Evolving and relative efficiency of MENA stock markets: evidence from rolling joint variance ratio tests

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Abstract

Multiple variance ratio tests, in rolling window procedure, were applied to weekly data (expressed in local and US dollar currencies) for five stock markets in the Middle East and North Africa during 1995-2009. Results indicated that the big and liquid stock markets of Israel and Turkey are ranked as the most efficient. The Egyptian and Moroccan stock markets converged towards efficiency by 2002, due to remarkable improvements in liquidity and information dissemination, whereas the Jordanian stock markets restored its efficiency at the end of the study period. Exchange rates did not matter in determining the dynamics of share returns for equity markets examined.

Resumen

Múltiples pruebas de cociente de varianza, con el procedimiento de desplazamiento de periodos (rolling window), se aplicaron a datos semanales (expresados en moneda local y dólares de los E.E.U.U.) para cinco mercados bursátiles en la región de Medio Oriente y África del Norte (MOAN), durante 1995-2009. Los resultados indicaron que los mercados bursátiles de Israel y

Turquía, grandes y con alta liquidez, están clasificados como los más eficientes. Los mercados egipcios y marroquíes convergieron hacia la eficiencia en el año 2002, debido a notables mejoras en la difusión de información y liquidez, mientras que el mercado jordano había restaurado su eficiencia al final del periodo de estudio. Los tipos de cambio no participaron en la determinación de la dinámica de las ganancias accionarias en los mercados de capital que fueron examinados.

Clasificación JEL: G14; G15.
Palabras Clave: hipótesis de caminata aleatoria; eficiencia del mercado de valores; pruebas de cociente de varianza, Bootstrap, Oriente Medio y África del Norte.

Introduction

According to Fama (1970), a market satisfies the weak-form efficient market hypothesis (WFEMH) if relevant information contained in historical prices is fully, rapidly, and correctly reflected into securities' prices. The WFEMH is a joint test of both the fair game property[1] and the validity of the market equilibrium model incorporated into the hypothesis. The common equilibrium-pricing model in tests of WFEMH is the hypothesis that expected returns are constant over time (Fama, 1991). The share price changes because of fluctuations in expected fundamentals. These fluctuations in expectations are, in turn, caused by the release of new information that arrives randomly. Hence, the price of a share is comprised solely of a permanent (fundamental) component which is represented by a random walk (RW) model with drift.

Lo and MacKinlay (1988) utilized the property that the variance of the RW is proportional to time interval and proposed their single variance ratio (VR) tests. However, their VR tests, which are based on asymptotic approximations, are biased (severe size distortions and low power) and right-skewed in finite samples, resulting in misleading statistical inference. Furthermore, it is customary in empirical work to investigate whether the VRs for several pre-determined holding periods are equal to unity. The null of the RW hypothesis (RWH) has to be rejected if it is rejected for some q

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[1]The WFEMH requires only two necessary conditions. First, it necessitates that the market is aware of all available and relevant information in the sense that it is not ignored. The second necessary condition asserts that the market correctly uses the available information in the sense that the expected return can be viewed as a fair game model in which no system of trading rules can reap higher expected returns than the equilibrium expected returns derived by the market. In other words, the actual returns can be randomly greater or lesser than expected returns, but on average, unexpected returns must be zero (Ahmed, 2011).

intervals. This sequential procedure results in an oversized testing strategy since the RWH requires that VRs for all aggregation intervals selected should equal unity. For this reason, several multiple VR (MVR) tests have been suggested to overcome these problems. Belaire-Franch and Contreras (2004) and Kim and Shamsuddin (2008), independently, developed MVR tests based on the exact rank and sign VR tests of Wright (2000) and the MVR test of Chow and Denning (1993). In addition, Kim (2006) introduced a wild bootstrap version of the MVR test of Chow and Denning (1993).

The current research is motivated by the inconclusive conclusion regarding testing for WFEMH in five of the Middle East and North Africa (MENA) countries, namely Egypt, Jordan, Morocco, Turkey, and Israel [as shown in table (1)]. Procedures and actions taken by these countries to enhance the role of their stock markets include: (1) relaxation (removal) of restrictions imposed on access of foreign investors to capital markets, (2) adopting automated trading systems [Egypt (2001), Jordan (2000), Morocco (1997), Turkey (1993) and Israel (1997)], and (3) regulatory reforms that include establishment of regulatory bodies to ensure shareholders' protection and to monitor market activities (Ahmed, 2013).

From table (1), one could identify the main reasons behind mixed conclusions regarding testing for the WFEMH in MENA countries under consideration. The first reason is using different data frequencies over wide range of periods. Moreover, traditional tests (e.g. serial correlation coefficients) depend on assumptions that are too restrictive to capture the patterns in share prices. Another important reason might be employing different tests with some of shortcomings (e.g. single VR tests). Furthermore, with the exception of Yilmaz (1999) and Ahmed (2013), all efficiency studies mentioned in table (1) tested for the WFEMH in an absolute sense, with an implicit assumption of efficiency being steady during the whole study period. In this context, a more relevant hypothesis to be tested in the case of emerging markets and markets under economic transition is how such infant markets converge towards efficiency since it takes time for the price discovery process to become known (Emerson, Hall and Zalewska-Mitura, 1997). Campbell, Lo and MacKinlay (1997) proposed the concept of relative efficiency, which is the efficiency of one market measured against another, indicating that it may be a more useful concept than all-or-none view investigated by majority of market efficiency literature. Lim and Brooks (2011) supported using VR methodology in overlapping sub-samples when testing for WFEMH to capture the gradual change in the level of efficiency through time, thereby it would be useful in identifying factors that lead markets to become (in)efficient. In addition, it may serve as a measure of constructing efficiency ranking because the main purpose of rolling window estimation is to measure how frequent the WFEMH is rejected during the

whole sample period where large percentage of rejections interpreted as an inferior degree of informational efficiency. Achieving and sustaining high levels of informational efficiency play a key objective for capital market development in emerging markets for three reasons.

First, the efficiency of the stock market in allocating capital to the most productive sectors of the economy crucially depends on its informational efficiency. A well-functioning stock exchange plays an important role for attracting foreign private investments and stimulating domestic savings leading to achieving higher rates of economic growth. Second, by serving as a conduit for improved corporate governance, unbiased market prices may be used as managerial incentives. Third, by conveying information through price signals, public confidence in market mechanisms improves, thereby decreasing risk premia for domestically listed firms (Ahmed, 2013).

Thus, the objective of the current research is to re-examine the issue of WFEMH for Egypt, Jordan, Morocco, Turkey and Israel from the beginning of 1995 until the beginning of 2011,[2] employing multiple VR tests, introduced by Belaire-Franch and Contreras (2004), Kim and Shamsuddin (2008) and Kim (2006), in rolling window procedure. By doing this, the issue of evolving market efficiency across time and relative efficiency of the employed countries are addressed. In this framework, factors leading to achieve market efficiency and/or events coincide with observable inefficiencies could be identified and, therefore, the issue of whether the recent American mortgage crisis [hitting the international financial markets by the second half of 2007] affected the efficiency of employed countries could be addressed. Financial crises characterized by panic and high levels of volatility and uncertainty are likely to adversely affect the ability of investors to efficiently price securities (Lim and Brooks, 2011). The analysis will be executed using weekly MSCI (Morgan Stanley Capital International) data denominated in both local and US dollar to introduce results from the perspective of local and international investors. The impact of exchange rate dynamics on testing for WFEMH is mixed. Patro and Wu (2004) concluded that inference on the RW is sensitive to currency denomination. However, Lagoarde-Segot and Lucey (2008) found that exchange rates do not matter in testing for WFEMH.

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[2] The study does not go beyond the first month of 2011 due to the problem of missing data arisen from closing Arab exchanges; specifically the Egyptian one, because of the turmoil accompanying the Arab Spring.

Table 1
Empirical research on testing for the WFEMH of MENA stock markets under consideration

Study	data	Methodology	Market	Main findings
Mecagni and Sourial (1999)	D: 1994 to1997	AR(1)-GARCH(p,q)-M	EGY	The significance of the AR(1) coefficient indicates departures from efficiency.
Smith, Jefferis and Ryoo (2002)	W: 1990-1998	CHODE	EGY, MOR among other MENA counties	EGY and MOR are not efficient.
Yilmaz (1999)	W: 1998-1998 Local-currency based data set.	CHODE in rolling window estimation.	TUR, ISR, JOR among other countries	All exchange markets moved towards efficiency by the end of the period
Al-Khazali, Ding and Pyun (2007)	W:1994 to 2003, US dollar-based dataset	R_1, R_2, S_1	EGY, JOR, MOR among other counties	Raw data for all countries were found violating the RW behaviour. However, they were found consistent with it after correcting for thin trading.
Buguk and Brorsen (2003)	W:1992 to 1999	LOMAC, R_1, R_2, S_1	TUR	LOMAC could not reject the null hypothesis whereas other tests reject the RW behaviour.
Haque, Hassan, Maroney and Sackley (2004)	W: 1988-2002	LB-Q, LOMAC, runs	EGY, JOR, MOR, ISR, among 10 MENA counties	EGY and MOR were found to be predictable whereas JOR and ISR were found to be efficient in pricing equities..
Lagoarde-Segot and Lucey (2008)	D: 1998 to 2004- local and US dollar datasets were employed	LOMAC, CHODE, WBCHODE, R_1, R_2	EGY, JOR, MOR, TUR ISR	According to LOMAC, CHODE, WBCHODE, the WFEMH was rejected for Egypt and Morocco but not for Jordan, Israel and Turkey, irrespective of the currency used. Reject the null for Egypt and Morocco when WBCHODE is employed. When R_1, R_2 were employed, the RW was rejected for Egypt, Jordan, Morocco, for both currencies and for Israel when series expressed in US dollar is employed.
Smith (2008)	W and M: 2000-2006	WBCHODE, JR_1, JR_2, JS_1	EGY, MOR, among 11 African exchange markets	EGY is efficient but MOR is not.
Ahmed (2013)	W: 1997-2007.	LOMAC, CHODE, WBCHODE, JR_1, JR_2, JS_1.	EGY	In the first sub-period, extends from 2nd of February 1997 to 21st of July 2002, the EGX imposed tight price limits on the movements of listed shares. Whereas in the second sub-period, stretches from 22nd of July 2002 to 29th of June 2007, the EGX shifted to adopt wide boundaries coupled with trading halt for a few minutes if share prices hit their new limits. The EGX, as whole, moved towards efficiency in the second sub-period indicating that the new circuit breaker regime facilitated the price discovery process. Inferential errors of using single LOMAC test when testing for the WFEMH has been highlighted.

