Efficient Markets Hypothesis in Canada: a comparative study between Islamic and Conventional stock markets

neifar, malika

IHEC SFAX UNIVERSITY

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NEIFAR Malika[1]

Abstract

In this paper we test the weak form of the Efficient-Market Hypothesis (EMH) using monthly data from 2004M08 to 2018M04 of stock prices by using linear and nonlinear (KSS 3 type, Sollis and Kruse) unit root tests. The informational market efficiency is examined in the Islamic and conventional markets in Canada. It aims to investigate whether Islamic market would be more or less efficient than the conventional one. Findings indicate that both Conventional Canadian Stock Index (CCSI) and Dow Jones Islamic Canadian Price Index (DJICPI) show characteristics of random walk indicating that the stock markets are **efficient.** The **major policy implications** is that in this country (**Canada**), fund managers and investors cannot enjoy excess returns to their investment.

Key words : Dow Jones Islamic Market (DJIM); Conventional Canadian Stock Index, Efficient-Market Hypothesis (EMH), linear and nonlinear unit root tests, KSS, Sollis, CHLL.

JEL classification: G1, G12, G14, C22, C12.

[1] [1] Professor in Quantitative Methods at New economic department, Institut des Hautes Etudes Commerciales (IHEC) - Sfax University. Postal address: Mailing address: Route Sidi Mansour Km 10, B.P. 43, 3061. Sfax, Tunisia. Email : malika.neifar@ihecs.usf.tn and mneifar68@gmail.com.

I. Introduction

Modern finance theory emphasises the role of information in asset market. This is the integral part of efficient market hypothesis. For a market to be efficient, it must react fully and correctly to all available and useful information (Fama, 1970). However, the efficient markets hypothesis has become controversial because substantial **inefficiencies** are observed ((Barberis & Thaler, 2003); (Hirshleifer, 2001)).

The purpose of this study is to examine whether the Islamic and Conventional stock prices in Canada markets follow a random walk process over the period 2004M08 - 2018M04 covering the 2008 GFC.

To test the weak form efficiency, the null and alternative hypotheses are defined as:

H_0: Each stock price (Islamic or conventional) follows a random walk process.

H_1: The Islamic (or conventional) stock price does not follow a random walk process.

The majority of previous studies apply the traditional unit root test in testing the null hypothesis of unit root in stock prices. The application of traditional unit root tests as the **ADF** and Phillips-Perron (**PP**) tests are less powerful and more size distorted when the data exhibit nonlinearity.

The empirical problem encountered in unit root tests is about choosing the right test procedure.

Different tests will be considered in this paper :

i. Recently, (Kapetanios, Shin, & Snell, 2003) (here after KSS) have developed a unit root test procedure in an exponential smooth transition autoregressive (ESTAR) framework, which has better power than previous approach.

The KSS test is based on the assumption that the mean reversion is symmetrical at every point. This assumption means that negative and positive deviations have got the same effect.

ii. (Chong, Hinich, Liewand, & Lim, 2008) test is different from the KSS test as it was developed by adding **the cutting parameter and the trend** to the model to be used in the unit root test.

The KSS test is based on the assumption that the mean reversion is symmetrical at every point. This assumption means that **negative and positive** deviations have got the **same effect**.

iii. (Sollis, 2009) developed a new procedure that allows for symmetrical or **asymmetrical** nonlinear adjustments by extending the scope of this assumption.

In (Kapetanios, Shin, & Snell, 2003), the locational parameter of the transition function, which is assumed to be exponential, is assumed to be the value zero. Imposing *the locational* *parameter* C *equal to zero* on the smoothed transition function can be particularly restrictive for the variables for which the threshold value can be different from zero.

iv. In this context**,** (Kruse, 2011) expands the unit root test of (Kapetanios, Shin, & Snell, 2003), by relaxing the assumption of the location parameter equal to zero for *a non-zero parameter*.

In this paper, we consider (Kapetanios, Shin, & Snell, 2003), (Chong, Hinich, Liewand, & Lim, 2008), (Sollis, 2009), and (Kruse, 2011) nonlinear unit root tests to study Efficient Market Hypothesis (**EMH**).

This paper is organised as follows. After a brief litereture review in section II, data collection and analysis are explained in section III. Econometric model and relevant tests are explained in section IV. We analyse the empirical results in section V. Section VI concludes the paper.

II. Review

Few studies have been done on the stock market efficiency. Most of them were conducted to examine the presence of random walk behaviour and hence to test for the conventional weak form of the efficient market hypothesis.

(Alharbi, 2009) provided a review of the market efficiency literature in the **GCC** region. Despite the growing interest in Islamic finance, there are few empirical studies that examined the informational efficiency of Islamic stock market. (Ariff & Iqbal, 2011) provided an overview of the existing literature on this subject.

Some references conclude for **in**efficiency as:

(Gandhi, Saunders, & Wooward, 1980) investigated efficiency of **GCC** financial markets. They tested Kuwaiti Stock Exchange efficiency from 1975 to 1978 using runs test. Findings suggested that the Kuwaiti Stock Exchange is **inefficient**.

(Bulter & Malaikah, 1992) examined efficiency *of Saudi and Kuwaiti* stock markets using runs tests. The study was conducted on individual stock returns for the sample period from 1985 to 1989 and the results indicated clear evidence of market **inefficiency** in both markets.

(Elango & Hussein, 2008) analysed the stock markets in the **six GCC** countries and tested for random walk using runs test. Their results indicated that the weak-form efficiency was **rejected** for all GCC markets during the study period from 2001 to 2006.

