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AN INVESTIGATION OF EFFICIENT MARKET HYPOTHESIS IN OECD COUNTRIES

This study aims to investigate whether stock price returns are on a random walk for OECD countries. Using quarterly data for the 2005:1 - 2011:2 period, LM unit root test is employed which endogenously determines up to two structural breaks in level and trend. The empirical findings suggest a combination of random walk and mean reversion results for OECD countries. The results show that efficient market hypothesis (EMH) is confirmed in 13 out of 34 OECD countries. However, with regard to the panel unit root test, the OECD countries share price index returns are mean reverting which highlights the fact that the EMH is not valid.

Keywords: *random walk; structural break; mean reversion; efficient market hypothesis.*

JEL Classification: G14; G15; C23.

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ПІДТВЕРДЖЕННЯ ГІПОТЕЗИ ЕФЕКТИВНОГО РИНКУ ДЛЯ КРАЇН ОЕСР

У статті досліджено, чи дійсно у країнах ОЕСР курс акцій на фондових біржах схильний до випадкових блукань. Використано квартальні дані з 2005:1 по 2011:2. Для аналізу застосовано загальний критерій множників Лагранжа, за яким можна визначити структурні розриви як у рівні, так і у тренді. Результати моделювання показали, що для всіх країн ОЕСР характерною є комбінація закону чергування та випадкового блукання. Для 13 з 34 країн ОЕСР знайшла своє підтвердження гіпотеза ефективного ринку. У той же час результати тестування одиничних коренів вказують на те, що у країнах ОЕСР для курсу акцій спрацьовує закон чергування, що, в свою чергу, суперечить гіпотезі ефективного ринку.

Ключові слова: *випадкове блукання; структурний розрив; закон чергування; гіпотеза ефективного ринку.*

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ПОДТВЕРЖДЕНИЕ ГИПОТЕЗЫ ЭФФЕКТИВНОГО РЫНКА ДЛЯ СТРАН ОЭСР

В статье исследуется, действительно ли в странах ОЭСР курс акций на фондовых биржах случайно блуждает. Использованы квартальные данные с 2005:1 по 2011:2. Для анализа применен общий критерий множителей Лагранжа, по которому можно определить структурные разрывы как в уровне, так и в тренде. Результаты моделирования показали, что для всех стран ОЭСР характерна комбинация закона чередования и случайного блуждания. Для 13 из 34 стран ОЭСР нашла подтверждение гипотеза эффективного рынка. В то же время результаты тестирования единичных корней указывают, что в странах ОЭСР для курса акций срабатывает закон чередования, что, в свою очередь, отрицает действие гипотезы эффективного рынка.

Ключевые слова: *случайное блуждание; структурный разрыв; закон чередования; гипотеза эффективного рынка.*

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1. Introduction. Efficient market hypothesis (EMH) and the random walk model have been widely discussed in the financial literature for several decades. In an efficient stock market, stock price dynamics are described by a random walk with a drift (Fama, 1970). Besides, return anomalies are chance results that tend to disappear in the long term. In this respect, future returns are unpredictable based on the historical observations. In other words, a capital market is considered efficient if stock prices at any time fully reflect all available and relevant information. Therefore, given only past price and return data, the current price should be unexpectable. Under EMH, capital markets are expected to be nonstationary therefore contain one or more unit root. However, if stock prices (or returns) are mean reverting then they are stationary where future movements are based on the past behavior.

The early examples of the EMH studies on stock markets are Fama and French (1988), Poterba and Summers (1988). Their results prove that mean reversion exists in the US stock prices. However, Lo and MacKinlay (1988), Kim et al. (1991), Richardson (1993) studies are unable to reject unit root hypothesis at stock markets. The empirical evidence on the random walk hypothesis with unit root tests has a growing literature body with the studies of Choudhry (1997), Zhu (1998), Balvers et al. (2000), Narayan and Prasad (2007), Koustas et al., (2008), Li and Chen (2010). However, after the study of Perron (1989) it is determined that structural shifts are highly effective on the unit root test results. The random walk hypothesis literature for capital markets expands by unit roots with structural breaks. Chaudhuri and Wu (2003), Chaudhuri and Wu (2004), Narayan and Smyth (2004), Sheddighi and Nian (2004), Narayan and Smyth (2007), Narayan and Narayan (2007), Chancharat and Valadkhani (2007), Lean and Smyth (2008), Narayan (2008), Ozdemir (2008), Lee et al. (2010) are the well-known studies that found mixed results on random walk hypothesis for the capital market returns.