Note: D= daily, W=weekly, M= monthly, LB-Q Ljung–Box Q statistic R_1, R_2, S_1 are rank, rank score, and sign tests of Wright (2000), WBCHODE=the wild bootstrapped version of CHODE test introduced by Kim (2006), JR_1 and JR_1 are joint rank tests of Belaire-Franch and Contreras (2004), JS_1 = joint signs test of Kim and Shamsuddin (2008). EGY=Egypt, JOR=Jordan, MOR=Morocco, TUR=Turkey, ISR=Israel.
Source: author's elaboration.

The remainder of the paper is organised as follows. Section 2 introduces the literature review whereas section 3 is devoted to present an overview of the MENA exchange markets under consideration with special reference to informational efficiency issues. Section 4 and 5 present econometric methodology and data, respectively. This would be followed by section 6 that presents the empirical results of the study. Finally, section 7 concludes.

1. Literature review

The RW model has two testable implications. First, stock returns are not predictable based on their own-past history. Second, the variance of return is linearly associated with the holding period. The former has been tested in the literature by examining serial correlation coefficients whereas the latter has been investigated using the VR tests. Since the literature investigating the RWH is voluminous, it is not feasible trying to cover it and, thus, the current review discusses only pioneer and recent studies. The first generation of studies prior to and during 1960s [Kendall,1953,[3] Cootner,1962; Fama, 1965; and Fama, 1970] supported the randomness of asset prices. However, departures from the RW behaviour in the early literature are statistically significant, it was concluded that such deviations were insignificant in economic terms, and, thus, the 'fair game' property of the EMH was not violated. In other words, the observed serial correlation in returns could not be employed to develop profitable trading systems. It is worth noting that the traditional tests [i.e. serial correlation coefficients and run tests] depend on assumptions that are too restrictive to capture the pattern in share prices. Accordingly, if stock price movements are more complicated than the RW model suggests, sophisticated methodologies are probably required to capture the deviation from the RW model.

Literature emerged since the second half of 1980s, employing more sophisticated econometric methodologies compared to those of the first generation studies, did provide support in favour of return predictability. Lo and MacKinlay (1988) employed their single VR test and presented evidence that the WFEMH is robustly rejected for the entire sample period (1962-1985) and for all sub-periods for variety of aggregate return indexes and size-sorted portfolios since positive serial correlation[4] is detected in return series over short horizons. They found stronger rejection of the RWH for equally weighted CRSP index than the value-weighted portfolios. Thus, they concluded that rejections are due largely to the behaviour of small stocks because the former was more sensitive to the behaviour of small stocks than the latter. In contrast to positive serial correlation detected at short-horizons by Lo and MacKinlay (1988), Poterba and Summers (1988) employed the single VR tests and reported evidence for mean reversion in returns on stock portfolios at long horizons.[5] These findings imply that investors were likely to benefit from employing investment techniques based on a contrarian strategy [i.e. buying stocks that have been out of favour for long periods of time]. Nevertheless, these findings are less robust than those of short-horizon

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[3] Kendall (1953) was the first to note the time dependence of the empirical variance (nonstationarity).

[4] The value of variance ratio was found to be significantly greater than one.

[5] The value of variance ratio was found to be significantly less than one.

predictability in returns. An important reason is that since long-horizon returns are measured over years, rather than days or weeks, there are far fewer data. Since the pioneer work of Lo and MacKinlay (1988), a variety of papers applying the single VR tests have found evidence of positive serial correlation at short-horizons for international equity markets [Claessens, Dasgupta and Geln, 1995; Haque, Hassan, Maroney, and Sackley, 2004; and Patro and Wu, 2004]. These results imply that traders were able to benefit from information contained in the past history of prices via employing momentum investment strategies.[6]

Given that the single VR tests tend to over-reject the null hypothesis of the joint test required when testing for RWH, scholars applied the MVR of Chow and Denning (1993) [e.g. Karemera, Ojah and Cole (1999) for 15 of emerging equity markets, Smith, Jefferis and Ryoo (2002) for eight African exchange markets, Jefferis and Smith (2004) for the South African Exchange, Smith (2007) for five MENA exchange markets] found evidence of short-horizon returns' predictability-based on past history. Other recent improvements to VR methodology (e.g. joint rank and sign tests of Belaire-Franch and Contreras (2004), Kim and Shamsuddin (2008) motivated scholars to re-visit the WFEMH for different countries [Smith (2009) for 10 European emerging markets, Al-Khazali, Dingand and Pyun (2007) for seven of MENA exchange markets, Smith (2008) for some African markets, Charles and Darné (2009) for Latin American exchange markets, and Lagoarde-Segot and Lucey (2008) for seven MENA exchange markets]. To conclude, the evidence of testing for WFEMH is still inconclusive and yields some contradictory conclusions even for the same country [e.g. results of Al-Khazali *et al.* (2007), Smith (2008) and Lagoarde-Segot and Lucey (2008) for the EGX)]. This could be attributed to the different frequencies employed and the period covered by the study. More importantly, all the above mentioned studies addressed the issue of WFEMH in an absolute sense assuming, implicitly, that the level of market efficiency remains unchanged during the entire sample period. It is reasonable to assume that the level of market efficiency changes due to changes in macro institutions, market regulations and information technologies (Lim and Brooks, 2011).

Another strand of literature concerned with factors affecting the market (in)efficiency addresses the issue by means of non-overlapping subsamples. Implementation of price limit system and financial crisis are among those factors that might hurt market efficiency. Price limits delay full incorporation

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[6] If equity returns are positively correlated over time, then a low (high) return in period t should imply a high likelihood that returns in period t+1 will also be low (high).Thus, traders are likely be able to take advantage of such information to improve their portfolio positions. Particularly, they can sell stocks that have recently performed poorly (losers) and buy stocks that have recently performed well (winners) in order to reap excess profits.

of information into prices (price discovery mechanism is delayed to the following days when prices hit their lower or upper limits) and, thus, prevent prices from reaching their equilibrium levels.[7] Chang and Ting (2000), Ryoo and Smith (2002), and Ahmed (2013) concluded that price limits adversely affect market efficiency in Taiwan, South Korea, and Egypt, respectively. The occurrence of financial crisis is likely to negatively affect market efficiency since, in times of financial turmoil characterized by panic, investors are probably unable to price securities efficiently (Yilmaz, 1999; Lim and Brooks, 2011). This concern motivated Hoque, Kim and Chong (2007) and Kim and Shamsuddin (2008) to explore the impact of the 1997 financial crisis on efficiency of eight emerging Asian equity exchange markets and Auer and Schuster (2011) to investigate the impact of the recent U.S. subprime mortgage crisis on international markets. Hoque *et al*. (2007) found that the crisis has not significant effect on the degree of efficiency since six of employed exchange markets showed signs of inefficiency in the pre- and post-crisis periods. Kim and Shamsuddin (2008) found that the MVR tests employed agreed that the stock markets of Taiwan, Hong Kong, and Japan were efficient in the pre- and post-crisis periods, yet, for the other six exchange markets, the effect of the financial turmoil is difficult to identify given that no agreement could be reached by the three tests employed. Auer and Schuster (2011), applying a battery of MVR tests for data of 55 countries (23 developed, 21 emerging and 11 frontier equity markets), concluded that the majority of developed and emerging markets were found to be efficient before and during the crisis whereas most of the frontier markets are not during the aforementioned periods.

Factors that may positively affect market efficiency include opening the domestic markets to foreign investors and the adoption of an electronic trading system. It is argued that the liberalization of a stock market improves the conditions for market efficiency since the number of market participants increases resulting in higher trading volumes and values which reflects greater tendency for securities' prices to incorporate important market information (Füss, 2005). Given that the majority of foreign investors are institutional investors with large portfolios, the cost of purchasing information is low relative to the sums they invest in these markets, thereby the equity portfolio inflows to emerging markets would result in an increase

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[7] The target of adopting price limits is to control daily volatilities of stock price movements via imposing price constraints in order to provide a cool-off period for rational reappraisal of investment decisions during times of overreaction and panic trading. Therefore, the main task of circuit breaker is to re-inform market participants, thereby facilitating price discovery mechanism. However, opponents of price limits assert that they are ineffective since they interrupt incorporation of information into prices which prevent prices from adjusting to their new equilibrium levels; thereby the price discovery mechanism is delayed to the following days.

in demand for information. In response to this, brokerage firms would be keen to allocate more resources to information gathering and processing. This, in turn, would increase the availability of information regarding individual stocks, sectors, and the whole economy to both international and local investors bringing the exchange closer to efficiency (Yilmaz, 1999). Kim and Singal (2000a, b) and Füss (2005) concluded that stock markets, in general, become efficient after allowing the participation of foreign investors. However, findings of Kawakatsu and Morey (1999a, b) revealed that employed emerging markets were consistent with the WFEMH even before the actual market opening date. Proponents of the positive impact of automation on market efficiency advocate that the execution process of trades becomes faster and less costly. Additionally, traders have access to broader information including bid and ask prices, and trading activities that occur at lower costs due to the existence of a limit order book. In Such computerized system, it is expected to attract more investors, boost trading volume and liquidity, and improve the price discovery process. Naidu and Rozeff (1994) found positive impact of automating the Singaporean Stock Exchange on its efficiency whereas Sioud and Hmaied (2003) found no evidence that automation has led the Tunisian exchange to become efficient.