Other references conclude for efficiency or with mixed results as:

(Dahel & Laabas, 1999) examined the randomness behaviour in stock markets of *Saudi Arabia, Kuwait, Bahrain and Oman*. Using unit root tests, they could **not reject the random walk hypothesis** suggesting that these markets were characterised by weak form efficiency.

(Hassan, 2002) examined empirically the issues of market efficiency and the time-varying risk return relationship for the Dow Jones Islamic Market (DJIM) over the 1996–2000 period. His paper employed variance ratio and Dickey–Fuller tests to examine the market efficiency of the DJIM. The results showed that DJIM returns are normally distributed and the returns showed that **DJIM** returns are **efficient**.

(Abraham, Seyyed, & Alsakran, 2002) examined efficiency in **three GCC** stock markets (Saudi Arabia, Kuwait and Bahrain) using runs test and variance ratio test. The obtained results showed evidence of weak form market **efficiency** in Saudi Arabia and Bahrain, **but not** in Kuwait.

(Gharbi & Halioui, 2014) examines the informational market efficiency in the Islamic and conventional markets in the Gulf Cooperation Council (GCC) region. Using ADF and PP unit root tests, findings indicate that both Dow Jones Islamic Market GCC and Dow Jones GCC Indexes show characteristics of random walk.

III. Data Analysis

The data consist of monthly observations on stock prices for Canada. The data were retrieved from OCDE (Organisation de Cooperation et de Developpement Economique).

As explained earlier, the goal of this work is to verify the validity of the Efficient Market Hypothesis (**EMH**). Both unit root tests were executed with the Conventional Canadian Stock Index (CCSI) and Dow Jones Islamic Canadian Price Index (DJICPI). The period of test is from 2004M08 to 2018M04, totaling **T=165** observations. The natural logarithm was applied to both the series. The software used for the analysis is Eviews 10 and STATA 15. A summary of the statistics is given in **Table 1**. Based on the results from **Table 1,** the Jarque–Bera test indicate that, **LDJICPI (LCCSI) i**s (not) approximately normal. The results showed that DJIM price is normally distributed.

We find significant correlation between the DJIM changes and the CCSI Index changes [rho = 0.182105 (p-value= 0.0196)]. The results also showed that the changes in the DJIM is caused by the CCSI Index changes [F=230.292 (p-value= 2.E-47)].

This paper also examines calendar anomalies of the DJIM price. The results showed that there is no turn-of-calendar-month of **LDJICPI** and **LCCSI** prices (see Table A 5 in Appendix).

The evolution of the stock indices is contained in Figure 1. In Figure 1, **LDJICPI and LCCSI** showed a visible structural break at GFC 2008-2009 and an eventual structural break at 2010-2011 in the series.

Table 1: Summary statistics.

	Mean	Median	Max	Min	Std. Dev.	Ske	Kurt	Jarque-Bera	Prob	Obs
LCCSI	7.384592	7.399783	7.638381	6.946274	0.159453	-0.755562	3.077950	15.74079	**0.000382**	165
LDJICPI	7.525242	7.539218	8.005114	6.929850	0.229515	-0.215924	2.744079	1.732415	0.420543	165

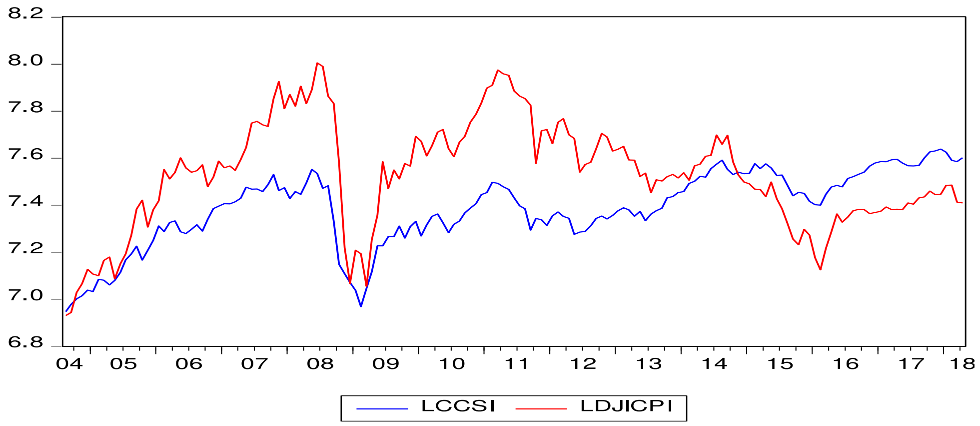

Figure 1: Evolution of LCCSI : Conventional Canadian Stock Index in log and LDJICPI: Islamic Canadian Price Index in log: all monthly data from 2004M08 to 2018M04

IV. Methodology

Standard univariate unit root tests can be expected to have low power if the time series contain a nonlinear type of dynamics (e.g. structural breaks (Zivot & Andrews, 1992)). Unit root tests could be classified as linear and nonlinear for time series. This helped to eliminate the situation as shown in the study by (Enders & Granger, 1998) that standard tests for unit root have lower power in the presence of misspecified model dynamics.

