

Wavelet analysis for Arab stock markets Co-movements

التحليل الموجي للتحرك المشترك لأسواق الأوراق المالية العربية

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Abstract: This study aims to investigate the Arab stock markets co-movements among four countries (Jordan, Saudi Arabia, Egypt and Morocco) using the Wavelet coherence method to illustrate the level of interdependence between them from 2014 to 2018. The method of Wavelet coherence transforms time series data into a frequency that makes it easier to analyse the correlation between time series. The results show that EGX30 index have a strong interdependence with Casablanca index and Saudi index in the long term, and Amman index have a strong interdependence in the shorter term with EGX30 index and Casablanca index, the results show also that Saudi index have a slightly low correlation with Casablanca and Amman indices.

Keywords: Arab stock markets; co-movement; integration; wavelet coherence.

Résumé : Cette étude vise à étudier le Co-mouvement des marchés boursiers arabes pour quatre pays (Jordanie, Arabie Saoudite, Égypte et Maroc) en utilisant la méthode de cohérence en ondelettes pour illustrer le niveau d'interdépendance entre eux de 2014 à 2018. La méthode de cohérence en ondelettes transforme les séries temporelles dans des fréquences facilitant l'analyse de la corrélation entre chaque série temporelle. Les résultats montrent que l'indice EGX30 présente une forte interdépendance à long terme avec les indices de Casablanca et de l'Arabie saoudite et que l'indice d'Amman présente une forte interdépendance à court terme avec les indices EGX30 et de Casablanca. En revanche, les résultats montrent aussi que l'indice de l'Arabie saoudite présente une corrélation légèrement faible avec les indices de Casablanca et d'Amman.

Mots-clés : marchés boursiers arabes; Co-mouvement; l'intégration; cohérence en ondelettes..

ملخص: يهدف هذا البحث إلى دراسة التحركات المشتركة لأسواق الأوراق المالية العربية بين أربع دول (الأردن، المملكة العربية السعودية، مصر والمغرب) باستخدام طريقة تماسك الموجات لتوضيح مستوى ترابطها من عام 2014 إلى عام 2018. طريقة تماسك الموجات تحول السلاسل الزمنية إلى ترددات مما يسهل تحليل العلاقة بين فيما بينها. حيث أظهرت النتائج أن مؤشر EGX30 لديه ترابط قوي مع مؤشر الدار البيضاء والمؤشر السعودي على المدى الطويل، ومؤشر عمان لديه ترابط قوي على المدى القصير مع مؤشر EGX30 ومؤشر الدار البيضاء. ، على النقيض من ذلك، تظهر النتائج أن المؤشر السعودي يرتبط ارتباطاً طفيفاً مع مؤشرات الدار البيضاء وعمان. الكلمات المفتاح : الأسواق الأوراق المالية العربية؛ التحرك المشترك؛ التكامل؛ تماسك الموجات.

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I- Introduction :

The movement towards a synchronized stock market landscape has gained momentum, especially during the past two decades, where tighter economical and financial linkages among developed economies have grown stronger. However, the rises of many important emerging markets including Arab stock markets, which have been a major driver of global growth for the past decades, have opened up additional channels for cross-border relations. Other causes behind the rapid increase in world trade, capital movements, and foreign investments between world economies are due to market liberalization, technological advances and removals of statutory controls. To investigate the propensity of one country to be affected by global shocks have enormous value for preventing future crises. The extent of financial and economical integration between a country-pair may indeed be reflected by the degree of stock markets co-movement that they exhibit. This co-movement process brings out two issues addressed in the literature. The first issue is the measure of market integration. The literature suggests that an increase in integration leads to diminished benefits for investors who seek diversification through international investments. The second issue involves empirical studies of risk spillovers with financial contagion. It has been recognized that the convergence from market integration implies a higher possibility of volatility transmission since a shock in one country will lead investors to re-assess the risk of their portfolios in other countries.

From these general trends, we can ask the more specific question: **are Arab stock markets exhibiting stronger co-movement between them?**

In fact, a growing body of literature has emerged on studying the co-movement of international stock prices (King et al. (1994), Lin et al. (1994), Longin and Solnik (1995, 2001), Karolyi and Stulz (1996), Forbes and Rigobon (2002), Brooks and Del Negro (2005, 2006)). In particular, most of those studies have found that the co-movement of stock returns is not constant over time. Aviral Kumar Tiwari et al (2013) examined the integration of nine Asian stock markets using the new methodology of wavelet multiple correlation and multiple cross-correlation proposed by Fernandez (2012). This novel approach eliminates several limitations encountered when conventional pairwise wavelet correlation and cross-correlation are used to assess the co-movement of a set of stock indices. Their results show that Asian stock markets are highly integrated at lower frequencies and comparatively less integrated at higher frequencies.

