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TESTING THE RANDOM WALK BEHAVIOR IN THE DAMASCUS SECURITIES EXCHANGE USING UNIT ROOT TESTS WITH STRUCTURAL BREAKS

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ABSTRACT

This study aims to test whether stock prices on the Damascus Securities Exchange (DSE) follow a random walk process, using weekly data during the period from January 2010 to Mars 2017. For that purpose, in addition to the ADF test, which does not account for structural breaks in the data, the Zivot and Andrews test with one break, the Lumsdaine and Papell test with two breaks and the Lee and Strazicich tests with one and two endogenously determined structural breaks are applied. The findings of the study provide evidence in favor of random walk hypothesis in the DSE despite considering up to structural breaks in the data. Moreover, the dates of endogenously captured structural breaks in the majority of models tested coincide with the political instability that erupted in 2011 in Syria.

Contribution/ Originality: This study contributes to the existing literature as it is the first, up to my knowledge, that examines the validity of the random walk hypothesis on the Damascus Securities Exchange (DSE) using Unit Roots Tests that allow for endogenous structural breaks in the data.

1. INTRODUCTION

Fama (1970) classified efficiency into three types: weak, semi-strong and strong forms of efficiency. The weak form of the efficient market hypothesis EMH suggests that futures prices cannot be predicted using past historical price data (Fama, 1970).

There are several approaches to examine the weak form of efficiency. However, the random walk hypothesis has been widely used by a large number of studies (Chaudhuri and Wu, 2003; Chancharat and Valadkhani, 2007; Hiremath and Kamaiah, 2012; Mishra and Smyth, 2017). If stock prices follow a random walk process, there is no

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tendency for the price level to return to a trend path over time. This suggests that future returns cannot be predictable based on the basis of historical information (Chaudhuri and Wu, 2003; Chancharat and Valadkhani, 2007).

A variety of approaches have been used to investigate the random walk properties of stock prices. One of the most common approaches is to test for a unit root in stock prices (Tiwari and Kyophilavong, 2014). If stock prices contain a unit root, this implies that the random walk hypothesis is accepted. But if the stock prices are mean stationary, this implies that the random walk hypothesis is rejected (Mishra and Smyth, 2017).

The traditional unit root tests, such as the Augmented Dickey Fuller (ADF), the Phillips and Perron (1988) or the Kwiatkowski *et al.* (1992) tests, were widely used in the literature to test for the EMH (Maghyereh, 2003; Marasheh and Shrestha, 2008; Al-Jafari and Altaee, 2011; Salameh *et al.*, 2011; Al-Ahmad, 2012; Al-Jafari and Abdulkadhim, 2012; Saeedi *et al.*, 2014; Tiwari and Kyophilavong, 2014). But, a limitation of these tests is that they fail to account for an existing break in the data, which could be resulted from any significant economic, financial, or political events. Perron (1989) was amongst the first who highlighted the importance of controlling for structural breaks in the data. The Perron test, however, treated the structural break as exogenous (Mishra and Smyth, 2017).

Trying to overcome the criticism to the Perron test, Zivot and Andrews (1992) have developed a model to test for a unit root with an endogenous structural break. Lumsdaine and Papell (1997) extended the Zivot and Andrews (1992) model to accommodate two structural breaks[1].

However, these endogenous tests were criticized for their treatment of breaks under the null hypothesis. Lee and Strazicich (2003) demonstrated that these endogenous break unit root tests assume no break under the null hypothesis. Thus, researchers might conclude that the series is trend stationary while in fact it is non-stationary with breaks (Narayan and Smyth, 2004; Glynn *et al.*, 2007). To address this issue, Lee and Strazicich (2003;2004) developed one break and two breaks minimum Lagrange Multiplier (LM) unit root tests in which the alternative hypothesis unambiguously implies the series is trend stationary (Glynn *et al.*, 2007).

Several studies have investigated the random walk behavior on developing and emergent markets. However, there are few studies that tested the randomness of these markets using unit root tests which allow for endogenous structural breaks in the stock prices series (Chaudhuri and Wu, 2003; Narayan and Smyth, 2004; Chancharat and Valadkhani, 2007; Chancharat *et al.*, 2009)

Damascus Securities Exchange (DSE) is a young and nascent stock market in the Middle East. It started trading in 10th March 2009, and the DSE weighted price index (DWX) was launched in 31-12-2009. The empirical researches that examined the efficiency of this market are rare.

