Autoregressive Distributed Lag (ARDL) approach for re-testing the Fisher effect in Indonesia

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Abstract

This article discusses about re-testing the validity of the Fisher hypothesis in Indonesia. By using Autoregressive Distributed Lag (ARDL) approach, we will know if there is any causality between interest rate and inflation or not, for the long-term relationship. Interest rate divided into two main points, real interest rate and nominal interest rate. Hence, there are three main variables for this research, inflation, real interest rate and nominal interest rate. We applied the bound test to know cointegration between variables. The result shows that there is no evidence of long-term relationship and short term relationship between nominal interest rate and inflation in Indonesia.

Keywords: *Autoregressive Distributed Lag, Fisher hypothesis, Inflation, Interest rate*

JEL Classification: E31, E43, C32.

INTRODUCTION

Fisher effect theory which discusses the relationship between interest rates and inflation in the long run continues to be tested through empirical studies in various countries (Everaert, 2014; İncekara et al., 2012). This is done as a form of testing whether thetheory is *Fisher effect* still considered valid or not with empirical studies in the country under study. The invalidity of this theory can occur given the growth of inflation and interest rates in each country is different, it is influenced by several fundamental economic factors. Some fiscal and monetary policies can also have an influence on the economic fundamental factors which will also have an impact on inflation and changes in interest rates.

Research conducted by (Benazić, 2013) shows that the Fisher Effect theory is still valid in Croatia in the period of research from 1996 to 2012. In that study (Benazić, 2013) using the VECM (Vector Error Correction Model) method and found thattheory *Fisher Effect* occurs entirely in the country of Croatia and only occurs in the long run. Then, (Zainal et al., 2014) in his study showed the validity of Fisher's hypothesis by testing the relationship between inflation and interest rates on the Malaysian Money Market. This study uses the ARDL econometrics methodology introduced by (Pesaran et al., 2001). Overall, the estimation results on *treasury bills* Malaysianand interbank

interest rates indicate that there is a long-term *Fisher effect* on the Malaysian money market.

Research conducted by (Yaya, 2015) in countries on the African continent found that of the ten countries studied, there was a long-term relationship between nominal interest rates and inflation in only three countries. The estimated long-term relationship of the perfect Fisher effect only occurs in Kenya. (Yaya, 2015) also found a positive relationship but less than areaction *one-for-one* to inflation rates in Cote d'Ivoire and Gabon, so these two countries are referred to as adherents to the *Fisher effect* partial. For the other seven countries, there is a result that there is no evidence or evidence of a long-term relationship between nominal interest rates and inflation. Researchers conducted by (Caporale & Gil-Alaña, 2019) using themethods *Univariate and Multivariate Analysis* found that thetheory *Fisher Effect* in the G-7 countries was not appropriate this is evidenced by the positive relationship between interest rates and inflation rates in the G country -7 but the relationship does not have a long-term relationship as hypothesized by Fisher.

Indonesia is one of the developing countries in Asia that has macroeconomic conditions including inflation and interest rates that are quite volatile. Fluctuations that arise due to economic conditions in the State of Indonesia itself, given the span of years from 2008 to 2017 there is a phenomenon of the global financial crisis which certainly has an impact on the economy in various continents including the Asian Continent and the countries in it including Indonesia. The global monetary crisis of 2007/2008 in the United States impacted the world economic slowdown, which was preceded by the weakening of financial markets in industrialized countries and developed countries which caused most of the capital outflow to *flow out*, the impact also increasingly spreading to developing countries which then had an impact in the real sector (Bayoumi et al., 2010).

The impact of the 2007-2008 monetary crisis began to be felt in Indonesia in the fourth quarter of 2008 by marking the decline in the rupiah exchange rate, the decline in international trade and capital flows which became one of the sectors driving economic growth (BAPPENAS, 2009). These conditions also impacted the country's economic fundamentals such as economic growth, inflation rates, interest rates, and several other aspects of the economy that experienced considerable fluctuations. Therefore, the government together with Bank Indonesia issued various policies to control the impact of the crisis and improve economic conditions including controlling people's purchasing power by controlling inflation and providing various leeway to the banking sector and financial (BAPPENAS, 2009). The impact caused by the crisis is still ongoing in the next few years so that the government continues to implement various policies to anticipate these conditions. The impact was also caused by policy changes made by various trading partner countries and developed countries so that the government and Bank Indonesia continue to make policy adjustments to maintain and encourage economic growth. Therefore we need a review of thetheory *Fisher Effect* in Indonesia in the period 2008-2017.

