Stock Market and Economic Forces: Evidence From Korea

Gautam Goswami
Fordham University
Graduate School of Business
113 West 60th Street
New York, New York 10023
e-mail: goswami@mary.fordham.edu

and

Sung-Chang Jung
Chonnam National University
College of Business Administration
300 Yong-Bong-Dong, Buk-Gu
Kwang-Ju, S. Korea 500-757
e-mail: scjung@orion.chonam.ac.kr

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Abstract

This paper investigates the effects of economic factors on Korean stock market. Using Vector Error Correction Model (VECM), this paper studies the short-run dynamics as well as long-run relationship between stock price and nine macroeconomic variables from Korean economy. We find that the Korean stock market is cointergrated with nine macroeconomic variables. The Korean stock prices are positively related to industrial production, inflation and short-term interest rate, and negatively related to long-term interest rates and oil prices. The foreign exchange rate changes may affect stock prices in either direction. Devaluation of Korean Won against US Dollar (Japanese Yen) is positively (negatively) related to stock price changes. Our fmdings are robust to time lag selection and generally supports the long-term hypothesized relationship. We also show that the forecasting ability of VECM is generally better than VAR estimating procedure.

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Introduction:

In last two decades, numerous studies investigated both theoretically and empirically the relationship between asset prices and economic activities. Real economic activities are commonly believed to affect the stock prices. Chen, Roll and Ross (1986) argued and empirically showed that economic state variables affect the future dividends as well as the discount rates, thus affecting the stock prices. Fama (1970, 1981) argued that in a multi-period economy the changes in real economic activities affect the consumption and investment opportunity set. Since these changes in consumption and investment opportunities are priced in capital markets, the stock price changes are related to innovations in economic state variables (see also Chen (1991)).

Since there exists a long-term relationship between the changes in stock prices and the macroeconomic state variables, a number of papers e.g. Fama (1981, 1990), Chen, Roll and Ross (1986) and Chen (1991) tested the relationships with US economic data. Fama (198 1) documents a strong positive correlation between common stock returns and real economic variables like capital expenditures, industrial production, real GNP, money supply, lagged inflation and interest rates. Chen, Roll and Ross (1986) find that the changes in aggregate production, inflation, the short-term interest rates, the maturity risk premium and default risk premium are the economic factors which explain the changes in stock prices. Chen (1991) also finds the state variables mentioned above along with market dividend-price ratio are indicators of recent and future economic growth. Other than these cross-sectional studies, several time-series analysis investigate the predictability of stock prices, e.g. Fama and Schwert (1977). Rozeff (1984) argued and tested whether dividend yield explains stock prices change and Keim and Stambaugh (1986) tested the effect of size and different risk measures on stock and bond returns[1].

Though the relationship between stock market returns and real economic activities in the US are well documented, there are very few studies with other economic data with the exception of studies in Japanese and Canadian economy. The earliest study on Japanese stock market was carried out by Hamao (1988) which parallels the work of Chen, Roll and Ross (1986). There have been several other researches (Elton and Gruber (1988), Brown and Otuski (1990)) on arbitrage pricing theory (APT) tests on Japanese stock return and several macroeconomic variables like industrial production, money supply, crude oil price, short-term interest rates etc. Most recently Mukherjee and Naka (1995) employed Vector Error Correction Model (VECM) to find that the Japanese stock market is cointegrated with a group of six macroeconomic variables.

Since 1980's, emerging stock have grown at a rapid rate. The proportion of emerging stock market capitalization to world capital market capitalization has grown from 4 percent in 1985 to almost 14 percent in 1994 according to IFC data sources. During this time, the deregulation of goods as well as financial markets has become an world wide phenomenon. One such country in which the stock market has grown about 14 % per year and considerable deregulation has taken place in last decade is South Korea. The aim of this paper is to investigate the dynamic relationship between stock price and

[1] See James, Koreisha and Partch (1985) for a time series causal analysis of stock prices and nominal

macroeconomic variables in Korean economy. We would also like to compare the effectiveness of both VAR and VECM methodology to predict future stock prices. There are several compelling reasons for undertaking this investigation. Firstly, the nature of relationship between the stock prices and the macroeconomic variables in developed economies like US and Japan may not be the same in a less developed economy like Korea. Secondly, though Korean stock market has grown considerably in last ten years, but to our knowledge there is no paper that investigates the relationship between stock prices and the macroeconomic variables. Thirdly, the Korean stock market capitalization is still only about 1.15% of world stock market value, and is considered to be a small open economy. We would like to investigate the relationship between stock market and macroeconomic variables, particularly the effect of foreign sector on stock market, in this representative small open economy. In order to investigate the relationship between stock market and economic variable, we use a multivariate time series technique, specifically, Johansen's vector error correction model. Since the stock prices and economic state variables are endogenously related to each other in a system of equations, the causal relationship can only be determined by using a cointegration analysis. Also another contribution of this paper is to show how selection of time lags in macroeconomic time series data affects the number of cointegrating vectors.

The remainder of the paper is divided in four sections. Section II develops the hypothesis to be tested with Korean economic data. Section III explains the data and the methodology used in the paper. Section IV presents the empirical results including the

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interest rates with US data.

comparison of VAR and VECM results. The concluding remarks are presented in Section V.

II. Hypothesis Development

Chen, Roll and Ross (1986) identified the important macroeconomic variables which may affect the stock price through basic valuation model. Most papers in this area follow a similar list of variables in testing the relationship between stock price and the economic factors. In addition to the basic macroeconomic variables as suggested by Chen Roll and Ross (1986), we include another factor which may affect the Korean economy. Korea being a small open economy, the foreign sector may have considerable effect on domestic stock prices. Thus, we divide the Korean economy in three different sectors, namely, the financial sector, the production or real sector and the foreign sector and choose several macroeconomic factors to represent each sector of the economy..