Al-Ahmad (2012) examined the weak form efficiency of the Damascus Securities Exchange (DSE), using daily stock returns of the weighted price index (DWX) from 31-12-2009 to 30-11-2011. She applied several tests of random walk (the autocorrelation test, the runs test, the unit root tests, the variance ratio test and of the GARCH (1,1) model). The results revealed that stock prices on the DSE do not follow the random walk model, and hence, the weak form efficiency of the DSE is rejected.

Abbas (2014) reexamined the randomness of the Damascus Securities Exchange using daily stock returns of the (DWX) index from 2009 until 2014. She used two parametric tests (serial-correlation test and variance ratio test), and two non -parametric tests (runs test and BDS test). She also found that daily returns do not confirm to a random walk during the period of study.

In their study, Al-Ahmad and Al-Saleh (2016) used the monthly returns of firms listed in the Damascus Securities Exchange from 2009 until 2014 to examine the random walk behavior in returns. They applied various tests (the unit root test, the autocorrelation test, the runs test and the GARCH model). And to take the impact of the Syrian crisis into account when judging the efficiency of the market, they divided the period of study into three

[1] Recently, the Lumsdaine and Papell test was extended further to account for a higher number of structural breaks in the data.

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periods, the pre-crisis period, the crisis period and the whole period. Their findings showed inability to reject the weak form efficient market hypothesis for more than half of the studied firms. The results also revealed that the Syrian crisis has negatively affected the efficiency of most of the studied firms.

Unlike these few previous studies, that did not account for endogenously captures structural breaks in the data, this study proposes to investigate the random walk hypothesis in the DSE using units roots tests that allow for endogenous structural breaks in the data. Allowing for structural breaks in the unit root tests is important to explore whether the political instability that erupted in 2011 in Syria caused a structural break in the data that should be taken into account before judging the efficiency of the Damascus Securities Exchange (DSE).

The remainder of this study proceeds as follows: section two describes the data and explains the methodology, section three discusses the findings and section four concludes the study.

2. DATA AND METHODOLOGY

2.1. Data

The data used in this study are the natural logs of weekly stock prices of Damascus Securities Exchange (DSE) represented by the weighted price index (DWX). The data consist of 372 observation covering the period from January 2010 to Mars 2017[2].

Table 1 presents the descriptive statistics of the data. As is shown in the table, the Jarque-Bera statistic is highly significant (P=0.000) thereby rejecting the hypothesis that the series is normally distributed.

Table-1. Descriptive statistic of the DWX (natural logs, weekly data)

Mean	Median	Max	Min	Std	Skewness	Kurtosis	Jarque-Bera	Obs.
7.097	7.119	8.028	6.645	0.261	0.407	3.955	24.434 P (0.000)	372

Source: Eviews output

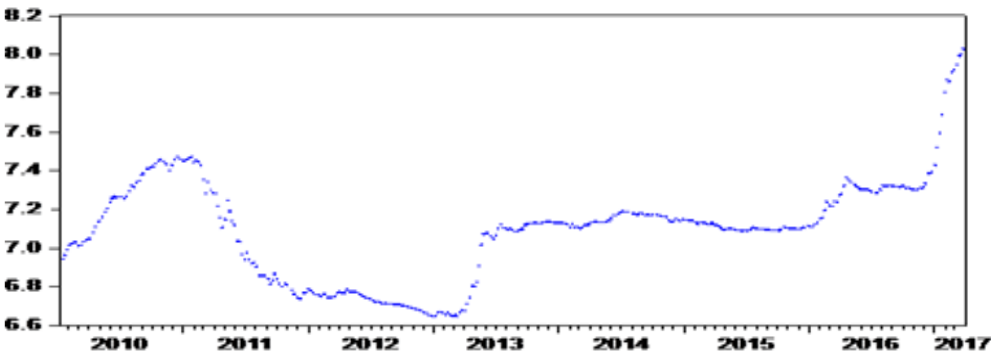

Figure-1. Time series plots of the DWX (natural logs, weekly data)

Source: Eviews output

2.2. Methodology

To test for the presence of a unit root in the serie studied, the Augmented Dickey-Fuller (ADF) test, which does not account for any structural breaks in the data, is first applied. The Zivot and Andrews (1992) test, which endogenously captures one structural break in the data, and the Lumsdaine and Papell (1997) test, which allows for the possibility of two breaks, are then used.

