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Money Supply and the Informational Efficiency of the Stock Market in Korea: Evidence from an Alternative Methodology

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Abstract

This article tests for informational efficiency of the Korean stock market with respect to the money supply. By applying the bootstrap simulation techniques, the results show that the stock market is informationally efficient regarding monetary policy performed during the period 1978-2000. The sensitivity of the results is checked for by utilizing the generalized impulse response functions and the generalized variance decompositions. The estimated results show that money supply does exert any significant effect on neither the first moment nor the second moment of the stock prices. This is interpreted as further empirical evidence for the efficient market hypothesis. The policy implication of the results is explained.

• **JEL Classifications:** E17; C32

• **Key Words:** Stock Market Efficiency; Money Supply; Bootstrap Simulation Technique; Rao Multivariate F-test; Korea

I. Introduction

The increasingly internationalisation of national stock markets contributes to the increasing integration of financial markets around the world. The purpose of this article is to investigate empirically whether the stock market in Korea is informationally efficient with respect to the money supply. A stock market in which the actual price embodies all currently available relevant information is

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called an efficient stock market. Fama (1970) gives a seminal review of "stock market efficiency" in which the Efficient Market Hypothesis (EMH) is formulated. In an efficient market it is assumed to be impossible to predict changes in prices. Hence, the possibility of making abnormal gains is ruled out. Every profit opportunity predicted by traders leads to an action that causes a price change that removes the profit opportunity for others, so no one can predictably make a profit. Thus, EMH in semi-strong version implies that the stock price equals the expected future price and includes all publicly available information, and that there are no predictable profit opportunities available.[1]

An important issue is to investigate how efficiently stock market agents incorporate the information contained in money supply. If the EMH hypothesis is valid then money supply is not going to improve on the predictability of the stock prices, because market participants are fully exploiting the information contained in this variable. If the stock market is inefficient with respect to money supply it has crucial consequences both at micro and macro levels. At the micro level, this implies that the agents can gain higher than normal rate of returns from the stock market. At the macro level, it calls into question the ability of the market to perform its fundamental role of channelling funds to the most productive sectors of the economy.

To test for whether the money supply improves the forecast of the stock prices in the Korean economy I will use bootstrap simulation technique to generate critical values using the true distribution of the data set. This approach has some advantages over standard tests. The standard tests are usually based on the assumption of normal distribution. However, this assumption may not be realised, especially for the financial data, and hence the (validity) efficiency of the tests may be questionable. The probability that extreme events occur in financial markets is usually much higher than what normal distribution would tell us. The bootstrap simulation technique is based on the true distribution of the data, which do not necessarily have to be normally distributed. One other advantage of this approach is that it performs well even if the data generating process is non-stationary and non-cointegrated (see Mantalos, 2000).

The reason that Korea was chosen as a case study is that Korea has one of the fastest growing economies in the world despite difficulties experienced during the

[1]There are two other forms of market efficiency formulated in the literature. The weak form, which implies that the price changes are random and independent. And the strong form that is based on the assumption that the price changes cannot be predicted even if such information that is not publicly available (insider information) is used.

Asian financial crisis. According to Choe and Moosa (1999), the economic growth rate in Korea has been about 9% on average per year during the last 30 years. The Korean financial market was heavily regulated at the beginning but it became deregulated gradually, which has enabled both intermediaries and capital markets to grow rapidly in the last decade.[2] Since 1992 the Korean stock market has been open for direct investment by foreigners. Thus, investigating whether this market is informationally efficient or not could be of a broader interest for both domestic and foreign investors and also for Korean policy makers to attract more domestic and foreign investment. This is especially important now since the national financial markets are increasingly becoming integrated and transactions can occur fast across borders.

