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Dynamic Analysis of the Stock Price Index and the Exchange Rate Using Vector Autoregression (VAR): An Empirical Study of the Jakarta Stock Exchange, 2001-2004

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Abstract:

*This research examines whether there is a causal relationship between the Rupiah exchange rate and the composite stock price index. The Vector Autoregressive (VAR) method is applied to analyze daily time series data from January 24th, 2001 to June 18th, 2004. It shows that the series are non-stationary and become stationary on the first difference or I (1). Although they have the same integration order, neither variable is co-integrated based on the Augmented Engle Granger Method and Johansen's Co-integration Test. Consequently, the modeling technique used in this study (VAR) is applied to the first difference level. From the VAR model, it was found that the Rupiah exchange rate is affected by both the past exchange rate and the stock price index (*ceteris paribus*). In contrast, the stock price index is only affected by past index movements. These results are supported by innovative accounting calculated by both Variance Decompositions (VDCs) and Impulse Response Function (IRF). We conclude that the index can be a leading indicator for the exchange rate following the Portfolio Balance Approach.*

Keywords: *Stock Price Index, Indonesia, Capital Market, Exchange Rate*
JEL Classification: G12, F31, E44

1. BACKGROUND

The capital market is an important part of a national economy. Capital markets are vital in many countries as their economic role is to shift funds from lenders to borrowers.

Indonesia's capital market is still an emerging market which is vulnerable to macroeconomic and political conditions. The monetary crisis experienced in Asia in 1997, triggered by the downfall of the Thai Baht, had a contagion effect on neighboring countries, including Indonesia. The depreciation of the *Rupiah* negatively impacted sectors in the national economy to different degrees of intensity.

The exchange rate crisis in turn led to a stock market crisis as a reaction to government policy to increase interest rates to pursue a tight monetary policy. When interest rates increase, capital owners tend to allocate their funds to other investments, such as time deposits. These kinds of investments are lower risk and have a negative effect on the capital market. In such a situation, investors are not interested in capital markets because the rate of return from stock yields is smaller than that from time deposits. Consequently, stock prices tend to decline as a market reaction to economic crisis. The fall of composite index stock prices, as an indicator of a capital market's performance, implies a negative reaction. This can be used to form a hypothesis about the interaction between money markets and the capital market.

The dynamic relationship between the movement of the exchange rate and the capital market is an interesting topic for study. Generally, there are two approaches to analyze the relationship between the exchange rate and stock prices. The Traditional Goods Market Approach, also known as the "flow oriented" exchange rate model, was introduced by Dornbusch and Fischer (1980). The Portfolio Approach or "stock oriented" exchange rate model was introduced by Branson (1983) and Frankel (1983). The Traditional Approach asserts that exchange rate movements will affect international competitiveness and the balance of payments as well as output and the current and future cash flow of a company and its stock price. On the other hand, the Portfolio Approach argues that the capital market affects the exchange rate through money demand.

The Traditional Goods Market Approach is grounded in the consideration that a company which is internationally oriented will export its products. Theoretically, a company benefits from the depreciation of the domestic currency because income from abroad will be greater when calculated in the domestic currency. At the same time, the price of the company's product in foreign markets tends to be cheaper than products from countries whose currencies are not experiencing depreciation. As a result, the company's products are more prices competitive. The opposite occurs for companies which use imported raw materials. The importing company benefits because of the appreciation of the domestic exchange rate. Further, exchange rate fluctuations also affect company transaction exposure related to company debts and receivables in foreign currencies.

The Portfolio Balance Approach stresses the role of capital account transactions where the capital market can influence the exchange rate through money demand or supply, as, like other commodities, the exchange rate is determined by market mechanisms dependent on supply and demand. The development of the capital market attracts capital inflows from foreign investors and hence increases domestic demand for money. On the other hand, when stock prices decline, capital will shift from the stock market to other forms of investment. According to this approach, declining stock prices reduce the wealth of local investors. This leads to a decreased demand for money, and, thus, a falling interest rate. The decline in the interest rate tends to support capital outflows (*ceteris paribus*), and, finally, causes a depreciation of the exchange rate. Thus, this approach states that there is a positive relationship between stock prices and the exchange rate, in contrast to the Goods Market Approach. The Portfolio Balance Approach argues that stock price fluctuations impact exchange rate fluctuations.