i. Linear and structural break unit root tests

In addition to traditional unit root tests (ADF, PP, and KPSS), for the purpose of analysing linear series, we use the unit root tests of (Ng & Perron, 2001)[2] and the Dickey–Fuller generalized least squares (henceforth **DF-GLS**) proposed in (Elliot, Rothenberg, & Stock, 1996). The choice of the Ng–Perron unit root test is made due to this test having greater power and not suffering from a size problem when the unit root process error is **close to one**. The choice of (Elliot, Rothenberg, & Stock, 1996) is made due to the efficiency of their test which modify the Dickey–Fuller test by using instead of the method of ordinary least squares, OLS, the structure of generalized least squares, GLS.[3]

The traditional unit root tests as the ADF and Phillips-Perron tests are less powerful and more size distorted when the data exhibit nonlinearity. In this paper, we consider KSS type tests, Sollis and Kruse tests to study Efficient Market Hypothesis (**EMH**) via nonlinear unit root tests. Three KSS type statistics are presented in the following : NLADF (or NLADFM for demeaned data and NLADFT for de-trended data), CHLL (or MKSS for original series), Sollis and Kruse test statics are also considered.

[2] The test seeks to solve or minimize the size of the selected lag problem, since the information criteria, like Akaike information criteria, tend to choose small number of lags. In addition, (Ng & Perron, 2001) proposed modifications to the information criteria for choosing the optimal lag, taking into account the tests are sensitive to the size of the autoregressive lag.

[3] Critical values are calculated by Eviews 10.

ii. Non-linear unit root tests

(Kapetanios, Shin, & Snell, 2003) propose the implications of the presence of a particular kind of nonlinear dynamics for unit root testing procedures. In addition to this, they provide an alternative framework for a test of the null of a unit root process against an alternative of nonlinear exponential smooth transition autoregressive (ESTAR) process, which is globally stationary.

(Kapetanios, Shin, & Snell, 2003) extended the Augmented Dickey–Fuller (ADF) test to tackle the problem of traditional tests in case of nonlinearity in the ESTAR framework which is known as KSS or **nonlinear ADF (NLADF)** test. The ESTAR model can be written as:

$$y_t = \rho y_{t-1} + \gamma y_{t-1}[1 - \exp(-\Theta y_{t-1}^2)] + \mathcal{E}_t \text{ , (1)}$$

Where

$$\mathcal{E}_t \sim i.i.d.(0, \sigma^2).$$

The null hypothesis of a unit root which in terms of the above model implies that β = 1 and Θ = 0. The authors consider the following model:

$$\Delta y_t = \phi y_{t-1} + \gamma y_{t-1}[1 - \exp(-\Theta y_{t-1}^2)] + \mathcal{E}_t$$

in which $\phi = \rho - 1$, y_t is the **demeaned or de-trended** series of interest and $[1 - \exp(-\Theta y_{t-1}^2)]$ is the exponential transitional function.[4] In the above equation, if Θ is positive, it effectively determines the speed of mean reversion. In test procedures, specific parameter Θ is zero under the unit root null hypothesis ($H_0 \colon \Theta = 0$) and positive under the globally stationary ESTAR alternative hypothesis ($H_1 \colon \Theta > 0$). Since γ is not identified under the null, testing the null hypothesis $H_0 \colon \Theta = 0$ directly is not feasible [(Davies, 1977)]. Therefore, using a first order Taylor series approximation, (Kapetanios, Shin, & Snell, 2003) obtained the following auxiliary regression:

$$\Delta y_t = \emptyset y_{t-1}^3 + v_t.$$

To handle the presence of **serial correlation in the error terms**, the above equation can be extended as follows

$$\Delta y_t = \emptyset y_{t-1}^3 + \sum_{j=1}^{p} \boldsymbol{\delta}_j \Delta y_{t-j} + v_t, \text{ (2)}$$

where δ is the coefficient of interest for testing the presence of a unit root.

(Kapetanios, Shin, & Snell, 2003) perform the KSS unit root test for $H_0 \colon \emptyset = \mathbf{0}$ against $H_1 \colon \emptyset < \mathbf{0}$ as the following t-test:[5]

$$\text{NLADFM or NLADFT} = \frac{\hat{\emptyset}}{\hat{\sigma}_{\hat{\emptyset}}}$$

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[4] When the data have non-zero mean such that x_t = μ + y_t, the demeaned data x_t - $\overline{x}$, where $\overline{x}$ is the sample mean, is used to perform KSS test. When the data have non-zero mean and non-zero linear trend such that x_t = μ + βt + y_t, the demeaned and de-trended data are obtained by x_t - $\hat{\mu}$ - $\hat{\beta}$t, where $\hat{\mu}$ and $\hat{\beta}$ are the OLS estimators of μ and β.

[5] The most common way of selecting an appropriate (optimal) lag structure is the use of information theoretic criteria such as the AIC, BIC, or HQ.

where NLADFM is for demeaned data and NLADFT is for de-trended data, where $\hat{\delta}$ and $\hat{\sigma}_{\hat{\delta}}$ are respectively, the estimated coefficient of δ and the estimated standard error of $\hat{\delta}$. The test statistic

NLADF does not have an asymptotic standard normal distribution and therefore, (Kapetanios, Shin, & Snell, 2003) provided the critical values on p. 364 of their article (see **Table A 2** in Appendix).[6] If the computed absolute value of the test statistic exceeds the critical values, the hypothesis $H_0: \emptyset = \mathbf{0}$, will be **rejected** in which case the time series is said **stationary**.