António Rua and Luís C. Nunes re-examined such co-movement by resorting to a novel approach, wavelet analysis focusing on Germany, Japan, UK and US and the analysis is done at both the aggregate and sectorial levels. They have found that the strength of the co-movement in the time-frequency space varies across countries as well as across sectors. For instance, even though the Japanese stock market is generally weakly correlated with the other developed countries stock markets considered, there are some sectors (technology and consumer goods) displaying strong co-movements at particular frequencies and time periods. Finally, it was also found that the degree of co-movement has changed over time.

Bashar Abu Zarour in his PH.D. thesis investigated the dynamic relationships among Arab markets themselves, and how do other factors; such as oil prices, affect the performance of these markets especially for Gulf Cooperation Council (GCC) stock markets. To do that, Arab markets have been divided into two sub-groups: oil production countries (GCC countries) and non-oil production countries (Jordan, Egypt, and Palestine). The results indicate the existence of

long-run relation between markets, however, the short-run linkages still very weak. Non-oil countries' markets can offer diversification benefits for rich GCC investors. Moreover, oil prices found to have a significant effect on GCC markets and dominate the long-run equilibrium. Oil prices play a significant role in affecting GCC markets' volatility.

This analysis is of particular interest in the context of the study of stock markets co-movement as it is by now a stylized fact that the degree of co-movement has changed over time and because one should be able to take into consideration the distinction between the short- and long-term investor, that is, the frequency domain. In fact, with wavelet analyses one can take into account the time and frequency domains simultaneously.

I.1. Theoretical background of Stock markets integration

Globalization of the world stock markets is the most significant development of the last decade. Various factors contributed to this including the advancement of technology and remote access in security trading, the emergence of new international financial institutions offering financial services regardless of geographical jurisdictions, trends of liberalization and the removal of restrictions that used to be imposed on foreign ownership, the movement towards regional integration of stock exchanges, clearing and settlements organizations and other financial institutions. The globalization phenomenon may be a blessing, since many experts believe that globalization may improve market efficiency, lower its risk due to the possibility of diversification, and use arbitrage in a relevant way. On the other hand, it may increase pricing volatility and trading instability, due to the high correlation between leading - major- stock markets and other markets or due to irrational trading in one market that may spread to other markets as witnessed in the last two decades (P. Srikanth, 2012, p 204).

The stocks are listed and traded on stock exchanges which are entities of a corporation or mutual organization specialized in the business of bringing together buyers and sellers of the organizations to a listing of stocks and securities. The creation of regional bodies in recent times has brought about stock market mergers and integration (Agyapong, 2014, p 564). In recent years, research surrounding the presence and influence of global market integration continues to attract more attention and further developments. For sovereign markets and economies to be deemed as integrated, two prerequisites are necessary - the Law of One Price (LoOP) and an absence of arbitrage (Emils Seilis, 2018, p 10).

There are various definitions of financial markets' integration in the economic literature. A commonly held view is that financial integration occurs if potential market participants face the same set of rules, have equal access to financial instruments and are treated equally when they are active on the market. This process requires the opening of domestic financial markets and institutions to foreign players and permitting domestic subjects to access foreign markets, removing borders to capital flow, removing obstacles and discrimination of foreign players and harmonization of standards and laws. The above mentioned definitions identify financial markets integration with capital flow liberalization. Other authors claim that financial integration occurs if the law of one

price holds and similar financial instruments are traded at the same price. Therefore this study focuses on features of the financial markets which that one might describe as ‘weaker’ forms of integration than price equalization, namely increasing activity of domestic players on international financial markets (Sum, 2012, p 48).

Market integration has been defined by many studies either based on asset pricing or statistical perspectives. Jorion and Schwartz (1986) defined integration as a situation where investors earn the same risk-adjusted expected return on similar financial instrument in different national markets. With integration, the world market index should be mean-variance efficient and, as a result, the only priced risk should be the systematic risk relative to the world market. A complete integration of capital market should imply the absence of arbitrage opportunities. Using adjusted pricing errors for 49 stock markets, Hooy and Lim (2009) also found a positive association between market integration and informational efficiency (Bakri Karim, 2012, p 21-22). Also, the integration can be defined broadly as the increasing interdependence of regions, either within or across countries, as reflected in the flow of goods, services and/or factors of production. The process of integration requires the gradual elimination of economic frontiers and trade-restricting instruments between regions so that the mobility of goods, services and factors is not constrained. This process of ‘integration from below’ can be reinforced by ‘integration from above’, which entails the active promotion of economic cooperation between territories through appropriate policies or institutions (Groenewold, 2017, p 177).