In the financial sector, following Chen, Roll and Ross (1986) we include two interest rate variables, one each for long-term and short-term interest rates*. The long-term interest rate is represented by the three year corporate bond interest rate. The short-term interest rate is represented by overnight (1 day) call money rate[3]. We hypothesize that the stock prices will be negatively related with long-term interest rates. The long-term interest rates affect the discount rate in the valuation model, thus any increase in the discount rate reduces the stock value. In other words, an increase in long-term interest rate slows down economic activity, thus reducing the stock prices. The effect of short-term interest on stock prices is not so clear. An increase in short-term interest rate may or may not reduce economic activity thus may or may not have a negative effect on stock prices. Typically, most researchers after Chen, Roll and Ross

[2] Also see James, Koreisha and Partch (1985) and Darrat (1990).
[3] Note that longer-term interest rate instruments are not available in Korea. since there is no three month treasury bill market like US T-bills, we choose 1 day call money rate to represent short-term interest rate.

(1986) have used default risk premium as one of the factors which affects stock market. Since Korean economy does not have a well developed speculative grade bond ('junk bond) market, we do not consider default risk premium as one of the factors.

We choose two variables to measure inflation, one being the money supply and the other consumer price index. We hypothesize that inflation computed from consumer price index affects the stock price negatively. Since an increase in inflation increases the discount rate, it should affect the stock price negatively. However, increase in inflation also increases the expected future cashflows, thus having a positive effect on the stock price. These two opposite effects may or may not neutralize each other. In most developing economies, a steady and low inflation helps the growth in real sector, and in effect have a positive effect on stock prices. Most previous studies however, Fama and Schwert (1977), Geske and Roll (1980), Chen, Roll and Ross (1986), Chen (199 1), and DeFina (1991) document negative relationship between stock price and inflation.

The effect of money supply on stock price is also not conclusive (see Darrat (1990)). In the short run, the increase in money supply will reduce the interest rate and thus discount rate in the valuation model. An increase in money supply also increases investments in the production sector which may increase the expected future cashflows, thus increasing the stock prices. In the long run, however, an increase in money supply will cause inflation and increase in interest rates which in turn will increase the discount rate in the valuation model. Therefore, the stock price may be negatively related to money supply. We hypothesize that due to these opposite effects of these two factors on stock prices the relationship may be either positive or negative.

The main economic variable in the production sector is a measure of real economic activity given by the industrial production. Following CRR (1986), James, Koreisha and Partch (1985) and other studies in this area, we hypothesize a positive relationship between the stock price and the industrial production. It is argued that economic activity as measured by stock prices is often dependent on oil prices, particularly in most developing economies or oil importing economies. To investigate this proposition, we include oil price as one of the factors. Since Korea is a net crude oil importer and performance of the economy is dependent on oil prices we hypothesize a negative relationship between oil prices and Korean stock market. Jones and Kaul (1996) investigated the effect of oil prices on stock markets and concluded that in oil importing economies like UK and Japan changes in oil prices appear to cause larger change in stock prices than changes in future real cashflows. However, in USA or Canada the effect changes in oil prices can be completely accounted for by changes in future real cashflows[4].

In Korea, like most other small open economies, the foreign sector plays a major role in its economic growth. We choose two factors to represent foreign sector, the trade balance and the foreign exchange rate[5]. Since Korea has two major trade partners, we include two exchange rates US Dollar per Won and Japanese Yen per Won as representative foreign exchange rates. We hypothesize a positive or negative relationship between the exchange rates and stock prices. The appreciation of Korean Won against US Dollar negatively affects the exports to US' and increases import of US goods. An appreciation of Korean Won may cause a decrease in stock prices for the export sector and an increase in stock prices in the import sector of the economy. However, since the trade balance between Korea and USA is positive and between Korea and Japan is negative, we conclude that appreciation of Korean Won against US dollar is negatively related to stock price changes and appreciation of Korean Won against Japanese Yen is positively related to stock price changes. We also hypothesize that the trade balance is positively related with stock prices because the depreciation of Korean Won increases

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[4] For related research on the effect of oil prices on economy see Hamilton (1983, 1988)
[5] Ajayi and Mougoue (1996) studied the short-run and long-run dynamics of stock prices and exchange rates in eight countries using an error correction model.

export of Korean goods as long as the demand for these goods are price elastic, thus increasing the stock prices.

III. Data and Methodology

3.1 *Data:*

We obtain the stock market data from various issues of *Securities Statistics Yearbook* published by Korean Securities Exchange Commission. The macroeconomic variables are collected from various issues of *Monthly Bulletin* published by Bank of Korea. The sample period spans from January 1980 to June 1996, consisting of 192 monthly observations for each variable.

The stock price in Korean market is represented by Korea Composite Stock Price Index. The Korean stock price index is a value-weighted average of all stocks traded in Korean Stock Exchange (KSE). We chose the monthly average as our stock price variable and denote it by (KOSPI).

Following Chen, Roll and Ross (1986) and Mukherjee and Naka (1995) we select nine macroeconomic variables which are short-term interest rate, long-term interest rate, inflation, money supply, industrial production. oil price, balance of trade from current account, and foreign exchange rates. The first four variables represent the financial sector of the economy. The long-term interest rate (CBY) is represented by the monthly average of yield to maturity for three year corporate bonds which is most widely believed to be the representative interest rate in Korean economy. Also note that longer term interest rate instruments comparable to ten or thirty year US Treasury bonds are not popular in Korea. The long-term Government bonds (ten years) are traded among only the financial institutions and the interest rates are controlled by Government. The overnight call money rate (CALL) represents the short-term interest rate which is again different from the short-term interest rate variables used by other studies using US, Canada or Japanese data. Since Korean Government bond market is not well developed, we can not use a T-bill rate for short-tern interest rate. Recent liberalization of interest rate market allows several short-term interest rate instruments to be traded in the market. Some of these market determined interest rates are three month CD rates available from 1990 and three month commercial paper rates available form mid 1993. The realized inflation (CPI) is measured from consumer price index which is indexed to 100 in the year 1990 and it represents the first inflation variable. The variable (IP) represents the end of the month industrial production figure from Bank of Korea. The variable (M2) is the average balance of money supply measured in billions of Won represents the second inflation variable. Oil import in Korea constituted about one third of all imports during 1980's and is now reduced to one sixth of all imports. Still, Korean economy is highly dependent on oil imports and therefore, the stock market may be affected by changing oil prices. The Variable (OIL) represents the US composite crude oil price and collected from the monthly energy review published by Energy Information Administration. These prices are very similar to both WTI and North Sea oil prices. The variable (TB) is the trade balance figure in millions of dollars collected from balance of payment accounts. Two different foreign exchange rates (WS) and (WY) represent the end of month foreign exchange rates in Korean Won per US Dollar and Korean Won per Japanese Yen.