It may be more reasonable to expect market efficiency to evolve over time in a dynamic manner that is likely not to be captured by an arbitrarily breakpoint as assumed by the approach of non-overlapping sub-periods (Lim and Brooks, 2011). To capture the possibility of smooth changes in market efficiency, Lim and Brooks (2011), Yilmaz (1999), Kim (2004), Kim and Shamsuddin (2008) advocated employing VR tests in a rolling window framework. Lim and Brooks (2011) pointed out that the application of a rolling window essentially helps in (1) capturing the persistence of stock price departures from a random walk benchmark over time, (2) allowing to assess the relative weak-form efficiency of stock markets where the market with lowest percentage of rejecting WFEMH is ranked as the most efficient, (3) identifying the events that coincide with periods of information inefficiency (e.g. financial crisis), and (4) determining the impact of postulated factors on the degree of market efficiency (e.g. financial liberalization).

2. Overview of the MENA exchange markets with special reference to informational efficiency issues

Literature identifies some factors that are likely to influence the informational efficiency of stock markets. These factors include accounting standards,

market size,[8] liquidity, financial liberalisation, improvements in microstructure (e.g. adopting automated trading system), quality of information and the speed it made available to market participants, and the enforcement of insider trading regulations (Jefferis and Smith, 2004;Yilmaz,1999; Smith, 2009; Füss, 2005). For example, Yilmaz (1999) concluded that emerging markets converge towards RW behaviour as they evolve through time from small, shallow and segmented markets into sizeable and liquid markets integrated with the world financial system. Disclosure of relevant information is a prerequisite for achieving reasonable degree of market efficiency (Füss, 2005). More importantly, the quality of disclosed information, and, hence, the market efficiency, depends on sound accounting laws and practices. Market liquidity[9] and size are of crucial importance to an investor's decision to invest in a particular market. Foreign and institutional investors are attracted to larger and more liquid stock markets since this ensures easy entry and exit from the market (Ahmed, 2011). Liquidity facilitates the price formation process; with more frequent trading, prices are likely to respond to new information quickly and, consequently, the market is more likely to be in agreement with the WFEMH (Smith, 2009).

To achieve international comparability in accounting disclosure, MENA countries have amended their national accounting standards to converge with the international set of financial reporting and accounting standards. Thus, all the countries under investigation, currently, pass the transparency criteria and other criteria of market quality set by FTSE (Ahmed, 2011). Regulatory framework that maximises equality among stock market shareholders is important to minimise the asymmetric information and, thus, to ensure market efficiency. The principle of equitable treatment of shareholders (e.g. prohibition of market manipulation and insider dealing) is partially implemented in Turkey[10] (OECD, 2006), partially observed in Egypt, largely observed in Jordan and materially not observed in Morocco[11] (Ahmed, 2011)

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[8] Market size is measured by the absolute value of market capitalization and/or its ratio to gross domestic product (GDP))

[9] Market liquidity could be viewed as the degree to which large transactions can occur in a timely fashion with minimal impact on prices.

[10] It has been assessed as Partly Implemented, primarily for the following reasons: the definition of insider trading is relatively narrow, it is difficult to prove some elements(OECD, 2006)

[11] According to OECD assessment of corporate governance principles, largely observed= only minor shortcomings are observed, which do not raise questions about the authorities' ability and intend to achieve full observance in the short term, Partially observed= while the legal and regulatory framework complies with the principle, practices and enforcement diverge., and Materially not observed = it means that, despite progress, shortcomings are sufficient to raise doubts about the authorities' ability to achieve observance.

whereas it has been successfully implemented in Israel (Israel Securities Authority, 2008)

Regarding the main financial indicators for MENA exchange markets under consideration, market capitalization of all exchanges continued to grow during 1995−2007, and then it sharply dropped in 2008 influenced by the American subprime mortgage crisis. Istanbul Stock Exchange (ISE) of Turkey and Tel Aviv Stock Exchange (TASE) of Israel have the biggest market size in terms of absolute market capitalization. In 2004, for example, market capitalization of ISE and TASE were US $ 98.3 billion and US $ 95.05 billion, respectively, which is approximately more than twice that of the EGX, three times that of Casablanca Stock Exchange (CSE of Morocco) and five times that of Amman Stock Exchange (ASE of Jordan). The ratio of market capitalization to GDP, which reflects the stock market size as a percentage of the country's economic activity, provides deep insights into the capital market size. Generally speaking, Jordan has the highest ratio of market capitalization to GDP through the whole period reaching its peak (232%) in 2007 whereas Turkey has the lowest percent of financial depth during the period under examination. The rank of Egypt and Morocco is approximately the same during the period under examination with Israel ranked the second. In 2006, for example, the market capitalization to GDP ratio reached 118.83%, 86.97%, 75.2% and 30.59% for Israel, Egypt, Morocco and Turkey, respectively. Regarding the number of listed companies, Egypt has the largest number in 2002 (1148) which declined significantly to reach 305 in 2009. This could be explained by the fact that the number of companies that were de-listed, because they did not comply with the new listing requirements of 2002, exceeded the number of the new listed companies. It is worth mentioning that the large number of listed companies in the EGX up to 2002, most of them were infrequently traded, could be attributed to the tax advantages of being listed in the stock exchange as listed companies benefited from tax exemption equivalent to the value of paid-in capital times interest rate determined by the Central Bank of Egypt. By the end of 2009, Israel ranked first with 609 listed companies, followed by Turkey (315), Egypt (305), Jordan (272) and Morocco (78), respectively (Ahmed, 2011).

Market liquidity could be measured by the value traded, the ratio of value traded to GDP, and the turnover ratio (the value of share traded divided by the market capitalization) that measures the activity of market relative to its size. A small but active stock market will have a high turnover ratio whereas a large, but less liquid stock market will have a low turnover ratio. Exchange markets under examination have experienced booms in their activities which are reflected in the exponential increase in values of traded stocks by approximately 7666%, 2523%, 1110.7%, 373.8%, 863.9% for Egypt, Jordan,

Morocco, Turkey, and Israel, respectively. With regard to the percent of value traded to GDP, it witnessed improvements for all countries during the study period with Turkey and Israel ranked the first and the second until 2001when the Jordanian exchange percent starts to have three-digit. According to the turnover ratio, ISE is the most liquid exchange during the whole period with three-digit percent, TASE ranked second whereas other markets lagged behind them, however, their liquidity has significantly increased from 12.33%, 28.89% and 6.38% in 2003 to 60.07%, 40.3%, and 45.73% in 2009 for Egypt, Jordan and Morocco, respectively (Ahmed, 2011).

3. Methodology

Campbell *et al*. (1997) classified the RW with drift into three models: (1) Random Walk 1 model (RW1) in which price increments are independently and identically distributed (IID), (2) Random Walk 2 model (RW2) relaxes the assumption of identical increments but still keeps the assumption of independence, and (3) Random Walk 3 model (RW3), also known as martingale difference sequence (MDS), relaxes the independence assumption to accommodate stylized facts of financial series such as volatility clustering by allowing for ARCH effects. The VR methodology exploits the fact that the variance of the RW increments is linear in all sampling intervals. In other words, if the natural logarithm of share price at time,p_t, is a RW then the variance of its q-differences grows proportionally with the difference q. Thus, the variance of q-period returns (i.e. $Var(a_t^q)$ where $Var$is the variance operator) is q times the variance of one period returns (i.e. $Var(a_t)$), which could be expressed in (1).

$$\frac{Var(a_t^q)}{Var(a_t)} = q \tag{1}$$

Accordingly, the VR for lag q, VR(q) expressed in (2), could be defined as the ratio of the variance of q-period return to q times the variance of one-period return, should be equal unity for any holding period q.

$$VR(q) = \frac{1}{q}\frac{Var(a_t^q)}{Var(a_t)} = 1 \tag{2}$$

To illustrate the VR methodology, consider that the logarithm of price series, p_t follows the RW with drift process.

$$p_t = \mu + p_{t-1} + \varepsilon_t \text{ or } \Delta p_t = a_t = \mu + \varepsilon_t \tag{3}$$

Where μ is the drift parameter, $E[\varepsilon_t] = 0$, $E[\varepsilon_t, \varepsilon_{t-g}] = 0$ for $g \neq 0$ for all t. Consider a time series with asset returns, a_t where t=1,2,…,T, the VR of Lo and MacKinlay (1988), using overlapping q-differences, is given by[12] (4)

$$VR(q) = \left\{ \frac{1}{Tq} \sum_{t=q}^{T} (a_t + a_{t-1} + \cdots + a_{t-q+1} - q\hat{\mu})^2 \right\} \div \left\{ \frac{1}{T} \sum_{t=1}^{T} (a_t - \hat{\mu})^2 \right\}$$
$$\tag{4}$$

Where $\hat{\mu} = T^{-1} \sum_{t=1}^{T} a_t$.