This study aims to investigate whether stock price returns are on random walk for all OECD countries (Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States). Due to this respect, the Share Price Index (SPI) is used to calculate the returns by quarterly data (2005:1 to 2011:2) and panel unit root methodology up to two breaks is utilized.

The basic contribution of this study is the analysis of international data that exploits increased power deriving from the unit root methodology, together with the flexibility of allowing up to two endogenous structural breaks in the level and the trend of individual series as proposed by Lee and Strazicich (2003, 2004).

The remainder of the article is composed of 4 sections. Section 2 presents the data and the methodology. Section 3 provides the empirical findings, the research findings and their interpretation are presented in Section 4.

2. Methodology and data. The very common unit root applications of time series starts with Dickey and Fuller (1979), Nelson and Plosser (1982), Campbell and Mankiw (1987), Cochrane (1988), Philips and Perron (1988). It is realized that the power of unit root applications is low on time series analysis due to the limited number of data. To solve this problem, panel data econometrics is developed which con-

tains both time series and cross sections to increase the data set. The literature on panel data unit root is expanded by Levin and Lin (1992, 1993), Breitung and Meyer (1994), Quah (1994), Maddala and Wu (1999), Choi (1999), Breitung (2000), Hadri (2000), Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003) studies. However, another weakness is that a structural break can be mistaken for non-stationarity. In other words, previous applications of a unit root may be invalid if a structural break exists.

The literature on unit root under structural shifts starts with Perron (1989) and is expanded by Zivot and Andrews (1992), Banerjee et al. (1992), Perron and Vogelsang (1992), Lumsdaine and Papell (1997), Perron (1997), Lee and Strazicich (2003, 2004). In this study, a univariate LM unit root test is used, proposed by Lee and Strazizich (2003, 2004). However, the origins of this unit root process depend on univariate one-break LM unit root test developed by Amsler and Lee (1995) and Im et al. (2002).

The LM unit root test considered by Lee and Strazicich (2003) starts by estimation of two-break LM unit root test statistics. If less than two breaks is significant, the one-break minimum LM test of Lee and Strazicich (1999) is applied. If less than one break is significant than no-break LM test of Schmidt and Phillips (1992) is applied. As such, the location of breaks, the number of breaks, and the number of lagged augmentation terms are jointly determined for each country. The steps in this procedure are proposed by Jewel et al. (2003) and Im et al. (2005). In determination of breakpoints and LM unit root test statistics, first unique fixed effects, differing time trend coefficients, and varying persistence parameters are allowed for each country. Second, the number of structural breaks are determined which varies by country. Third, heterogeneous break points are being sought which are endogenously determined for each country. Fourth, time-specific fixed effects are allowed to capture common year structural breaks. Finally, the optimal number of augmentation terms is allowed in the unit root test which is heterogeneous and determined jointly with breaks.

The minimum LM unit root test starts with computation of univariate LM unit root test statistics for each country with two-breaks. Due to this the following equation needs to be estimated according to LM (score) principle:

$$\Delta Y_{it} = \delta_i^{'} \Delta Z_{it} + \phi \tilde{S}_{t-1} + \sum_{1}^{k} \gamma_i \Delta \tilde{S}_{t-i} + \varepsilon_t, \quad (1)$$

where ΔY_{it} and Z_{it} are the first differenced values of Y_{it} and Z_{it} respectively, while Z_{it} is a vector of exogenous variables defined by the data generating process where $Z_{it} = [1, t, D_{1it}, D_{2it}, DT_{1t}, DT_{2t}]$. D_{1it}, D_{2it}, are dummy variables that capture the first and the second structural break respectively. $D_{1it} = 1$, if $t >$ Time Break 1, zero otherwise, $D_{2it} = 1$, if t > Time Break 2, zero otherwise. Besides, $DT_{1t} = t -$ Time Break 1 if $t >$ Time Break 1, zero otherwise, $DT_{2t} = t -$ Time Break 2 if $t >$ Time Break 2, zero otherwise.