A limitation on these endogenous break tests is that the critical values are derived while assuming no breaks under the null hypothesis of unit root (Glynn *et al.*, 2007; Narayan and Smyth, 2007). To address this issue, the

[2] The data was collected from the official web site of the DSE (www.dse.com).

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minimum Lagrange Multiplier (LM) unit root tests with one and two structural breaks proposed by Lee and Strazicich (2003;2004) are also used in this study.
Below is a brief explanation of the tests applied.

2.2.1. The ADF Test

The ADF unit root test is used in this study to examine the time series properties of the data without allowing for any structural breaks. The ADF test is applied as follows:

$$\Delta Y_t = \delta Y_{t-1} + \sum_{i=1}^{k} \rho_i \Delta Y_{t-i} + \varepsilon_t \qquad (1)$$

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \sum_{i=1}^{k} \rho_i \Delta Y_{t-i} + \varepsilon_t \qquad (2)$$

$$\Delta Y_t = \beta_1 + \beta_2 T + \delta Y_{t-1} + \sum_{i=1}^{k} \rho_i \Delta Y_{t-i} + \varepsilon_t \qquad (3)$$

Where Y_t denotes the time series being tested, ΔY_t is the first difference of the variable, β_1 is the constant, β_2 is the estimated coefficient for the deterministic trend T, ρ and δ are coefficients to be estimated, K is the lag length, and ε_t is a pure white noise.

Accepting the null hypothesis ($\delta = 0$) implies that the series is not stationary. Worth noting that a rejection of the null hypothesis in equations (2), (3) and (4) indicates that the series is stationary with zero mean, mean stationary and trend stationary respectively.

2.2.2. The Zivot and Andrews (1992) Test

Zivot and Andrews (1992) have developed methods to endogenously search for a structural break in the data. To estimate the Zivot and Andrews test, three models are proposed: model (A) allows for a one-time shift in the intercept; model (B) allows for a break in the slope; while model (C) allows for a break in intercept and slope (Narayan and Smyth, 2004). These three models have the following forms:

$$\Delta Y_t = \beta_1 + \beta_2 T + \theta\ DU_t + \delta Y_{t-1} + \sum_{i=1}^{k} \rho_i \Delta Y_{t-i} + \varepsilon_t \qquad (4)$$

$$\Delta Y_t = \beta_1 + \beta_2 T + \gamma DT_t + \delta Y_{t-1} + \sum_{i=1}^{k} \rho_i \Delta Y_{t-i} + \varepsilon_t \qquad (5)$$

$$\Delta Y_t = \beta_1 + + \beta_2 T + \theta\ DU_t + \gamma DT_t + \delta Y_{t-1} + \sum_{i=1}^{k} \rho_i \Delta Y_{t-i} + \varepsilon_t \qquad (6)$$

Where the dummy variable DU_t captures structural change in the intercept at time TB; $DUt = 1$ if $t > TB$ and zero otherwise; the dummy variable DT_t represents a change in the slope of the trend function (captures shift in the trend variable at time TB); $DT_t = t\text{-}TB$ if $t > TB$ and zero otherwise; TB denotes the time of break. The break date is chosen as the one which minimizes the one-sided t-statistic for the ADF unit root (δ) Glynn *et al.* (2007).

The null hypothesis under the three models is that $\delta = 0$, which implies that the series has a unit root with a drift that excludes any structural breaks whereas the alternative hypothesis is that $\delta < 0$, which implies that the

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series is breakpoint stationary with a one-time break occurring at an unknown point in time (Waheed *et al.*, 2006; Narayan and Smyth, 2007).