To test for RW1 and RW3 models, Lo and MacKinlay (1988) introduced two test statistics, expressed in (5) and (6), which are asymptotically distributed as standard normal, under assumptions of homoscedasticity (IID random walk assumption) and heteroscedasticity (under their assumption H^*), respectively.[13]

$$Z_1(q) = [VR(q) - 1] \left[\frac{2(2q-1)(q-1)}{3q(Tq)} \right]^{-1/2} \sim N(0,1), \tag{5}$$

$$Z_2(q) = [VR(q) - 1] \left[4 \sum_{j=1}^{q=4} \left(1 - \frac{j}{q}\right)^2 \delta_j \right]^{-1/2} \sim N(0,1) \tag{6}$$

Where

$$\hat{\delta}_j = \frac{\sum_{t=j+1}^{T} (a_t - \hat{\mu})^2 (a_{t-j} - \hat{\mu})^2}{\left[\sum_{t=1}^{T} (a_t - \hat{\mu})^2 \right]^2} \tag{7}$$

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[12] The null hypothesis is that VR*(q)*=1, and the alternative hypothesis is *VR(q)≠*1. If the null of RW is rejected and VR*(q)>*1, then positive first order correlation does exist in return series and, hence, variances of returns grow faster than linearly (mean aversion). If the null is rejected and VR*(q)<*1, then negative first order correlation is detected in return series and, hence, variances of returns grow slower than linearly (mean reverse).

[13] Testing for independence without assuming identical distributions is quite problematic for time series data. If no restrictions are imposed on how the marginal distributions of the underlying data can vary through time, it would be almost impossible to perform statistical inferences because the sample distributions of even the most elementary statistics cannot be derived.

The aforementioned test statistics have two limitations. First, they test the hypothesis that an individual VR is one; however, the null hypothesis requires VR(q) = 1 for all q. Therefore, the approach of Lo and MacKinlay (1988) may be misleading as it tends to over-reject the null hypothesis of a joint test. It may involve much larger Type I error than the nominal level of significance. Second, the sampling distribution of the test statistics was found to be far from normal in finite samples, showing severe bias and right skew. These finite sample deficiencies may give rise to serious size distortions or lower power, which can lead to misleading inferences. This is especially true when the sample size is not large enough to justify asymptotic approximations (Charles and Darné, 2009).The remedy of the first weakness is proposed by Chow and Denning (1993) who showed that the joint test can be carried out by comparing a set of variance ratio estimates with unity and by treating the above mentioned test statistics as Studentized Maximum Modulus variates. The null hypothesis to be tested is $MVR(q_i) = 1$for $i = 1, ..., m$against the alternative hypothesises that $MVR(q_i) \neq 1$for some i. Accordingly, the null of RW (i.e. IID or MDS sequences) should be rejected if the MVR is significantly different from one for some i . Chow and Denning (1993) defined their test statistics as follows:

$$MZ_1 = \max_{1 \leq i \leq m} |Z_1(q_i)| \tag{8}$$

$$MZ_2 = \max_{1 \leq i \leq m} |Z_2(q_i)| \tag{9}$$

Where MZ_1 and MZ_2 are test statistics, introduced by Chow and Denning (1993), under the assumption of IID and heteroscedasticity respectively, and $Z_1(q_i)$ and $Z_2(q_i)$ are defined in (5) and (6), respectively. The second limitation has been approached in different ways by Wright (2000) who generated test statistics which have exact distributions under the null hypothesis. Given T observations of asset returns $\{a_1, a_2, ... a_T\}$and that $r(a_t)$ is the rank of $a_t$among a_t´s, Wright (2000) defined two standardised random variables r_{1t} and r_{2t} as follows:

$$r_{1t} = \left[r(a_t) - 0.5(T + 1)/\sqrt{[(T - 1)(T + 1)/12]} \right]$$

$$r_{2t} = \Phi^{-1}[r(a_t)/(T + 1)] \tag{11}$$

Where Φ is the standard normal cumulative distribution function.

The series r_{1t} is a simple linear transformation with a sample mean of zero and a sample variance of unity whereas the series r_{2t}, known as the inverse normal, has zero mean and approximately unit variance. Wright (2000) derived VR-based rank test statistics by replacing these transformations of the ranks in the expression of VR(q) given in (4), and, thus, the tests statistic $Z_1(q)$ given in (3) can be expressed as follows:

$$R_1(q) = \left(\frac{(Tq)^{-1} \sum_{t=q}^{T} (r_{1t} + r_{1t-1} + \cdots + r_{1t-q+1})^2}{T^{-1} \sum_{t=1}^{T} r_{1t}^2} - 1 \right) \left(\frac{2(2q-1)(q-1)}{3qT} \right)^{-1/2} \quad (12)$$

$$R_2(q) = \left(\frac{(Tq)^{-1} \sum_{t=q}^{T} (r_{2t} + r_{2t-1} + \cdots + r_{2t-q+1})^2}{T^{-1} \sum_{t=1}^{T} r_{2t}^2} - 1 \right) \left(\frac{2(2q-1)(q-1)}{3qT} \right)^{-1/2} \quad (13)$$

Under the null hypothesis that a_t is generated from an IID sequence $r(a_t)$ is a random permutation of numbers of 1,2,..., T with equal probability, thus, the exact sampling distributions of R_1 and R_2, given by (12) and (13) respectively, may easily be simulated to an arbitrary degree of accuracy. In other words, the process involves computing $R_1(q)$ and $R_2(q)$ for a large number of permutations of $r(a_t)$, say 10000, and observing the empirical distribution of the obtained series to compute p-value for two-tailed test.

$$\left(\frac{(Tq)^{-1} \sum_{t=q}^{T} (r_{1t}^* + r_{1t-1}^* + \cdots + r_{1t-q+1}^*)^2}{T^{-1} \sum_{t=1}^{T} r_{1t}^{*2}} - 1 \right) \left(\frac{2(2q-1)(q-1)}{3qT} \right)^{-1/2} \quad (14)$$

$$\left(\frac{(Tq)^{-1} \sum_{t=q}^{T} (r_{2t}^* + r_{2t-1}^* + \cdots + r_{2t-q+1}^*)^2}{T^{-1} \sum_{t=1}^{T} r_{2t}^{*2}} - 1 \right) \left(\frac{2(2q-1)(q-1)}{3qT} \right)^{-1/2} \quad (15)$$

Where: $r_{1t}^* = \left[r^*(a_t) - 0.5(T+1)/\sqrt{(T-1)(T+1)/12} \right]$,
$r_{2t}^* = \Phi^{-1}[r^*(a_t)/(T+1)]\{r^*(a_t)\}_{t=1}^{T}$ is any permutation of 1, 2, ..., T each with equal probability.

Wright (2000) derived a sign-based test statistic S_1, given in (16), under the assumption of MDS returns permitting conditional heteroscedasticity (Assumptions A_1 and A_2 in Wright (2000) and that the drift parameter $\mu=0$). This is based on the IID series S_t which has mean zero and variance one. If returns, a_t, are positive then each S_t is equal to 1 with probability 0.5 otherwise S_t equals -1 with probability 0.5 as well.

$$S_1(q) = \left(\frac{(Tq)^{-1} \sum_{t=q}^{T} (s_t + s_{t-1} + \cdots + s_{t-q+1})^2}{T^{-1} \sum_{t=1}^{T} s_t^2} - 1 \right) \left(\frac{2(2q-1)(q-1)}{3qT} \right)^{-1/2} \tag{16}$$

The exact sampling distribution of S_1 is given by (17), and the critical values of the test can be obtained by simulating its sampling distribution. The null hypothesis is rejected if observed R_1, R_2 and S_1 are greater than their corresponding values obtained from simulation.

$$\left(\frac{(Tq)^{-1} \sum_{t=q}^{T} (s_t^* + s_{t-1}^* + \cdots + s_{t-q+1}^*)^2}{T^{-1} \sum_{t=1}^{T} s_t^{*2}} - 1 \right) \left(\frac{2(2q-1)(q-1)}{3qT} \right)^{-1/2}$$

$$\tag{17}$$

Where $\{s_t^*\}_{t=1}^{T}$ is an IID sequence, each element of which is with probability 0.5 and -1 otherwise. In the spirit of the methodology of Chow and Denning (1993), Belaire-Franch and Contreras (2004) and Kim and Shamsuddin (2008) extended single rank and sign tests of Wright (2000) to the multiple rank and sign tests. Thus, applying the procedure proposed by Chow and Denning (1993), individual rank and sign test statistics expressed in (12), (13) (16) could be extended to joint tests (JR_1, JR_2 and JS_1 respectively) by computing each test statistic for m different values of q and selecting the one with the maximum absolute value as follows:

$$JR_1 = \max_{1 \leq i \leq m} |R_1(q_i)|$$

$$JR_2 = \max_{1 \leq i \leq m} |R_2(q_i)|$$

$$JS_1 = \max_{1 \leq i \leq m} |S_1(q_i)|$$

The ranks-based procedures are exact under the IID assumption whereas the signs-based procedures are exact under both the IID and MDS assumptions (Charles and Darné, 2009). The exact sampling distributions of JR_1, JR_2 and JS_1 are given by (21), (22), and (23) respectively.

$$\max\{|R_1^*(q_1)|, |R_1^*(q_2)| \cdots |R_1^*(q_m)|\}$$

$$(21)$$

$$\max\{|R_2^*(q_1)|, |R_2^*(q_2)| \cdots |R_2^*(q_m)|\}$$

$$(22)$$

$$\max\{|S_1^*(q_1)|, |S_1^*(q_2)| \cdots |S_1^*(q_m)|\}$$

$$(23)$$

However, the approach of Chow and Denning (1993) possesses asymptotic test statistics whose sampling distribution is approximated based on its limiting distribution. For this reason, Kim (2006) employed the wild bootstrap which is applicable to data with unknown form of unconditional and conditional heteroscedasticity, to approximate the sampling distribution of MZ_2 given in (9). The wild bootstrap test based on MZ_2 can be conducted in three steps. First, generate a bootstrap sample of T observations $a_t^* = \eta_t \cdot a_t (t = 1, \cdots, T)$ where η_t is a random sequence with zero mean and unit variance. Second, calculate MZ_2^* that is the MZ_2 statistic in (9) obtained from the wild bootsrap sample generated in the first stage. Third, repeat the aforementioned steps sufficiently many, say *m*, times to create the wild bootsrap distribution of the test statistic $\{MZ_2^*(j)\}_{j=1}^m$ The wild bootstrap distribution $\{MZ_2^*(j)\}_{j=1}^m$ is used to approximate the sampling distribution of the MZ_2 statistic. The *p*-value of the test is estimated as the proportion of $\{MZ_2^*(j)\}_{j=1}^m$ greater than MZ_2 statistic calculated from the original data. In implementing the wild bootstrap test, a specific form of η_t should be chosen. In the current research, the standard normal distribution for η_t is used as Kim (2006) reported that other choices provide qualitatively similar small sample results.