Problems related to foreign exchange rates, particularly to the US dollar, occur because the stock market is open to foreign investors. These investors do not only take into account the return rates of stocks or portfolios, but also consider the exchange rate when investing in foreign stock markets.

2. RESEARCH VARIABLES

The variables used in this study are:

1. Composite Index of Stock Prices (IHSG)
2. Rupiah Exchange Rate to the US Dollar

Time series transformation:

Δ IHSG$_t$ = $\ln\left[\dfrac{IHSG_t}{IHSG_{t-1}}\right]$ is the return on the composite index of stock prices

Δ EX$_t$ = $\ln\left[\dfrac{EX_t}{EX_{t-1}}\right]$ is the exchange rate difference

Data

The study uses secondary data obtained from the following sources:

Table 1
Research Variables, Data Sources, Type and Period

Variable	Source	Type	Period
Composite Index of Stock Prices (IHSG)	Jakarta Stock Exchange, www.jsx.co.id	Daily	January, 24 2001 - June, 18 2004
Rupiah Exchange Rate to US Dollar	Indonesian Economic and Finance Statistics (SEKI), www.bi.go.id	Daily	January, 24 2001 - June, 18 2004

3. METHODOLOGY AND RESULTS

The research methodology used was a multiple step testing procedure employing stationary test, lag length determination, the co-integration test and the VAR or VEC (Vector Error Correction) model. Each is explained in more detail below.

Stationary Test (Unit Root)

The stationary test can be calculated using both the unit root test and autocorrelation function. However, this research only employed the unit root test to determine the stationary series.

Unit Root Test

Variable Y_t with one unit root is well known as a random walk with a non-stationary time series. If there is a unit root in a series, the testing will treat to first difference, second difference, and so on, until the series becomes stationary.

Two commonly used unit root test methods are the Augmented Dickey-Fuller Test (ADF Test) and the Phillips-Perron Test (PP Test). To determine whether a variable has a unit root we will use a comparative value between ADF (PP) and the table value of ADF (PP). If the absolute value of ADF (PP) is smaller than the critical absolute value (the table value of ADF at a certain significant level), then that variable can be said to contain a unit root (be non-stationary). The unit root test results can be summarized as follows:

Table 2
Unit Root Test Results by ADF and PP Test Methods

Variable	ADF Test	PP Test	Integration Order
IHSG	-0.392513	-0.409839	I(1)
D(IHSG)	-12.04807	-24.70132	
EX	-1.609835	-1.569623	I(1)
D(EX)	-11.28100	-25.17982	

Source: Estimation result calculated by Eviews version 3.0
Note: *, **, *** are significant levels of 10%, 5% and 1% respectively

Table 2 shows that the data of those variables have a unit root. This means that the original data are non-stationary. This is consistent with previous studies by Ajayi and Mougoue (1996), Indrawati (2002), Sudjono (2002), Sulistyo (2002) and Asmila (2001).

Since the original data are non-stationary, the next step is to conduct the unit root test for the first difference data. Both ADF and PP indicators show that variable first difference data indicate a significant result at 1%. We can thus conclude that all the research variables are stationary on the first difference meaning that the research variables are integrated at order 1 (I (1)).

Lag Length Determination in VAR

Both VAR/VEC and co-integration models are sensitive to lag length. Therefore, the determination of optimal lag length is important in the development of the model.