Table 1 shows the descriptive statistics for all these variables. The variables are presented in levels in panel A, in natural logarithms in panel B and in first difference form in panel C. The data shows that the Korean Stock market grew approximately at the rate of 13.6% per year (1.136% per month) for last fifteen years. The industrial production grew at the rate of 0.76% per month and Korean won has depreciated at a average rate of 0.17% per month against US dollar. Korean won depreciated against Japanese Yen at a four times higher rate of 0.60% per month. Though money supply M2 grew at a rate of 1.47% per month, the inflation rate as indicated by consumer price index grew at a lower rate. Both long-term and short-term interest rate changes are negative but small. The oil price and trade balance have decreased over fifteen years but at a very low rate.

3.2 *Methodology*

To find relationship between stock prices and economic variables and to forecast future stock prices, one may either use a ordinary least square regression (OLS) if one assumes that stock prices are only affected by other macro-economic variables or an autoregressive moving average model (Box and Jenkins method) if one assumes the future values of stock market are forecast solely on the basis of its own past history. If neither of the assumptions are correct, one may follow vector autoregression (VAR) approach i.e., in a system of simultaneous equations, a vector of variables is explained by lagged values of that vector. However, the variables need to be stationary to obtain proper estimates of the coefficients and most studies first difference the economic variables to attain stationarity. If the vector has cointegrated components. i.e., a linear combination of the variables is stationary, then using VAR with first difference data cause specification problems. Moreover, the relationship between the dynamic path of these variables and current deviation from the equilibrium path need to be examined and can only be done using an error correction models. Gonzalo (1994)‘conducted a simulation test for several methods of estimating long-run relationships and concluded that the estimates resulting from Johansen's vector error correction model has better properties than others. Therefore, we use Johansen's vector error correction model to find cointegrating factors or long-term relationship as well as short-term relationships among the macro economic variables[6].

Unit root test

Following Chen, Roll and Ross (1986) most papers in this area originally used an ordinary least square regression to find a relationship between the stock price changes and the changes in economic factors. However, most macroeconomic time series data are non-stationary'. In order to check the stationarity of the macroeconomic variables, we use Augmented Dickey-Fuller unit root test for all the variables used in this study. Using independently and identically distributed processes, Dickey and Fuller (198 1) calculated the empirical distribution of t-statistics under the null hypothesis that the series has an unit root. To test the unit root hypothesis, the following form of the Augmented Dickey-Fuller test is used on each of the variables.

$$\Delta x_t = \alpha + \beta T + \rho x_{t-1} + \sum_{i=1}^{m} \lambda_i \Delta x_{t-i} + \varepsilon_t \qquad (1)$$

where x_t = the logarithm of the variable in period t,

[6] See Enders (1995) for more explanations.
[7] A series is stationary if the mean, variance and autocorrelation are constant.

T = time trend

Δx_{t-1} = $x_{t-1} - x_{t-2}$

ε_t = i.i.d. disturbance with mean 0 and variance σ^2

$\alpha, \beta, \rho, \lambda$ = coefficients

In an unit root test, the null hypothesis to be tested is that the coefficient of x with one lag is equal to zero (H_0: $\rho = 0$). If unit root test rejects the null hypothesis that the series has an unit root, it means that the series is stationary and thus can be used for Vector Auto Regression (VAR). But, if the unit root test can not reject the null hypothesis, it means that the series are not stationary and we need to apply difference operator to make the series stationary before testing for VAR. In the presence of unit roots, a multivariate regression analysis may give rise to spurious results i.e., may have high R^2, but the least square estimates are not consistent and statistical inferences may not hold. We also use Phillips-Perron test (1988) to avoid the restrictive assumptions in Dickey-Fuller test that errors are statistically independent and have a constant variance. Phillips-Perron test has milder assumption on error terms and its test statistic is a modification of D-F t-statistics.

If however the variables are non stationary but a linear combination of the variables are stationary, then testing for VAR after differencing the economic variables once gives rise to two problems*. Firstly, by differencing once each economic variable time series, we loose some information. Secondly, VAR method's deficiency to include long-term relations among variables gives rise to misspecification bias. In an error

[8] Campbell and Ammer (1993) use a VAR methodology to investigate the relationship between the real interest rate and stock and bond markets.

correction model, however, the time path of cointegrated variables are induced by the magnitude of the deviation from the long-term equilibrium. Assuming that there exists a long-term relationship, the short-run movements of the combination of variables should be affected by the extent of the disequilibrium. Since our interest is to examine the dynamic paths of such variables with the deviation from the long-term equilibrium relationship, we first test for cointegrating vectors with the non-stationary series and then use an error correction model. In an error correction model, the short-run dynamics of the economic variables in the system are influenced by the deviation from long-run equilibrium. By using Johansen's Vector Error Correction Method, we estimate the coefficients for long-term relationship as well as short-run dynamics of the economic variables. A cointegration analysis is more appropriate than VAR because it can investigate the long-term as well as short-term dynamic comovements among macroeconomic variables. Also, in the presence of a cointegrating vector, the VAR analysis after differencing once the data set of time series of variables is erroneous. The linear combination of variables is already stationary time series, differencing the relationship entails a mispecification error.