To study the unknown power properties of JS_1 test, Kim and Shamsuddin (2008) conducted a Monte Carlo simulation to compare its power properties with MZ_2 and MZ_2^* Their Monte Carlo results indicated that MZ_2^* and JS_1 tests are good alternatives in testing for the MDS of a financial return. They found that both tests maintain desirable power properties with longer holding periods, although there is tendency that the power of the tests gets, to a degree, lower with longer holding periods. According to their Monte Carlo results, these new VR tests have superior small sample properties to MZ_2. It

is worth mentioning that MZ_2^* has higher power than JS_1 particularly when the underlying return series follows an AR(1) or long memory model with GARCH(1,1) errors; relative power is reversed when the underlying return series has a stochastic volatility term. When both MZ_2^* and JS_1 tests are carried out on one series there are four possible outcomes (Smith, 2008): (1) neither test rejects its null hypothesis, in which case it is inferred that the returns series is an MDS; (2) both tests reject the null and, thus, the series of returns is not an MDS; (3) JS_1 rejects and MZ_2^* does not reject; the series is an MDS satisfying Assumption H* of Lo and MacKinlay (1988); and (4) JS_1 does not reject and MZ_2^* rejects; the return series is an MDS satisfying Assumptions A1 and A2 of (Wright, 2000).

4. Data

Weekly data of MSCI indexes for Egypt, Morocco, Jordan, Turkey, and Israel employed in the current study was collected from Data Stream. Lo and MacKinlay (1988) recommended using weekly data to avoid biases inherent in daily series.[14] To examine the presence of exchange rate effects on test of financial asset dynamics, data denominated in domestic and US$ currencies is employed to introduce results from the perspective of domestic and international investors. From the perspective of foreign investors, the performance of stock markets using common currency is what matters since foreign stocks are assets comprise both the local currency stock index and the dollar/local currency exchange rate. This combination, thus, accounts for any stock market changes that are in fact induced by exchange rate movements, which would be important to foreign investors. In other words, some movements of the equity price indexes are likely to be reflection of the foreign exchange exposure of listed firms. Stock prices denominated in the common currency implicitly represent the sum of the returns on two assets: the domestic stock index and the domestic currency. The study period starts from 4th of January, 1995 to 5th of January, 2011. The data points are associated with Wednesdays, however; those associated with Tuesdays are employed if the markets under consideration are closed in Wednesdays.

5. Empirical results

Following Kim (2004), the rolling window procedure is applied in a fixed window size of 260 observations (equivalent to 5 year of employed weekly

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[14] Biases inherent in daily data include the biases associated with non-trading, asynchronous prices, and the bid-ask spread.

data, assuming each year has, on average, 52 weeks). To detect the smooth change in the level of informational efficiency on a monthly basis, the MVR analysis is conducted using the first 260 observations corresponding to the first sub-period; then the sample is rolled 4 points forward, eliminating the first 4 observations, performing the VR tests for the new window and repeat this procedure until the end of the series. For the sample period considered here, return series for an index a_t includes 836 observations. Thus,

Sub-period 1: $a_1, a_2, a_3, ..., a_{260}$
Sub-period 2: $a_5, a_6, a_7, ..., a_{264}$
$\vdots$
Sub-period 145: $a_{577}, a_{578}, a_{579}, ..., a_{836}$.

Accordingly, there are 145 overlapping sub-samples for each index. The RW behaviour of each index is tracked across these sub-periods and the market with the highest percentage of rejecting WFEMH would be classified as the least efficient, in contrast to, the market with the lowest percentage of rejections would be ranked as the most efficient.

Table (2) presents statistical descriptions of local and US dollar-based data in panels A and B respectively. For of local-currency based data, the average weekly return in Turkey is more than twice that of Egypt, around four times that of Israel and Morocco, and around fifteen times that of Jordan. For a measure of risk, Turkey has the highest sample standard deviation which is around one and half, twice, more than twice, and around three times as that of its counterparts in Egypt, Israel, Jordan and Morocco respectively. Accordingly, Turkey has the highest approximate Sharpe ratio, a measure of risk-adjusted performance, followed by Morocco, Egypt, Israel, and Jordan.

The relative ranking of mean returns is not maintained for exchange rate-adjusted data as Egypt comes with the highest mean return followed by Turkey, Morocco, Israel, and Jordan. On a risk-adjusted basis, Morocco has the largest Sharpe ratio followed by Egypt, Israel, Turkey and Jordan. Domestic investors, with the exception of Morocco, would obtain higher risk-adjusted returns than would international investors.

All return series denominated in both local and US dollar currencies are significantly left-skewed and exhibit excess kurtosis. Therefore, the unconditional normality is soundly rejected by Jarque-Bera (JB) statistics beyond 1% level of significance. There is also evidence of autoregressive conditional heteroscedasticity in weekly returns according to the ARCH test.

Table 2

Descriptive statistics of local and US dollar-based weekly equity returns of MENA countries

Descriptive statistics	Panel (A): statistical description for the local currency-based data				
	Egypt	**Jordan**	**Morocco**	**Turkey**	**Israel**
Mean	0.00318	0.00045	0.00180	0.00657	0.00171
Std. Dev.	0.040	0.0267	0.0223	0.0623	0.0306
Skewness	-0.526*	-0.5770*	-0.321*	-0.2430	-0.3310*
t-statistic(1)	(-6.261)	(-6.869)	(-3.821)	(-2.892)	(-3.940)
Kurtosis	6.604*	8.928*	8.070*	5.257*	5.172*
t-statistic(2)	(21.257)	(34.965)	(29.905)	(13.312)	(12.811)
J-B statistic	490.49	1269.27	908.808	143.1843	179.419
[p-value]	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*
Standardised returns(3)	0.0795	0.0168	0.0807	0.1054	0.0555
ARCH test(4)	53.61	135.41	18.07	28.00	77.97
p-value	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*
Descriptive statistics	Panel (B): statistical description for the US dollar-based data				
	Egypt	**Jordan**	**Morocco**	**Turkey**	**Israel**
Mean	0.00257	0.00044	0.00186	0.00219	0.00160
Std. Dev.	0.0411	0.0264	0.0247	0.0706	0.0328
Skewness	-0.571*	-0.6299*	-0.2707*	-0.5404*	-0.3481*
t-statistic(1)	(-6.797)	(-7.498)	(-3.222)	(-6.433)	(-4.144)
Kurtosis	6.643*	8.642*	7.705*	4.958*	5.163*
t-statistic(2)	(21.488)	(33.279)	(27.752)	(11.549)	(12.758)
J-B statistic	507.376*	1160.12*	780.711*	174.146*	179.698*
[p-value]	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Standardised returns(3)	0.0625	0.0166	0.0753	0.0310	0.0487
ARCH test(4)	53.92*	157.92*	61.23*	40.90*	57.53*
p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Notes: (1)t-statistic, between parentheses, is calculated as $t = (S' - 0)/SE(S')$, where S' is value of skewness coefficient of certain index, 0 is the value of skewness coefficient for a normal distribution, and $SE(S')$ is the standard error of the estimated skewness coefficient which calculated as the square root of 6/n, where n is the number of observations. (2) t-statistic, between parentheses, is calculated as $t = (K' - 3)/SE(K')$, where K' is value of kurtosis coefficient of certain index, 3 is the value of kurtosis coefficient for a normal distribution, and $SE(K')$ is the standard error of the estimated kurtosis coefficient which calculated as the square root of 24/n, where n is the number of observations. (3) Standardised return (or the approximate of Sharpe ratio), providing a measure of the return-risk profiles of the equity markets employed, is computed as the average of mean return of each series divided by its standard deviation. Unlike the standard Sharp ratio, computed as an asset's excess return divided by the asset's standard deviation, the approximate Sharpe ratio is computed as each series' mean return divided by the series standard deviation. * , ** indicate that the null hypothesis should be rejected at 1% or less and 5% or less level of significance respectively. (4) Testing for conditional heteroscedasticity is based on Lagrange Multiplier principle test. Consider the null hypothesis of no ARCH errors versus the alternative hypothesis that the conditional error variance is given by an ARCH(q) process. Number of lags considered is 4.
Source: author's own calculations.

First, before proceeding to apply the rolling window analysis, MZ_2^*, JR_1, JR_2, and JS_1 tests are executed using the full sample for 2, 4, 8, and 16 week-holding periods[15] for both local and dollar-based datasets, (see table 3). From table (3), the Turkish and Israeli stock exchanges are found to be consistent with the WFEMH irrespective of the employed test or currencies as the null could not be rejected at any conventional level of significance. According to MZ_2^* the Jordanian, the Egyptian, and the Moroccan exchange markets are consistent with the WFEMH from the perspective of both domestic and international investors. It may be too early to draw a concrete conclusion regarding the behaviour of stock prices in Egypt, Jordan, and Morocco as it is likely that the rejection of the WFEMH in the whole sample is driven by the behaviour of equity prices in earlier times of the employed sample. Conversely, the incapability of rejecting the WFEMH in the case of Turkey and Israel for the whole period under investigation does not necessarily indicate that the behaviour of their equity prices is consistent with the RW throughout the study period.