2.2.3. The Lumsdaine and Papell (1997) Test

Lumsdaine and Papell (1997) extended the three models A, B and C of Zivot and Andrews test to allow for two endogenous structural breaks. These models are named as model (AA), (BB) and (CC). The modification of model which allows for two structural breaks in both the intercept and slope (model CC) is expressed as follow:

$$\Delta Y_t = \beta_1 + \beta_2 T + \theta\ DU1_t + \gamma DT1_t + \omega DU2_t + \psi DT2_t + \delta Y_{t-1} + \sum_{i=1}^{k} \rho_i \Delta Y_{t-i} + \varepsilon_t \quad (7)$$

Where $DU1_t$ and $DU2_t$ are indicator dummy variables for a mean shift occurring at *TB1* and *TB2*. The other two dummy variables (i.e. $DT1_t$ and $DT2_t$) are indicators for structural breaks in the trend at *TB1* and *TB2* respectively. $DU1_t$=1 if t>*TB1* and zero otherwise; $DU2_t$=1 if t>*TB2* and zero otherwise; $DT1_t$= *t-TB1* if t>*TB1* and zero otherwise; and $DT2_t$=*t-TB2* if t>*TB2* and zero otherwise. Worth noting that the null hypothesis under the Lumsdaine and Papell test is the same as the one under the Zivot and Andrews test (Valadkhani *et al.*, 2005).

2.2.4. The Lee and Strazicich Test

Lee and Strazicich (2003) proposed using a minimum Lagrange Multiplier LM test for testing the presence of a unit root with two structural breaks, while Lee and Strazicich (2004) suggested a one break LM unit root test. The authors considered two models of structural break, model A which allows for structural break in the intercept under the alternative hypothesis, and model C which allows for structural break in both the intercept and trend under the alternative hypothesis. The LM root test has the advantage that it is unaffected by structural breaks under the null[3].

3. RESUTS AND DISCUSSION

The study started through using the ADF test, which does not take into account any structural breaks. The model is estimated both with and without a trend. Based on the results presented in table 2, the series under investigation is not stationary at the level.

Table-2. The results of ADF unit root test

	T-statistic	lag	Critical values
Intercept	-0.737	9	-3.448 (1%) -2.869 (5%) -2.570 (10%)
Intercept and trend	-1.108	9	-3.984 (1%) -3.422 (5%) -3.134 (10%)

Notes: The optimal lag length of the ADF test was selected based on the Schwartz Info Criterion (SIC). ***and ** indicate significance at the 1% and 5% level of significance respectively.

As suggested by Perron (1989) the failure to find stationarity in the data may be due to the fact that unit root tests have low power when structural breaks are ignored. To address this problem, the Zivot and Andrews test (models A and C)[4] is applied. The results, reported in table 3, reveal that the stock prices series still contains a unit root.

[3] See Lee and Strazicich (2003;2004). for details about the data-generating process (DGP) proposed to specify the minimum Lagrange Multiplier LM test.

[4] According to Perron (1989). one can adequately model most economic time series data using these two models.

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As revealed in the table, the endogenously captured break in the two models (A and C) occurred in 2011. The breakpoint captured in model A is statistically significant in intercept (**θ is significant**), and the breakpoint captured in model C is significant in both the intercept and slope (**θ and γ are statistically significant**).

Table-3. The results of the Zivot and Andrews test

Break in	Break date Year: month: week	θ	γ	δ	Lag k	Critical values
Intercept	2011:5:3	-0.0230 (-4.020)		-0.029 (-4.097)	8	-5.340 (1%) -4.800 (5%)
Both Intercept and Trend	2011:5:3	-0.021 (-2.778)	0.00005 (3.078)	-0.0285 (-3.865)	8	-5.570 (1%) -5.080 (5%)

Notes: The T-statistic are reported in brackets. ***and ** indicate significance at the 1% and 5% level of significance respectively. Following Lumsdaine and Papell (1997) and Ben-David *et al.* (2003) for annual data Kmax is assumed to be equal to eight.

The failure of the Zivot and Andrews test to reject the unit root null hypothesis could be due to the failure of this test to allow for more than one structural break (Aslan, 2010). Thus, the Lumsdaine and Papell (1997) unit root test with two structural breaks is next applied.

As can be seen from table 4, the results of models AA and CC suggest that the calculated t-statistics are lower than the critical values. Hence, one cannot reject the unit root null hypothesis.

The results reveal that in addition to the breaks identified earlier in 2011, the two breaks test captures structural breaks in 2013 and 2016. Worth noting that, in model AA, only the first breakpoint, captured in 2011, is significant. In model CC, the first break, captured in 2013, is significant in both the intercept and slope while the second, captured in 2016, is significant only in slope.