Cointegration test

Engle and Granger (1987) provide methods of testing for cointegration in a single-equation framework. Johansen (199 1) multivariate estimation of Vector Error Correction Model (VECM) allows testing for cointegration in a system of equations. This method does not require a specific variable to be normalized and gives more efficient estimators of cointegrating vectors (Phillips (1991)). The VECM is a better method firstly for its capability of using all variable as endogenous. Secondly, VECM allows one to estimate both a long-term equilibrium relationship and a short-term dynamic error correction process. The VECM can be written as follows:

$$\begin{bmatrix} \Delta(KOSPI_t) \\ \Delta(CALL_t) \\ \Delta(CBY_t) \\ \Delta(CPI_t) \\ \Delta(IP_t) \\ \Delta(M2_t) \\ \Delta(OIL_t) \\ \Delta(TB_t) \\ \Delta(WS_t) \\ \Delta(WY_t) \end{bmatrix} = \sum_{i=1}^{k-1} [\Gamma_i] \begin{bmatrix} \Delta(KOSPI_{t-i}) \\ \Delta(CALL_{t-i}) \\ \Delta(CBY_{t-i}) \\ \Delta(CPI_{t-i}) \\ \Delta(IP_{t-i}) \\ \Delta(M2_{t-i}) \\ \Delta(OIL_{t-i}) \\ \Delta(TB_{t-i}) \\ \Delta(WS_{t-i}) \\ \Delta(WY_{t-i}) \end{bmatrix} + [\Pi] \begin{bmatrix} \Delta(KOSPI_{t-k}) \\ \Delta(CALL_{t-k}) \\ \Delta(CBY_{t-k}) \\ \Delta(CPI_{t-k}) \\ \Delta(IP_{t-k}) \\ \Delta(M2_{t-k}) \\ \Delta(OIL_{t-k}) \\ \Delta(TB_{t-k}) \\ \Delta(WS_{t-k}) \\ \Delta(WY_{t-k}) \end{bmatrix} + \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_4 \\ \mu_5 \\ \mu_6 \\ \mu_7 \\ \mu_8 \\ \mu_9 \\ \mu_{10} \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \\ \varepsilon_7 \\ \varepsilon_8 \\ \varepsilon_9 \\ \varepsilon_{10} \end{bmatrix} \quad (2)$$

Where A is a first difference notation, X_t is a (1 Ox 1) vector integrated of order one, μ is a (1 Ox 1) constant vector representing a linear trend in a system, k is the lag structure, and ε_t is (10x1) Gaussian white noise residual vector. Γ_i is a (10x10) matrix which represents short-term adjustments among variable across ten equations at the ith lag. The coefficient matrix II contains information about long-run relationship between the ten variables in the data vector. If the matrix II has full rank, it implies that the vector process $\boldsymbol{X_t}$ is stationary and VAR model without differencing the data set can be used. If the rank of matrix II is zero i.e. a null matrix, implies that there is no long-term relationship between level variables and a first difference VAR model is appropriate. If the rank of matrix II is r which lies between one and nine, it implies that there exist (10 x r) matrices of α and β such that $\Pi = \alpha\beta'$ where α denotes the adjustment coefficient and β denotes the cointegrating vector. In this case the vector $\beta'\boldsymbol{X_t}$ is stationary, even though $\boldsymbol{X_t}$ is nonstationary. Since the error correction term is stationary, equation 2 can be interpreted as a vector error correction (VECM) model. From the above equation, in the presence of cointegration a VAR model in first differences is misspecified, as it omits the error correction term $\alpha\beta X_t$ and thus overlooks the long-term relationship.

Since the purpose of our study is to investigate the long-term relationships between stock prices and macroeconomic variables in Korean economy, our hypothesis of cointegration vectors in Korean economy is

$$H_2(r): \Pi = \alpha \beta'$$

where α and β are (10x r) matrices.

In order to test this hypothesis, the order of the cointegration vector needs to be determined first. The order of cointegration (r) is determined by constructing the Trace statistics and the estimated values of the characteristic roots or eigenvalues. Since in practice, we don't know the order of cointegration (r), Johansen (1991) proposes two ways to perform likelihood ratio tests for the value of(r) which differ in assumptions of alternative hypothesis. In both the test, the null is same and stated as at most q cointegrating vectors exist. The first likelihood ratio test method tests the restriction $r > q$ $(q < n)$ against the completely unrestricted model $r < n$, where n is total number of variables. In the second test however, the alternative hypothesis is that there exists only one additional cointegrating vector i.e., $r \leq q + 1$. The log-likelihood ratio statistic associated with first test is called the Trace Statistic and that associated with second test is called as λ_{max} statistic and are given below in equations (3) and (4).

$$Trace = -T \sum \ln(1- \lambda_i) \quad (3)$$

and $$\lambda_{max} = -T \ln(1- \hat{\lambda}_{r+1}) \quad (4)$$

Since the asymptotic distributions of the test statistics and estimators depend on which assumption regarding the linear trend, it is important to choose the appropriate model formulation. From Johansen and Juselius (1989) we use the following the test statistic

$$LR = T\sum \ln[(1-\hat{\lambda}_i^*)/(1-\hat{\lambda}_i) \quad (5)$$

where LR is distributed as a chi-square with (p-r) degrees of freedom, and λ and λ^* are the eigenvalues based on with or without a linear trend respectively.

IV. Empirical Results

In table 1, the descriptive statistics of the level data, data in natural logarithm as well as data in first difference form are presented. We then test for stationarity of the data set before choosing VAR or VECM analysis.

4.1 Unit Root Test:

Before testing for the relationship between the ten variables in the system of equations, we first test for the joint stationarity by employing unit root test. Table 2A shows the results of Dickey-Fuller unit root test for both level and first difference data truncated at 4 lags as well as 12 lags. According to the level data results presented in Table 2A and Table 2B, which are robust to lag lengths, suggests that all ten variables are generally non-stationary. The Dickey-Fuller test on the first difference data truncated at 12 lags all variables except KOSPI, IP, M2, and WS reject the unit root test i.e. are stationary process. Since four variables do not reject the unit root test, it seem the test may not be robust to lag lengths and we repeat the test with four lags. Table 2B shows that all variables except M2 are integrated to order one. We use the data with four lags and conclude that all series are I(1). We also present Phillips - Perron test for unit roots in table 3 (A and B) to show that the first difference series for all variables at both time lag 12 and 4 are integrated to order one. Since Phillips - Perron test is a generalization of the Dickey-Fuller procedure that allows for fairly mild assumptions concerning the distribution of errors, we base our conclusion predominantly from this test statistics. One of key issues in such an empirical analysis is the choice of lag variables. There is no clear theory stating how to choose the number of lag variables except Sims (1980). We first check the raw data first and using D-F test conclude that either 4 or 12 will be the most appropriate number of lag variables. However, we do test several alternative lag lengths' effect on the number of cointegrating factors.