Table 3

Results of joint VR tests of local and US dollar-based weekly equity returns of MENA countries

Test employed	Panel (A): Results for the local currency-based data				
	Egypt	**Jordan**	**Morocco**	**Turkey**	**Israel**
MZ_2^* -p value	0.069	0.1223	0.3425	0.7167	0.7957
JR_1- p-value	0.0002*	0.0067*	0.0001*	0.5190	0.4042
JR_2 -p-value	0.0017*	0.0031*	0.0004*	0.8225	0.4388
JS_1 p-value	0.0004*	0.0004*	0.0000*	0.1717	0.2195
Test employed	Panel (B): Results for the US dollar-based data				
	Egypt	Jordan	Morocco	Turkey	Israel
MZ_2^* -p value	0.0331*	0.1106	0.1162	0.7788	0.4611
JR_1-p-value	0.0001*	0.0063*	0.0004*	0.8804	0.4845
JR_2-p-value	0.0003*	0.0035*	0.0001*	0.8323	0.3546
JS_1-p-value	0.0069*	0.0008*	0.0000*	0.3815	0.7370

Note: number of both wild bootstrap MZ_2^* and Monte Carlo simulation (of JR_1, JR_2, and JS_1) was set to 10000 replications. *, ** indicate the rejection of the null at 1% (or less) and 5% (or less) respectively.
Source: author calculations

To track the evolution of efficiency across time, the above mentioned tests are executed for the aforementioned time horizons with moving sub-sample window, where the number of replication for both wild bootstrap and Monte

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[15] For weekly data, widely-used holding periods are q=2, 4, 8, and 16 [see for example Lo and MacKinlay (1988)].

Carlo simulation is set to 10000. If the *p*-values of employed tests are less than 5%, the null hypothesis has to be rejected at 5% level of significance for that period. Plots of *p*-values of $MZ_2{}^*$, JR_1, JR_2, and JS_1 for Egypt, Jordan, Morocco, Turkey, and Israel are displayed in Figures (1) through (5) in the appendix, respectively. In each figure, panel (A) introduces the results of domestic currency-based datasets whereas panel (B) presents exchange rate-adjusted data sets. It is worth mentioning that the *p*-values of each test are plotted against the last time points of moving sub-samples windows.

The behaviour of the Egyptian exchange did not satisfy the WFEMH in earlier periods, approximately up to 2002, but the WFEMH could not be rejected by, almost all tests, as the observations pertaining to earlier periods are dropped from the window. This is in line with the conclusion drawn by (Ahmed, 2013) where the inefficiency of the EGX up to the end of 2002 could be explained by many reasons. These reasons include (1) tight symmetric price limits of ±5% imposed on daily movements of stock prices as they delay price discovery process, (2) limited information available to market participants about corporations' development due noncompliance with mandatory disclosure requirements, (3) and information asymmetry among market participants because of selective disclosure[16] and self-dealing.

The EGX convergence towards efficiency is a reflection of the growth in its size and liquidity, the relaxation of price limits and stipulating the trading halt mechanism,[17] and remarkable improvements in the infrastructure and environment of trading such as the new automated trading system, shortening the duration of financial settlements, and allowing for trading on margin and market maker activities. What is more, corporate governance standards in Egypt have witnessed considerable improvement, between 2001 and 2004 (World Bank, 2001; World Bank, 2004; Fawzy, 2003).

According to $MZ_2{}^*$ and JS_1 test which are robust for heteroscedasticity, the CSE of Morocco moved towards efficiency by the end of 2002. Before 2002, the CSE was characterized by a lack of transparency (local accounting standard were employed), small number of individual investors, and extreme

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[16] Selective disclosure takes place when corporate insiders provide some important information to selected group of people (e.g. certain investors or analysts) without making this information available to the public, which creates potential insider trading. Consequently, informed investors are likely using such information in trading at the expense of less informed investors.

[17] Starting from 22nd of July 2002, the EGX expanded the price boundaries imposed on daily movements of listed shares which are accompanied by applying trading halt for a period of 30 minutes, 45 minutes or until the end of the trading session if the weighted average price of stocks hit the limits of ±10%, ±15% or ±20% respectively, when compared to their opening prices.

illiquidity represented by non-trade of many stocks for several consecutive weeks (Ghysels and Cherkaoui, 2003; Ahmed, 2011). Extensive series of reforms, deregulations and privatization have taken place in recent years which has been reflected in the market size and liquidity (Ahmed, 2011). For example, the market capitalization ratio to GDP jumped from 24.09% in 2001 to 100.36% in 2007. Similarly the value of stock traded to GDP and turnover ratio increased from 2.58% and 9.74% in 2001 to 34.93% and 42.09% in 2007, respectively. Important reasons that are likely to cause the CSE move towards efficiency include adopting the international accounting standards, improvements in the information dissemination process (e.g. the CSE created its own website to provide market participants with information regarding corporate developments on timely basis). For this reason, it has passed the criteria of transparency and market depth information set by FTSE for stock market quality (Ahmed, 2011).

The Jordanian exchange was efficient in pricing equities up to the end of 2005. Periods of inefficiencies are detected since then, however; the duration of these periods differs from one test to another. The Jordanian exchange was overvalued by the end of 2005 because of spillover effect from oil-producing regional neighbours (i.e. Saudi Arabia and Kuwait) experiencing sharp increase in oil prices. However, a process of price correction took place when Arab investors from Gulf countries had withdrawn considerable funds from the ASE to cover their financial positions in their domestic markets after the sharp decline in stock prices in Saudi Arabia and other Gulf stock markets[18] (Saadi-Sedik and Petri, 2006).

Results of the Turkish and Israeli stock exchange markets are not surprising since both exchanges, as mentioned earlier, are the biggest in size (according to the absolute value of market capitalization), the most liquid (according to the turnover ratio), and more importantly they currently pass the 22 criteria set by FTSE to assess stock market quality and, thus, they are classified as developed exchanges (Ahmed, 2011). In addition, both possess very-developed financial system (Lagoarde-Segot and Lucey, 2008).

Given that both MZ_2^* and JS_1 are robust for heteroscedasticity, they are used to rank the efficiency of markets under examination, as shown in table (4).

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[18] By the end of 2005, Arab investors accounted for 36% of market capitalization in Jordan.

Table 4
Results of relative efficiency of MENA markets under examination

Country	MZ_2^*			JS_1		
	No of sub-samples in which WFEMH is rejected	% Of whole sub-samples	Rank	No of sub-samples in which WFEMH is rejected	% Of whole sub-samples	Rank
Panel A: Local currency- based dataset						
Egypt	40	28.27%	3	49	33.79%	4
Jordan	35	24.13%	2	16	11.03%	2
Morocco	44	30.34%	4	41	28.27%	3
Turkey	0	0%	1	7	4.82%	1
Israel	0	0%	1	16	11.03%	2
Panel B: US $ currency- based dataset						
Egypt	45	40.68%	4	17	11.72%	3
Jordan	43	29.65%	3	11	7.58%	2
Morocco	33	22.75%	2	49	33.79%	4
Turkey	0	0%	1	0	0%	1
Israel	0	0%	1	0	0%	1

Source: author's own calculations based on the results of MVR tests applied using rolling window procedure.

According to JS_1 and MZ_2^* Turkish and Israeli exchange markets are the most efficient irrespective of the currency employed. Jordan is ranked as the second efficient market from the perspective of domestic investor according to both JS_1 and MZ_2^* Egypt and Morocco are ranked as the third and the fourth according to MZ_2^* where this rank is reversed according to JS_1 when local currency-based dataset is employed. When dataset based on US dollar is employed Jordan maintains the second rank according to JS_1 but comes the third, after Morocco, according to MZ_2^* It is worth noting that, with the exception of results based on JS_1 test applied to datasets denominated in local currencies, the number of sub-samples in which the WFEMH has to be rejected is very similar for Jordan and Egypt.

Roughly speaking, based on the empirical results of MVR tests robust for heteroscedasticity, it seems that exchange rate dynamics do not have

significant impact on testing for weak-form-efficiency in the countries under examination. The current study and that conducted by Lagoarde-Segot and Lucey (2008) agree that dynamics of exchange rates did not matter in testing for the WFEMH in exchange markets under investigation. However, their analysis was conducted in a static manner whereas the current study executed the analysis in a dynamic manner through the rolling window procedure. On the other hand, Patro and Wu (2004) found that inference of the WFEMH testing is sensitive to currency domination (local and US$ currencies were used). In addition, Karemera *et al.* (1999) concluded that exchange rates did matter in determining the dynamics of share returns in two groups of the exchange markets they examined. The first group of countries (Argentina, Brazil, Hong Kong, Indonesia Mexico, the Philippines and Turkey) have had suffered from unsettled exchange rate regimes whereas the second group of countries (Singapore and Taiwan) have had strict monetary and exchange rate controls during their study period[19]. The recent American mortgage crisis did not affect the efficiency of stock markets under examination. These findings are in line with other empirical work tested the impact of financial crisis on market efficiency (Hoque *et al.,* 2007; Auer and Schuster, 2011).

The conclusion reached here conforms to that of Lagoarde-Segot and Lucey (2008) who studied the exchange markets under consideration. Their results showed that Turkey and Israel showed the strongest evidence of weak-form-efficiency followed by Jordan, Egypt, and Morocco, and the rank of Egypt and Jordan was very close as the case here. They interpreted these findings in terms of liquidity and market size. In addition, they debated that the extent of weak-form- efficiency in the MENA stock exchanges is mainly explained by differences in stock market development (e.g. market capitalisation, and turnover ratio) and corporate governance (e.g. disclosure and shareholder protection). The Turkish and Israeli exchange markets seem to be the most efficient markets among those studied here.