$\tilde{S}_{t-i}$ is the detrended value of Y_{it-1}, where $S_{t,i} = Y_t - \tilde{\psi}_x - Z_t\tilde{\delta}$ for $t = 2,\ldots,T$. $\tilde{\psi}_x$ is given by $Y_1 - Z_1\delta$ where Y_1 and $Z_1$are the first observations of Y_t and Z_t respectively. $\tilde{\delta}$ is a vector of coefficients estimated from the regression of ΔY_{it} on ΔY_{it}.

The unit root null hypothesis is described by $\phi = 0$ (implying a unit root with two breaks), and the LM test statistics are given by:

$$\tilde{\tau} = 1 \text{ Statistics for the null hypothesis } \phi = 0 \quad (2)$$

The minimum LM unit root t-statistic determines the endogenous location of two breaks by utilizing a grid search as follows:

$$LMit = \inf_{\lambda} \tilde{\tau}(\lambda) \quad (3)$$

The determination of TB is denoted by minimum LM test on equation 3 where $\lambda = \frac{TB}{T}$.

The quarterly data starts from the first quarter of 2005 to the second quarter of 2011 for all 34 OECD countries. The share price indices are obtained from the OECD Statistics of Main Economic Indicators (MEI). Capital market returns are calculated by share price indices by the following formula:

$$R_{i,t} = \frac{SPI_{i,t} - SPI_{i,t-1}}{SPI_{i,t-1}}, \quad (4)$$

where $R_{i,t}$ denotes return of i'th country on time t. $SPI_{i,t}$ and $SPI_{i,t-1}$ show share price index on time t and $t-1$ respectively.

3. Empirical results. The results of the LM unit root tests on the share price index returns allowing for possible time-fixed effects are shown in Table 1. To allow for the possibility of a trend stationary alternative, all unit root tests include both an intercept and time trend. The first column represents the country names with the panel LM test statistic on the last row. While second column shows the LM unit root test statistics, third column shows the optimal number of breaks. The optimal number of lagged differenced terms that correct for serial correlation is given in the fourth column, and the location of the breaks appears in the last column.

Table 1. **LM unit root tests on share price index returns, 2005:1 – 2011:2**

Country	Univariate LM Unit Root Test Statistics	Optimal N of Breaks	Optimal Lag Length	Break Location(s)
Australia	-3,807***	2	8	2007Q3, 2010Q1
Austria	-4,153**	1	0	2008Q3
Belgium	-0,202	0	4	-
Canada	1,104	0	7	-
Chile	-4,546*	2	6	2007Q4, 2010Q1
Czech Republic	-4,258*	1	0	2008Q3
Denmark	-5,333*	0	0	-
Estonia	-6,033*	2	1	2007Q3, 2009Q2
Finland	-3,583**	1	0	2009Q3
France	-5,986*	0	2	-
Germany	-0,886	0	3	-
Greece	-2,06	1	8	2009Q3
Hungary	-0,653	0	7	-
Iceland	-4,805*	2	6	2007Q4, 2008Q3
Ireland	-2,905	1	0	2008Q3
Israel	0,185	0	3	-
Italy	-2,773	1	5	2008Q3
Japan	-3,551**	1	0	2010Q3
Korea	-1,55	0	7	-
Luxembourg	-7,375*	2	7	2008Q1, 2008Q3