There are general parameters used to determine optimal lag: Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Likelihood Ratio (LR). Optimal lag can be obtained from the VAR or VEC equation that gives the smallest AIC, SIC or LR values. Based on Enders (1995:88), AIC, SIC and LR is defined as follows:

$$AIC(k) = T\ln\left(\frac{SSR(k)}{T}\right) + 2q \quad \text{(1)}$$

T = number of observations

SSR = Sum Square Residuals

k = lag length

q = number of regressors = k + 1 = number of estimated parameters

$$SIC(k) = T\ln\left(\frac{SSR(k)}{T}\right) + q\ln(T) \quad \text{(2)}$$

$$LR = -2\left(l^{r} - l^{u}\right) \quad \text{(3)}$$

l = log likelihood

r = restrictive regression

u = unrestrictive regression

Previous studies have used a different lag length. Ajayi and Mougoue (1996) applied various lag lengths for each country from lag 3 until lag 13; Asmila (2001), used daily data, employing lag 8 for Indonesia, lag 5 for the Philippines, and lag 6 for Thailand and Singapore. Sudjono (2002) used lag 9 for all periods from January 1990 – December 2000, lag 3 for the pre-crisis period and lag 2 for the post-crisis period. Meanwhile, Indrawati (2002) used monthly data and employed lag 3 for Indonesia, while Sulistiyo (2002) used weekly data and employed lag 7. Lag length is determined by the type of time series data (e.g. monthly, weekly, and daily) and the sample size.

In this study, the lag length used to estimate the VAR model is based on LR. Calculations showed that direct determination by minimum AIC and SIC criteria did not give the optimal value as the AIC and SIC values tended to decrease. Therefore, the study employed the minimum LR value. By assuming that there are 20 trading days in a month, lag length was defined from lag 1 to lag 20. The recapitulation table of log likelihood for the VAR model between the IHSG and exchange rate (EX) shows that the smallest LR value occurs when lag equals 5 (Appendix, **Table 1**). Thus, the co-integration test and the VAR Model use lag 5. This lag follows the weekly trading period.

Co-integration Test

The co-integration test aims to prove if there is co-movement and relationship stability between two or more variables in the long-run. If one series has a unit root and is integrated in the same order then the co-integration test is used to explore whether that series is co-integrated. Enders (1995) in Sulistiyo (2002) defines co-integration as follows:

1. Co-integration is a linier combination of non-stationary variables
2. All variables must be integrated at the same order
3. If x_t has n components then it is possible that there is n-1 co-integration vector. While if x_t only consists of two variables/ components, then there is one co-integration vector. This number of co-integration vectors is the co-integration rank of x_t.

In this study, the co-integration test used two methods: the Augmented Engle Granger Method and Johansen's Co-integration Test. The Augmented Engle Granger Method verifies whether the residual linier combination of both variables is stationary. A comparison of the residual value of the ADF Test equal to –0.743298 (< Critical Value 5%: -2.8655) indicates that there is a residual unit root. In other words, there is no co-integration between stock prices and the exchange rate.

The Johansen's Co-integration Test also gave the same conclusion as shown in the following table:

Table 3
Co-integration Test using Johansen's Co-integration Test for Model 1

Eigen value	Likelihood Ratio (LR)	5% Critical Value	1% Critical Value	Hypothesized No. of CE(s)
0.003998	3.540743	15.41	20.04	None
0.000296	0.243466	3.76	6.65	At most 1

*(**) denotes rejection of the hypothesis at 5% (1%) significance level
L.R. rejects any co-integration at 5% significance level

It can be concluded from both the Engle Granger and Johansen's Co-integration tests that there is no co-integration between the stock price index and the exchange rate. This indicates that there is no stable relationship and co-movement in the long run between the stock price index and the exchange rate. This differs from previous studies by Asmila (2001), Indrawati (2002), Sudjono (2002) and Sulistiyo (2002). This could be due to the different observation periods and data characteristics (monthly, weekly or daily).

According to Enders (1995) in Indrawati (2002), if there is co-integration then the appropriate estimation technique is Vector Error Correction (VEC). However, since there is no co-integration in this study, the appropriate method is VAR Difference (VARD).