(Chong, Hinich, Liewand, & Lim, 2008) test developed a modified **nonlinear** unit root as the form of unit root test developed by KSS. The test is different from the KSS test as it was developed by adding **the cutting parameter and the trend** to the model to be used in the unit root test. The equation to be used for the test is as follows:

$$\Delta y_t = \mu + \beta\, D(trend) + \emptyset y_{t-1}^3 + \sum_{j=1}^{p} \delta_j \Delta y_{t-j} + v_t \quad (3)$$

where y_t is the **original series** to be examined and $D(trend)$ is the trend variable and this variable can be in different forms. The trend variables used frequently are **linear trend (t)** and **nonlinear trend** variables (t^2). The null hypothesis for nonstationarity is H_0: $\emptyset = 0$ and the alternative hypothesis for stationarity is $H_1: \emptyset < 0$. The test statistics is the test statistics of the $\emptyset$ parameter as it is the case with KSS test:

$$\text{CHLL or MKSS} = \frac{\hat{\emptyset}}{\hat{\sigma}_{\hat{\emptyset}}}.$$

Since the asymptotic distribution of the *t* statistic in this case is also unknown, the corresponding critical values are simulated by (Chong, Hinich, Liewand, & Lim, 2008) from 5000 replications of various sample sizes. The resulting critical values are given in **Table A 3** (see Appendix).

The KSS test is based on the assumption that the mean reversion is symmetrical at every point. This assumption means that negative and positive deviations have got the same effect.

(Sollis, 2009) developed a new procedure that allows for symmetrical or asymmetrical nonlinear adjustments by extending the scope of this assumption. In this test, the speed of mean reversion will be different depending on the sign of the shock, not only the size (Cuestas & Ramlogan-Dobson, 2013). The model to be used for the test based on the AESTAR model proposed by (Sollis, 2009) is as follows:

$$\Delta y_t = \emptyset_3 y_{t-1}^3 + \emptyset_4 y_{t-1}^4 + \sum_{j=1}^{p} \delta_j \Delta y_{t-j} + v_t. \quad (4)$$

As it is the case with the KSS test, y_t is raw data, demeaned data or detrended data. The null hypothesis of nonstationarity is H_0: $\emptyset_3 = \emptyset_4 = 0$. The critical values of **F statistics** were **tabulated** by (Sollis, 2009).[7] When the null hypothesis is rejected, the null hypothesis of symmetric ESTAR, H_0: $\emptyset_4 = 0$, be tested against the alternative of asymmetric ESTAR, H_0: $\emptyset_4 \# 0$, by means of astandard hypotheses test. For standard F critical values to be applicable for this test $\emptyset_3 < 0$, so that under the null being tested the series is stationary (Sollis, 2009).

[6] In this paper, for KSS test, we use critical value calculated by STATA 15.

[7] The resulting critical values are given in **Table A 4** (see Appendix).

In (Kapetanios, Shin, & Snell, 2003), the locational parameter of the transition function, which is assumed to be exponential, is assumed to be the value zero. Imposing a locational parameter equal to zero on the smoothed transition function can be particularly restrictive for the variables for which the threshold value can be different from zero. In this context, **(Kruse, 2011)** expands the unit root test of (Kapetanios, Shin, & Snell, 2003), by relaxing the assumption of the location parameter equal to zero for a non-zero parameter. Thus, (Kruse, 2011) test gains in power compared with (Kapetanios, Shin, & Snell, 2003). Following (Kapetanios, Shin, & Snell, 2003), (Kruse, 2011) applies a first-order Taylor expansion to the transition function and proceeds with the following regression

$$\Delta y_t = \emptyset_2 y_{t-1}^2 + \emptyset_3 y_{t-1}^3 + \sum_{j=1}^{p} \delta_j \Delta y_{t-j} + v_t. \quad (5)$$

In this case, the null hypothesis of a unit root is H_0: $\emptyset_3 = \emptyset_2 = 0$ and the alternative hypothesis of a globally stationary ESTAR process is H_1: $\emptyset_3 < 0$, $\emptyset_2 \neq 0$. Note that in H_1, the $\emptyset_2$ has two-sidedness due to the fact that the location parameter, *c*, may assume real values. This testing problem is non-standard in the sense that one parameter is one-sided under H_1 while the other one is two-sided. The problem of one parameter in the test being unilateral, $\emptyset_3 < 0$, and the other being two-sided, $\emptyset_2 \neq 0$, renders the use of the standard Wald test inappropriate. To solve the problem, (Kruse, 2011) proposes a test τ, which is a version of the Wald test based on the Hessian matrix as proposed by (Abadir & Distaso, 2007). Hence, we get the following test statistic for the unit root hypothesis against globally stationary ESTAR :

$$\tau = t^2_{\emptyset_{\frac{\perp}{2}}=0} + 1(\widehat{\emptyset}_3 < 0)t^2_{\emptyset_3=0}.$$

The two summands appearing in the test statistic τ can be interpreted as follow: the first term is a squared t statistic for the hypothesis $\emptyset_{\frac{\perp}{2}} = \emptyset_2 - \emptyset_3 v_{23} / v_{33} = 0$ with $\emptyset_{\frac{\perp}{2}}$ being orthogonal to $\emptyset_3$. And, the second term is a squared t statistic for the hypothesis $\emptyset_3=0$, the one-sidedness under H_1 is achieved by the multiplied indicator function. The limiting distribution of **τ statistic** is derived in (Kruse, 2011). The critical values of τ were **tabulated** by (Kruse, 2011, p. 6).

