Statistical analysis on the effect of exchange rate on stock price in Indonesia: an application of ARDL and IGARCH models

P Adam\(^1\), E Cahyono\(^1\), Mukhsar\(^1\), H Millia\(^2\), B Abapihi\(^1\), N Mukhtar\(^1\) and Lilis La Ome\(^1\)

\(^1\)Department of Mathematics, Universitas Halu Oleo, Kendari 93232, Indonesia
\(^2\)Department of Economics, Universitas Halu Oleo, Kendari 93232, Indonesia

adampasrun@gmail.com (corresponding author)

Abstract. This study aimed to examine the influence of the IDR/USD exchange rate on stock prices in Indonesia. The data used were the IDR/USD exchange rate and the monthly composite price index that spanned from January 2004 to October 2017. To test the effect of the IDR/USD exchange rate on stock prices, the distributed lag (ARDL) autoregressive model and integrated general autoregressive conditional heteroskedasticity (IGARCH) were used. The result of analysis showed that there was influence of IDR/USD rate to stock prices either in short term and in long term. In the long term, every 1% decrease in the exchange rate of IDR/USD, the change in stock price rise.

1. Introduction

Foreign currency is a tool of transactions in international trade activities both in the real sector and in the financial sector. This change in foreign exchange rates can affect other macroeconomic variables. In the real sector, the effect of exchange rate changes on other macroeconomic variables can occur through trade in goods and services. In the financial sector, the effect of exchange rate changes on other macroeconomic variables can occur through trading activities of assets in financial markets [1].

There are two theories that explain the relationship between foreign currency exchange rates and stock prices; they are the good market theory and the portfolio balance theory. The goods market theory states that the exchange rate can affect the stock price. This effect can occur because exchange rate changes can affect the profits of the companies through the import of raw materials and the export of goods produced. Changes in these profits can in turn affect the stock prices of these companies [2, 3]. In international trade, the nature of this influence will vary in each country and will depend on the dominance of exports and imports. If the export activity of a country is more dominant, then the appreciation of the exchange rate will reduce the competitiveness of the export market, which in turn can decrease the domestic stock price. Conversely, if the import activity of a country is more dominant, then the appreciation of the exchange rate will lower the cost of imports, which will eventually raise the price of domestic stocks [4, 5, 6]). Furthermore, the portfolio balance theory states that stock prices can affect the exchange rate. Thus, if the stock price falls, the company’s wealth and the wealth of a country may decline. This decline in wealth will cause money demand to fall, so the government will lower interest rates through its monetary policy. This falling interest rate can lead to capital flows out of the country which in turn depreciates currency rates [5].
If it is seen from the relationship between exchange rate and stock price, previous research can be grouped into two research groups which are called research group about causal relationship between exchange rate and stock price and research group about the influence of exchange rate to stock price. The first research group was studied by previous researchers such as [7, 8, 9]. They found that there was a two-way relationship between exchange rates and stock prices. In Indonesia, the results of research on the relationship between exchange rates and stock prices were reported by [10]. Based on the results of data analysis, they found that the stock price was not influenced by the exchange rate, and only the stock price that affected the exchange rate. More recent research in Indonesia was reported by [11], but the stock price data used was micro data because it used individual stock price data from companies: PT. Telekomunikasi Indonesia, Tbk, PT JasaMargaTbk and PT. Perusahaan Gas Negara Tbk. They found that the exchange rate affected the stock price of the company PT. Indonesian telecommunications and exchange rates did not affect the share price of PT JasaMargaTbk and PT. Perusahaan Gas Negara Tbk. The differences in findings from [10, 11] could be due to differences in time of data retrieval [10] and/or different use of stock price variables. Furthermore, the conclusions of the results of the analysis in this study group were based on an vector of autoregressive analysis. Meanwhile, the second research group or research on the effect of exchange rate on stock prices was examined by previous researchers, among others: [12, 13, 14]. They found that there is influence of exchange rate to stock price. This conclusion was based on simple regression analysis, generated method of moment or ARDL.