The European Central Bank listed the characteristics that all market participants in a financially integrated market must possess:

- face a single set of rules when they decide to deal with those financial instruments and/or services.
- have equal access to the above-mentioned set of financial instruments and/or services; and
- are treated equally when they are active in the market.

I.1.1. Benefits from stock markets integration

Economic theory suggests that financial integration brings with it significant benefits, including lower costs of trading financial assets, more diverse investor portfolios, and more stable consumption patterns, particularly during periods when the level of economic activity fluctuates widely. Given the absence of restrictions on capital mobility, financial integration allows the level of domestic investment to no longer be constrained by the size of the domestic savings pool, since integration allows foreign capital to be used to underwrite domestic investment (Park, 2013, p 02).

- **International risk sharing for consumption smoothing:** Risk is shared among the countries when a country is allowed to access other countries’ capital markets. By being able to borrow capital during bad times such as when a country faces a recession, or lending capital during the good times like when a country economy is expanding, the risk is shared among those countries and the capital that flows through borrowing and lending helps smooth consumption. Especially if the nature of the shock is temporary, this ‘counter cyclical’ function of capital markets becomes quite important.
- **Better opportunities for investors and borrowers:** Through integration and increased competition, investors are offered with product and service innovation at a lower cost.

They can extend their portfolio diversification and can allocate their capital at the location where it is most productive. Regulation of cross-border traders and investment will be strengthened and regulators are able to offer greater protection for investors and increase their investment confidence.

- **Increased opportunities for less developed stock market:** Countries that are less developed in their capital market structure are often overlooked because they are usually small and only offer a few illiquid financial products and services. With the introduction of capital market integration plan, they will be less marginalized because of the new regulatory framework that they will have to follow, and as the market developed as a region, the more developed markets will help improve the less developed markets at a faster pace.
- **Increase banking system efficiency and financial stability:** Financial openness may increase the efficiency in the financial intermediary process, lower costs of investment and leads to higher growth. Capital can be allocated more efficiently from the fact that savings can flow more easily and at a lower cost. when foreign banks penetrate into the domestic market, the quality and availability of financial services will increase, country's access to capital will improve, domestic supervisory will develop therefore increase the domestic financial stability.

I. 1. 2. Costs of Stock markets integration:

Despite many benefits that could arise from stock market integration, there are potential costs and weaknesses to be considered as well. We can describe the costs that integration could bring as the following (Piumsombun, 2013, p 23-24):

- **Concentration in capital flows but lack of access:** The positive side would suggest that the region's financial integration could bring more inflows into less developed capital markets that would normally be overlooked. However, the potential cost taken from historical evidences of when markets integrate is capital tends to flow to a few countries that is relatively more developed. So even though the markets are integrated, the small economies would still not have the access to the funds
- **Herding, contagion and volatility of capital flows:** Financial openness might be associated with high level of volatility of capital movements. Capital flows in and out of the country from fundamental analysis and speculation, so investors' sentiments can constantly change from new information, thus markets have the potential to fluctuate excessively on a scale that can create financial crises. Volatility augmented from herding behavior and contagion effects. Herding, whether rational or irrational, results in a large movement of capital flows in or out of particular assets and worsens the asset price fluctuations. Contagion effects can occur when a country faces a sudden shock

that transmits that negative effect to the neighbouring countries or to the whole region. Indirect effects also come with competitiveness effects and terms-of-trade shocks.

I. 2. Overview of Arab stock markets:

Realizing their economic importance, most Arab countries have established stock markets. All these markets are continuous auction markets. In other words, any investor who wishes to trade in a security must do so through the agency of a stockbroker. The trading mechanism is continuous and strict price and time priority rules are followed. For any two or more buy (sell) orders, the order with the highest (lowest) price has the execution priority. Similarly, if two or more orders of the same type have similar prices, the order which is noted on the electronic trading board first has the execution priority. As they stand, the trading mechanisms of Arab stock markets are likely to suffer from one major weakness; lack of predictable immediacy. They simply channel the investors orders to the market place and provide related supporting services. The brokers thus do not take any position vis-à-vis the orders and do not need to commit their own capital. In other words, the absence of market-makers who stand ready and willing to buy at the bid price is likely to be a key factor in making Arab stock markets suffer from immediacy. This section will discuss the foundation of Arab stock markets with some economic background for each country including in this research, and shown financial data of some Arab indices in **Table (1)**.