4.2 Johansen's multivariate cointegration test

We report the results for all time lags in Tables 4A and 4B. The results of Johansen's Cointegration test in terms of Trace and λ_{max} are reported in Table 4A with deterministic trend and in Table 4B with no linear deterministic trend. In table 4C, we present the detailed results of cointegration analysis based on lag K = 4. Both the Trace Statistics and λ_{max} indicate that there are at least two cointegrating factors. The Trace test rejects the null hypothesis of $r \leq 2$ in favor of $r > 2$ whereas the λ_{max} rejects the hypothesis of $r \leq 1$ in favor of $r = 2$.

Though we are quite convinced that the lag 4 is the most appropriate lag, we carry out Johansen's multivariate test for lags 1 to 12. We also find the long-term relationship for all the above lags. However, when we use data with 12 month lags, the Trace test rejects the null hypothesis of $r \leq 10$ in favor of $r > 10$ whereas the λ_{max} rejects the hypothesis of $r \leq 9$ in favor of $r = 10$. The number of cointegrating vectors in the case of 12 lags is 10, which implies that the number of cointegrating vectors seem to be dependent on the choice of time lags. The fact that there are ten cointegrating factors and ten variables, the use of 12 lags seems to be misspecified. However, in order to find the appropriate time lags, we present the number of cointegrating vectors as well as the

Akaike and Schwartz Statistics for time lags 1 to 12 in Table 4A and 4B. Since both Akaike and Schwartz Statistics do not improve much after time lag 4, we conclude 4 time lags will be the most appropriate time lag to choose. We carry out test with all lags but only present the direction and the relationship of each factor with stock prices in Table 5.

In the presence of more than one cointegrating vector, we consider only the cointegrating factor represented by largest eigenvalue. When we use four month lags, the long-term relationship between the stock prices in Korean Stock market and the economic factors is given by the cointegrating factor:

$$\beta = (1.00,\ -6.57,\ 7.17,\ -76.84,\ -3.99,\ -0.47,\ 4.88,\ -0.55,\ -20.34,\ 15.41). \quad (6)$$

These values represent the coefficients for KOSPI, CBY, CPI, IP, M2, TB, WS, and WY and a linear trend. These are also the long-term elasticity measures. The actual relationship can be represented by

$$KOSPI = 6.57\ CALL - 7.17\ CBY + 76.84\ CPI + 3.99\ IP + 0.47\ OIL - 4.88\ M2 + 0.55\ TB + 20.34\ WS - 15.41\ WY \quad (7)$$

Then we test whether there is linear trend in the data by checking $-2\ln(Q, H_2^*(4)| H_2(4))$ is 185.88. This is chi-square distributed with eight degrees of freedom. We reject the null hypothesis that there is no linear trend at the 1% level. Therefore, we claim that there is linear deterministic trend in the data and just state all other results with linear trend.

To check the nature of the residuals we need to run diagnostic tests on the correlogram (r_k) to discern whether the time series of variables used appear to be uncorrelated or not. We use Jarque-Bera (1980) normality test and chose Box-Ljung (1978) test over Box-Pierce (1970) test as it appears to have better finite sample properties. The Box-Ljung test statistic is given by

$$Q' = T(T+2)\sum_{k=1}^{p}\frac{r_k^2}{T-k} \quad (8)$$

and is distributed Chi-square with 12 degrees of freedom. To check the normality of the residuals we use Jarque-Bera (1990) test statistic which is computed from skewness (SK), excess Kurtosis (EK) and the number of regressor. The test statistic is distributed asymptotically as $\chi^2(2)$. The J-B test Statistic is given by

$$J-B = [\frac{(T-m)}{6} \times \frac{(SK^2 - EK^2)}{4}] \quad (9)$$

The Jarque-Bera test statistic and Box-Ljung test statistics are presented in Table 6.

4.3 Comparison of VECM and VAR

We have already presented the long term relationship between the Korean stock prices and other economic variables in equation 7 above. The short-term adjustment process using a Vector Error Correction Model is presented in Table 7. The VAR is unable to find the long-term relationship but presents only the short-term relations. However, in the presence of cointegrating vectors, the VAR short term relationships are misspecified. The VAR results are presented in Table 8. Comparing the results we find these results are quite different and VAR results may lead to misleading forecasts. We compare both the models by their forecasting ability by two different measures, root mean square error and Theil's inequality coefficient. The RMSE's of VAR and VECM are 0.0495339 and 0.046729 and the Theil's U coefficients for VAR and VECM are 0.501957834 and 0.003917535. We conclude that VECM's forecasting ability is superior to that of VAR's.

V. Conclusion

Following Fama (1981) and Chen, Roll and Ross (1986) we expect to find an equilibrium relationship between the stock prices in Korea and few macroeconomic variables. Since most of the time series of macroeconomic variables are non-stationary, vector error correction model (VECM) enable us to study the equilibrium relationship within the system of equations. Moreover, we can investigate the long-term relationship as well as the nature of short-term adjustment process between the Korean Stock Index and other macroeconomic variables. We find that the Korean stock market is cointergrated with nine macroeconomic variables. The Korean stock prices are positively related to industrial production, inflation and short-term interest rate, and negatively related to long-term interest rates and oil prices. The foreign exchange rate changes may affect stock prices in either direction. Devaluation of Korean Won against US Dollar (Japanese Yen) is positively (negatively) related to stock price changes. Our findings are robust to time lag selection and generally supports the long-term hypothesized relationship. We also show that the forecasting ability of VECM is generally better than VAR estimating procedure.