Because time series data in finance has high volatility over time, the residual in a model with the multiple regression model or the autoregressive distributed lag (ARDL) model may not meet homoskedastic assumption. One alternative to eliminate residual heteroskedasticity is to use the autoregressive conditional heteroskedasticity (ARCH) model or the general autoregressive conditional heteroskedasticity (GARCH) model [15] which consists of several types of models, the integrated general autoregressive conditional heterokedasticity (IGARCH) model is one of them. Meanwhile, according to our best knowledge, a study of the effect of the exchange rate on stock prices using the ARDL and IGARCH models has not been conducted.

Therefore, this study aims to examine the effect of exchange rate on stock prices in Indonesia. The econometric model used to examine this effect is the ARDL model and the IGARCH model, hereinafter abbreviated as ARDL-IGARCH.

2. Literature Review
In theory, the relationship between exchange rates and stock prices has been raised in the introductory section. Therefore, this section will be the literature review section on empirical studies. These empirical studies are grouped into: (1) the relationship between exchange rates and stock prices, (2) the relationship between exchange rates, stock prices and other macroeconomic variables, and (3) the effect of exchange rate on stock prices.

Ya-Qiong and Chuan-Bao[16] examined the relationship between exchange rates and stock prices from several firms in China using a panel regression model. They found that there was a relationship between exchange rates and stock prices of all firms. Inci and Lee [17] investigated the relationship between exchange rate changes and stock returns in the countries: France, Germany, Italy, Switzerland, the UK, the USA, Canada, and Japan. They found that there was a relationship between exchange rates and stock returns in all these countries. Dahir et al. [18] examined the relationship between exchange rates and stock prices in BRICS countries (Brazil, Russia, India, China, and South Africa). They used daily exchange rate and daily stock prices that spanned from 2006 to 2016. Vavelet analysis showed that in the long run, there was a positive relationship between exchange rate and stock prices. In the short term in 2008, this relationship was negative.

Zolfaghari and Sahabi[19] investigated the effect of exchange rates on stock prices of companies engaged in the oil sector in Iran. They used the Markov Regime-Switching GARCH model to test the effect. They found that there was an influence of exchange rate toward stock prices in all companies. Jo et al. [20] examined the effect of the Korean WON exchange rate on Korean stock prices. The
result of random matrix theory test to daily data that spanned from January 3, 1990 until August 5, 2014 showed that there was positive influence of exchange rate to stock price.

Mishra [21] examined the effect of fundamental macroeconomic variables (exchange rate, interest rate, industrial production, foreign investment and inflation) on stock returns in India. The result of data analysis using multiple regression model showed that all macroeconomic variables affected stock return. M gammal [22] investigated the influence of exchange rates, inflation and interest rates toward stock prices in the Countries: Kingdom Saudi Arabia and United Arab Emirate. They used multiple regression to test the effect. The test results showed that the exchange rate, inflation and interest rates positively affected the price of shares in both countries.

3. Data and Methodology

3.1. Data

This research data consisted of exchange rate (EX) and stock price index (ST). The exchange rate was proxied by IDR/USD considering that USD is the world currency commonly used at the time of transaction in international trade both in real sector and in finance sector. The data spanned from January 2004 to October 2017. The data source was Fusion Media Limited.

For the purpose of analysis, the stock price was stated with RST and exchange rate was stated with REX. The RST and REX variables on t time was stated with $RST_t = \ln(ST_t)\text{ and } REX_t = \ln(EX_t)$.

3.2. Methodology

The econometric model used to test the effect of the IDR/USD exchange rate on stock prices in Indonesia was the ARDL(p,q)-IGARCH(r,s) model where p, q, r and s were the length of the time lag. The ARDL model was developed by [23, 24] named the ARDL model with the LVAR model and this term has been used by [25, 26, 27]. Furthermore, the IGARCH model was developed by [28]. This model was a special form of the GARCH model developed by Bollerslev (1986) [29] where the constant parameters in the GARCH model were omitted. The ARDL-GARCH model was proposed by [30].

To test the effect of the IDR/USD exchange rate on the stock price using the ARDL(p,q)-GARCH(r,s) model, the first step was to test the stationerity of the two variables RST and REX. The stationary test used was Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test. According to both tests, a variable is stationary or integrated of order d, I(d), if the P-value of the two test statistic is smaller than the significance level of 1% or 5%.