Saudi stock exchange

The Saudi joint-stock companies started their business in the mid-1930s when the “Arab Automobile Company” was established as the first joint stock company in the Kingdom of Saudi Arabia. By 1975, there were 14 joint-stock companies. The market remained unofficial until 1984 when the Saudi Arabian Monetary Agency (SAMA) was entrusted with the task of regulating the market on a daily basis. Brokerage was limited to stock trading through commercial banks in order to improve the regulatory framework of trading. In 1984, the Saudi Share Registration Company (SSRC) was founded by commercial banks. It helped joint-stock companies in central registration. It also settled and cleared all stock operations. The electronic settlement and clearing system was introduced in 1989. One year later, the Electronic Securities Information System (ESIS) was developed and operated by SAMA. Tadawul, which is the new system for trading, clearing, and settling securities, went into operation in October 2001. In 2003, the Capital Market Authority (CMA) was established under the Capital Market Law (CML). The CMA serves as a government organization responsible for running and regulating the Saudi Capital Market, and it reports directly to the Prime Minister. The CMA has a legal personality and enjoys financial and administrative autonomy. It aims at regulating and developing the capital market in Saudi Arabia. Also, it has the power to set up and impose regulations and rules to protect investors and secure fairness and efficiency in the securities market (Elsheikh, 2017, p 30-31). The Saudi Stock Market is the largest Arab market in terms of market value or what is known as “Market Capitalization” and the daily traded volumes and rates. It also holds a very advanced place in the ranking of emerging markets. It is characterized by the small number of listed companies in the market given the large size of the Saudi economy. The volume of transactions in the market is considered relatively limited compared to the number of issued stocks. This can be defined as a tight market, which leads to large fluctuations in stock prices. A number of factors and variables effect the price of traded stocks on the market. They include domestic economic conditions, economic growth, as well as the problems the economy may suffer from like inflation and unemployment. The profitability of joint-stock companies and current developments in global stock markets also effect it as well as the domestic

economic policies in terms of expenditure and government expenditure on services and projects in addition to the amount of money and liquidity in the economy (Capital Market Authority).

Amman stock exchange:

Amman Financial Market started by the establishment of the few public shareholding companies where they set up their shares long before the setting up of the Jordanian Securities Market. In the early thirties, the Jordanian public already subscribed to and traded in shares; the Arab Bank was the first public shareholding company to be established in Jordan in 1930, followed by Jordan Tobacco and Cigarettes in 1931, Jordan Electric Power in 1938, and Jordan Cement Factories in 1951. The first corporate bonds were issued in the early sixties. As a result, an unorganized securities market has emerged in the form of non-specialized office. This prompted the government to contemplate the idea of setting up a market to regulate issuance of and dealing in securities, in a manner that would ensure safe, speedy and easy trading, and protect small savers, through a mechanism that would define a fair price based on supply and demand (Osama Samih Shaban, 2017, p 544). Amman Financial Market is considered one of the emerging markets, which was established in 1976. It started its operations on January 1st, 1978 and was run by a board comprised of the public and private sectors. Amman Financial Market suffers from many weaknesses such as: economical, legal, political and social conditions. The market management issued many regulations to improve the market performance and to solve the problems and stresses that face the market (Sattam Allahawiah, 2012, p 236).

The Amman Financial Market was a major step on the path of developing the financial sector in Jordan. It allowed the country to achieve the best utilization of available financial resources. The main objectives of the AFM were the followings (Marashdeh, 2006, p 102):

1. To mobilize savings by encouraging investments in securities, thereby channelling savings to serve the interests of the national economy.
2. To regulate and control the issuance of securities and dealings. This is to ensure the soundness, ease, and speed of transactions in accordance with the financial interests of the country.
3. To collect statistical data, that is important to achieve market objectives.

The ASE is managed by a board of directors and a full-time Chief Executive Officer (CEO) appointed by the board. The board consists of seven members, three of them including the chairman and deputy chairman are appointed by the JSC's Board of Commissioners and the other four members are elected by the ASE's General Assembly which consists of the Financial Brokers and Dealers and any other entities designated by the Board of Commissioners (AL-TAL, 2014, p 40).

The Egyptian stock market:

Formal stock market activity in Egypt began in 1888 when the Alexandria Stock Exchange was established while Cairo Stock Exchange was established in 1903. Cairo Stock Exchange became one of the most active markets in the world during the 1940's until a comprehensive nationalization program started in 1959 (Marashdeh, 2006, p 92).

