Dynamic Mean Reversion of Stock Prices: Evidence from Amman Stock Exchange

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ABSTRACT

This study aims to investigate the relative mean reversion process of stock prices in Amman stock exchange using daily data over the period (2004-2013). Symmetric and asymmetric versions of the partial adjustment model are utilized to achieve the objectives of the study. The simple model of mean reversion, which is commonly used to estimate the speed of mean reversion, is extended to a single equation Error Correction model (ECM), which accounts for both short and long term effects. The results show that stock prices significantly but very slowly move toward their fundamental values. The adjustment rate is 9% indicating that 7 days are required to eliminate half of the deviation of the actual stock price from the fundamental value. The asymmetric partial adjustment model shows that the adjustment coefficient is higher for prices above their fundamental values (31%) than for prices below their fundamental values (15%), thus the stock prices are slower when the adjustment requires an increase in price level than a decrease in price level. Finally, the ECM shows that stock prices change their actual values relative to the long-run fundamental value but in a slow manner.

Keywords: Partial Adjustment Model, Mean Reversion, Stock Prices, Error Correction Model, Amman Stock Exchange.

INTRODUCTION

Mean reversion refers to "a tendency of asset prices to return to a trend path" (Balvers et al., 2000). Thus, stock prices can be characterized as random walk (unit root) or mean reverting (trend stationary) processes. This issue has been the focus of several researchers since 1980s*. The empirical evidence on mean reversion is mixed though, and has been highly debated. If it is established that stock prices are mean reverting then investors can forecast future movements in stock prices based on past behavior, and trading strategies can be developed to earn abnormal returns. This has direct implications for the efficient market hypothesis of Fama (1970). If stock prices are non-stationary then shocks will have a permanent effect, indicating that stock prices will reach a new equilibrium and future returns cannot be predicted based on historical movements in stock prices, thus markets are efficient. In other words, mean reversion can be considered as evidence against the efficient market hypothesis.

The assessment of relative mean reversion introduces the problem of specifying an accurate proxy for the fundamental value. Hereby the fundamental value process around which stock prices are expected to mean revert

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* (The early and influential papers about mean reversion in returns and stock prices are, Debondt and Thaler, 1985; Summers, 1986; Fama and French, 1988; Poterba and Summers, 1988).

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should be specified, which may substantially improve the estimation accuracy of mean reversion. The fundamental value of a stock can be defined as the present value with constant discount rate of optimally forecasted future real dividend payments (Shiller, 2001). According to this view, the fundamental value of the stock can be calculated using present value models such as Gordan (1959) model. On the other hand, a large amount of literature has developed the fundamental value of the stock based on the valuation ratios and price multiples such as price to earnings ratio, price earnings to growth ratio, etc. The mean reversion process involves answering many questions regarding whether it significantly exists, the speed of adjustment toward the mean, whether this adjustment is symmetric or not and whether it exists on the short or long run. This study aims to answer these questions. It investigates the dynamic symmetric and asymmetric mean reversion process of stock prices in Amman stock exchange (ASE) using daily data over the period (2004-2013). To the best of author's knowledge; this is the first study in Jordan that uses the partial adjustment model to examine the mean reversion in stock prices. We use this model because it is the best model that can answer the research questions. The partial adjustment model is advantageous because it determines the speed of adjustment in stock prices and whether it is symmetric or asymmetric. Amihud and Mendelson (1987) argue that the partial adjustment model distinguishes between the intrinsic value of the security and its observed price. They explain that the difference between the two values is attributable to noise which in turn comes from two sources: first is the noise trading which is induced by temporary liquidity needs of traders and second is the trading mechanism in the market in which buy and sell orders do not compromise with each other's due to several reasons such as random arrival. The remainder of the study is organized as follows: Section 2 reviews the literature. Section 3 describes data and methodology. Section 4 discusses the results of analysis. Section 5 concludes.