METHODS

Fisher hypothesis stated that in the long term, there was a one-to-one relation between nominal interest rate and inflation expectation level. The proportion was described through the following identity function,

$$R_t = r_t^e + \pi_t^e \quad \text{.....(1)}$$

Where R_t represented the nominal interest rate on period t. r_t^e was the ex-ante real interest, and $\pi_t^e$was the inflation expectation level. By the existence of monetary illusion, any full change shall be transmitted to the nominal interest rate, r_t^ehad constant value in the long term. In general, rational expectation assumption, inflation expectation level was equal to the actual inflation plus estimated zero error term,

$$\pi_t^e = \pi_t + \varepsilon_t \quad (2)$$

Finally, the obtained empirical equation is in the following form

$$R_t = \alpha + \beta r + \beta\pi_t + \mu_t \quad (3)$$

Where β was the interest rate coefficient which the value is expected to be equal to one. The estimation of β was not significantly different from one which indicated the strong shape of Fisher hypothesis. When the value indicated lower than one then it was called partial Fisher effect.

The data used in this study was the annual data of the Republic of Indonesia. Variables included in this study were nominal interest rate and inflation. The inflation was calculated as the percentage change of Consumer Price Index/CPI in one year. The data will be taken through the World Development Indicator on the World Bank. Beside using annual data, this study took different sample amount in each country depended on the data availability of the referred source.

The model specification in equation (3) was re-described in equation (4) where the equation had included the state element as follows:

$$R_{it} = \alpha + \beta\pi_{it} + \varepsilon_t \quad (4)$$

With R_{it} showed the nominal interest rate of Indonesia, π_{it} as actual inflation of Indonesia and ε_t as Error Term. The econometrics modeling in equation (4) were two models which would be used in this study to compare the analysis result of Indonesia as the object of this study.

A new co-integration technique has been developed by (Pesaran et al., 2001)based on the Autoregressive Distributed Lag (ARDL) model. This technique had more advantage than the standard method. This technique could avoid the trouble caused by the conventional root unit testing result as well as the small sample usage which caused the less significant test result. This technique could also solve the endogenity problem and incapability in providing hypothesis of estimated coefficient in the long term which is related to the Engle-Granger method. Finally, the use of ARDL method was certainly able to investigate the long term relation between nominal interest rate and inflation.

The Bound Testing was started by Vector Autoregressive (VAR) on the level,

$$Y_t = \mu + \sum_{j=1}^{p} \text{Øj } Y_{t-j} + \varepsilon t \quad (5)$$

Where $Y_t = [i_t\ \varepsilon_t]$`. The Vector Error form was $\varepsilon = [\varepsilon_i, \varepsilon_\pi]$` ~ N(0, Ω) where Ω was positive,

$$\Omega = \begin{bmatrix} \omega ii & \omega i\pi \\ \omega i\pi & \omega\pi\pi \end{bmatrix} \quad (6)$$

Manipulation of equation (6) made the VAR model more specified into *vector error correction model* (VECM)

$$\Delta Yt = \mu + \lambda Y_{t-1} + \sum_{j=1}^{p-1} \gamma\ \Delta Y_{t-j} + \varepsilon_t \quad (7)$$

Where the short term coefficient

$$\gamma j = \begin{bmatrix} \gamma ii,j & \gamma i\pi,j \\ \gamma \pi i,j & \gamma \pi\pi.j \end{bmatrix} = -\sum_{k=j+1}^{p} \emptyset k \quad \text{.....(8)}$$

Coefficient λ in the long term multiplier matrix was as follows

$$\lambda = \begin{bmatrix} \lambda ii & \lambda i\pi \\ \lambda \pi i & \lambda \pi\pi \end{bmatrix} = -I2 - \sum_{j-1}^{P} \emptyset j \quad \text{.....(9)}$$