The Egyptian stock market has experienced fundamental changes during four major periods from 1888-1958, 1959-1971, 1972-1992, and 1992-present. In the earliest phase, the market was active and growing out at a remarkable rate. By the 1940s, both the Cairo and Alexandria exchanges were very active, and the combined Egyptian stock exchange ranked fifth in the world in terms of overall market capitalization. However, in the second period from 1959-1971, the Egyptian stock market was seriously marginalized by government intervention and restrictions that left it effectively inoperable. In the third period (1972-1992), serious attempts were made to revive the failing stock market to no avail, and the stock exchange continued to stagnate. Finally, in the 1990s, the Egyptian stock market went through a significant revival due to government liberalization policies. The restructuring of financial markets and privatization programs were key elements in stimulating economic development and capital investment in 1990s (Zarour, 2006, p70).

Recent events in Egypt have had a notable impact on the volatility of the EGX and the level of foreign investment, which has rebounded in 2013. To stimulate capital to the market, the EGX is in the process of introducing the first ETF on EGX 30 index with a local investment firm. In addition, the management intends to conduct road shows in the Arab world to increase their investment in the Egyptian capital market.

Attracting investment to the EGX is a priority not only to address some capital flight that has occurred as a result of political instability in Egypt, but also to reduce ownership concentration. The market, as its competitors in the Arab world, is still characterised by high concentration of ownership due to the fact that companies are only required 10% of their equity but also the dominance of a few large firms in the overall market capitalization (OECD, 2014, p 75).

The Casablanca Stock Exchange

The Casablanca Stock Exchange in Morocco (CSE) was established in 1929, it is the third oldest stock market in Africa. The CSE was a state institution under the authority of the Ministry of Finance. The CSE was a broker/dealer market, dominated by the banking sector. It was characterized by a lack of transparency and small number of individual investors. The exchange was extremely illiquid as many stocks did not trade for several weeks. A major financial reform for the financial sector, simultaneously with the privatization program, took place in Morocco during 1993. One of the main objectives of the program was to make fundamental changes in the operations of the stock market. As a result of this program a dealer/market maker structure was created and a securities commission was established to ensure shareholder protection and the market maker became legally and financially autonomous. Also, as a result of reform there are no restrictions for foreign participation (Marashdeh, 2006, p 108).

The Casablanca Stock Exchange is committed to compliance with the highest international standards in order to provide its clients with high-quality services. To this end, the Casablanca Stock Exchange has renewed the certification of its Quality Management Systems (QMS) ISO 9001 and its Information Security Systems (ISMS) ISO 27001. The maintenance of international standards ISO 9001 and ISO 27001 allows the Casablanca Stock Exchange to stay abreast of market developments while meeting legal and regulatory requirements. In terms of developing its market

offering, the Casablanca Stock Exchange has introduced a foreign currency sub-fund. This will enable securities to be quoted in foreign currencies, including in the post-trade process, and be disseminated through various channels, as well as allow foreign stocks to be included in the MAD benchmark. This will, on the one hand, allow foreign companies to enter the Moroccan market to raise foreign currency funds and, on the other hand, attract capital from the Middle East, Asia and the West to Africa (TAWFIKI, 2017, p 20).

II– Data and Methodology:

II– 1 Data:

The data that will be used through this research consist of monthly prices of five Arab stock indices (Saudi Stock Market, Dubai Financial Market, Amman Stock Exchange , Egyptian Exchanges, Casablanca Stock Exchange), and the time period run from January 2014 to December 2018, This data have been collected from the following website: www.investing.com .

The study employs monthly data instead of higher frequency data to avoid the problem of non-synchronous trading. The daily and weekly data contain too much noise and are subject to the problem of non-synchronous infrequent trading.

II– 2 Methodology:

Wavelet is a signal decomposition technique. It is used to decompose (separate) the original time series into different timescales, by doing that and then studied them separately, we can show that the causal relationship differs depending on the timescale (Mansur Masih, 2013, p 06).

There are two kinds of wavelets: mother wavelets $\psi(t)$ and father wavelets $\varphi(t)$.

$$\int \psi(t)dt = 0, \quad \int \varphi(t)dt = 1.$$

The former are effectively represents the detail and high-frequency parts of time series, while the latter are good in representing the smooth and low-frequency components. Therefore, father wavelets used for the trend components and mother ones for all deviations from the trend. Unfortunately, except some special case, there is no analytical formula for computing a wavelet function. Wavelets are usually derived using special two-scale dilation equation. For a father wavelet $\varphi(t)$ a dilation equation has the following view (Gorovyy, 2009, p 09):

$$\varphi(t) = \sqrt{2} \sum_k l_k \varphi(2t - k)$$

A mother wavelet $\psi(t)$ is related to a father one by formula

$$\psi(t) = \sqrt{2} \sum_k h_k \psi(2t - k)$$

The coefficients l_k and h_k are defined as

$$l_k = \frac{1}{\sqrt{2}} \int \varphi(t) \varphi(2t - k) dt, \quad h_k = \frac{1}{\sqrt{2}} \int \psi(t) \varphi(2t - k) dt.$$