Among studies that have tested for the EMH hypothesis are Mookerjee (1987), Jeng *et. al.* (1990) and Serletis (1993). Mookerjee (1987) reports that the USA and the UK appear to be informationally efficient with respect to money supply, while France, Belgium, Canada, Italy, Japan and Switzerland are not during the period 1975-1985. Jeng *et. al.* (1990) investigate the hypothesis of EMH during the period 1921-1930 for Belgium, Canada, Czechoslovakia, France, Hungary, Japan, Poland, Sweden, UK and US. Most stock markets are found to be informationally efficient, but not those of the United States and United Kingdom. Serletis (1993) uses cointegration analysis and finds that the US stock market was efficient regarding money supply during 1970-1988. To the authors best knowledge, the bootstrap approach has not been applied before to test for EMH. Furthermore, I will also use the generalized impulse response functions and the generalized variance decompositions to trace out the effect of one-time shocks to the system. These estimations are based on the vector moving average presentation of the vector autoregressive model and they are insensitive to the ordering of the variables in the model, see Pesaran and Shin (1998).

The rest of this article is organised as follows. Section 2 describes the data, the time-series properties of the data and causality tests. Estimated results are reported in Section 3. The final Section provides conclusions.

II. The Data, Time-Series Properties of the Data and Causality Tests

The data used in this study consist of Koreas general stock price index (*SP*) and

[2]The Korean experience can serve as a benchmark for the reform of other developing countries.

Koreas broad money supply (*M2*) on a quarterly basis for the period 1978:01-2000:04 from *International Financial Statistics*. The data are seasonally unadjusted. The reason for considering seasonally unadjusted data is that the common practice of filtering non-seasonal models to seasonally adjusted data can lead to misspecifications (see among others Newbold, 1980).[3] The variables are transformed into natural logarithmic in order to make the econometric estimation more advantageous and also to make the economic interpretation of the estimated parameters easier.

It is well known that most macroeconomic time-series are characterized by unit roots, which calls the use of standard econometric methods in question. Therefore it is important to check the time-series properties of data in order to avoid spurious and misleading inferences. For this end, I use KPSS (Kwiatkowski et al. 1992) and Perron (1989) test methods to test for unit roots.[4] To test for the informationally efficient market hypothesis I implement causality tests. By causality I mean causality in the Granger sense. The Stock prices are Granger caused by the money supply if including the money supply in the information set will improve the forecast of the stock prices. The Granger causality tests are conducted by applying the following vector autoregressive (VAR) process:

$$\begin{bmatrix} lnM2_t \\ lnSP_t \end{bmatrix} = \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} + \begin{bmatrix} A_{11,1} A_{12,1} \\ A_{21,1} A_{22,1} \end{bmatrix} \times \begin{bmatrix} lnM2_{t-1} \\ lnSP_{t-1} \end{bmatrix} + \ldots + \begin{bmatrix} A_{11,p} A_{12,p} \\ A_{21,p} A_{22,p} \end{bmatrix} \times$$

$$\begin{bmatrix} lnM2_{t-p} \\ lnSP_{t-p} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} \tag{1}$$

where $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t})'$ is a vector of error terms, and A_i is the coefficient matrix. The lag order p of the process is chosen by a combination of Schwarz (1978) Bayesian criterion, Hannan and Quinn (1979) information criterion, and diagnostic tests. Then, *lnSP* does not Granger-cause the *lnM2* if the following hypothesis:

$$H_0: A_{12,i} = 0 \quad for \quad i = 1, \ldots, p \tag{2}$$

is true. In a similar way, *lnM2* does not Granger-cause the *lnSP* if the following hypothesis is not rejected:

[3] I owe this point to an anonymous referee.

[4] The KPSS test and the Perron test are explained in more detail in Hatemi-J (1999).

$$H_0: A_{21,i} = 0 \quad for \quad i = 1, \ldots, p \tag{3}$$

It is well known in the literature that the Wald test for testing the Granger causality may have non-standard asymptotic properties if the variables included in the VAR model are integrated or cointegrated. However, Toda and Yamamoto (1995) and Dolado and Lütkepohl (1996) have independently proposed a solution that guarantees standard χ^2 asymptotic distribution for the Wald tests performed on the coefficients of cointegrated VAR processes with integrated variables, if at least one coefficient matrix is unrestricted under the null hypothesis. Similarly, if all the matrices are restricted, it is shown that adding one extra lag to the process and concentrating on the original set of coefficients will result in Wald tests with standard asymptotic distributions. This result leads to a number of interesting implications because it provides the possibility of testing null hypotheses as restrictions on coefficients of stationary variables.