Where I_2 was the identity matrix 2x2. Under this assumption, the nominal interest rate equation could be written as follows:

$$\Delta i_t = \theta_0\theta_1 i_{t-1} + \theta_2\pi_{t-1} + \sum_{i=0}^{n} \gamma 1i\, \Delta i_{t-i} + \sum_{i=0}^{n} \gamma 2i\, \Delta\pi_{t-i} + \mu t \quad \text{..... (10)}$$

The co-integration between nominal interest rate and inflation was tested through lag variable limitation and the interception of the equation above was equal to zero. This hypothesis was tested by F-statistic average. (Pesaran et al., 2001) suggested that the use of Cumulative Sum of Recursive Residuals (CUSUM) and Cumulative Sum of Squares of Recursive Residual (CUSUMQ) was aimed to estimate the parameter consistency level on a model.

RESULTS AND DISCUSSION

Descriptive statistics analysis results

Distribution of a general picture of each variable used in the study can be explained individually through the display of *mean, median, maximum, minimum, standard deviation, skweness, kurtosis, Jarque-Bera* and *probability*. This is in accordance with the research variables conducted, which is to see how the causality or relationship between inflation and interest rates in Indonesia.

Table 1. Indonesian descriptive analysis results

	IR^I	INF^I	RIR^I
Mean	6.636417	5.709417	0.414518
Median	6.500000	4.860000	0.537201
Maximum	9.500000	12.14000	0.786550
Minimum	4.250000	2.410000	-1, 104829
Standard Deviation	1.198594	2.3331237	0.374837
Skewness	0.043008	0.929976	-1,800650
	IR^I	INF^I	RIR^I
Kurtosis	2.688767	3.309073	6.138971
Jarque-Bera	0.521325	17.77474	114, 1125
Probability	0.770541	0.000138	0.000000

In Table 1. shown the results of descriptive statistical analysis of each variable used in testing regarding causality or the relationship between inflation and interest rates in Indonesia with time vulnerable from 2008-2017. In this case there are three variables namely Indonesian IR (*Interest Rate*), INF (*Inflation*) Indonesia, and RIR (*Real Interest Rate*) of Indonesia.

Autoregressive Distributed Lag (ARDL) estimation results

The Bound Testing co-integration test was used to detect the long term balance on a research model. Detecting long term balance was conducted through comparing critical value and F-statistics on the testing result. Independent variable which was integrated to I(0) was assumed as the lower bound while the independent variable which is integrated to I(1)was assumed as the upper bound. There will not be a co-integration

if the F-statistics value is below the lower bound and co-integration will occur if it is above the upper bound. However, if the F-statistics value is between the lower and upper bound then the co-integration test can not be concluded.

Table 2. Bound testing result

Model	*F-Statistic*	Significant	*Lower Bound*	*Upper Bound*
Interest Rate (IRi)	13,37441	10%	3.17	4.14
		5%	3.79	4.85**
		2,5%	4.41	5.52***
		1%	5.15	6.36****

Notes: *) Significant on 10%, **) Significant on 5%, ***) Significant on 2.5%, ****) Significant on 1%

Based on Table 2, the result showed that the Bound Test was known from the Fisher Effect model in Indonesia (IRi) on the level of significance 5%, 2.5%, and 1%. The F-statistic value was higher than the lower and upper bound value which means there was a co-integration among variables of the Fisher Effect in Indonesia. That it means there was a short term balance which moved to the long term in every variable on the model. However, bound test was not the last test to determine the Fisher Effect validity. The long term and short term estimation test should also be conducted to get more valid result.

Lag length determination test was important in a test using ARDL bound testing method to determine the maximum lag and optimum lag. The optimum lag test was aimed to obtain the appropriate lag length which will be used to determine the best lag length to formulate the ARDL model and to measure the effect of a variable in affecting other variables in a model. The study of optimum lag test could use Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SC). In this study using the optimum lag test with the Akaike Information Criterion (AIC) approach.