If the first step was found that RST and REX were integrated of order zero, I(0), then the ARDL(p,q) model that stated the relationship between Exchange rate of IDR/USD and stock price is as follow.

$$RST_t = \alpha_1 + \sum_{i=1}^{p} \beta_{1i} RST_{t-i} + \sum_{j=0}^{q} \gamma_{1j} REX_{t-j} + \varepsilon_{1t}$$

where $\alpha_1, \beta_{1i} (i = 1, 2, ..., p), \gamma_{1j} (j = 0, 1, 2, ..., q)$ are the parameter, and $\varepsilon_{1t}$ is residual. The residual $\varepsilon_{1t}$ is assumed to have normal distribution, homocedastic, and has no autocorrelation. The long-term multiplier of the IDR/USD exchange rate against the stock price is

$$\gamma = \frac{\sum_{i=1}^{p} \gamma_{1i}}{1 - \sum_{i=1}^{p} \beta_{1i}}$$

The magnitude of the effect of the IDR/USD exchange rate on the stock price is determined by the value of the long-term multiplier $\gamma$ on the equation (2)[31].

If $RST_t$ and $REX_t$ were integrated of order one, I(1), or combination I(0) dan I(1), then the second step conducted is to test the cointegration of these two variables. The cointegration test used is the ARDL bounds testing approach developed by [32]. This cointegration test uses equation (3)

$$D(RST_t) = \alpha_1 + \sum_{i=1}^{p-1} \beta_{1i} D(RST_{t-i}) + \sum_{j=0}^{q-1} \gamma_{1j} D(REX_{t-j}) + \delta_1 RST_{t-1} + \delta_2 REX_{t-1} + \varepsilon_{2t}$$
where $\alpha_i$, $\beta_i$ ($i = 1, 2, \ldots, p - 1$), $\gamma_j$ ($j = 0, 1, \ldots, q - 1$) and $\delta_k$ ($k = 1, 2$) are the parameters of the regression equation, $\varepsilon_{2t}$ is residual and $D(RST_t) = RST_t - RST_{t-1} = RST - RST(-1)$. According to this test, both RST and REX variables are cointegrated if the hypothesis of $H_1: \delta_k \neq 0$, $k = 1, 2$ is accepted or the hypothesis of $H_0: \delta_k = 0 \forall k$ is rejected. The criterion for acceptance of the hypothesis is that $H_1$ is accepted if the F-statistic value is bigger than critical bound value $I(1)$, or $H_0$ is accepted (RST and REX are not cointegrated), if the F-statistic value is smaller than the critical bound value $I(0)$.

The third step is to do ARDL model estimation. If RST and REX re the process of I(1) and not cointegrated, then the ARDL model estimated is the ARDL model in the first difference. In this state, it is said that in the long run, there is an effect of REX change on RST with long-term multipliers in equation (2) [31]. However, if RST and REX are the I(1) prosessor the combination of I(0) and I(1) and cointegrated, then the ARDL model estimated is ECM (error correction model). The parameters of ARDL model and ECM estimated use the least squares method and the length of the time lag determined based on the Swardz Criterion (SC).

The important part of the estimation in the ARDL model is to perform residual diagnostic tests, namely: normality, homoskedasticity, and autocorrelation. Normality test uses Jarque Berra test, homoskedastic test uses White test, and autocorrelation test uses ARCH test. The third statistic of this test follows the Chi-Square distribution. The most important test result required here is the autocorrelation test. If it is found that the residual ARDL model has an autocorrelation, then the final step to test the effect of the IDR/USD exchange rate on the stock price is to estimate the parameters of the ARDL(p, q)-IGARCH(s, r) model. The method used is likelihood maximum method. The formulation form of the ARDL(p,q)-IGARCH(s,r) model in which RST and REX are the process of I(0), as follows:

$$ RST_t = \alpha_2 + \sum_{i=1}^{p} \beta_{2i} RST_{t-i} + \sum_{j=1}^{q} \gamma_{2j} REX_{t-j} + \varepsilon_{2t} $$