Table 1. Summary Statistics of all variables from January 1980 to December 1995

	KOSPI	CALL	CBY	CPI	IP	M2	OIL	TB	WS	WY
	Panel A: Data in Level Form									
Mean	488.81	13.12	16.12	93.21	84.55	56237	22.04	-36.79	762.11	511.66
Median	541.00	12.49	14.45	86.40	86.20	40464	19.08	-87.80	774.90	526.31
Std. dev	330.61	3.65	4.74	24.65	38.19	41613	6.81	539.13	70.49	176.39
Max.	1110.5	24.80	32.20	142.30	166.30	156492	37.48	1764.1	892.20	904.21
Min.	101.70	8.30	10.97	47.80	30.10	9922.3	11.26	-1512	580	233.91
	Panel B: Data in Natural Logarithm									
Mean	5.87	2.54	2.75	4.50	4.33	10.65	3.05	-0.033	6.63	6.175
Median	6.30	2.51	2.67	4.45	4.45	10.61	2.95	-0.04	6.65	6.26
Std. dev	0.87	0.25	0.25	0.26	0.49	0.79	0.31	0.50	0.10	0.36
Max.	7.01	3.22	3.49	4.96	5.10	11.96	3.64	1.37	6.79	6.80
Min.	4.54	2.10	2.41	3.87	3.43	9.07	2.45	-1.53	6.36	5.45
	Panel C: Data in First Difference (all 10^{-2})									
Mean	1.136	-0.324	-0.452	0.549	0.764	1.471	-0.119	-0.210	0.170	0.602
Median	0.740	-0.705	-0.499	0.4401	1.0171	1.5081	-0.380	0.291	0.173	0.258
Std. dev	6.137	6.897	3.894	0.651	4.599	1.850	6.387	41.18	0.846	3.311
Max.	17.31	23.10	11.63	3.661	14.50	9.014	35.26	180.12	4.20	10.78
Min.	-15.31	-21.92	-15.96	-0.458	-18.93	-5.60	-25.68	-149.6	-2.589	-8.527

Table 2A: Unit Root test (ADF) for both level and First Difference Data with12 lags

	Level Data			First Difference Data		
	Without C and Trend	With C	With C and Trend	Without C and Trend	With C	With C and Trend
KOSPI	0.8924	-1.5519	-1.9578	-2.0460**	-2.3508	-2.4379
CALL	-1.0217	-2.1755	-2.0660	-3.6552***	-3.7058***	-3.845**
CBY	-1.1704	-2.7875*	-2.7624	-3.4016***	-3.5355***	-3.5585**
CPI	3.0769	-0.8172	-2.6144	-2.5564**	-3.5112***	-3.4278*
IP	3.0460	-1.2958	-1.5680	-1.5586	-3.0871**	-3.2081*
M2	1.8635	-0.6510	-3.6001**	-1.1659	-2.1200	-2.0824
OIL	-0.8511	-1.8856	-2.0773	–4.2545***	–4.3060***	–4.3579***
TB	-1.4938	- 1.4927	-1.5541	-3.9395***	-3.9301***	-4.0787***
w s	0.5113	- 1.9827	-2.0494	-2.4980**	-2.5393	-2.2 199
WY	1.3401	-0.6637	-2.7147	-3.0958**	-3.3943**	-3.3686*

(*), (**), and (***) indicate significance level at 10%, 5% and 1% respectively

Table 2B. Unit Root test for both level and First Difference Data with Four lags

	Level Data			First Difference Data		
	Without C and Trend	With C	With C and Trend	Without C and Trend	With C	With C and Trend
KOSPI	-1.5417	-0.9126	-1.3047	-5.1949***	-6.1942***	-6.1936***
CALL	-1.3334	-2.8461*	-2.5400	7.0858***	-7.1579***	-7.3409***
CBY	-1.5240	-3.0926**	-2.9007	-5.5667***	-5.7111***	-5.8217***
CPI	3.3618	-0.8323	-2.348 1	-3.0021***	-4.0563***	-3.9289**
IP	5.4014	-1.0296	-1.6160	-6.8929***	-9.7847***	-9.8344***
M2	5.866 1	-0.7590	-2.9560	-3.8118***	-7.9144***	-7.9396***
OIL	-0.5577	-1.8090	-2.4422	-7.4793***	-7.4761***	-7.4667***
TB	-1.8926*	-1.9013	-1.9435	-9.4280***	-9.4083***	-9.4757***
WS	0.9178	-2.5081	-2.4712	-2.8966***	-3.0003***	-2.8728
WY	1.7904	-0.9975	-2.3642	-5.4417***	-5.7500***	-5.6988***

(*), (**), and (***) indicates significance level at 10%, 5% and 1% respectively

Table 3A: Unit Root test (Phillips-Perron) for both level and First Difference Data with 12 lags

	Level Data			First Difference Data		
	Without C and Trend	With C	With C and Trend	Without C and Trend	With C	With C and Trend
KOSPI	1.8732	-1.1240	-1.2594	-10.2691”’	-10.2717***	-10.2648***
CALL	-1.1298	-2.5559	-2.2485	-15.2882***	-15.4053***	-15.7632***
CBY	- 1.4843	-2.1794	-2.0869	-9.5919***	-9.5911 • **	-9.5776***
CPI	4.9809	-2.2038	-3.9920**	-7.6262***	-10.3557***	-10.6430***
IP	4.9066	-0.6709	-4.9825***	-19.3773***	-25.6642***	-25.5849***
M2	11.3497	-2.4070	-4.9318***	-10.4745***	-13.6897***	-13.9648***
OIL	-0.3964	-1.7891	-2.4820	-5.6572***	-5.6307***	-5.6026***
TB	-7.6997***	-7.7243•**	-7.7375***	-35.475***	-35.3930***	-35.815***
w s	1.1717	-2.7850*	-2.4905	-8.3 142***	-8.5658***	-8.779***
WY	2.0655	-1.3050	-2.3930	-12.111***	-12.1618***	-12.152***

(*), (**), and (***) indicates significance level at 10%, 5% and 1% respectively

Table 3B. Unit Root test (Phillips-Perron) for both level and first difference data with 4 lags