Shukur and Mantalos (2000) have conducted a Monte Carlo simulation study to investigate the size and power of various generalisations of tests for Granger-causality in VAR models that are integrated or cointegrated. The authors report the properties of eight versions of the test in two different forms, the standard form and the modified form by Toda and Yamamoto (1995) and Dolado and Lütkepohl (1996). In their study, the standard and the modified Wald tests have shown to perform badly, especially when the sample size is small. However, the authors found that the *small-sample corrected* LR-tests, and especially Rao (1973) multivariate F-test, perform best regarding both size and power, even in small samples. In addition, the authors found that all the tests perform poorly when here is no cointegration, especially in small samples. In another Monte Carlo simulation study, Mantalos (2000) have showed that, even when the non-stationary variables are not cointegrated, the bootstrap test exhibits the best performance in almost all situations. In this study I use bootstrapped Rao multivariate F-test to increase the precision of causality tests. It is important to emphasize that bootstrapped simulation tests are not sensitive to the assumption of normality since they are based on the empirical distribution of the underlying data. This is an appealing property because the probability for extreme events in financial markets is usually much higher than what the normal distribution would suggest. That is, financial time-series usually exhibit fat tails in their distribution (leptokurtosis). Thus, the assumption of normally distributed error terms in the empirical model does not hold. This in turn implies that the standard regression analysis is not

efficient anymore. One way to handle a data set that is characterised by lepto-kurtosis phenomena is to apply bootstrap simulation techniques for generating more efficient and precise critical values.[5]

III. Estimation Results

Tests for nonstationarity have been applied using the KPSS and Perron (1989) unit root test methods. The results, presented in Tables 1 and 2, reveal that each variable is characterized by one unit root. The finding that the stock prices contain a unit root is consistent with the weak form of market efficiency, which means that the price changes are random and independent.

Since the variables are found to be non-stationary and integrated, it is important to apply bootstrapped Rao F-test to avoid invalid inference. Before testing for causality the lag order in the VAR model, i.e. p, was carefully chosen by applying a combination of three criteria. Both Schwarz-Bayesian criterion and Hannan-Quinn criterion picked the lag order one. This lag order did not pass the

Table 1. Test for unit roots using the KPSS test

Truncation lags →	0	1	2	3	4
H_0: $I(0)$, H_1: $I(d)$					
Money Supply	9.087	4.631	3.135	2.285	1.934
Stock Prices	6.971	3.520	2.369	1.794	1.451
H_0: $I(1)$, H_1: $I(d)$					
Money Supply	0.135	0.148	0.189	0.230	0.188
Stock Prices	0.222	0.178	0.153	0.137	0.130

Notes: 1.The KPSS test is based on the following model:

$$y_t = r_t + \varepsilon_t$$

where ε_t is a stationary random error, and r_t is a random walk process defined below:

$$y_t = r_{t-1} + u_t$$

The initial value (r_0) is used as fixed and serves the role of an intercept. The null hypothesis of stationarity is defined as the hypothesis is that the variance of the residuals in the random walk component (u_t) is zero.

2. The critical values for the KPSS test are 0.347, 0.463, 0.574 and 0.739 at the 10%, 5%, 2.5% and 1% significance level, respectively. For more details regarding KPSS test see Hatemi-J (1999).

[5]For more details regarding Rao multivariate F-test and the bootstrap simulation techniques see Hatemi-J (1999).