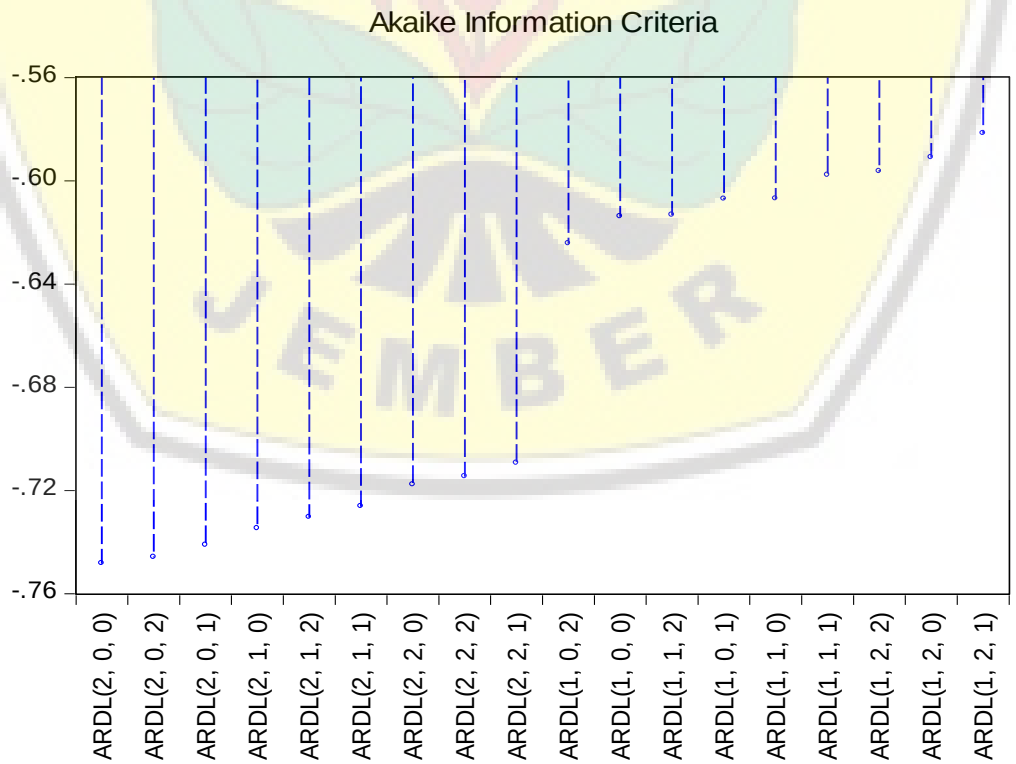

Figure 1. Optimum lag result

Based on Figure 1 optimum lag result showed that by using Akaike Information Criterion (AIC) approach, the best and most appropriate model is ARDL (1,2,1) with lower error rate than the other model. It means, the value of Y was 1 lag, X1 was 2 lags, and X2 was 1 lag.

After determining optimum lag and confirming that the model was co-integrated, the next step was conducting long term estimation to determine the co-integration relation in each variable in the ARDL model. The ARDL specification was used along with Akaike Information Criterion (AIC) approach based on the optimum lag testing result.

Table 3. The result of ARDL long term coefficient Fisher effect estimation (2,0,0)

Variable	Coefficient	Std. Error	t-statistic	Probability
INFI	0.547977	0.113012	4.848844	0.0000
RIRI	-0.752176	0.738632	-1.018337	0.3107
C	3.576756	0.834832	4.284403	0.0000

Based on Table 3, the analysis result showed that the long term estimation of inflation had a positive significant effect on Fisher Effect. However the interest rate had a negative significant relation to Fisher Effect. That in this case, the estimation result stated that in the long term inflation and real interest rate had no significant positive effect on Fisher Effect. That was due to the two variables showed different results that indicated the whole independent variables (X1 X2) had a negative effect on the dependent variable (Y) interest rate (IRi).

Empirically, the negative effect on interest rate variable in the Fisher effect model in 2008 until 2017 was caused by the change on the policy which regulated the interest rate. In 2008 until mid-2016, the implemented interest rate policy was the BI Rate, however on August 2016 the interest rate policy was changed into 7 Days Repo Rate.