Empirical VAR Model

After determining lag length and co-integration, the next step is to determine the VAR research variables. Because all variables are stationary at I(1) then the VAR estimation technique used is VAR Difference (VARD).

The general VAR model is as follows:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \dots + A_k Y_{t-k} + BX_t + \varepsilon_t$$

Y_t = n x 1 endogenous variable matrix

X_t = m x 1 exogenous variable matrix

ε_t = n x 1 error term matrix

$A_1, A_2, \dots, A_k, B$ = the estimated coefficient matrix

A_i = n x n matrix of the estimated coefficient of endogenous variable

B = n x m matrix of the estimated coefficient of exogenous variable

Enders (1995) used the above VAR model without using exogenous variables but introducing A_0, n x 1constant matrix as follows.

$$Y_t = A_0 + A_1 Y_{t-1} + A_2 Y_{t-2} + \dots + A_k Y_{t-k} + \varepsilon_t$$

The ordinary VAR model with two endogenous variables, no exogenous variables and with lag length (2) is as follows:

$$\begin{bmatrix} Y_{1,t} \\ Y_{2,t} \end{bmatrix} = \begin{bmatrix} A_{10} \\ A_{20} \end{bmatrix} + \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} Y_{1,t-1} \\ Y_{2,t-1} \end{bmatrix} + \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} Y_{1,t-2} \\ Y_{2,t-2} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{bmatrix}$$

Based on Enders (1995), if there is co-integration, the appropriate model to use is the Vector Error Correction because the VARD estimation does not account for data co-movement and has potential misspecification errors.

Two equations can be formed from the VAR results (Appendix, **Table 2**):

DEX = 0.1230110511*DEX(-1) - 0.1652380202*DEX(-2) + 0.01658500182*DEX(-3) + 0.07835173292*DEX(-4) + 0.07115448813*DEX(-5) - 0.09178172169*DIHSG(-1) - 0.003643146553*DIHSG(-2) - 0.03015099301*DIHSG(-3) - 0.006618103407*DIHSG(-4) - 0.02401037843*DIHSG(-5) + 9.234977846e-05

DIHSG = 0.03323035117*DEX (-1) + 0.04600784034*EX (-2) - 0.03240669139*DEX (-3) + 0.04234041229*DEX (-4) - 0.02787453835*DEX (-5) + 0.1570384772*DIHSG(-1) - 0.03437060179*DIHSG(-2) + 0.0280093135*DIHSG(-3) - 0.02320546596*DIHSG(-4) + 0.04486668382*DIHSG(-5) + 0.0004836351458

Both VAR equations above consist of the same variables on the right hand side. OLS is the most efficient estimator (Pyndick and Rubinfeld, 1998). Only some lags are significant in the equations above.

For the ***first*** equation, in which the dependent variable is DEX, the significant variables are the previous exchange rate differences from one until five days before. In general, these differences positively impact the present exchange rate. The rate of return from the aggregate index one day before also affects the exchange rate in the opposite direction.