$$ \sigma_t^2 = \sum_{i=1}^{s} \theta_{i} \sigma_{t-i}^2 + \sum_{j=1}^{s} \delta_{j} \varepsilon_{2t-i}^2 $$

$$ \sum_{i=1}^{s} \delta_{i} + \sum_{i=1}^{s} \theta_{i} = 1 $$

In the equation (4) and (5), $\varepsilon_{2t}$ is white noise (or residual) that is independent and identically distributed with mean 0 and variance $\sigma_t^2$ or $\varepsilon_{2t} \sim iid N(0, \sigma_t^2)$. Meanwhile, if RST and REX are I(1) process and not cointegrated, then RST and REX in the equation (4) is replaced with D(RST) and D(REX). By inserting the component of IGARCH(r,s) on ARDL(p,q), then the variance residual $\sigma_t^2$ in (5) hopefully becomes homoscedastic residual. In addition, residual $\varepsilon_{2t}$ in equation (4) has no autocorrelation. In this case, the autocorrelation is tested using Q-Statistic test. Furthermore, the parameters of the ARDL(p, q)-IGARCH(r, s) model in (4) and (5) are tested by the P-value test of the z-statistic. If the P-value is smaller than the significant level (1% or 5%), then it is said that there is an effect of the IDR/USD exchange rate on the stock price.

4. Results and Discussion

4.1. Results

The result of the test statistic estimation from the ADF test and the PP test is summarized in Table 1. It appears in Table 1 that both variables RST and REX are not stationary. Meanwhile, both variables D(RST) and D(REX) are stationary. Thus, both of the time series of stock price and exchange rate are stationary on the first difference, or integrated of order one, I(1).
Table 1. ADF test and PP test

| Variables | ADF test statistic | PP test statistic |
|-----------|--------------------|-------------------|
|           | Constant           | Constant & trend   | Constant           | Constant & trend   |
| $RST$     | -1.725772          | -2.376530         | -1.704512          | -2.357502         |
| $D(RST)$  | -10.19453*         | -10.23840*        | -10.31304*         | -10.32907*        |
| $REX$     | -0.808191          | -1.678288         | -0.967990          | -1.916999         |
| $D(REX)$  | -11.31883*         | -11.29070*        | -11.31437*         | -11.28292*        |

Note: * significant 1%.

The statistical estimation results of the F-test and its critical values are summarized in Table 2. It is showed in Table 2 that the test statistic value of the F-test is 1.646560. This statistic value is smaller than the criterion value bound I(0) at the level of significance of 1% and 5%. Thus, $RST$ and $REX$ are not cointegrated.

Table 2. ARDL Bound test

| Sample (T) | Number of explanatory variable (k) | F-Statistics | Critical Value |
|------------|-----------------------------------|--------------|----------------|
|            |                                   |              | I(0)           | I(1)           |
|            |                                   |              | 1%             | 5%             |
|            |                                   |              | 1%             | 5%             |
| 165        | 1                                 | 1.646560     | 6.84           | 4.94           |
|            |                                   |              | 7.84           | 5.73           |

As mentioned in section 4.1 that the independent variables of the IDR/USD rate (REX) and the dependent variables of stock price (RST) are stationary variates on the first difference or integrated of order one, I(1). Therefore, the ARDL model estimated is the ARDL model with $D(RST)$ and $D(REX)$ variables. Next, based on the SC information criterion, it is obtained the ARDL(1,0) model. The ARDL(1,0) model estimation result is summarized in the table 3.

Table 3. ARDL(1,0) model

| Variable and Constant | Coefficient | t-Statistic | Prob.* |
|-----------------------|-------------|-------------|--------|
| $D(RST(-1))$          | 0.045295    | 0.732965    | 0.4646 |
| $D(REX)$              | -1.406940   | -10.38849   | 0.0000 |
| C                     | 0.015980    | 4.321874    | 0.0000 |
| R-squared             | 0.429861    |             |        |
| Durbin-Watson Statistics | 1.947014  |             |        |
| Schwarz Information Criterion (SIC) | -3.256431 |             |        |

Note: The probability values (P-value) of the JarqueBera test, the LM test, and the Arch test are 0.00, 0.85, and 0.00.