V. Empirical Results

The traditional ADF, PP, and KPSS tests results are given in Table B 1 (see Annexe). Results of **ADF** test show that for both price series, the null hypothesis of the presence of a unit root is not rejected when a constant and a linear trend were incorporated as the deterministic term in the model. When only a constant term was included, it is apparent that the null hypothesis of nonstationarity is rejected only for **LDJICPI**. Results of **PP** test show that for both price series, the null hypothesis of the presence of a unit root is rejected when only a constant term was included in the model. When a constant and a linear trend were incorporated as the deterministic term, it is apparent that the null hypothesis of nonstationarity is rejected only for LCCSI. Results of KPSS test say that stationary hypothesis is not rejected for **LDJICPI (**LCCSI) when only a constant term was included (a constant and a linear trend were incorporated as the deterministic term) in the model.

In this part, for the linear series, we decided also to use the (Elliot, Rothenberg, & Stock, 1996) generalized least squares **detrending** tests (DF-GLS), the ERS point optimal test, and (Ng & Perron, 2001) linear unit root tests. The choice of these tests was made because of the problem of the size and power of the previous traditional tests. **Table B 2** shows the results of these unit root tests (see Annexe).

In **Table B 2,** the DF-GLS and ERS (PO) tests do not reject the null hypothesis of unit root test. Therefore, for both market of Canada included in this study, the overwhelming evidence of **nonstationarity** in levels is supported.

We decided also to use Zivot & Andrews **statatistic** for **1 Structural break** within **unit root** test. Null hypothesis of nonlinear unit root is not rejected for both markets with breack date referring to GFC periods (2008-2009).

Given the inconsistent results provided by the linear unit root testing procedures, the study next applies a battery of nonlinear unit root tests.[8] In particular, the study implements the KSS type and Sollis nonlinear unit root tests. Prior to implementing the nonlinear STAR unit root tests, the study utilized the BDS procedure to test the null hypothesis of linearity against the alternative of a nonlinear model. The results from the BDS tests are presented in **Table B 4** (see Annexe). Based on the results from the BDS procedure, the null hypothesis of linearity is rejected in favor of the alternative of nonlinearity in all of the cases.

The study next applies the KSS type nonlinear unit root tests. The nonlinear KSS (NLADFM for demeaned data and NLADFT for de-trended data) and MKSS (or CHLL for original series) unit root tests were conducted using the brut or corrected (from outliers effect) stock price data in log for Canada. **Table B 5** presents the results from the nonlinear KSS type unit root test results. **Table B 6** presents the results from the nonlinear MKSS (or CHLL) unit root test results. The results suggest that the null hypothesis of nonlinear unit root in the stock prices for both market are rejected by **NLADFT test**. In each case, the test statistic is greater than the critical value at least at the 5 percent level of significance. Results are mixte by **NLADFM.** Null hypothesis of nonlinear unit root are not rejected by CHLL statistics. This result is maintained by CHLL test statistics.

To check the robustness of the results obtained from the KSS type nonlinear unit root tests, the study applies the (Sollis, 2009) nonlinear unit root testing procedure. Again, the (Sollis, 2009) nonlinear unit root tests are conducted using the raw, demeaned and detrended stock price data for both canadian stock markets.

Table B *7* displays the nonlinear unit test results from the (Sollis, 2009) procedure. The results indicate that the null hypothesis of nonlinear unit root should not be rejected at least at the 5 percent level in all of the cases.

To check the robustness of the results obtained from the KSS, CHLL, and Sollis nonlinear unit root tests, the study applies the (Kruse, 2011) nonlinear unit root testing procedure. Again, the (Kruse, 2011) nonlinear unit root tests are also conducted using the raw, demeaned and detrended stock prices data for Canada. **Table B 8** in Annexe displays the nonlinear unit test results from the (Kruse, 2011) procedure. Again, the results indicate that the null hypothesis of

[8] The reason for preferring the nonlinear unit root tests is that the transition between regimes considered to be more appropriate for the economic structure is smooth and has a better power than previous tests.

nonlinear unit root should not be rejected at least at the 5 percent level in all of the considered cases.

VI. Conclusion

In this paper we test the weak form of the Efficient-Market Hypothesis (EMH) using **monthly** data from 2004M08 to 2018M04 of stock prices by using linear and nonlinear (KSS 3 type, Sollis and Kruse) unit root tests. The informational market efficiency is examined in the Islamic and conventional markets in Canada. It aims to investigate whether Islamic market would be more or less efficient than the conventional one. All linear and nonlinear unit root tests results are summed up in **Table 2** here after. From traditional linear unit root tests (Panel A) no clear cut results are found while more recent unit root tests conclusion (Panel B) is clear. Both market Conventional Canadian Stock Index (CCSI) and Dow Jones Islamic Canadian Price Index (DJICPI) show characteristics of random walk indicating that the stock markets are **efficient.** This latter result is maintained with non linear unit root tests (Panel C) except for KSS type test results which are mixte.

Findings indicate then that the **major policy implications** is that in this country (**Canada**), fund managers and investors cannot enjoy excess returns to their investment.

Stocks' price could include diverse information, but incorrectly, and as a consequence, market will over or under-react to such information. Even if econometric tests confirm the random walk hypothesis, this is not sufficient for capital markets to be informational efficient. Then, more investigations are needed in subsequent papers.

Table 2: Sum up results of considered 'unit root tests'.

Panel A : **Traditional Linear tests from Table B1**			
	Trend	LCCSI	LDJICPI
PP	c	**SL2**	**SL2**
	[c, t]	**SL2**	Ho
ADF	c	Ho	**SL2**
	[c, t]	Ho	Ho
KPSS[9]	c	Ho	**SL2**
	[c, t]	**SL2**	Ho

Note : C for model with constant. [c, t] for model with constant and linear trend.

