On the Cointegrating Relationship between Stock Prices and Earnings

Doowoo Nam
College of Business Administration,
Inha University
E-mail : dnam@inha.ac.kr.

The purpose of this study is to investigate a simple present value model involving earnings (i.e., the earnings discount model) that presumes a relationship between stock prices and earnings. The model suggests a simple linear equilibrium relationship between stock prices and earnings. The tests for cointegration render strong support for the cointegration hypothesis between stock prices (Pt) and earnings (Xt) even at the one-percent significance level. The tests are based on residuals from a cointegrating regression of Pt on Pt+1 + Xt. This suggests that there is a stable long-run equilibrium relationship between stock prices and earnings. The results of the tests lead to the acceptance of the present value model of stock prices involving earnings.

<Key Words> : Cointegration, Earnings per share, Stock prices, CRDW test, DF test, ADF test

I. INTRODUCTION

Since the Miller and Modigliani's seminal paper was published in 1961, many researchers have shown that "stock prices can be valued using either earnings per share or dividends per share" (Megginson, 1997). In the analysis of the effects of dividend policy on the value of the firm, Miller and Modigliani (1961) present "the fundamental principle of valuation" based on the assumptions of perfect markets, rational behavior, and perfect certainty:

$$P_t = \frac{D_t + P_{t+1}}{1+\rho_t} \qquad (1)$$

논문제출일 : 2007. 7.3. 게재확정일 : 2007. 8.17

where Pt is the stock price at time t, Dtthe dividend per share for period t, and ρ_t the rate of return during period t. The capitalization of income method of valuation states that the fundamental value of any asset depends on the cash flows that are expected to receive from the asset (Sharpe, Alexander, and Bailey, 1995). That is,the fundamental value of any asset is the sum of the present value of the expected cash flows from the asset. This method is applied to stocks to get a simple stock valuation model, which is called the present value model of stock prices or the dividend capitalization (or discount) model:

$$P_t = \sum_{1 \le k \le \infty} \mathbf{E}_t \left(D_{t+k} \right) \delta^k \tag{2}$$

where Dt+k is the dividends paid at the end of period (t+k), δ the discount factor. Sharpe, Alexander, and Bailey (1995) state that earnings are related to dividends by the payout ratio:

$$D_t = \lambda_t X_t \tag{3}$$

where Xt is the earnings for period t, and λ_t the payout ratio at time t. The relationship between stock prices and earnings is derived using Eqs. (2) and (3):

$$P_t = \sum_{1 \le k \le \infty} \mathbf{E}_t \left(\lambda_{t+k} X_{t+k} \right) \delta^k \tag{4}$$

Eq. (4) can be labeled as the earnings capitalization (or discount) model, and provides a "general formula for determining a stock's fundamental value that involves discount earnings" (Sharpe, Alexander, and Bailey, 1995).

Koop (1991) and Yuhn (1997) show that the present value model of stock prices involving dividends, Eq. (2), can be represented as

$$P_t = \delta \left(P_{t+1} + D_t \right) + \varepsilon_t \tag{5}$$

where Pt is the real stock price at the beginning of time t, Dt the real dividend paid for period t, and εt the serially independent forecast error. By substituting Eq. (3) into Eq. (5), the present value model of stock prices involving earnings can be written as

$$P_t = \delta \left(P_{t+1} + \lambda_t X_t \right) + \varepsilon_t \tag{6}$$

where Xt is the real earnings for period t. The cointegrating relationship in stock prices and dividends has been tested by several researchers−Campbell and Shiller (1987) using the U.S. stock data, Koop (1991) using the U.S. and Canadian data sets, and Yuhn (1997) for the stock markets of the U.S., Canada, Japan, the U.K., and Germany, among others. The Campbell and Shiller's cointegration study of stock prices and dividends is based on Eq. (2), whereas both Koop (1991) and Yuhn (1997) conduct the cointegration tests based on Eq. (5). In this paper, the cointegration tests on the relationships in Eq. (6) will be performed and their implications will be examined. Yuhn (1997) uses the cointegration technique as a tool for testing the efficient markets hypothesis in the stock markets of several countries. Therefore, it is important to note that the existence of cointegration in stock prices and earnings in Eq. (6) can imply market efficiency, in a sense that all the available information about market fundamentals (earnings in this study) are fully reflected in stock prices.