In determining the short term among variables in the model, we used ARDL bound testing approach. Table 4 was the short term estimation result on the Fisher Effect model with ARDL as the fittest model (2,0,0).

Table 4. The result of ARDL short term coefficient *Fisher Effect* estimation (2,0,0)

Variable	Coefficient	Std. Error	t-statistic	Probability
D(IRI(-1))	0.357815	0.083251	4.298014	0.0000
D(INFI)	0.039204	0.010301	3.806023	0.0002
D(RIRI)	-0.053814	0.050959	-1.056024	0.2932
CointEq(-1)	-0.071544	0.018367	-3.895269	0.0002

Cointeq = IRI - (0,5480*INFI – 0,7522*RIRI) + 3,5768

From the short term estimation result, the CointEq was -0,071544 with 0,0002 probability, which means the model was co-integrated. The negative value of β showed that the model will reach balance with 7,15 percent speed per month.

According to the empirical study, inflation and nominal interest rate had significant positive relation in the Fisher Effect model. That was due to in the short term, the number of inflation and interest rate in 2008 until 2017 by using monthly data was considered as stable.

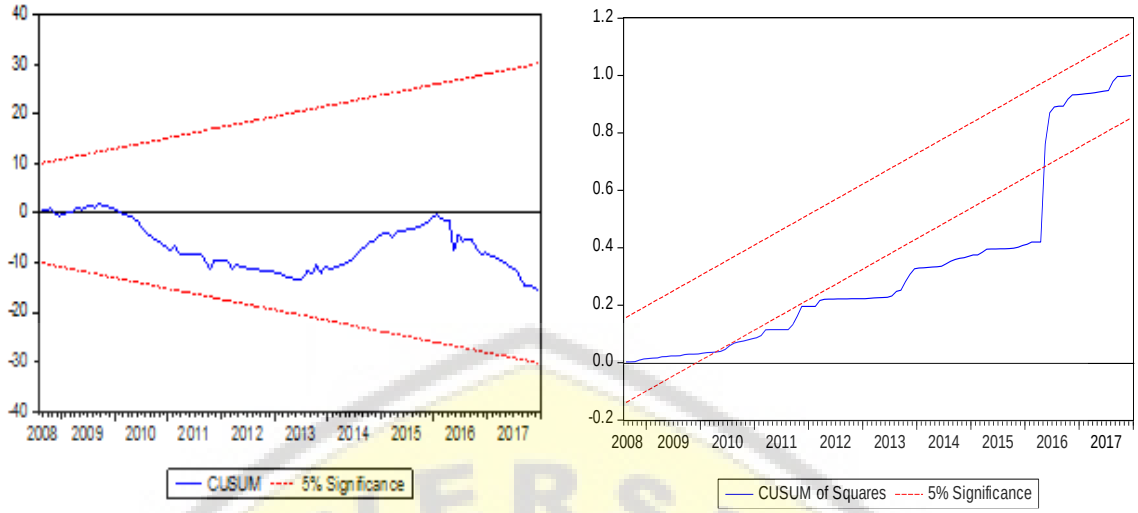

Figure 2. The result of CUSUM and CUSUMQ testing with *Recursive Residual* approach

Next, a model stability test was conducted to detect the stable model certainty movement on its parameter coefficient. This test used two kinds of test, the CUSUM and CUSUMQ tests. CUSUM test was conducted through recursive residual approach, while the CUSUMQ was conducted through recursive residual approach where its R^2 had been adjusted (Adjusted R^2).

Based on Figure 2, the model stability test result by using CUSUM and CUSUMQ showed that the Fisher Effect was stable because the CUSUM line was inside the significant border of 5% (red). The different result was obtained from the CUSUMQ where the result was considered as unstable because the CUSUMQ line was outside the significant border of 5% (red).

