 0.752  | 0.233  | -1.246 | -0.679 |
| 2011 | 0.983   | 0.004  | 1.25 | -1294 | -0.794      | 1366| -0.313| 1.304  | -2.271 | -0.608 | -0.018 |
| 2012 | -1388   | 0.903  | 1.297| -1999 | -0.969      | -1011| 4.229 | -0.361 | -0.142 | 0.06   | -1.037 |
| 2013 | 0.465   | -1.75  | 0.455| -0.101| -1.296      | 0.231| -2.302| -3.057 | 0.355  | -0.434 | -1.164 |
| Date | Bahrain | Kuwait | Oman | Qatar | Saudi Arabia | UAE | Egypt | Jordan | Morocco | Tunisia | Turkey |
|------|---------|--------|------|-------|--------------|-----|-------|--------|--------|--------|--------|
| 2014 | −1671   | 1739   | 0.581| 2207  | −0.415       | 0.609| −0.751| 0.616  | −0.073 | 0.514  | 0.656  |
| 2015 | 0.796   | −0.292 | −0.279| 0.46  | 0.527        | 1.03 | −0.225| 1.17   | 1024   | −0.993 | 2876   |
| 2016 | −0.981  | 0.742  | 0.999| −2.97 | 0.719        | 0.336| 2205  | −0.194 | −2891  | 0.592  | −2326  |
| 2017 | −1818   | −0.794 | −0.604| 0.747 | −1.79        | −3268| −0.126| 1434   | 1283   | −0.158 | −0.953 |
| 2018 | 1453    | −0.748 | 1396 | 0.805 | 0.497        | 1501 | −0.233| 0.621  | −1506  | 0.01   | 0.059  |
| 2019 | 0.935   | −0.644 | −0.978| −0.843| 1072         | 1.83 | −1971 | −2169  | −2.28  | 0.29   | 1426   |
| 2020 | −2759   | 0.487  | 1624 | 1184  | −2182        | −1.32| 0.349 | 0      | 0.689  | 0.204  | 0.641  |
| 2021 | −1217   | −0.409 | 2512 | −3151 | −2135        | 0.568| 0.612 | 0.511  | 0.221  | −2313  | −2774  |
| Mean (2007_2021) | −0.297  | 0.086  | 0.529| −0.171| −0.385       | 0.103| 0.001 | 0.631  | −0.334 | −0.242 | −0.187 |
| SDV  | 1321    | 1149   | 1036 | 1677  | 1435         | 1312| 1703  | 1717   | 1356   | 0.8    | 1407   |

| CALM |
|------|
| 2007 | −0.054 | 0.009 | −0.436| 0.045 | −0.786       | −0.653| 0.694 | 0.476  | −0.279 | 0.731  | −0.09  |
| 2008 | 0.205  | 0.887 | 0.409| −0.442| 0.607        | −0.744| 0.727 | −0.386 | 0.193  | 0.356  | 1416   |
| 2009 | −0.597 | 0.263 | −0.543| −0.3  | 0.356        | −1042| −0.01 | −1205  | −0.261 | 0.805  | 0.295  |
| 2010 | −0.167 | 0.325 | −0.039| 0.428 | −1571        | −0.602| 0.606 | −0.642 | −0.278 | −0.283 | 0.173  |
| 2011 | 0.819  | 0.005 | −0.732| −0.227| −0.291       | −0.079| 1.02  | −0.464 | −0.071 | 0.764  | −0.417 |
| 2012 | −0.046 | 0.36  | 0.493 | −0.302| 0.224        | −0.049| 1251  | 0.01   | 0.566  | −1146  | −1059  |
| 2013 | 1468   | −1077 | 1136 | −0.442| 0.419        | 0.218| 0.905 | 0.594  | −0.251 | −0.29  | 1284   |
| 2014 | −0.379 | 0.565 | −0.488| 0.242 | −0.82        | −0.145| −0.783| −0.881 | −0.175 | 0.445  | −0.12  |
| 2015 | −0.117 | 0.341 | 0.532| −0.17 | 0.89         | 0.408| 0.138 | 1047   | −0.434 | 1207   | 1648   |
| 2016 | −0.828 | 1175  | −0.576| 0.205 | −0.387       | 0.183| −0.341| −0.45  | 0.374  | 0.548  | 0.021  |
| 2017 | −0.142 | −0.582| −0.449| −0.134| −0.049       | −0.328| 0.133 | 0.271  | 0.273  | −0.556 | 0.287  |
| 2018 | 0.103  | 0.789 | 0.354| 0.066 | −1.53        | 1665 | −0.29 | −0.14  | 0.389  | −2119  | −0.218 |
| 2019 | 1028   | −0.682| −0.268| −0.172| −0.728       | −0.265| −0.04 | −0.684 | −0.341 | −0.217 | −0.458 |
| Date       | Bahrain | Kuwait | Oman  | Qatar   | Saudi Arabia | UAE   | Egypt | Jordan | Morocco | Tunisia | Turkey |
|------------|---------|--------|-------|---------|--------------|-------|-------|--------|---------|---------|--------|
| 2020       | 0.188   | 0.037  | 0.034 | −0.364  | −1089        | −0.717| 0.153 | −0.662 | 0.303   | −1083   | 0.473  |
| 2021       | 1323    | 0.113  | 0.713 | −0.702  | 0.739        | 0.336 | 0.271 | 0.39   | −0.497  | 0.528   | 0.181  |
| Mean (2007_2021) | 0.187 | 0.123  | 0.009 | −0.151  | −0.268       | −0.121| 0.296 | −0.182 | −0.033  | −0.021  | 0.228  |
| SDV        | 0.679   | 0.614  | 0.566 | 0.302   | 0.803        | 0.658 | 0.563 | 0.629  | 0.346   | 0.911   | 0.738  |
has a smaller impact on expected stock returns on the other. Nevertheless, the financial stress appears to have highest predictive abilities. Further, the results provided that financial stress would give rise to change investors’ portfolios, and this would influence the stock market dynamics. Indeed, the detection of different stock market states can help investors and portfolio managers to adjust their investment portfolios according to the financial stress states.

6 Conclusion

This paper attempts to explore the predictive power effect of the relationship between the financial stress and monthly stock market return in MENA region through three regimes, namely the bullish, the bearish and the calm stress for the period 2007-2021. We employ the Hidden Markov Model to estimate the transition matrix and the derivation of steady state probabilities.

Our fundamental findings is that the bullish state exists and persists, and has the longest conditional expected duration for the majority markets in the MENA region, except Bahrain, Qatar and Jordan. Interestingly, the transition probability from the bullish to the calm regime is too small for the financial market of Bahrain, United Arab Emirates and Egypt. Moreover, the estimated mean returns for each regime divulge that the bearish and calm states are more attractive destination for both portfolio managers and investors. About the power impact of turbulent period, the 2007-2009 financial crisis, the 2011 Arab Spring, the oil crisis and the COVID-19 pandemic, we verify that in all states these events have an adverse impact on almost MENA countries.

The findings of our research have important implications in economic and financial terms. In fact, the study proves that financial stress is considered as an important driver of stock market volatility and portfolio managers and investors try to deal with these challenges caused by financial market vulnerabilities. Indeed, they are invited to better understand the predictive effect of financial stress on market dynamics and the transmission of shocks in order to follow an exhausting path towards the adoption of new investment strategies that will hopefully improve the returns and mitigate the portfolio risk, while stock prices reveal extreme volatility. As it helps decision-making to exhibit an appropriate time reference to design a more reasonable arbitrage portfolio and improve risk-hedging strategies.

Declarations

Conflict of Interest None.

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