The cointegration technique is one of the major innovations in econometrics in the 1980s. Ghosh (1993) briefly explains the development of the studies of cointegration in his paper on the index spot and futures price changes: "Granger (1981) introduced the concept of cointegration where two variables may move together although they are nonstationary. The rationale behind the concept of cointegration is that there exists a long-run equilibrium relationship between the two variables. In the short-run they may deviate from each other, but market forces will bring them back together. Engle and Granger (1987) extended this concept and showed that cointegrated series have an error correction representation, and vice versa. With the error correction representation,a proportion of the disequilibrium in one period is expected to be corrected in the next period." Engle and Granger (1987) present several empirical examples to show performance of the cointegration tests in practice. In a series of examples it is found that consumption and income are cointegrated, wages and prices are not, short and long interest rates are, and nominal GNP is cointegrated with M2, but not Ml, M3, or aggregate liquid assets. Barnhart and Szakmary (1991) find spot and forward exchange rates are cointegrated and estimate the appropriate error correction model. Bessler and Covey (1991) apply the cointegration techniques to the study of daily futures and cash prices on live cattle and investigate whether the daily futures market for live cattle is cointegrated with the cash cattle market from August 21, 1985 through August 20,1986. Their findings indicate marginal support for the cointegration hypothesis.

The purpose of this study is to test the hypothesis,which is derived from Eq. (6),that stock prices and earnings are cointegrated. In order to perform the cointegration test, some basics of cointegration are reviewed in sections II and III. Then, in section IV the tests on the hypothesis of cointegration between stock prices and earnings are conducted by applying the cointegration technique to the S&P 500 annual data, and then the implications of the results from the tests are discussed. Section V concludes the paper.

II. REVIEW OF COINTEGRATION

The procedure for the cointegration test is composed of two major parts—testing the order of integration of the original series along with their linear combinations, and testing cointegration usually given that the series are integrated of order 1, I(1). The discussions on the concept of cointegration in this section are largely based on Bessler and Covey (1991).

1. Order of Integration

A series of data indexed by time (a set of data in which order of observation is important) is said to be integrated of order d if it requires d first differences to reduce the resulting series to stationarity. Stationarity means that the characteristics of the time series are describable in terms of the time separating observations and not the particular time of the observations. Researchers find that many economic time series appear to requirefirst differencing (d= 1) to achieve stationarity, which implies that the series are integrated of order one, I(1).

Dickey and Fuller (1979) propose a simple test for nonstationarity—the Dickey-Fuller (DF) test. They suggest running the regression of the first differences of the series on lagged values of the levels of the series. For the test the null hypothesis is that each series is generated as a random walk. The rejection of the null hypothesis implies that the coefficient of the lagged level from the regression of the first difference on the first lag of the levels of the series is negative and significantly different from zero, which indicates that the original series is stationary. As the distribution theory underlying such a test is nonstandard, Monte Carlo-generated critical values should be used. Engle and Granger (1987) suggest an additional test of nonstationarity, which adds lags of the dependent variable, sufficient to produce white noise residuals in the Dickey-Fuller regression. It is called the augmented Dickey-Fuller (ADF) test, and also relies on Monte Carlo-generated critical values.

2. Cointegration

Two series, X(t) and Y(t), are said to be cointegrated if they are individually integrated of orders d and b, but their linear combination, Z(t) = X(t) - aY(t), is integrated of order (d - b). The most typical case studied in the literature is where d = b = 1. Where two series are shown to be cointegrated, an error correction model can be used to represent their dynamic joint process (Engle and Granger, 1987).

Given that one cannot reject the hypothesis that each of two series is integrated of order one, one can proceed to consider whether or not their joint process is cointegrated. A test for cointegration can be made from the observed residuals from the ordinary least squares regression of X(t) on Y(t). An ordinary least squares regression of X(t) on Y(t)should yield residuals Z(t), which are stationary, by the definition of cointegration. If the estimated Durbin-Watson statistic (CRDW) exceeds the critical value for the particular sample size, then the null hypothesis—the two series are not cointegrated—can be rejected. The critical values for this statistic have been studied using Monte Carlo methods.

An alternative test for cointegration is to apply the Dickey-Fuller (DF) test of unit roots to the observed residual series Z(t). If X(t) and Y(t) are cointegrated, one would expect the residuals from the cointegrating regression to be stationary. To test this, one would run the regression of changes in the observed residuals on levels of the residuals lagged one period. One can reject the null hypothesis of no cointegration if the regression coefficient is negative and significantly different from zero. The augmented Dickey-Fuller (ADF) test is defined in a fashion analogous to the Dickey-Fuller test, except lags of the dependent variable are included in each regression. Appropriate lags are determined by applying the finite prediction error (FPE) or other criteria for model selection. The FPE statistic is $\frac{SSE}{T} * \frac{T+k}{T-k}$ where SSE is the residual sum of squares, T the number of observations, and k the number of parameters estimated, and a model with a lower FPE statistic is preferred (Ramanathan, 1992). Again, Monte Carlo critical values should be used for the DF and ADF tests because of the nonstandard distribution theory that underlies these tests.