To analyze the co-movement level in the long run, we will use the Wavelet Squared Coherence (WSC) method introduced by Torrence & Compo (1998). The wavelet or frequency analysis over a time window is usually conducted with either Discrete Wavelet Transform (DWT), where the signal from corresponding wavelet coefficients is reconstructed by choosing a discrete subset, or Continuous Wavelet Transform (CWT), where a finite signal is projected into continuous frequency bands. In general, the latter proves to be more advantageous than the former in terms of the freedom to select the wavelets according to data length. The frequency bands are basically scaled versions of a frequency with scale 1. The mother wavelet function with function space $L^2(\mathbb{R})$ reconstructs the original signal data into frequency components for easier analysis. We choose the CWT approach because it is simpler in conveying the results, interpreting the outcomes and finding useful patterns. Time series data are basically transformed into wavelets with lengths based on the frequencies over the time period by using the CWT approach. The WSC is described simply as the ratio between the cross-spectrum and the product of the spectrum of each series. In other words, it is the correlation of frequency and time between time series.

The WSC can be defined as the squared value of the smoothed cross-wavelet spectrum that is normalized by the smoothed individual wavelet spectrum. When this value of the WSC is plotted as a coloured map, we can clearly distinguish the co-movement level at different time periods and different frequencies, and these results can be achieved only through wavelet transformation.

The mother wavelet or wavelet function characterizes the basic wavelet shapes (small waves) and covers the entire domain of interest. We use the wavelet transform instead of the Fourier transform for our analysis for two reasons. First, while the Fourier transform is also capable of converting information from time domain into the frequency domain, it exhibits wavenumber (frequency) information only. On the other hand, the wavelet transform is capable of exhibiting both spatial and wavenumber information, which are required for our comprehensive financial time series analysis. The wavelet transformation also has a special characteristic of avoiding being infinitely differentiable and allowing smoother interpolation. Various types of wavelets including Meyer wavelets, Poisson wavelets, Shannon wavelets, Mexican hat wavelets, and Morlet wavelets are often used in the past literature. Because we require a good balance between time and frequency emplacement to examine stock market interdependence, we will use Morlet wavelets since Morlet wavelets allow trade between time and frequency resolutions on an almost equal scale (Yonghong and othres, 2017, p 387-388).

Definition of the cross wavelet power of two-time series $x(t)$ and $y(t)$ is as follows:

$$W_{xy}(u, j) = W_x(u, j) \cdot W_y(u, j)$$

In this formula, $W_x(u, s)$ and $W_y(u, s)$ represent continuous wavelet transforms of time series $x(t)$ and $y(t)$. The star (*) signifies a complex conjugate, parameter u allocates a time position, and parameter j symbolises the scale parameter. A low wavelet scale denotes the high-frequency part of the time series – a short investment horizon. Whenever the time series exhibit a high common power, the cross-wavelet power reveals areas in the time frequency space. In the co-movement

analysis, we search for areas where the two-time series in the time-frequency space co-movement, but do not necessarily have high power. A useful wavelet technique for finding these co-movements is wavelet coherence (MENTES, 2019, p 375). The closer the value of wavelet coherence to 1, the stronger is the degree of synchronization between the time series $x(t)$ and $y(t)$, i.e. they are exhibiting stronger co-movement (Bogdanova, 2015, p 09).

III- Results and discussion :

To examine the co-movement level between each Arab stock market index in the long run, a wavelet analysis was conducted. This wavelet coherence approach is utilized to capture the interdependence across time and frequencies. The frequencies here signify the duration in days in which a movement in one variable affects the other variable in a specific time period. Since there are 4 time series in our dataset (Amman, Casablanca, Egypt and Saudi Arabia) and wavelet coherence is conducted in pairs, there are 6 coloured maps indicating the degree of interdependence.

Figure (01) shows the wavelet coherence between stock market indices of four Arab countries. Arrows indicate the phase difference, and it enables us to understand the details about delays of oscillation of the two examined time series. In figures, arrows have different meanings. Primarily, it shows that there is a correlation between the time series. But to understand the relationship more in detail, the direction of the arrow should be observed. For the positive correlation between series, the arrows point to the right. On the other hand, arrows to the left when there is a negative correlation and time series are anti-phase. And finally, when the arrows are pointing up means that the first time series leads the second one, an arrow pointing down indicates that the second time series lead the first one. The X-axis corresponds to a time scale and the Y-axis to the frequency scale. For a better understanding of the results, the frequencies are converted into time units where the finest scale corresponds to one month and the coarser scale – to five years. Additionally, the statistically significant coherencies are determined on the basis of Monte Carlo experiments and then they are contoured on the map.