(suite)

Panel B : **Recent U R tests from Tables B2 and B3.**				Panel C : **Non-linear tests from Tables B5, B6, and B7.**			
	Trend	LCCSI	LDJICPI		Data	LCCSI	LDJICPI
Ng-Perron stat				**KSS type stat**			
MZa		Ho	Ho	**NLADFM**	Brut	Ho	Ho
MZt		Ho	Ho		Corrected	**SL2**	**SL2**

[9] This test is for stationarity against unit root hypothesis.

MSB		Ho	Ho	**NLADFT**	Brut	**SL2**	**SL2**
MPT		Ho	Ho		Corrected	**SL2**	**SL2**
ERS (PO)	c	Ho	Ho	**CHLL**	Brut	Ho	Ho
	[c, t]	Ho	Ho		Corrected	Ho	Ho
ERS (DF-GLS)				**Sollis F stat**	Trend		
		Ho	Ho		_	Ho	Ho
1 Structural break unit root stat					c	Ho	Ho
Zivot & Andrews		Ho	Ho		[c, t]	Ho	Ho
				Kruse τ stat	Trend		
					_	Ho	Ho
					c	Ho	Ho
					[c, t]	Ho	Ho

Note: Ho suggest that the Unit root hypothesis is not rejected. **Brut** and **Corrected** from **abnormal** events data are used for KSS type Nonlinear unit root tests. **SL2** suggest that process is stationary. Traditional unit root tests: Augmented Dickey and Fuller (ADF) and Phillips and Perron (PP). Traditional test for stationarity: Kwiatkowski, Phillips, Schmidt and Shin (KPSS). More recent unit root tests: Elliott-Rothenberg-Stock point optimal ERS (PO) and Elliott-Rothenberg-Stock generalized least squares ERS (DF-GLS). Non linear unit root tests: Kapetanios, Shin andSnell (KSS), Chong, Hinich, Liewand, & Lim (CHLL), and Sollis. Tables B2-B7 are given at Appendix.

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Appendix: Tables for critical values.

Table A 1: Asymptotic critical values for the *(Kapetanios, Shin, & Snell, 2003)* (KSS) Table 1 p 364.

(Asymptotic critical values for the KSS test)

Significance Level	Case 1	Case 2	Case 3
1%	-2.82	-3.48	-3.93
5%	-2.22	-2.93	-3.40
10%	-1.92	-2.66	-3.13

Note: Case 1, Case 2 and Case 3 refer to the underlying model with the raw data, demeaned data and de-trended data, respectively.

Table A 2: Asymptotic critical value from *(Kruse, 2011)* Table 1 page 6.

(Critical values of the τ statistic)

Significance Level	dt = 0	dt = 1	dt = [1 t]
1%	13.15	13.75	17.10
5%	9.53	10.17	12.82
10%	7.85	8.60	11.10

Note: dt = 0 : without constante, dt = 1 : with constant, dt = [1 t] : with constant and trend.

Table A 3: The Simulated Critical Values of modified KSS statistic (CHLL or MKSS):

Sample Size	**Specification of Trend**					
	Linear (trend)			**Nonlinear (trend ^{2})**		
	10%	5%	1%	10%	5%	1%
25	-3.10	-3.42	-4.33	-3.13	-3.50	-4.31
50	-3.06	-3.38	-4.05	-3.10	-3.44	-4.07
100	-3.05	-3.35	-3.96	-3.07	-3.40	-4.02
200	**-3.03**	**-3.31**	**-3.90**	**-3.06**	**-3.39**	**-3.96**
400	-3.00	-3.29	-3.89	-3.04	-3.35	-3.94
800	-2.99	-3.29	-3.88	-3.04	-3.35	-3.94

Table A 4: The Simulated Critical Values of Sollis test.

	No Term			*Constant*			*Trend*		
# of Observations	*10%*	*5%*	*1%*	*10%*	*5%*	*1%*	*10%*	*5%*	*1%*
50	3.577	4.464	6.781	4.009	4.886	6.891	5.415	6.546	8.799
100	3.527	4.365	6.272	4.157	4.954	6.883	5.460	6.463	8.531
200	3.496	4.297	6.066	4.173	4.971	6.806	5.590	6.597	8.954
Asymptotic	1.837	2.505	4.241	3.725	4.557	6.236	5.372	6.292	8.344

Note : Source : researchgate.net/figure/Critical-values-of-Sollis-test_tbl9_323005993/download.

Annexe : Calendar anomalies analysis

Table A 5: Result of turn-of-calendar-month significant effect on DJIM price.

Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**

@MONTH=1	0.003145	0.094530	0.033272	0.9735
@MONTH=2	0.011901	0.094530	0.125892	0.8998
@MONTH=3	0.009105	0.094530	0.096321	0.9233
@MONTH=4	0.021642	0.094530	0.228940	0.8189
@MONTH=5	0.061551	0.096331	0.638951	0.5229
@MONTH=6	0.061543	0.096331	0.638873	0.5229
@MONTH=7	0.045901	0.096331	0.476489	0.6337
@MONTH=8	0.037303	0.094530	0.394610	0.6931
@MONTH=9	0.047167	0.094530	0.498960	0.6178
@MONTH=10	0.016585	0.094530	0.175449	0.8607
@MONTH=11	-0.008919	0.094530	-0.094350	0.9248
C	7.505558	0.066843	112.2861	0.0000
	Robust Statistics			
R-squared	0.008591	Adjusted R-squared		-0.062687
Rw-squared	0.012346	Adjust Rw-squared		0.012346
Akaike info criterion	181.4834	Schwarz criterion		221.4756
Deviance	7.430781	Scale		0.215368
Rn-squared statistic	1.407425	Prob(Rn-squared stat.)		0.999722