Table-4. The results of the Lumsdaine and Papell test

Break in	Break date Year: month: week	θ	γ	ω	ψ	δ	Lag k	Critical values
Intercept	2011:5:2 2016:2:2	-0.022 (-3.897)		0.006 (1.516)		-0.031 (-4.307)	8	-6.740 (1%) -6.160 (5%) -5.890 (10%)
Both Intercept and Trend	2013:3:2 2016:2:4	0.0220 (4.022)	0.0002 (3.577)	-0.009 (-1.438)	0.0007 (4.036)	-0.038 (-4.986)	8	-7.190 (1%) -6.750 (5%) -6.480 (10%)

Notes: The T-statistic are reported in brackets. ***, ** indicate significance at the 1% and 5% level of significance respectively. The optimal lag length is determined by the general to specific method suggested by Ng and Perron (1995) and following Lumsdaine and Papell (1997) and Ben-David *et al.* (2003) for annual data Kmax is assumed to be equal to eight.

To test the robustness of the results from the Zivot and Andrews (1992) and Lumsdaine and Papell (1997) unit root tests, the LM unit root tests with one and two breaks proposed by Lee and Strazicich (2003;2004) are also applied. The results, presented in tables 5 and 6, reveal that the stock prices still follow a random walk, whether allowing for one or two breaks.

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Table-5. The results of the Lee and Strazicich one break unit root test

Break in	Break date Year: month: week	θ	γ	S{1}	Lag k
Intercept	2011:3:1	-0.031 (-2.617)		-0.007 (-2.303)	8
Both Intercept and Trend	2011:5:2	-0.054 (-2.595)	-0.023 (-3.896)	-0.029 (-4.074)	8

Notes: The coefficient of S{1} tests for the unit-root. The critical values for the unit-root test are tabulated in Lee and Strazicich (2004). The T-statistic are reported in brackets. ***, ** indicate significance at the 1% and 5% level of significance respectively.

The results of Lee and Strazicich one break test reveal that the two models, A and C, endogenously captured significant break in 2011.

According to the results of Lee and Strazicich two breaks test, the endogenously captured breaks occurred in 2011 and 2016. Worth noting that the two breakpoints are insignificant in model A, while they exerted a significant change in trend only in model C.

Table-6. The results of Lee and Strazicich two break unit root test

Break in	Break date Year: month: week	θ	γ	ω	ψ	S{1}	Lag k
Intercept	2011:3:1 2016:4:2	-0.031 (-1.65)		0.004 (0.212)		-0.007 (-2.406)	8
Both Intercept and Trend	2011:9:4 2016:4:3	-0.028 (-1.476)	-0.012 (-2.900)	-0.018 (-0.957)	0.007 (2.167)	-0.035 (-4.568)	8

Notes: The coefficient of S {1} tests for the unit-root. The critical values for the unit-root test are tabulated in Lee and Strazicich (2003). The T-statistic are reported in brackets. ***, ** indicate significance at the 1% and 5% level of significance respectively.

Based on all the tests applied, one can draw the conclusion that stock prices on the Damascus Securities Exchange (DSE) follow a random walk process, which implies that the DSE is efficient in the weak form.

Coming back to the breaks that were noticed in the data, it is not surprising to note that the significant structural breaks in the majority of models tested occurred in 2011, which coincides with the debut of the Syrian crisis.

4. CONCLUSION

This study examines the random walks hypothesis in the Damascus Securities Exchange (DSE) using weekly data during the period from January 2010 to Mars 2017. In addition to the ADF test, the study utilizes unit root tests that allow for endogenous structural breaks in the data, this includes the Zivot and Andrews one structural break, the Lumsdaine and Papell two structural breaks and the Lee and Strazicich one and two structural breaks tests. The findings of the study confirm that the random walk model holds on the DSE, which implies that stock prices completely reflect the information contained in the data, and consequently it is unlikely to make abnormal profits using past price movements. The findings also reveal that the political instability that erupted in 2011 in Syria caused a structural break in the stock price series. Worth noting that the results of the unit root tests were not sensitive to the recognition of breaks in the data as allowing for more structural breaks did not lead to a reversal of the inference regarding the randomness of the series studied.

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