When the wavelet coherence is valued close to “1”, it indicates higher correlation (illustrated by yellow colour in the figure), whereas when the values are near “0” (blue colour in figure) that represents low or no correlation. The significant area is shown as bordered with a dashed white line. The squared wavelet coherence coefficient can be regarded as a local linear correlation measure between two- time series in the time-frequency space.

It appears that the co-movement level of Amman-Casablanca and Amman-EGX30 (Egypt) pairs have a strong interdependence in the shorter term, ranging from 32 days to 128 days. It also appears that the EGX30-Saudi and EGX30- Casablanca pairs seem more balanced and their interdependence is stronger in the long term, We can see also that the Saudi-Amman and Saudi-Casablanca pairs shows a slightly lower correlation. Since the arrow direction is highly varied across frequency and time period, it is hard to tell the overall leading or lagging trend between countries' stock market index, but the trend, regardless of whether it is leading or lagging.

IV- Conclusion:

Market integration is central to both questions. In finance, markets are considered integrated when assets of identical risk command the same expected return irrespective of their domicile. In theory, liberalization should bring about emerging market integration with the global capital market, and its effect on emerging markets is then clear. Foreign investors will bid up the prices of local stocks with diversification potential while all investors will shun inefficient sectors. Overall, the cost of equity capital should go down, which in term may increase investment and ultimately increase economic welfare.

The empirical findings of this study indicate that some Arab stock markets are found to be integrated with each other, and some others are not. These empirical findings have several important implications in regards to portfolio diversification. This means that the potential of investors for obtaining abnormal profits through portfolio diversification is limited. The reason for this is that as Arab stock markets are co-integrated especially in the short term, abnormal profits will be arbitrated away in the short term. However, despite no arbitrage opportunities, investors can still achieve arbitrage profits through portfolio diversification in Arab markets in the long term.

Future empirical studies can expand the existing literatures on Arab stock markets integration by exploring multiple factors leading to market integration. For example, taking into account characteristics of each stock market and past trends may allow global investors to comprehend the factors that propel co-movement among stock markets. Understanding the integration level between stock markets will enable investors to calculate the risks and returns involved in each stock market with better accuracy.

Finally, Arab stock markets need a plan that put these markets in a position that able to attract portfolio investors, signs these markets as a target from foreign investors, and facilitates the integration and co-integration between Arab financial markets. This plan is therefore to enhance and develop Arab stock markets, increasing market liberalization, improving market efficiency, through increasing market liquidity and trading activities.

V- Appendices:

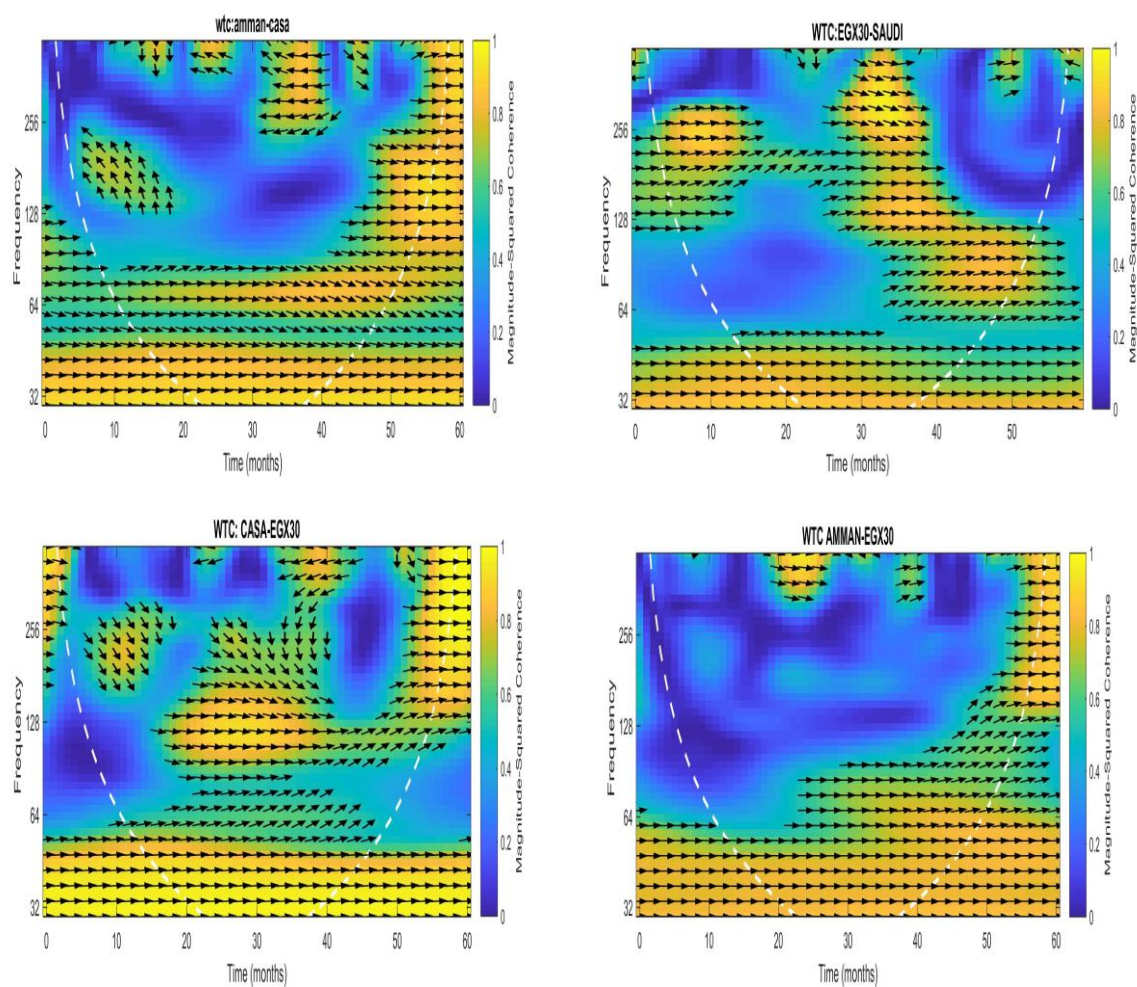
Table (1) : First Quarter 2019 data of Arab stock markets.