	Level Data			First Difference Data		
	Without C and Trend	With C	With C and Trend	Without C and Trend	With C	With C and Trend
KOSPI	1.8725	-1.1244	-1.2530	-10.2161***	-10.4209***	-10.4292***
CALL	-1.0415	-2.585	-2.3 11	-15.057***	-15.081***	-15.200***
CBY	- 1.4269	2.2200	-2.1661	-9.7139***	-9.7973***	-9.8298***
CPI	7.0512	-2.8611’	-4.2406***	-6.6491 • **	-9.3509***	-9.5276***
IP	4.0716	-0.6735	-3.9443**	-20.7503***	-23.9094***	-23.8372***
M2	9.650 1	-1.8948	-4.9873***	-9.0669***	-12.7876***	-12.8255***
OIL	-0.3927	-2.0966	-2.885 1	-6.7815***	-6.7673***	-6.7499***
TB	-6.1071***	-6.1156***	-6.1294***	-29.6424***	-29.5668***	-29.5896***
w s	1.6520	-2.9529**	-2.5370	-6.8741***	-7.1175***	-7.2857***
WY	2.1320	-1.2983	-2.2567	-11.7999***	-12.0873***	-12.0877***

(*), (**), and (***) indicates significance level at 10%, 5% and 1% respectively

Table 4A: Number of Cointegrating Vectors with different lags (model with deterministic trend)

Time Lag	No. of Cointegrating Vectors		Single equation for KOSPI		System of equations	
	Trace Statistic	λ_{max}	Akaike Statistics	Schwartz Statistics	Akaike Statistics	Schwartz Statistics
12	10	10				
11	9	9	-5.924	-3.84	-69.89	-47.5 1
10	8	8	-5.83	-3.96	-69.29	-49.08
9	8	7	-5.81	-4.11	-68.69	-50.27
8	7	7	-5.76	-4.28	-68.26	-51.96
7	8	6	-5.81	-4.46	-68.05	-51.18
6	6	4	-5.80	-4.66	-68.20	-55.77
5	6	3	-5.73	-4.76	-68.36	-57.67
4	3	2	-5.71	-4.96	-68.21	-60.26
3	4	1	--5.71	-5.12	-68.37	-61.80
2	6	3	--5.76	-5.30	-68.47	-62.94
1	7	6	-5.71	-5.41	-68.36	-64.18

Table 4B: Number of Cointegrating Vectors with different lags (model with no linear deterministic trend)

Time Lag	No. of Cointegrating Vectors		Single equation for KOSPI		System of equations	
	Trace Statistic	λ_{max}	Akaike Statistics	Schwartz Statistics	Akaike Statistics	Schwartz Statistics
12	10	10				
11	10	9				
10	9	9	-5.86	-3.98	-68.85	-48.46
9	9	8	-5.80	-4.10	-68.13	-49.54
8	8	8	-5.82	-4.3 1	-67.92	-51.45
7	8	8	-5.83	-4.50	-67.94	-53.24
6	8	4	-5.82	-4.66	-67.90	-54.96
5	8	4	-5.73	-4.75	-68.06	-56.86
4	6	2	-5.70	-4.92	-68.00	-59.2 1
3	8	1	-5.72	--5.68	-67.95	-60.20
2	8	8	-5.74	-5.27	-68.20	-62.16
1	8	8	-5.75	-5.42	-68.16	-63.81

Table 4C. Test Statistics for the Number of Cointegrating factors in Johansen's tests for Cointegration with four lags.

Hypothesized No. of CE(s)	Trace Statistic	λ_{max}	Critical values			
			Trace (5%)	Trace (1%)	λ_{max} (5 %)	λ_{max} (1%)
r = O	303.96***	70.08***	233.11	247.18	62.81	69.09
$r \leq 1$	224.88***	61.34**	192.89	205.95	57.12	62.80
$r \leq 2$	163.54**	42.59	156.00	168.36	51.42	57.69
$r \leq 3$	120.94	36.37	124.24	133.57	45.28	51.57
$r \leq 4$	84.57	29.38	94.15	103.18	39.37	45.10
$r \leq 5$	55.18	21.51	68.52	76.07	33.46	38.77
$r \leq 6$	33.67	13.33	47.21	54.46	27.07	32.24
$r \leq 7$	20.33	12.48	29.68	35.65	20.97	25.52
$r \leq 8$	7.85	7.70	15.41	20.04	14.07	18.63
$r \leq 9$	0.15	0.15	3.76	6.65	3.76	6.65

(*), (**), and (***) indicates significance level at 10%, 5% and 1% respectively

Table 5: The Direction and relationship of different factors with stock prices (predicted vs. actual) for lags 1 to 12.

Vari	Pred	Time lags											
ables	icted	1	2	3	4	5	6	7	8	9	10	11	12
CALL		+	(–)	+*	+*	+*	+*	+*	(–)*	+	(–)	(–)	+*
CBY	(-)	(–)	(–)	(–)*	(–)*	(–)*	(–)*	(–)*	+*	+*	+	+	(–)*
CPI	±	+	+*	+*	+*	+*	+*	+*	+*	(–)*	(–)*	(–)*	+*
IP	+	+	+	+*	+*	+*	+*	+*	(–)*	(–)*	(–)*	(–)	+*
M2	±	(–)	(–)	(–)	(–)*	(–)*	(–)*	(–)*	(–)*	+*	+*	+*	(–)*
OIL		+	(–)	(–)	(–)*	(–)*	(–)*	(–)*	+*	+	+	+	(–)*
TB	±	+	+	+	+	+	+	+	(–)*	+	+	(–)	(–)*
WS	±	(–)	(–)	+*	+*	+*	+*	+*	(–)*	+*	+*	(–)*	(–)*
WY	±	+	(–)	*	(–)*	–*	(–)*	*	+*	(–)	(–)	(–)	+*