The End of *Table 1*

Country	Univariate LM Unit Root Test Statistics	Optimal N of Breaks	Optimal Lag Length	Break Location(s)
Mexico	-3,674**	1	0	2008Q3
Netherlands	-2,555	1	5	2008Q4
New Zealand	-0,629	0	3	-
Norway	-3,443**	1	3	2009Q3
Poland	-5,983*	1	1	2007Q3
Portugal	-4,629*	2	5	2007Q3, 2010Q2
Slovak Republic	-7,223*	2	7	2007Q4, 2010Q3
Slovenia	-4,233*	0	0	-
Spain	-3,698**	1	0	2009Q2
Sweden	-4,854*	0	2	-
Switzerland	-2,108	0	5	-
Turkey	-4,590*	2	7	2007Q4, 2009Q1
United Kingdom	-4,689*	0	5	-
United States	-1,746	0	3	-
Panel LM stat.	-55,60*			-

Notes: All tests allow for time fixed effects and all regressions include an intercept and time trend. Structural breaks denote a shift in the level or intercept.
The 1, 5 and 10% critical values for the LM unit root test with no break are: -3,63, -3,06 and -2,77.
The 1, 5, and 10% critical values for the minimum LM test with one break are: -4,239, -3,566, and -3,211.
The 1, 5, and 10% critical values for the minimum LM test with two breaks are: -4,545, -3,842, and -3,504.
The 1, 5, and 10% critical values for the panel LM unit root test (with or without breaks) are: -2.326, -1.645 and -1.282.
*, ** and *** denote statistical significance at the 1%, 5%, 10% levels.

The univariate LM test results indicate there are 21 rejections of the unit root at the 10% level of significance or better. In other words, the results are mean reverting for 21 OECD countries. Thus, the EMH hypothesis is not valid for Australia, Austria, Chile, Czech, Denmark, Estonia, Finland, France, Iceland, Japan, Luxemburg, Mexico, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Turkey and the United Kingdom. In addition, the results indicate that in Belgium, Canada, Germany, Greece, Hungary, Ireland, Israel, Italy, Korea, Netherlands, New Zealand, Switzerland and the United States capital market returns are random walk which is consistent with the EMH.

With regard to the panel unit root test, a strong rejection of the unit root null is found which proves that equity returns of OECD countries capital markets are mean reverting. In other words, past stock price returns can be used to anticipate future returns when testing all countries as whole rather than examining countries one by one.

An examination of the break points in Table 1 reveals some clustering of the break dates. Structural break is found to exist in 20 out of 34 countries, 8 of which contain two breaks. Most structural breaks are around 2008 relating economic conjecture crises (notably financial crisis of 2008). The 2008 crisis which is formerly known as global economic crisis starting with the shortfall of liquidity in the U.S. banking system in late 2007 and causing declines in credit availability and damaged investor confidence, while securities suffered large losses during late 2007 to mid 2009.

4. Conclusion. The efficient market hypothesis (EMH) states that past prices (or returns) are insufficient to anticipate future stock prices (or returns). Predictability of

stock returns on the basis of past price changes have been extensively investigated with various methodologies. Unit root methodology is one of the basic research techniques to find out if capital market returns are on a random walk process. Under EMH, capital markets are expected to be nonstationary therefore contain one or more unit root. However, if stock prices (or returns) are mean reverting then they are stationary where future movements are based on past behavior.

The share price index returns data from all OECD countries are examined over the period 2005:1 – 2011:2 to test for stationarity. The methodology is using a LM unit root test that endogenously determines breaks in level and trend as proposed by Lee and Strazicich (2003, 2004).

The results indicate that Belgium, Canada, Germany, Greece, Hungary, Ireland, Israel, Italy, Korea, Netherlands, New Zealand, Switzerland and the United States capital market returns are random walk which is consistent with the EMH. However, the results for the rest of OECD countries are mean reverting. In other words, the EMH hypothesis is not valid for Australia, Austria, Chile, Czech, Denmark, Estonia, Finland, France, Iceland, Japan, Luxemburg, Mexico, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Turkey and the United Kingdom. This indicates that past stock price returns can be used as a proxy for future returns, whereas these results present the existence of inefficient stock markets.

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