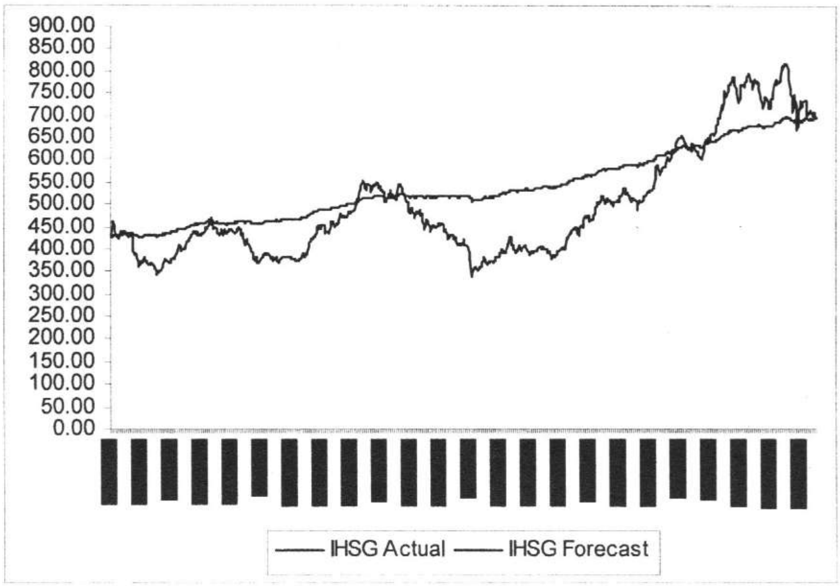
In the ***second*** equation, in which the dependent variable is DIHSG, the significant variable is only the positive rate of return one day before. In general, the relationship between the exchange rate and the rate of return is negative. This means that if the rate of return on stocks increases (the stock price index increases) then the exchange rate will improve, that is the Rupiah appreciates. Conversely, if the index decreases, then the Rupiah will depreciate.

Both equations show that the exchange rate is not only affected by the dynamics of previous fluctuations, but also by the stock price index. However, the stock price index is only influenced by the fluctuations of previous indices. This indicates that, for the sample period analyzed in this study, the index was a leading indicator of exchange rate fluctuations.

If the composite stock price index increases, as a benchmark of stock price fluctuation, then average stock prices will also increase. This will be followed by a rise in capital inflows and finally an increased demand for domestic currency, leading to currency appreciation. This follows the Portfolio Balance Approach.

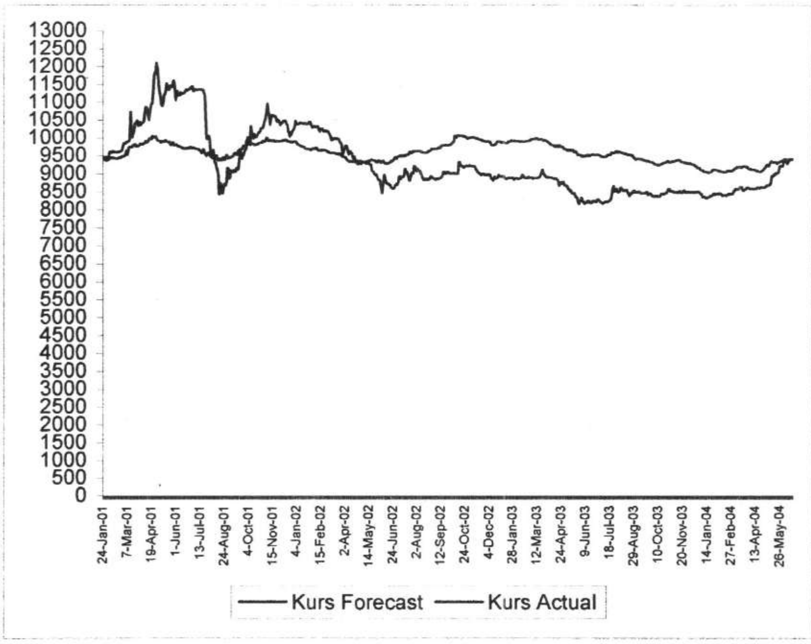
The VAR model can also be used to forecast performance, as seen in the following graph:

Figure 1
Actual and Forecast IHSG



The above graph, from January 2001 until June 2004, indicates that while the IHSG has fluctuated, it has tended to increase since 2001. The lowest value was noted in October 2002 at 337.48 and it peaked in April 2004 at 818.16. VAR model forecasts can only catch real data trends. According to Pindyck and Rubinfeld (1998), this is typical of a VAR model. Therefore, the VAR model is a powerful tool for only short-term forecasting. Using this model, the IHSG was predicted to hit 693 on June 19, 2004.