Conclusion

The current research was motivated by the inconclusive conclusion regarding testing for the WFEMH in five selected MENA exchange markets and by the arguments of Campbell *et al*. (1997) and Emerson *et al*. (1997) that evolving

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[19] With the aim to overcome some macroeconomic imbalances and to achieve higher economic growth rates, MENA exchanges under examination have introduced economic reform policies that include economic liberalization policies such as fiscal, monetary and foreign trade policies and relaxation of restrictions imposed on the flows of foreign direct investments. Israel was the first among MENA countries to launch its economic reform programmes in 1985 followed by Turkey and Morocco (1989), Egypt (1992), and Jordan (1995).

and relative efficiency is a more relative hypothesis to be tested rather than the absolute efficiency hypothesis. The MVR tests of Belaire-Franch and Contreras (2004), Kim and Shamsuddin (2008) and Kim (2006) have been applied in a rolling window procedure on to weekly data, expressed in both domestic and US dollar currency, during the period extends from 4th of January, 1995 to 5th of January, 2011. Applying the rolling window procedure casts doubts on the validity of testing for the WFEMH in an absolute sense since the degree of market efficiency of Egypt, Morocco, and Jordan were found to vary across time. As one may expect, the big, the most liquid exchange markets of Turkey and Israel, that satisfy the 22 criteria set by FTSE to assess market quality, were found to be the most efficient in pricing equities since the null of RW could not be rejected through, almost, all sub-samples. In addition, Turkish and Israeli exchange markets both possess very-developed financial system.

The EGX of Egypt convergence towards efficiency, by 2002, could be attributed to many reasons. First, adopting the new electronic trading system, whose capacity is 18 times that of the old trading system, is thought to have positive impact on market efficiency since the execution process of trades becomes faster and less costly. In addition, traders have access to broader information including bid and ask prices. In Such computerized system, it is expected to attract more investors, boost trading volume and liquidity and improve the price discovery process (Ahmed, 2013). Second, the new circuit breaker regime (relaxing the price limits and adopting trading halts for a few minutes if the price hit their new boundaries) facilitated the price discovery process as information is efficiently incorporated into equity prices once trading is resumed after trading suspended. Third, the EGX witnessed remarkable developments in the fields of disclosure, transparency and information dissemination; thereby it currently passes the transparency criteria set by FTSE. Fourth, the Capital Market Authority, an independent regulatory agency, succeeded to ensure shareholders' protection and to actively monitor market activities (Ahmed, 2011).

The Jordanian exchange was found efficient in pricing equities up to 2005. Efficiency could be explained in terms of size, liquidity, and automation. However, the Jordanian exchange has experienced inefficiencies since then. Overvaluation of the Jordanian equities could be attributed to the spill-over effects from neighbouring oil-producing countries that experienced sharp increase in oil prices. A process of price correction took place when Arab investors withdrew considerable funds from the Jordanian market and thus it restored its efficiency. The ASE currently passes the criteria of transparency criteria and other criteria of market quality set by FTSE. For example, the Jordan Securities Commission (created in 1997 and is entrusted with

supervisory and legislative functions) actively monitor the ASE, according to FTSE (Ahmed, 2011)

The CSE of Morocco converged towards efficiency by late 2002 due to remarkable improvements in liquidity, information dissemination, transparency and disclosure. Morocco has amended its national accounting standards to converge with the international set of financial reporting and accounting standards. In addition, the CSE created its own website to provide market participants with information regarding corporate developments on timely basis. Accordingly, the CSE currently passes the transparency criteria set by FTSE. The Securities Commission[20], the regulatory body, actively succeeded to monitor market activity according to criteria set by FTSE (Ahmed, 2011).

Active participation of foreign investors,[21] who are mainly international ones with large portfolios, may have resulted in an increase in demand for information since the cost of purchasing information is low relative to the sums invested by them. Devoting resources to information gathering and processing may have led to increase the availability of information regarding individual stocks, sectors, and the whole economy to both international and local investors. Such participation is considered an important factor leading the exchange markets under examination to move towards efficiency (Ahmed, 2011).

The relative ranking of the Egyptian, Jordanian and Moroccan exchange markets depends on the test employed. However, it is worth mentioning that, with the exclusion of results based on the JS_1test applied on to data sets denominated in local currencies, the number of sub-samples in which the WFEMH has to be rejected is very similar for Jordan and Egypt.
Broadly speaking, the empirical results suggest that the exchange rates did not matter in determining the dynamics of share returns for equity markets examined here. In addition, the recent financial crisis did not seem to affect testing for the WFEMH in the exchange markets under examination. These findings regarding the impact of exchange rate and financial crisis on testing for the WFEMH are in line with findings of other scholars (Hoque *et al.,* 2007; Auer and Schuster, 2011; Lagoarde-Segot and Lucey, 2008).

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[20] The securities Commission in Morocco is known as Conseil De´ontologique des Valeurs Mobilie`res or CDVM.
[21] Foreign investors have complete access to MENA exchanges under consideration with unrestricted repatriation of capital and income from investment, with the exception of JSE of Jordan. Foreign investors are allowed to hold majority stakes in all sectors in the ASE except construction, mining and commercial service companies.

Appendix

Figure 1
Multiple VR tests for Egypt
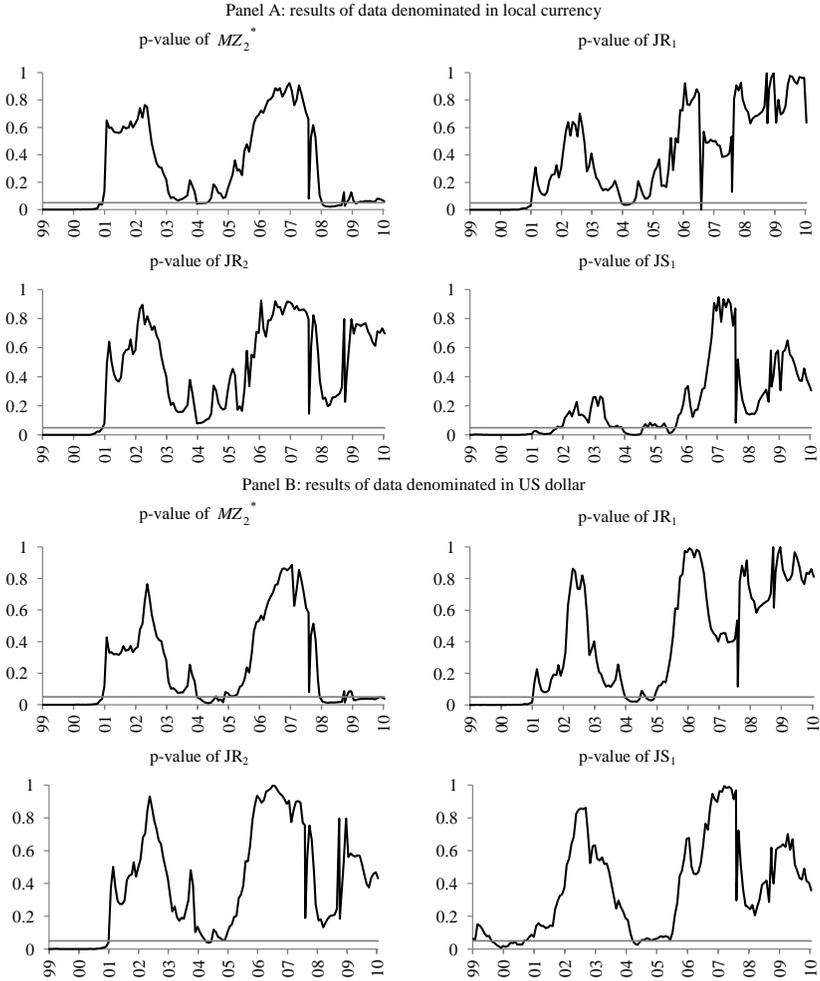
Panel A: results of data denominated in local currency

p-value of MZ_2^* p-value of JR_1

p-value of JR_2 p-value of JS_1

Panel B: results of data denominated in US dollar

p-value of MZ_2^* p-value of JR_1

p-value of JR_2 p-value of JS_1

Note: The horizontal line represents 5%.
Source: author's own calculations based on applying MVR methodologies described in section 4 on to Egyptian data.

Figure 2
MVR tests for Jordan
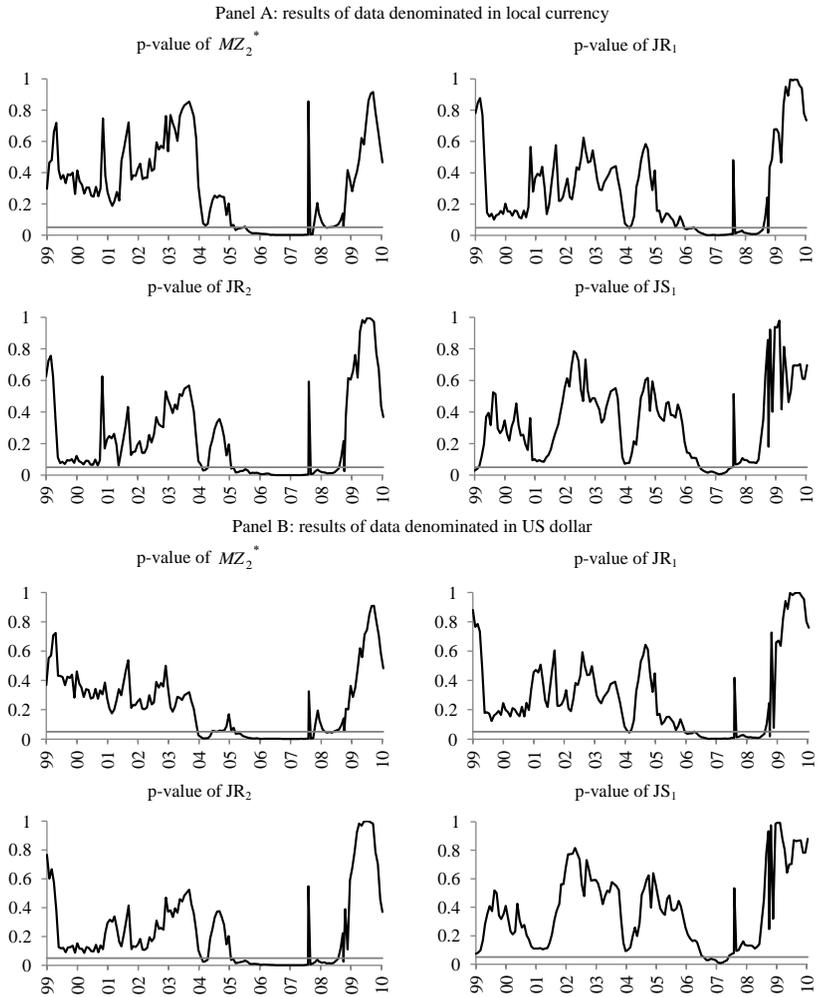
Panel A: results of data denominated in local currency

p-value of MZ_2^*

p-value of JR_1

p-value of JR_2

p-value of JS_1

Panel B: results of data denominated in US dollar

p-value of MZ_2^*

p-value of JR_1

p-value of JR_2

p-value of JS_1

Note: The horizontal line represents 5%.
Source: author's own calculations based on applying MVR methodologies described in section 4 on to Jordanian data.