III. TEST STATISTICS FOR COINTEGRATION

Engle and Granger (1987) propose a set of seven test statistics for testing the null hypothesis of no cointegration against the alternative of cointegration. The seven test statistics proposed are all calculable by least squares.

1. Cointegrating Regression Durbin-Watson (CRDW)

$$Y_t = aX_t + c + u_t$$

where Yt and Xt are the original data sets and ut is the residuals from the cointegrating regression. The null hypothesis is CRDW = 0.

After running the cointegrating regression, the Durbin-Watson statistic is tested to see if the residuals appear stationary. If they are nonstationary, the Durbin-Watson will approach zero, and thus the test rejects no cointegration (i.e., finds cointegration) if CRDWis large.

2. Dickey-Fuller Regression (DF)

$$\Delta u_t = -\phi u_{t-1} + \varepsilon_t$$

where △ut and ut-1 are the first difference and the first lag of the residuals, respectively, from the cointegrating regression, and ϵ_t is the white noise. The test statistic is the t-ratio for ϕ.

This method tests the residuals from the cointegrating regression by running an auxiliary regression as described by Dickey and Fuller. It assumes that the first order model is correct.

3. Augmented DF Regression (ADF)

$$\Delta u_t = -\phi u_{t-1} + b_1 \Delta u_{t-1} + \cdots + b_i \Delta u_{t-p} + \varepsilon_t$$

The test statistic is the t-ratio for ϕ. The augmented Dickey-Fuller test allows for more dynamics in the DF regression and consequently is over-parameterized in the first order case but correctly specified in the higher order cases.

4. Restricted VAR (RVAR)

$$\Delta Y_t = \beta_1 u_{t-1} + \varepsilon_{1t}$$

$$\Delta X_t = \beta_2 u_{t-1} + \gamma \Delta Y_t + \varepsilon_{2t}$$

The restricted vector auto-regression test is similar to the two step estimator. Conditional on the estimate of the cointegrating vector from the cointegrating regression, the error correction representation is estimated. The test is whether the error correction term is significant. In this case a first order system is assumed. The test is based on the sum of the squared t-statistics for β_1 and β_2.

5. Augmented Restricted VAR (ARVAR)

The augmented RVAR test is the same as the RVAR test but with p lags of ΔYt and ΔXt in each equation. That is, the only difference between the RVAR and ARVAR tests is that in the latter a higher order system is postulated.

6. Unrestricted VAR (UVAR)

$$\Delta Y_t = \beta_1 Y_{t-1} + \beta_2 X_{t-1} + c_1 + \varepsilon_{1t}$$

$$\Delta X_t = \beta_3 Y_{t-1} + \beta_4 X_{t-1} + \gamma \Delta Y_t + c_2 + \varepsilon_{2t}$$

The test is based on the value of 2[F1 + F2] where F1is the F-statistic for testing β_1 and β_2 both equal to zero in the first equation, and F2 is the comparable statistic in the second.

The unrestricted VAR test is based on a vector auto-regression in the levels which is not restricted to satisfy the cointegration constraints. The F-tests from the two regressions can be made independent and the overall test is the sum of the two Fs times their degrees of freedom, 2. This assumes a first order system again.

7. Augmented Unrestricted VAR (AUVAR)

This test is the same as the UVAR test except for p lags of ΔXt and ΔYt in each equation, which implies that it is an augmented or higher order version of the UVAR test. Because of its simplicity, the CRDW might be used for a quick approximate result. Fortunately,none of the best procedures require the estimation of the full system, merely the cointegrating regression and then perhaps an auxiliary time series regression. Although Engle and Yoo (1987) have calculated critical values for several variables and sample sizes, there is still no optimality theory for such tests and alternative approaches may prove superior.

IV. EMPIRICAL ANALYSIS

For the test of cointegration between stock prices and earnings, the Standard and Poor's composite stock price index (S&P 500 index) and the nominal earnings, which is the earnings per share for the S&P 500 index adjusted to the price index, are collected from "Security Price Index Record - Statistical Service" published by Standard & Poor's Corporation for the time period from 1947 through 1994. The Bureau of Labor Statistics' Producer Price Index (PPI) with the base year of 1982 is used as a deflator to get the real prices and earnings. The variable Pt(Prices) is the S&P 500 index for the last month (January) of each year, divided by the January PPI of each year. The other variable Xt(Earnings) is the four-quarter total EPS divided by the January PPI. The definition of the variables used in this study is summarized in Table 1.