Fisher effect was a conception where the interest rate and inflation were considered to have a positive relation where both were influencing each other. Some theoretical models assumed that Fisher hypothesis was valid. However, although there had been many empirical supports on the hypothesis, in fact it was difficult to prove regarding there were many studies in some countries which rejected the Fisher effect hypothesis. Based on the previous study such as the study of (Yaya, 2015) in the African countries found that from 10 observed countries, only three of them indicated the long term relation between nominal interest rate and inflation. The perfect estimation of Fisher effect long term relation only happened in Kenya. He also found a positive insignificant relation of one-for-one reaction on the inflation in Cote d'Ivoire and Gabon, that these two countries were considered implementing partial Fisher effect. And seven other countries indicated that there were not any facts or evidence of the long term relation between nominal interest rate and inflation. Other researcher (R., Santos Alimi, Bernad O, 2001) found that there were not any facts or evidence of Fisher effect in Nigeria. Although there was a long term relation among variables (amount of circulated money, real income, price and nominal interest rate), but causality did not explain the strong relation between inflation and interest as stated by Fisher hypothesis.

Based on the result, Indonesia was a country which empirically considered that Fisher effect was invalid. It was proved by the Bound Test result through ARDL approach which showed negative value which means there was not any long term

relation between nominal interest rate and inflation. The invalid Fisher effect in Indonesia proved that the interest rate did not have the one-to-one basis with the inflation. Basically, inflation rate stabilization was the main goal of the monetary policy in various countries including Indonesia. Maintaining price stability did not only use the interest rate, but also the other instrument such as exchange rate.

Through the study, the result showed that in the short term, the nominal interest rate and inflation had a positive significant relation to the Fisher Effect model. However, in the long term, Fisher Effect was considered as invalid (Caporale & Gil-Alaña, 2019). That was because in the long term, the interest rate showed negative significant result in the Fisher effect model. The invalid Fisher effect in Indonesia in the long term had several possibilities which could make it happen. One of them was the policy change which was stated in the interest rate instrument, where in the study period of 2008 until 2017, there was a change on the policy of interest rate determination which initially used BI Rate into 7 Days Repo Rate on August 2016.

From various literatures and previous studies, the long term relation between inflation and nominal interest rate tend to go hand in hand that it is called Fisher effect. The concept of Fisher effect was introduced by Irving Fisher in the 20th century. He explained that interest has an important role in monetary policy and inflation as the goal of monetary policy. However, some studies also mentioned that the observed country did not implement the Fisher effect concept. The invalid Fisher effect either in the short term or long term in the interest rate variable reflected the change on the real interest rate and actual inflation value which were important as the reflection of monetary policy stance where the interest rate either in the short term or long term was incapable to provide appropriate and accurate description for the monetary policy by maintaining high interest rate in the certain period as the indication of high inflation expectation. Therefore in this case, the Fisher Effect invalidity concluded that by implementing those ways above, in fact, the monetary policy runs effectively.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The relationship between interest rates and inflation is summarized based on the concept *Fisher Effect* for a case study in Indonesia. Testing and synthesis of the two economic variables is carried out using the ARDLmethod *bound testing*. Based on the estimation results, we obtained the main points which are then concluded in this study. First, theValidity is *Fisher Effect* proven from the bound test results. When two related variables namely inflation and nominal interest rates are not indicated to have a positive relationship in the long run, it shows that the *Fisher Effect* does not apply to countries that are used as objects of research. This is in line with research conducted at this time with the object of research in Indonesia. The *Autoregressive Distributed Lag* (ARDL) approach is the type of approach used in this study.

Second, the results of testing the short-term relationship show that Indonesia has no indication of a short-term correlation between interest rates and inflation. When followed by testing to test long-term relationships, *bound testing is* used and then indicates that there is also no long-term relationship between interest rates and inflation

in Indonesia. This means that the theory is *Fisher Effect, considered* invalid in Indonesia in the 2008-2017 research period.

Recommendations

From the aspect of policy, overall control, coordination and policy mix are needed to respond to the phenomena that occur. The policy mix in question is the central bank's policy mix in which the main target is price stability. Instruments of central bank policy used include monetary policy, macroprudential policy, and foreign capital management flows. The findings that show the absence of *Fisher Effect* in Indonesia shows that monetary policy has been running as it should. It's just that, in terms of performance, the government needs to increase its efforts in dealing with price stability / inflation issues given the unstable global economic conditions through other alternatives by not only focusing on the Consumer Price Index (CPI) but also by giving more consideration to asset prices (financial and property).

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