2. Literature Review

The first direct empirical evidence of mean reversion is introduced by Fama and French (1988) and Poterba and Summers (1988) in U.S. stock prices over long horizons. However, this evidence is questioned by (Lo and MacKinlay, 1988; Richardson and Stock, 1989; Kim *et al.,* 1991) who find that US stock prices follow a random walk. They argue that the tests used in both papers have very little statistical power, thus, the results could plausibly be due to pure chance. With long time horizons, there are not enough independent data observations available for statistical tests to be robust. Moreover, the results in both papers are more or less leaded by stock returns before World War II (1926-1940). If returns from this time period are removed from the data set, then mean reversion disappears. They also argue that it is impossible to distinguish between irrational (hence inefficient) bubbles or crashes, and rational variations in expected returns that occur randomly over time.

Damodaran (1993) develops a simple approach to estimate price adjustment coefficients by using the information in return processes. This approach is used to estimate the price adjustment coefficients for firms listed on the NYSE and the AMEX as well as for over-the-counter stocks. He finds evidence of a lagged adjustment to new information in shorter return intervals for firms in all market value classes. In specific, based on research results in the period (1977-1981), the mean of price adjustment coefficient is 67% in the first day, 95% in the second day, 98% in the third day and 100% in the sixth day. In the second period (1982-1986), the prices are adjusted with a mean of 68% in the first day, 96% in the second day, 99% in the third day and 100% in the fourth day. Brisley and Theobald (1996) and Ariff and Chan (2002) find similar evidence with respect to the speed of mean reversion on a daily basis in Hong Kong and Japan, respectively. However, Lim and Hooy (2010) measure the speed with which the aggregate stock market in 49 countries responds to global market-wide public

information. Their results show wide variations in the speed of stock price reversion over time and across countries. The panel analysis confirms that market size, trading volume, short sales restrictions and the degree of investment ability are significant determinants of price delay even at the country level.

The subsequent papers have employed panel data approach examining stock indexes for groups of countries. Koutmos (1999) tests the hypothesis that stock returns in emerging Asian stock markets adjust asymmetrically to past information. He finds that positive past returns are more persistent than negative past returns of an equal magnitude. This finding supports the asymmetric partial adjustment price model where news suggesting overpricing (negative returns) are incorporated faster into current prices than news suggesting underpricing (positive returns). Balvers, *et al*. (2000) investigates mean reversion in 18 developed countries' stock indices with a sample period from 1969 to 1996. They document strong evidence in favor of mean-reversion that is robust to model specification and data. The half-life implied by the speed of reversion is found to be from three to three and a half years. Likewise, Chaudhuri and Wu (2004) provide evidence of mean reversion using monthly data for 17 emerging capital markets over the period (January 1985-April 2002) and reject the random walk hypothesis. They find that the half-life of mean-reversion is about 30 months, which is close to findings from developed countries.

Gropp (2004) provides evidence of portfolio mean reversion from the three stock exchanges, NYSE, AMEX and NASDAQ over the period (1926-1998). He finds strong evidence of mean reversion in portfolio prices. His findings imply a significantly positive speed of reversion with a half-life of approximately three and a half years. Miyakoshi *et al.* (2007) examine the market efficiency and asymmetric of price adjustment in Tokyo Stock Exchange over the period (1980-2005). They find that the stock price does not fully adjust to the market value of stocks hoped by investors and does not adjust symmetrically in upturn and downturn if the market is not efficient, and in addition the market value generally diverts from the fundamental value of stocks even though the market is efficient. Manzan (2007) investigates nonlinear mean reversion in yearly S&P500 data over a relatively long period of time (1871 -2003). The results suggest that the market price experiences significant swings away from its fundamental valuation but reverts back in the long-run. The deviation of stock prices from their fundamental valuation can be strongly characterized by a nonlinear adjustment process.