Table 1. Descriptions of the Variables

Variables	Descriptions
Nominal X	Earnings per share (EPS) for each year
Nominal P	S&P 500 Composite Price Index in January of each year
PPI(JAN)	January Producer Price Index (PPI) for each year
X (Earnings)	Nominal X divided by PPI(JAN)
P (Price)	Nominal P divided by PPI(JAN)
(P+X)t	Pt+1 + Xt

1. Tests for Order of Integration

The Pt and Pt+1 + Xt series are tested for order of integration using the Dickey-Fuller test as shown in Table 2. The tests on levels are regressions of the first differences on lagged levels, and the tests on first differences are regressions of the second differences on lagged first differences and second differences. The results are as follows:

Table 2. Tests for Order of Integration

	Levels	Differences
Pt	$D(P) = 11.7 - 0.0268L(P)$ (-0.49)	$2D(P) = 8.56 - 1.21LD(P) + 0.163L2D(P)$ (-5.48)
Pt+1 + Xt	$D(P+X) = 14.3 - 0.036L(P+X)$ (-0.71)	$2D(P+X) = 8.52 - 1.20LD(P+X) + 0.17L2D(P+X)$ (-5.49)

*) Note: D is the difference operator (for example, D(Pt) = Pt - Pt-1), and L is the lag operator (for example, L(Pt) = Pt-1). 2D and LD mean the second difference and the lag of first difference of a variable, respectively.

The Monte Carlo critical values derived by Engle and Yoo (1987) suggest a critical value of -3.67 for 50 data points. The null hypothesis on al regressions--the series are random walks in their levels--is rejected if the coefficient associated with the levels in each regression is negative and significantly different from zero (Bessler and Covey, 1991). Since the t-statistics for Pt and Pt+1 + Xt are -0.49 and -0.71, respectively, the null hypothesis that each series is generated as a random walk cannot be rejected. In the test on the first differences, however, the null hypothesis that each first difference is generated by a random walk is rejected--the t-statistics of -5.48 for Pt and -5.49 for Pt+1 + Xt. The test results indicate that each series is I(1), and therefore the cointegration tests can be pursued.

2. Tests for Cointegration

Tests for cointegration are carried out by checking the residuals from the cointegrating regression. Among seven techniques proposed by Engle and Granger (1987), three methods,which are simple and widely used, are selected for testing— cointegrating regression Durbin-Watson (CRDW) test, Dickey-Fuller regression (DF) test and augmented Dickey-Fuller regression (ADF) test. The appropriate degree of lags for the ADF test is determined by examining the FPE statistic. The FPEs are calculated for the cases of one, two, three and four lags, and then one lag is chosen since the FPE statistic for one lag is the lowest. The detailed results of the regressions for the tests are provided in Table 3. The critical values for each test are provided in Engle and Yoo (1987). The results of the tests are summarized as follows:

Table 3. Tests for Cointegration

	Regression Equation	Critical Values (50 observations)
Cointegrating Regression (CRDW)	$P = 0.62 + 0.897(P + X)$ Durbin-Watson Statistic = 2.09	1.49 for 1% level 1.03 for 5% level 0.83 for 10% level
Dickey-Fuller Regression (DF)	$\mathbf{D}(RESID) = -1.06\mathbf{L}(RESID)$ (-7.13)	-4.32 for 1% level -3.67 for 5% level -3.28 for 10% level
Augmented Dickey-Fuller Regression (ADF)	$\mathbf{D}(RESID) = -1.24\mathbf{L}(RESID) + 0.168\mathbf{LD}(RESID)$ (-5.66)	-4.12 for 1% level -3.29 for 5% level -2.90 for 10% level

*) Note: RESID is the residuals from the cointegrating regression. One lag is used in the ADF test.

The Durbin-Watson statistic of 2.09 associated with the residuals from the regression equation is greater than the critical value of 1.49 even at the one-percent significance level to reject the null hypothesis of no cointegration. Therefore, the null hypothesis of no cointegration can be rejected, which implies that the Durbin-Watson statistic on the residuals from the cointegrating regression does support the cointegration hypothesis for Pt and Pt+l + Xt.