Figure 2
Actual and Forecast Exchange Rate



The chart above shows that the exchange rate was relatively stable from January 2001 to June 2004. Further, forecasts also tend to be relatively stable. According to this forecast, the exchange rate will reach Rp 9,405 on the next day.

4. CONCLUSION

The study's analysis of the dynamics between the stock price index and the exchange rate using the Vector Autoregressive (VAR) method can be summarized as follows:

1. This study has tried to explore the dynamic relationships between the stock price index and the exchange rate using the VAR method to explain the impact of one variable on itself and on the other variable.
2. Based on cumulative return value, the IHSG is more volatile than the exchange rate. In fact, the IHSG tends to increase more than the exchange rate.

3. The unit root test shows that the Rupiah exchange rate to the US Dollar and the Composite Index of Stock Prices are non-stationary and will be stationary at the first difference.
4. The VAR model is very sensitive to lag length. By using the minimum Likelihood Ratio (LR), it can be concluded that the optimal lag for this VAR model is 5, related to the five day work week at the Jakarta Stock Exchange. In other words, a week is needed to make an adjustment between the IHSG and *Rupiah*-dollar exchange rate.
5. Based on co-integration tests using the Augmented Engle Granger and Johansen's Co-integration Test methods, the two research variables are not co-integrated, meaning that the dynamic movement of these two variables are different.
6. The VAR model shows that the exchange rate is not only affected by exchange rate dynamics, but also by stock price index dynamics. However, the stock price index is only affected by the index itself. It can thus be concluded that the stock price index is a leading indicator for the exchange rate as suggested by the Portfolio Balance Approach.
7. By using the VAR model, we can forecast future exchange rate and stock price index values in the short run.

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APPENDIX

Table 1
Recapitulation of the Log Likelihood Value and LR on VAR's Model between IHSG and Exchange Rate for Lag 1 - 20

Lag	Log Likelihood	LR Statistics $-2(l_{-1} - l)$
1	5079.218	**8.690**
2	5083.563	-8.608
3	5079.259	-4.044
4	5077.237	-4.458
5	**5075.008**	**-10.286**
6	5069.865	1.690
7	5070.710	-8.576
8	5066.422	-9.250
9	5061.797	-8.964
10	5057.315	-6.626
11	5054.002	-4.390
12	5051.807	-9.068
13	5047.273	-10.046
14	5042.250	-1.676
15	5041.412	-3.890
16	5039.467	-7.98
17	5035.477	-8.892
18	5031.031	-9.024
19	5026.519	-10.000
20	5021.519	

Table 2
VAR Estimation Results

	DEX	DIHSG
DEX(-1)	**0.123011**	0.033230
	(0.03514)	(0.05702)
	(3.50039)	(0.58273)
DEX (-2)	**-0.165238**	0.046008
	(0.03526)	(0.05721)
	(-4.68660)	(0.80416)
DEX (-3)	0.016585	-0.032407
	(0.03567)	(0.05788)
	(0.46496)	(-0.55988)
DEX (-4)	**0.078352**	0.042340
	(0.03526)	(0.05721)
	(2.22218)	(0.74003)
DEX (-5)	**0.071154**	-0.027875
	(0.03472)	(0.05633)
	(2.04967)	(-0.49483)
DIHSG(-1)	**-0.091782**	**0.157038**
	(0.02169)	**(0.03520)**
	(-4.23085)	**(4.46107)**
DIHSG(-2)	-0.003643	-0.034371
	(0.02212)	(0.03590)
	(-0.16469)	(-0.95752)
DIHSG(-3)	-0.030151	0.028009
	(0.02212)	(0.03590)
	(-1.36290)	(0.78024)
DIHSG(-4)	-0.006618	-0.023205
	(0.02215)	(0.03594)
	(-0.29880)	(-0.64566)
DIHSG(-5)	-0.024010	0.044867
	(0.02197)	(0.03564)
	(-1.09311)	(1.25878)
C	9.23E-05	0.000484
	(0.00031)	(0.00050)
	(0.30039)	(0.96945)