Recently, Wang *et al.* (2015) investigate the mean reversion process in stock prices in seven Asian stock markets over the period (December 1990 to March 2013). Using LM Fourier unit root test, the results show that stock prices in all these seven stock markets demonstrate significant mean reversion. Their results of stationary test can be divided into two parts. When a level term is included in the model, the stock price of Thailand is mean-reverting while stock prices of other regions (Mainland of China, HK of China, Japan, South Korea, Malaysia and Singapore) are non-stationary; when a trend term is included the stock prices in seven stock markets are all mean reversion processes. Overall, the previous studies show mixed evidence of the mean reversion process. This study tackles this important issue in Amman Stock Exchange. To the best of author's knowledge; this is the first study in Jordan that uses the partial adjustment model to examine the mean reversion in stock prices. The Jordanian stock market is a frontier market that witnesses continuous fluctuating stock prices because of financial, economic and political factors; it also had a noticeable deterioration in the last few years. Thus, it is imperative for academicians, investors, regulators, corporations and practitioners to know whether stock prices deviate from their fundamental values, whether they revert to their intrinsic values and how quickly they do so. The findings of this research could have vital insights to the efficient

market hypothesis. More importantly, investors could formulate investment strategies to achieve abnormal returns during the reversion process.

3. Data and Methodology

Our data set consists of the daily trading data of 57 companies listed in ASE over the period (2004-2013). The reason behind selecting this period of study is to have a balanced period before and after the global financial crises which happened in 2008. The population of the study consists of all the companies listed in ASE over the period of the study which count to 262 companies. The daily trading data of all these companies is downloaded from the formal website of the ASE. The sample companies are selected according to a filtering process using the following criteria:

1. In order for the company to be included in our sample, it should be listed over the whole study period.
2. Stock that had split or Mergers during the study period is excluded.
3. Stock should be traded at least 10 days each month over the study period to be included in our sample. This condition is set to avoid thin trading problem, thus, by applying it the stocks that are thinly traded will not be included in the sample of the study.

The resulting sample (57 stocks) represents all sectors in the ASE. 52% of the sample stocks belong to the financial sector, 26% of them belong to the service sector and 22% of the sample stocks belong to the industrial sector. The mean reversion of stock prices could happen to all stocks regardless to which sector they belong to.

The mean reversion process is tested using the following partial adjustment model:

$$P_{t+1}^{i} - P_{t}^{i} = \lambda_0 + \lambda_1 (V_{t+1}^{i} - P_{t}^{i}) + \varepsilon_{t+1}^{i}$$

Where: P_{t+1}^{i} is the natural logarithm of stock price of company i at time $t+1$. P_{t}^{i} is the natural logarithm of stock price of company i at time t. V_{t+1}^{i} is the natural logarithm of the fundamental value of the stock of company i at time $t+1$.The fundamental value of the stock is calculated using the price to earning ratio. Our main interest lies in the coefficient λ_1 which estimates the speed of reversion of the stock i price to its fundamental value. Thus, in order for partial adjustment to exist, λ_1 should be statistically significant and between zero and one, not zero or one. At λ_1=1, a complete adjustment toward the fundamental value occurs, while at λ_1=0, no adjustment toward the fundamental value takes place. λ_1>1, implies an adjustment more than necessary (Over-adjustment).

To investigate whether the mean reversion process differs in the cases of increase and decrease in stock prices, we use the asymmetric partial adjustment model. In other words, the asymmetric adjustment model has been developed to allow for the rate of adjustment to vary depending on whether the stock price is below or above the fundamental value as follows:

$$P_{t+1}^{i} - P_{t}^{i} = \psi_0 + \psi_1 (V_{t+1}^{i} - P_{t}^{i})^{positive} + \psi_2 (V_{t+1}^{i} - P_{t}^{i})^{negative} + \omega_{t+1}^{i}$$

To capture both short and long term dynamics of the adjustment process, as well as changes in the co-integrating relation over time, we use a Single Equation Error Correction Model (ECM) to estimate the speed of mean reversion.

$$\Delta P_{t}^{i} = \alpha_0 + \beta_0 \Delta V_{t}^{i} + \beta_1 (P_{t-1}^{i} - \beta_2 V_{t-1}^{i}) + e_{t}^{i}$$

Where: $\beta_1 (P_{t-1}^{i} - \beta_2 V_{t-1}^{i})$ is the error correction (EC) component of the model, which measures the speed at which prior deviations from the equilibrium are corrected.