(suite) Result of turn-of-calendar-month significant effect on ***LCCSI*** price

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	7.394842	0.044552	165.9824	0.0000
@MONTH=1	0.003278	0.063006	0.052019	0.9585
@MONTH=2	0.022689	0.063006	0.360108	0.7188
@MONTH=3	0.025529	0.063006	0.405183	0.6853
@MONTH=4	0.034982	0.063006	0.555217	0.5787
@MONTH=5	0.016324	0.064206	0.254250	0.7993
@MONTH=6	0.001596	0.064206	0.024861	0.9802
@MONTH=7	0.008410	0.064206	0.130987	0.8958
@MONTH=8	0.000647	0.063006	0.010277	0.9918
@MONTH=9	-0.015239	0.063006	-0.241873	0.8089
@MONTH=10	-0.015399	0.063006	-0.244411	0.8069
@MONTH=11	-0.008677	0.063006	-0.137723	0.8905
	Robust Statistics			
R-squared	0.007929	Adjusted R-squared		-0.063397
Rw-squared	0.012689	Adjust Rw-squared		0.012689
Akaike info criterion	199.2270	Schwarz criterion		238.9775
Deviance	3.413312	Scale		0.138592
Rn-squared statistic	1.420023	Prob(Rn-squared stat.)		0.999709

Annexe : Unit root tests results

Linear unit root tests

Table B 1 : Conventional unit root tests (ADF PP and 'KPSS') results for Stock **Prices in log**.

		(PP)		(ADF) [10]		(KPSS) [11]	
		LCCSI	LDJICPI	LCCSI	LDJICPI	LCCSI	LDJICPI
With Constant	t-Statistic	-2.6876	-3.1151	-2.5437	-2.9207	0.9746	0.2390
	Prob.	0.0783	0.0274	0.1071	0.0451	***	**Ho**
		*	**	**Ho**	**		
With Constant & Trend	t-Statistic	-3.2266	-3.1052	-3.0916	-2.9538	0.0730	0.2349
	Prob.	0.0829	0.1086	0.1118	0.1487	**Ho**	***
		*	**Ho**	**Ho**	**Ho**		

Note : **Ho** ≡ null hypothesis of nonstationarity (stationarity) for ADF and PP (for KPSS) is not rejected.

Table B 2: **Recent Linear unit root** test results for **stock prices in log**.

		Ng-Perron test statistics				ERS	ERS
		MZa	MZt	MSB	MPT	Point optimal	DF-GLS
LCCSI		-8.39199	-2.03827	0.24288	10.8937	12.42773	-2.0354
LDJICPI		-3.89979	-1.33673	0.34277	22.6178	27.44314	-1.000632
critical values	1%	-23.8000	-3.42000	0.14300	4.03000		
	5%	-17.3000	-2.91000	0.16800	5.48000	5.653	-2.967000
	10%	-14.2000	-2.62000	0.18500	6.67000		
Conclusion		Ho	Ho	Ho	Ho	Ho	Ho

Note : Automatic Lag Length based on Modified AIC. ERS : Elliott-Rothenberg-Stock point optimal test statistic, critical value : for 1% level, 5% level, 10% level are repectively **4.1235, 5.653, 6.8355.** ERS tests are applied in autoregression with **constant and linear trend**. **Ho** ≡ null hypothesis of nonstationarity is not rejected.

Table B 3: Zivot & Andrews Structural breaks unit root test (One break) results for Stock **Prices in log.**[12]

Variable	LCCSI	LDJICPI
breack[13] date	**2008M08**	**2009M03**
Minimize Dickey-Fuller t-statistic	-4.307288 (0.205)	-3.758557 (0.5267)
breack date[14]	**2009M03**	**2009M01**
Maximize trend break t-statistic	-0.301297 (> 0.99)	-1.234381 (0.9598)
breack	**2008M06**	**2009M03**

[10] Notes: (*)Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant.

[11] Notes: a: (*) Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1% and (no) Not Significant. b: Lag Length based on AIC. c: Probability based on Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1).

[12] (Zivot & Andrews, 1992).

[13] Break Specification: Intercept only. Exogenous: Constant, Linear Trend.

[14] Trend Specification: Trend and intercept. Exogenous: Constant, Linear Trend.

date[15]		
Maximize intercept & trend break F-statistic	-4.547618 (0.1963)	-2.989376 (0.8605)
Conclusion	Ho	Ho

Note : (.) give p-value. Ho ≡ null hypothesis of nonstationarity (in presence of one breack) is not rejected.

Table B 4: BDS dependence test Results.[16]

BDS test statistics	**Dimension (m)**	**2**	**3**	**4**	**5**	**6**
LCCSI		21.98758	22.80707	23.99413	25.54465	27.70686
LDJICPI		23.05230	24.61459	26.03067	28.09386	30.90099

Note : Critical value are those of **Normal** distribution. This output is from Eviews 10.

Nonlinear unit root tests

Table B 5: KSS Nonlinear unit root test results for level LSP series.

Panel A : Demeaned data (**NLADFM** test statistic).