Table 2. Test for unit roots using the Perron test

	H_0: I(1), H_1: I(0)	H_0: I(2), H_1: I(1)
Money Supply	–2.929 (5)	–3.832 (3)
Stock Prices	–1.757 (0)	–6.860 (0)

Notes: 1. The Perron test is based on the following regression:

$$y_t = c + \beta t + dDTB_t + \theta DUM_t + \alpha y_{t-1} + \sum_{t=1}^{n} b_i \Delta y_{t-i} + v_t,$$

where t=linear trend term, DTB=1 if $t=TB+1$ (TB=time break=1997: 01) and DTB=0 otherwise, DUM=0 if $t<=TB$ and DUM=1 if $t>TB$, and Δ is the first difference operator. This regression allows for a structural break in both the mean value and the deterministic trend of the variable under investigation. The null hypothesis of a unit root is α=1. The number of optimal lagged differences (n) is chosen by adding lags until the Ljung-Box test do not reject the null hypothesis of no serial correlation of v_t at the 5% significance level.

2. The critical values for the Perron test are –3.460, –3.750, –3.990 and –4.330 at the 10%, 5%, 2.5% and 1% significance level, respectively. Note that the lambda (defined as the ratio of pre-break sample size over after-break sample size) is around 0.8 in this study.

multivariate tests for autocorrelation. To remove autocorrelation another additional lag was included, which was successful in dealing with autocorrelation. I also tested for the assumption of normality. The multivariate tests for normality showed that the residuals are not normally distributed.[6] However, the bootstrapped Rao F-test is not sensitive to the assumption of normality. The results of the bootstrapped Rao F-test that is applied to the VAR(2) model for the quarterly data of *SP* and *M2* in Korea is presented in Table 3. This test method results in drawing the inference that these variables do not Granger cause each other at the conventional significance levels. This means that the stock market in Korea is informationally efficient with respect to the money supply and the agents fully take into consideration the information contained in the money supply.

The robustness of the estimated results is checked for by applying the impulse response functions and the variance decompositions. I made use of generalized impulse response functions and generalized variance decompositions developed by Pesaran and Shin (1998) because unlike the traditional impulse response functions, generalized impulse response functions and generalized variance decompositions do not require orthogonalization of shocks and are invariant to the ordering of the variables in the model. By these estimates it is possible to trace out the effect of one-time shocks to the system. In a system consisting of stock prices and money supply the likely impact of an exogenous impulse in each variable was

[6]The estimated results for Schwarz-Bayesian and Hannan-Quinn criteria and diagnostic tests are not presented here to save space but they are available from the author upon request.

Table 3. Test results for Granger-causality during the period 1978:1 to 2000:4

Null Hypothesis	P-values of Bootstrapped Rao F-test
Money supply does not Granger Cause Stock Prices	0.136
Stock Prices do not Granger Cause Money Supply	0.089

estimated. Based on the estimated results, not presented but available on request, it can be concluded that the broad money supply does render any significant effect to neither the first moment (mean value) nor the second moment (variance) of the stock prices for forty quarters. These methods provide further empirical support that the Korean stock market is informationally efficient.

IV. Conclusions

The objective of this article is to test for informational efficiency of the Korean stock market with respect to the money supply for the period 1978-2000. An alternative methodology is applied, which is not sensitive to the assumption of normality distribution of the residuals in the model and it performs well for non-stationary data.

By applying the bootstraps simulation techniques on Rao multivariate F-test, the results show that the Korean stock market is informationally efficient regarding monetary policy performed during the period. This means that the agents fully take into consideration the information contained in money supply, which in turn implies that money supply is not going to improve on the forecastability of the stock prices, because market participants are fully exploiting the information contained in this variable. Hence, the possibility of making abnormal gains through the money supply is ruled out.

By applying the generalized impulse response functions and the generalized variance decompositions further evidence is provided for the assumption of information efficiency of the Korean Stock Market. The conclusions made here appears to be quite robust because different methods bootstrapped causality tests, impulse response functions and variance decompositions to drawing the same inference.

The last few decades have been characterised by the introduction of a number of policy measures aiming to remove restrictions and to facilitate the access of foreign investors to the Korean financial and stock markets. Such policies have resulted in enormous growth of these markets. Based on the estimated results

presented in this study, it can be concluded that these deregulation policies have been successful in terms of paving the way for the ability of the market to perform its fundamental role of providing information needed to channel funds to the most productive sectors of the economy. This might serve as an example for other developing countries that need reforms in order to develop the full potential of their economies.

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