When EC=0, then P_{t-1}^{i} and V_{t-1}^{i} are in equilibrium.

When EC>0, then P_{t-1}^{i} is above its equilibrium value; to restore equilibrium, ΔP_{t}^{i} must be negative.

When EC<0, then P_{t-1}^{i} is below its equilibrium value; to restore equilibrium, ΔP_{t}^{i} must be positive.

β_0 estimates the short term effect of an increase in V_{t}^{i} on P_{t}^{i}.

β_1 estimates the speed of return to equilibrium after a deviation.

β_2 estimates the long term effect of a one percent increase in V_t^i on P_t^i.

All models are estimated using panel corrected standard errors which are robust to both contemporaneous correlation across units and unit level heteroskedasity.

4. Results of Analysis

Table 1 displays the estimation results of the symmetric partial adjustment model of stock prices. As signified by the Lagrange Multiplier (LM) and significant Hausman tests, the fixed effects model is the best specification. The results show a statistically significant λ_1 indicating that the Jordanian stock prices do significantly revert to their fundamental values but in a slow manner. Thus, the partial adjustment rate is 9% implying that 7 days[1] are needed to eliminate half of the deviation from the fundamental value. These results are contrasting with Damodaran (1993) who find that the mean of price adjustment coefficient of US stock prices ranges from 67% in the first day to 100% in the sixth day. Our results are also different from Brisley and Theobald (1996) and Ariff and Chan (2002) who document similar results to those of US stock prices in Hong Kong and Japan, respectively. However, these differences have been justified by Lim and Hooy (2010) who measure the speed of price adjustment in the aggregate stock market in 49 countries and argue that the speed of mean reversion differs from one stock exchange to another depending on the specific characteristics of the market such as its size, trading volume, short selling and investment ability.

Table 1. The Symmetric Partial Adjustment Model

Independent	Fixed	Random	Pooled
Intercept	0.0009	0.0009	0.0009
	0.0006	0.0007	0.0007
$(V_{t+1}^i - P_t^i)$	0.0887	0.0882	0.0882
	0.0000	0.0000	0.0000
Lagrange Multiplier			136.3
			0.0000
Hausman Test		15.7716	
		0.0001	
Adjusted R	0.3284	0.3282	0.3282

Table 2 reports the estimation results of the asymmetric partial adjustment model of the stock prices in Amman Stock Exchange. The results show that prices adjust quicker when the adjustment requires a decrease in

[1] The half-life time of mean reversion is calculated as $[\ln(.5)/\ln(1-\lambda_1)]$

the stock price than increase in the stock price. Thus, the coefficient of the speed of mean reversion when the price is above the fundamental value (ψ_1) is 31% while when the price is below the fundamental value (ψ_2) it equals 15%. Zenzerović (2011) has explained the quicker adjustment of stock prices when the adjustment requires a decrease in the stock price than an increase in the stock price. He argues that this stems from investors' higher risk aversion during market downturns and market specialists' easier task to maintain price continuity during market upturns, which result in faster return adjustments during market declines. Sichel (1993) suggests that the presence of asymmetry can also be due to asymmetry in business cycles, thus, stock markets are fundamentally tied to business conditions where contractions tend to be steeper than expansion and troughs tend to be more pronounced than peaks. Our results are consistent with Koutmos (1999) who study the asymmetric mean reversion process in several Asian stock markets and finds that negative returns are incorporated in the current prices faster than positive returns.