It is showed at the bottom of Table 3 that the residual ARDL(1,0) model has no autocorrelation. However, the residual ARD(1,0) model is not normally distributed and heteroskedastic. This violates the residual assumptions of the ARDL model in equation (1) especially the homoskedastic assumption. Therefore, the ARDL-IGARCH model can be used to test the effect of the IDR/USD exchange rate on stock prices. Based on the statistical value of SC information criteria, it obtains the result of ARDL(1,0)-IGARCH(1,1) model. The estimation results of these model parameters are summarized in Table 4.
Table 4. ARDL (1,0)-IGARCH(1,1) Model

| Variables and Constant | Coefficient | z-Statistic | Prob. |
|------------------------|-------------|-------------|-------|
| Panel A. Model ARDL(1,0) |             |             |       |
| C                      | 0.013435    | 71.36646    | 0.0000|
| D(RST(-1))             | 0.098372    | 457.0891    | 0.0000|
| D(REX)                 | -1.232626   | -128.0234   | 0.0000|
| Panel B. Model IGARCH(1,1) |         |             |       |
| (ε²(-1))               | -0.053689   | -92.10777   | 0.0000|
| GARCH(-1)              | 1.053689    | 1807.678    | 0.0000|
| R-squared              |             |             |       |
| Durbin-Watson statistics | 2.019172   |             |       |
| Schwarz Criterion      | -3.517496   |             |       |

It is showed in the table 4 that all of the componets of IGARCH(1,1) are significant. Furthermore, the variable coefficient of D(REX) is significant 1%. It can be said that there is an influence of IDR/USD exchange rate toward the stock price either in the short term and the long term. The D(RST(-1)) variable is also significant 1%. It means that the stock price is influenced by the stock price on the first month in the past. Next, in the long term, each decrease of 1% of IDR/USD exchange rate change, the stock price change rises 1.37%.

The Jarque Berra test statistic values and the Arch tests are summarized in Table 5. It is showed in Table 5 that the residuals of the ARDL(1.0) model are normally distributed and with constant variance (or homocedastic). The residuals of the ARDL(1.0) model also do not have autocorrelation.

Table 5. The statistical values of Jarque Berra, Arch Test and Q-Test

| Test Names                        | Statistic Value Test | Prob. |
|-----------------------------------|----------------------|-------|
| Normality Test of Jarque Berra    | 3.878803             | 0.1438|
| Heterokedastic Arch Test          | 2.821200             | 0.0930|
| Autocorrelation Q-test with time lag 3 | 3.4680   | 0.325 |

4.2. Discussion

The result of ARDL-IGARCH analysis shows that the IDR/USD exchange rate significantly influences the stock price in Indonesia. This conclusion is consistent with the findings of: [12], [13], [14], [16], [17], [18], [19], [20] and [22]. Furthermore, the effect of the IDR /USD exchange rate change is negative. This negative influence can be caused by the buying factor of shares in Indonesia by investors. When the USD exchange rate weakens against the IDR and the stock price rises, investors will tend to choose to buy shares in Indonesia instead of buying USD currency, because they want to get a greater advantage of their investment activity.

The results of this study are not in line with the studies: [10] and [11]. The difference of this research with [10] research can be caused by the difference of data retrieval period [10]. Furthermore, the difference of this study with [11] research can also be caused by the different time period of data. In addition, the difference may also be caused by the use of stock price data where [11] used individual share price data from PT JasaMargaTbk and PT. Perusahaan Gas Negara Tbk.

5. Conclusions

This study aims to examine the effect of the IDR/USD exchange rate on stock prices in Indonesia. The data used is monthly data from the IDR/USD exchange rate and the composite share price index as a proxy of the stock price. Data used is spanned from January 2004 to October 2017. The stationary test
results indicate that the IDR/USD exchange rate and the stock price are integrated of order one, I(1). The cointegration test results find that the IDR/USD exchange rate and stock price are not cointegrated. Furthermore, the results of data analysis using the ARDL-IGARCH model indicate that the IDR/USD rate affects stock prices both in the short term and in the long term. In the long term, every 1% decrease in the exchange rate change of IDR/USD, change of stock price rises up 1.37%.

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