	Criteria	**Lags**	**KSS stat.**	**p-value**	**1% cv**	**5% cv**	**10% cv**	**Conclusion**
LCCSI	AIC	8	-0.331	0.921	-3.538	-2.952	-2.658	Ho
	SIC	2	-1.605	0.554	-3.459	-2.895	-2.611	Ho
LDJICPI	AIC	3	-1.581	0.583	-3.538	-2.952	-2.658	Ho
	SIC	3	-1.581	0.568	-3.459	-2.895	-2.611	Ho

Note : Ho ≡ null hypothesis of nonstationarity is not rejected.

Post correction from outlier effects.[17]

	Criteria	**Lags**	**KSS stat.**	**p-value**	**1% cv**	**5% cv**	**10% cv**	**Conclusion**
LCCSI	AIC	0	-3.038	0.039	-3.531	-2.942	-2.647	**SL2**
	SIC	0	-3.038	0.033	-3.445	-2.881	-2.598	**SL2**
LDJICPI	AIC	4	-5.827	0.000	-3.531	-2.942	-2.647	**SL2**
	SIC	1	-5.280	0.000	-3.445	-2.881	-2.598	**SL2**

Table B 5 (suite) Nonlinear unit root test results for level LSP series.

Panel B : Detrended data (**NLADFT** test statistic).

	Criteria	**Lags**	**KSS stat.**	**p-value**	**1% cv**	**5% cv**	**10% cv**	**Conclusion**
LCCSI	AIC	2	-3.470	**0.044**	-4.010	-3.420	-3.120	**SL2**
	SIC	2	-3.470	**0.035**	-3.900	-3.329	-3.042	**SL2**
LDJICPI	AIC	4	-4.082	**0.008**	-4.010	-3.420	-3.120	**SL2**

[15] Trend Specification: Trend and intercept. Exogenous: Constant, Linear Trend.

[16] It is applied to the detrended time series (nonlinear trend).

[17] For LCCSI, D2008 and D2016 are dummy var iables are used to correct respectively for GFC effect and for abnormal mouvement in 2016. D2008 = 1 for year 2008 and 0 if not, and D2016 = 1 for 2016 and 0 otherwise. For LDJICPI, in addition to D2008 and D2016, D2011 is a dummy variable used to correct for abnormal mouvement in 2011. D2011 = 1 for year 2011 and 0 if not.

	SIC	0	-3.020	0.105	-3.900	-3.329	-3.042	Ho

Note : NLADF is based on OLS demeaned data. KSS test for Ho: Unit root vs Ha: Stationary nonlinear ESTAR model. Critical value for different levels are given by **STATA**. SL2 : stationary process (reject of unit root hypothesis). Ho ≡ null hypothesis of nonstationarity is not rejected.

Post correction of outlier effects.

	Criteria	Lags	KSS stat.	p-value	1% cv	5% cv	10% cv	Conclusion
LCCSI	AIC	3	-4.933	0.000	-3.996	-3.403	-3.104	**SL2**
	SIC	0	-3.898	0.010	-3.884	-3.312	-3.025	**SL2**
LDJICPI	AIC	4	-5.919	0.000	-3.996	-3.403	-3.104	**SL2**
	SIC	1	-5.330	0.000	-3.884	-3.312	-3.025	**SL2**

Table B 6: CHLL Nonlinear unit root test results for level LSP series. [18]

Original data (**MKSS** test statistic).

	Trend	Lags	CHLL stat.	10% cv	5% cv	1% cv	Conclusion
LCCSI	Linear	12	2.455974	-3.03	-3.31	-3.90	Ho
	Nonlinear	12	2.455877	-3.06	-3.39	-3.96	Ho
LDJICPI	Linear	12	2.166836	-3.03	-3.31	-3.90	Ho
	Nonlinear	12	2.166926	-3.06	-3.39	-3.96	Ho

Note : Non stationary process (no rejection of unit root hypothesis). This Table is done by **Eviews 10**. Same result is obtained if corrected series **from outliers effect** are used. Ho ≡ null hypothesis of nonstationarity is not rejected.

Table B 7: Sollis Nonlinear unit root test results for level LSP series.[19]

	Trend	Lags	Sollis stat.	1% cv	5% cv	10% cv	Conclusion
LCCSI	_	12	2.738359	6.272	4.365	3.527	Ho
	c	12	2.058728	6.883	4.954	4.157	Ho
	[c, t]	12	2.729759	8.531	6.463	5.46	Ho
LDJICPI	_	12	3.717552	6.272	4.365	3.527	Ho
	c	12	3.310378	6.883	4.954	4.157	Ho
	[c, t]	12	0.627143	8.531	6.463	5.46	Ho

Note : c : constant, [c, t]: linear trend.

Table B 8: Kruse Nonlinear unit root test results for level LSP series.[20]

	Trend	Lags	Kruse	1% cv	5% cv	10% cv	Conclusion

[18] Critical value (cv) are from Table A 3 given in Appendix for different size sample.
[19] Critical value (cv) are from Table A 4 given in Appendix for different size sample.
[20] Critical value (cv) are from Table A 2 given in Appendix for different size sample.

LCCSI	_	12	2.00194	13.15	9.53	7.85	Ho
	c	12	1.90871	13.75	10.17	8.60	Ho
	[c, t]	12	1.51936	17.10	12.82	11.10	Ho
LDJICPI	_	12	5.36029	13.15	9.53	7.85	Ho
	c	12	1.01220	13.75	10.17	8.60	Ho
	[c, t]	12	1.07665	17.10	12.82	11.10	Ho

Note : c : demeaned data, [c, t]: detrended data.