Figure 3
MVR tests for Morocco
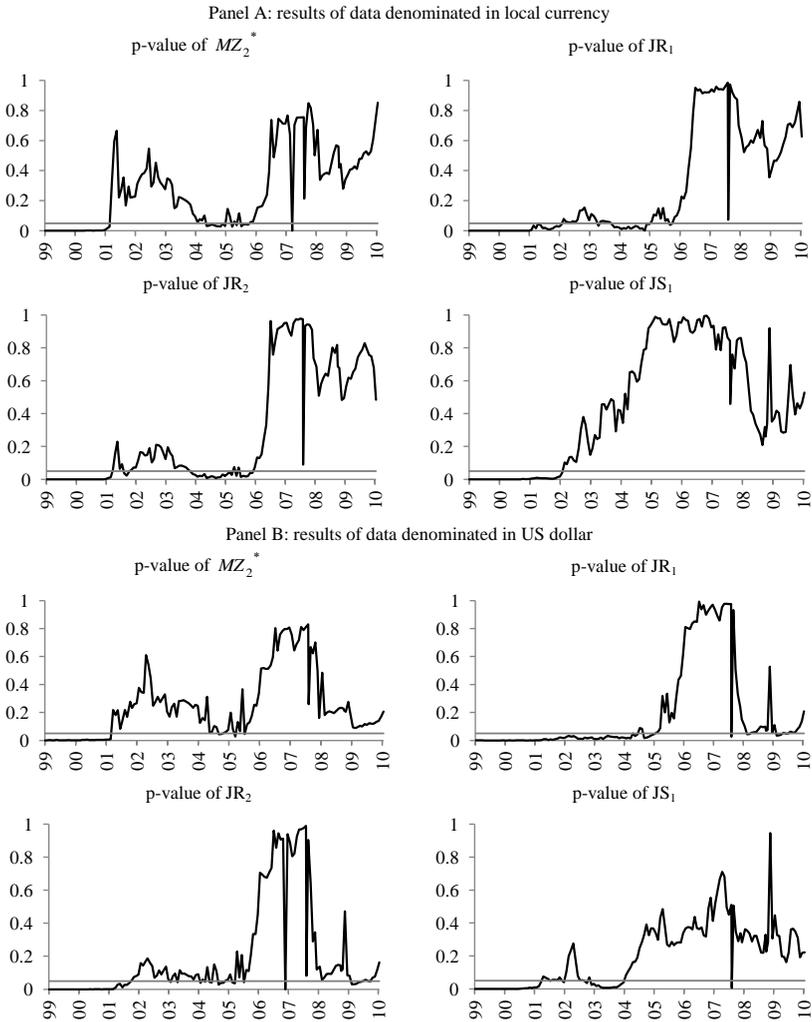
Panel A: results of data denominated in local currency

p-value of MZ_2^*

p-value of JR_1

p-value of JR_2

p-value of JS_1

Panel B: results of data denominated in US dollar

p-value of MZ_2^*

p-value of JR_1

p-value of JR_2

p-value of JS_1

Note: The horizontal line represents 5%.
Source: author's own calculations based on applying MVR methodologies described in section 4 on to Moroccan data.

Figure 4
MVR tests for Turkey

Panel A: results of data denominated in local currency
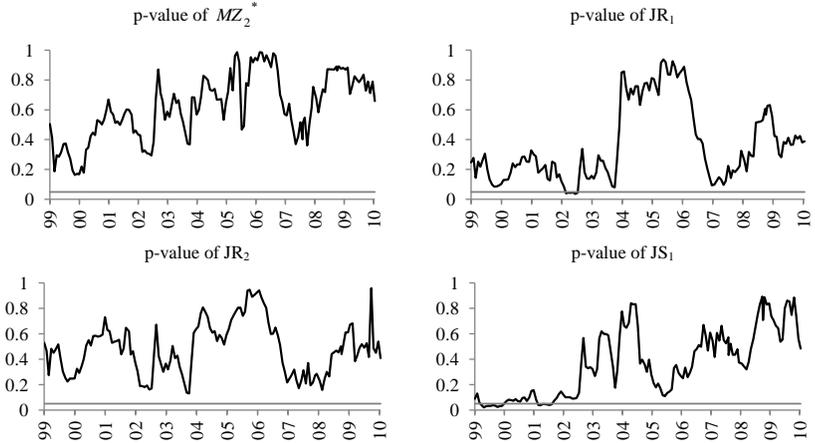
p-value of MZ_2^*

p-value of JR_1

p-value of JR_2

p-value of JS_1

Panel B: results of data denominated in US dollar

p-value of MZ_2^*

p-value of JR_1

p-value of JR_2

p-value of JS_1
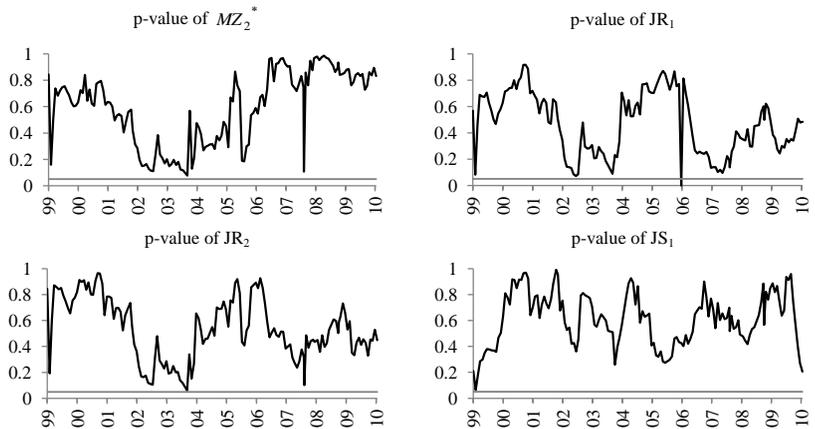
Note: The horizontal line represents 5%.
Source: author's own calculations based on applying MVR methodologies described in section 4 on to Turkish data.

Figure 5
MVR tests for Israel
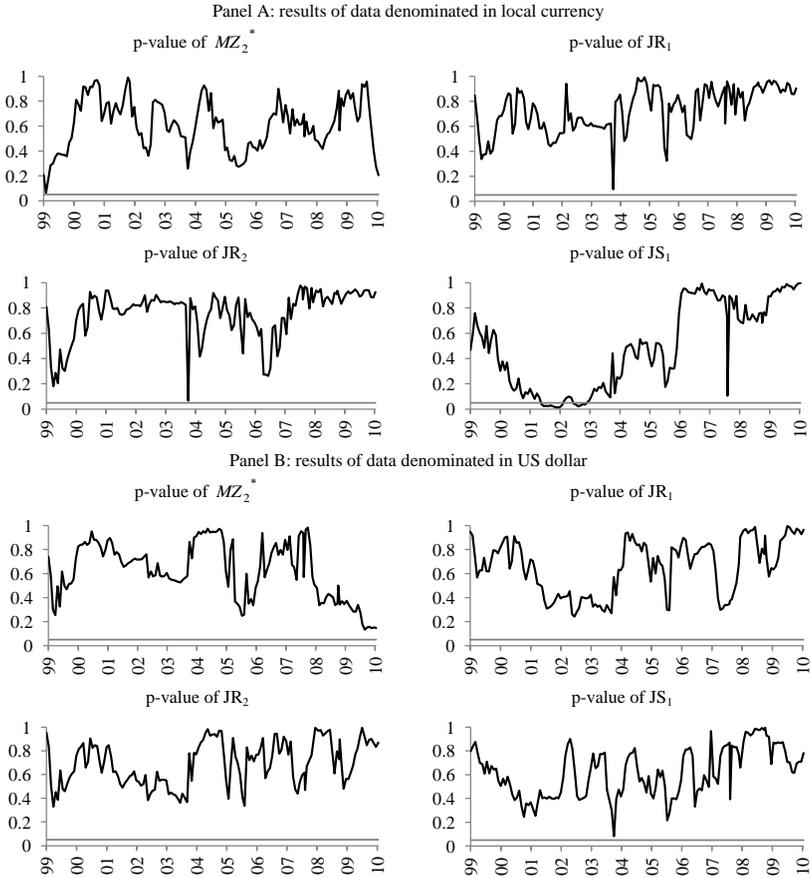
Panel A: results of data denominated in local currency

p-value of MZ_2^* p-value of JR_1

p-value of JR_2 p-value of JS_1

Panel B: results of data denominated in US dollar

p-value of MZ_2^* p-value of JR_1

p-value of JR_2 p-value of JS_1

Note: The horizontal line represents 5%.
Source: author's own calculations based on applying MVR methodologies described in section 4 on to Israeli data.

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