As a second test for cointegration, the Dickey-Fuller test is applied to the residuals from the cointegrating regression equation. The t-statistic of -7.13 from the Dickey-Fuller regression is far below the one-percent critical value of -4.32. Therefore, the result of the DF test suggests that the null hypothesis of no cointegration can be rejected again.

Finally, the augmented Dickey-Fuller test on residuals, using one lag, also offers support for a cointegration-type relationship between Pt and Pt+l + Xt—the null hypothesis of no cointegration is rejected at the one-percent level when one lag is used since the t-statistic of -5.66 is in the critical region.

3. Implications of Test Results

All three tests carried out in this study result in the same conclusion, that is, the rejection of the null hypothesis of no cointegration. Given that Pt and Pt+l + Xt are cointegrated, the conclusion of cointegration between Pt and Pt+l + Xt implies that stock prices (Pt) are cointegrated with earnings (Xt).

These tests are closely related to the issue of whether stock prices are a mirror of the fundamental value of underlying firms, or whether they are driven by other forces such as speculative behavior, as the cointegration test on the relationship between stock prices and dividends are. The existence of cointegration between stock prices and dividends implies that the present value model of stock prices involving dividends is true. Likewise, the existence of cointegration between stock prices and earnings supports the present value model of stock prices involving earnings. The results from the tests on cointegration between stock prices and earnings suggest that there is a long-run equilibrium path of stock prices resulting from the efficient flow of information on market fundamentals. Therefore, the U.S. stock market is efficient.

V. CONCLUSION

The purpose of this studyis to investigate a simple present value model involving earnings (i.e., the earnings discount model) that presumes a relationship between stock prices and earnings. The model suggests a simple linear equilibrium relationship between stock prices and earnings.

The tests for cointegration, based on residuals from a cointegrating regression of Pt on Pt+l + Xt, show strong support for the cointegration hypothesis betweenstock prices and earnings even at the one-percent significance level. This means that there is a stable long-run equilibrium relationship between stock prices and earnings. The results of the tests lead to the acceptance of the present value model of stock prices involving earnings.

REFERENCES

Barnhart, S. W., and A. C. Szakmary, "Testing the Unbiased Forward Rate Hypothesis: Evidence on Unit Roots, Cointegration, and Stochastic Coefficients," *Journal of Financial and Quantitative Analysis,* 26, 1991, pp. 245-267.

Bessler, David A., and Ted Covey, "Cointegration: Some Results on U.S. Cattle Prices," *Journal of Futures Markets*, 11, 1991, pp. 461-474.

Campbell, John Y., and Robert J. Shiller, "Cointegration and Tests of Present Value Models," *Journal of Political Economy*, 95, 1987, pp. 1062-1088.

Dickey, David A., and Wayne A. Fuller, "Distribution of the Estimators for Auto regressive Time Series with a Unit Root," *Journal of the American Statistical Association*, 74, 1979, pp. 427-431

Engle, Robert F., and Clive W. J. Granger, "Co-Integration and Error Correction: Representation, Estimation, and Testing," *Econometrica*, 55, 1987, pp. 251-276.

Engle, Robert F., and Byung Sam Yoo, "Forecasting and Testing in Co-Integrated Systems," *Journal of Econometrics*, 35, 1987, pp. 143-159.

Ghosh, Asim,"Cointegration and Error Correction Models: Intertemporal Causality between Index and Futures Prices," Journal of Futures Markets, 13, 1993, pp. 193-198.

Granger, Clive W. J., "Some Properties of Time Series Data and Their Use in Econometric Model Specification," *Journalof Econometrics*, 16, 1981, pp. 121-130.

Koop, Gary, "'Cointegration Tests in Present Value Relationships - A Bayesian Look at the Bivariate Properties of Stock Prices and Dividends," *Journal of Econometrics*, 49, 1991, pp. 105-139.

Megginson, William L., *Corporate Finance Theory*, Addison-Wesley Educational Publishers Inc. (Reading, MA), 1997.

Miller, Merton H., and Franco Modigliani, "Dividend Policy, Growth, and the Valuation of Shares," *Journal of Business*, 34, 1961, pp. 411-433.

Ramanathan, Ramu, *Introductory Econometrics with Applications,* 2nd Ed., HBJ, Inc. (Orlando, FL), 1992.

Sharpe, William F., Gordon J. Alexander, and Jeffery V. Bailey, *Investments,* 5th Ed., Prentice Hall (Englewood Cliffs, NJ), 1995.

Yuhn, Ky-Hyang, "Financial Integration and Market Efficiency: Some International Evidence From Cointegration Tests," *International Economic Journal*, 11, 1997, pp. 103-116.