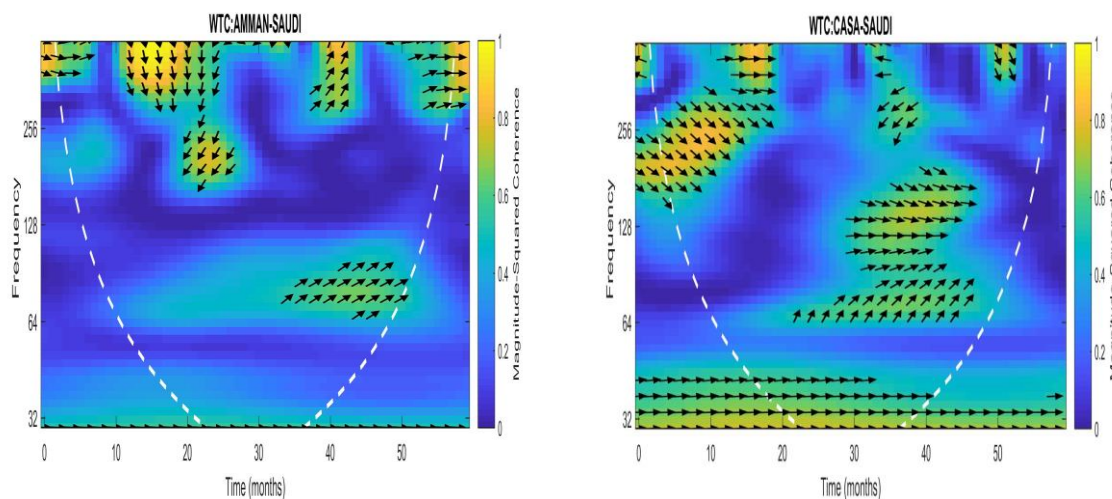
	Amman Stock Exchange	Saudi Stock Market	Egyptian Exchanges	Casablanca Stock Exchange
Number of Listed Companies	193	201	252	75
Market Capitalization In US Dollar (Million)	22,724.00	557,602.00	46,691.00	58,341.1
Trading Volume In US Dollar (Million)	499.00	47,214.00	4,405.00	894.2
Traded Shares (Million)	249.4	7,669.00	15,552	39.5
Number of trading days	62	64	61	62
Turnover ratio (%)	2.2	8	9.4	1.5
Number of new issues	2	3	0	-

Value of new issues (Million \$)	15.5	166	0	-
Local index	1,914.3	8,819.4	14,738	10,912.2
Change in index (%)	0.29	12.68	13.06	-3.98

The source: Arab monetary fund report.

Figure (1): wavelet coherence of Arab stock markets co-movement from 2014 to 2018.





The source: Prepared by researchers using MATLAB software.

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