(*) indicates significance level at 10%

Vari	Pred	Time lags											
ables	icted	1	2	3	4	5	6	7	8	9	10	11	12
CALL		+	(–)	+	+	+	+*	(–)	(–)	(–)*	(–)	(–)	(–)*
CBY	(-)	(–)	(–)	(–)	(–)	+	(–)*	+	+*	+*	+	+	+*
CPI	±	+*	+*	+*	+*	(–)	+*	+	(–)*	(–)*	(–)*	(–)*	(–)*
IP	+	+	+	+	+	+	+*	+	(–)*	(–)*	(–)	(–)	(–)*
M2	±	(–)	(–)	(–)	+	+	(–)*	+	+*	+*	+	+	+*
OIL		(–)	(–)	(–)	(–)	(–)	(–)*	(–)	+	+*	+	+	+*
TB	±	+	+	+	+	+	(–)	+	+	+	+	+	+*
w s	±	+	+	+	+	+	+*	(–)	(–)	(–)*	(–)	(–)	(–)*
WY	±	(–)	(–)	(–)	(–)	(–)	(–)*	(–)	(–)	(–)*	(–)	(–)	(–)*

(*) indicates significance level at 10%

Table 6 Test for residuals

		k = 4
	J-B normal	B-P Q(12)
KOSPI	1.885'	8.10
CALL	1.704	8.43
CBY	11.83'	9.51
CPI	4.663	5.26
IP	5.486	19.29
M2	8.618'	27.95'
OIL	159.89'	19.537
TB	39.91'	8.69
w s	23 1.97'	12.03
WY	3.33	11.47

(*) indicates significance level at 5%

Table 7: Vector Error Correction Model (VECM) results for first difference variables with 4 lags (standard errors) and [t-statistics] are in first and third parenthesis.

Variables	Time lag1	Time lae 2	Time lag 3	Time lag 4
KOSPI	0.1102	-0.0224	-0.2061**	-0.2099*
	(0.08130)	(0.0791)	(0.0869)	(0.0854)
	[1.3557]	[-0.28291	[-2.37161	[-2.45821
CALL	-0.0950	0.08379	-0.1076	0.0395
	(0.07257)	(0.0738 1	(0.0744)	(0.0695)
	[-1.13511	[1.1351]	[-1.4458]	[0.5689]
CBY	-0.2662**	0.1934	0.0685	-0.1698
	(0.1449)	(0.1488)	(0.1408)	(0.1292)
	[-1.83631	[1.2997]	[0.4868]	[-1.31381
CPI	0.2618	0.2864	1.2722	0.7739
	(0.9485)	(0.9380)	(0.8969)	(0.8263)
	[0.2760]	[0.3053]	[1.4185]	[0.9366]
IP	0.069 18	-0.0088	0.0465	0.0636
	(0.1290)	(0.1427)	(0.1384)	(0.1176)
	[0.5360]	[-0.06221	[-0.33591	[0.5412]
M2	0.7947***	0.9205***	-0.0616	0.3173
	(0.2909)	(0.3005)	(0.274 8)	(0.2709)
	[2.7318]	[3.6313]	[-0.22451	[1.1709]
OIL	-0.2689***	0.2448**	-0.1120	-0.0963
	(0.0927)	(0.1247)	(0.1249)	(0.0998)
	[-2.89881	[1.9631]	[-0.8967]	-[0.9652]
TB	-0.0463**	-0.0 198*	-0.0147	-0.0155
	(0.0194)	(0.0215)	(0.0201)	(0.0150)
	[-2.38011	[-0.92461	[-0.73461	[-1.03031
w s	-0.2559	-0.3998	-0.5909	-0.8598
	(0.6602)	(0.7492)	(0.7920)	(0.7423)
	[-0.3876]	[-0.53361	[-0.53361	[-1.15831
WY	-0.0092	-0.1406	0.1281	-0.092 1
	(0.1371)	(0.1463)	(0.1465)	(0.1421)
	r-O.067 1]	r-O.96151	[0.8750]	r-O.64781

(*), (**), and (***) indicates significance level at 10%, 5% and 1% respectively

Table 8: Vector Auto Regression (VAR) results for first difference variables with 4 lags (standard errors) and [t-statistics] in first and third parenthesis

Variables	Time lag1	Time lag 2	Time lag 3	Time lag 4
KOSPI	0.1874**	0.0330	-0.1548	-0.1074
	(0.0834)	(0.0822)	(0.0904)	(0.0862)
	[2.2471]	[0.4012]	[-1.71151	[- 1.24601
CALL	-0.0445	0.1211	-0.1278	0.0547
	(0.0744)	(0.0765)	(0.0780)	(0.0729)
	[-0.59841	[-1.58301	[-1.63751	[0.7509]
CBY	-0.2046	0.1852	0.0044	-0.2474
	(0.1511)	(0.1564)	(0.1466)	(0.1346)
	[-1.35381	[1.1836]	[0.0299]	[-1.83791
CPI	-0.1293	-0.4284	0.4544	-0.0276
	(0.93 19)	(0.9258)	(0.8917)	(0.8167)
	[-0.13871	[-0.46271	[0.5095]	[-0.03271
IP	0.1646	0.0192	-0.0820	0.0953
	(0.1338)	(0.1501)	(0.1455)	(0.1236)
	[1.2298]	[O.1281]	E-0.56351	[0.7711]
M2	0.7329***	0.6689**	-0.25 10	0.2107
	(0.3047)	(0.3070)	(0.2837)	(0.2837)
	[2.4051]	[2.1786]	[-0.88491	[0.7423]
OIL	-0.256 1	0.3 179	-0.1268	-0.0460
	(0.0975)	(0.1295)	(0.1306)	(0.1030)
	[-2.62711	[2.4545]	[-0.97041	[-0.44651
TB	0.0096	0.0262	0.0184	0.0034
	(0.0148)	(0.0193)	(0.0195)	(0.0151)
	[0.6472]	[1.35501	[0.9465]	[0.2263]
w s	-0.7138	-0.7459	-0.6273	0.1244
	(0.6709)	(0.7752)	(0.8002)	(0.1399)
	[-1.06381	[-0.96231	[-0.78391	[0.8892]
WY	0.1244	-0.0357	0.2559	-0.0028
	(0.1399)	(0.1508)	(0.1504)	(0.1465)
	[0.8892]	r-O.23721	[1.7014]	[-0.0193]

(*), (**), and (***) indicates significance level at 10%, 5% and 1%

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