Table 2. The Asymmetric Partial Adjustment Model

Independent	Fixed	Random	Pooled
Intercept	-0.0046	-0.0045	-0.0045
	0.0000	0.0000	0.0000
$(V_{t+1}^{\cdot} - P_t^{\cdot})^{positive}$	0.1489	0.1433	0.1434
	0.0000	0.0000	0.0000
$(V_{t+1}^{\cdot} - P_t^{\cdot})^{negative}$	0.3109	0.3110	0.3110
	0.0053	0.0060	0.0062
Lagrange Multiplier			125.2
			0.0000
Hausman Test		36.5247	
		0.0000	
Adjusted R	0.3582	0.3573	0.3573

Table 3 reports the estimation results of the error correction model of stock prices in Amman Stock Exchange. The results indicate that stock prices significantly revert to their equilibrium values in the long run but in a very slow manner. Thus, the value of the coefficient of the error correction term β_1 is -10%. However, in the short run, the increase in the fundamental value has a statistically significant negative effect on the stock price with a coefficient of -12.7%. These results are consistent with Manzan (2007) who find that the S&P500 market price experiences significant swings away from its fundamental valuation but reverts back in the long-run.

Table 3. The Error Correction Model

Independent	Fixed	Random	Pooled
Intercept	0.0080 0.9741	0.0070 0.9746	0.0070 0.9746
$(V_{t-1}^{i} - \beta_2 P_{t-1}^{i})$	-0.1009 0.0000	-0.1009 0.0000	-0.1009 0.0000
ΔV_t^i	-0.1269 0.0109	-0.1266 0.0122	-0.1266 0.0122
Lagrange Multiplier			138.0 0.0000
Hausman Test		6.7876 0.0336	
Adjusted R	0.2811	0.2811	0.2811

5. Conclusions

This study has examined the dynamic adjustment of stock prices toward the fundamental values in Amman Stock Exchange using daily data over the period (2004-2013). The results provide evidence in favor of the asymmetric relative mean reversion process in both the short and the long runs. In specific, we find that stock prices adjust by a daily speed of 9% toward their fundamentals implying a half-life reversion of 7days. Moreover, stocks react to bad news faster than to good news. On the long run, the prices reach their equilibrium values but very slowly. Our results have important implications for investors and researcher who are interested in the validation of the efficient market hypothesis.

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الارتداد الديناميكي لأسعار الأسهم نحو الوسط: دليل من بورصة عمان للأوراق المالية

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ملخص

تهدف هذه الدراسة إلى اختبار عملية الارتداد النسبي لأسعار الأسهم نحو الوسط في بورصة عمان للأوراق المالية باستخدام بيانات يومية على الفترة (2004–2013). تم استخدام نموذج التعديل الجزئي المتماثل وغير المتماثل لتحقيق أهداف الدراسة. تم تطوير نموذج الارتداد نحو الوسط البسيط إلى نموذج تصحيح الخطأ ذي المعادلة الأحادية لأخذ التأثيرات قصيرة الأجل وطويلة الأجل بعين الاعتبار. بينت النتائج بأن أسعار الأسهم تتحرك بشكل دال إحصائياً ولكن بطيء نحو قيمها الأساسية. بلغ معدل التعديل 9% مما يدل أنه يلزم سبعة أيام حتى تلغي أسعار الأسهم نصف الانحراف عن قيمها الأساسية. بين نموذج التعديل الجزئي غير المتماثل بأن معامل التعديل أكبر للأسعار التي تزيد عن قيمها الأساسية (31%) مقارنة مع الأسعار التي أقل من قيمها الأساسية (15%). وبالتالي فإن تعديل الأسعار باتجاه الزيادة أبطأ منه في حالة التعديل باتجاه الانخفاض. وبالنهاية فقد بين نموذج تصحيح الخطأ بأن أسعار الأسهم الفعلية تتجه نحو القيم الأساسية على المدى الطويل ولكن بشكل بطيء.

الكلمات الدالة: نموذج التعديل الجزئي، الارتداد نحو الوسط، أسعار الأسهم، نموذج تصحيح الخطأ، بورصة عمان للأوراق المالية.

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