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Article

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The Causal Relationship between Fuel Consumption, Exchange Rates and Economic Growth in South East Sulawesi, Indonesia

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ABTRACT

This article reports the results of a study examining the causal relationship between fuel consumption, exchange rates, and economic growth in Southeast Sulawesi, Indonesia. The data used are annual time series data ranging from 1988 to 2016. The estimation results of the VAR model and the Granger causality test indicate that the causal relationship that occurs is only a short-term causality, namely from fuel consumption to economic growth.

Keywords: Fuel Consumption, Exchange Rate, Economic Growth, VAR Model, Granger Causality Test
JEL Classifications: C120, C320, E21, F31

1. INTORODUCTION

Fuel (crude oil and natural gas) is a useful source of energy as raw material for industries: goods, electricity, and transportation (Viljoen, 1979; Adam et al., 2016; Millia et al., 2020). In order to grow their industries, each country needs crude oil and gas. Indonesia carries out import activities to meet domestic crude oil needs. The reason is the failure of domestic crude oil production to meet domestic industry needs. This practice of importing crude oil will lead to an increase in the cost of production. Indonesia is one of the exporting countries for natural gas to fulfil global needs. As such, domestic stock of natural gas becomes scarce, causing the production costs to rise. The rise in these costs may lead to an increase in goods prices, affecting changes in other macroeconomic variables, among others, economic growth (Adam et al., 2016).

Foreign currency, meanwhile, is a medium for international trade transactions. As the exchange rate of foreign currency appreciates (the exchange rate for domestic exchange rate depreciates), the prices of foreign goods in the domestic country become more expensive, while the prices of domestic goods abroad become cheaper. Thus, exports can grow, and imports can decrease. This may lead to changes in the value of the trade balance, which ultimately can influence a country's economic growth (Mauro et al., 2008; Mishkin, 2008; Saidi et al., 2015; Adam et al., 2017) and its region such as province. In addition, the appreciation of foreign currency exchange rates (especially USD currency) can affect fuel consumption expenditure since an increase in the price of imported fuel in USD can cause domestic fuel prices to become expensive in the domestic currency (Gargett and Hossain, 2008). This could lead to a drop in demand for imported fuels. As a result, oil consumption can decrease (Schryder and Peersman, 2013). Conversely, an increase in oil consumption can cause household expenditure to rise, causing aggregate income to rise. This increase in aggregate income can cause saving on rising, reducing the domestic interest rate (Mankiw, 2007). A decline in the domestic rate as such, according to the uncovered interest rate parity theory, may lead to a depreciation of the foreign exchange rate (domestic currency exchange rate appreciates) (Pilbeam, 2006).

A number of researchers have empirically tested hypotheses concerning the relationship between fuel consumption and economic growth. Their findings, however, have been inconsistent.

For example, Nondo et al. (2010), Payne (2011), Ishida (2012), and Ha et al. (2018) examined the relationship between energy/fuel consumption in different countries. Nondo et al. (2010) looked at the relationship between fuel use and economic growth in Africa and found a long-term, one-way relationship from energy use to GDP (gross domestic product). Payne (2011) studied the connection of natural gas fuel consumption with economic growth in the US and discovered the effect of economic growth on the consumption of natural gas fuel. Ishida (2012), however, found that economic growth was not linked to fuel consumption when analyzed the relationship between fuel consumption and world economic growth. Finally, Ha et al. (2018) examined the relationship between fuel and economic growth in China, and they revealed a two-way relationship between fuel consumption and economic growth.

Furthermore, scholars have also explored the relationship between exchange rates and economic growth, among others, Akpan (2010) in Nigeria, Chen and Chou (2015) in Finland, Italy, Portugal, France and Switzerland, and Owoundi (2015) in Sub Saharan Africa. Ha et al. (2018) analyzed China's fuel and economic growth relationship and found a two-way connection between fuel consumption and economic growth. Furthermore, the relationship between exchange rates and economic growth was examined by, among others, Akpan (2010) in Nigeria, Chen and Chou (2015) in Finland, Italy, Portugal, France and Switzerland, and Owoundi (2015) in Sub Saharan Africa. Akpan (2010) found that there is no relationship between exchange rates and economic growth. While Chen and Chou (2015) documented the evidence of exchange rates effect on economic growth, Owundi (2015) found the reverse: that the economic growth affect exchange rates. Variations in results could be attributable to (1) the period for the collection of research data or (2) socio-political and economic conditions in a country where the research has been carried out (Ozturk, 2010). Therefore, the question arises: "is there any a short and/or long-term relationship between fuel consumption, exchange rate and economic growth in Southeast Sulawesi in Indonesia?" This is primarily because South East Sulawesi's cultural, socio-political and economic characteristics are distinct from other areas in Indonesia or elsewhere.

So far our knowledge is concerned, the issue above reflects a research void that has not been explored mainly in the case for South East Sulawesi. In this regard, this study aims to examine the causal relationship between fuel consumption, exchange rates and economic growth in South East Sulawesi, Indonesia. The time sample chosen covers the period from 1988 to 2016 for time series data on fuel consumption, exchange rates and economic increase. To test the causal relationship, the VAR model and the Granger causality test are used.

2. LITERATURE REVIEW

This section provides a literature review on the results of empirical research. The results of the tests indicated that fuel and economic growth were not causally linked. Fatai (2014) investigated the causal relationship between energy consumption and economic growth in 18 Sub-Saharan African countries using annual data from 1980 to 2011. These countries were grouped into four groups of countries, covering Central Africa, East Africa, Southern Africa, and West Africa. The VAR panel test results show that while there was no relationship between energy consumption and economic growth in the Central and West Africa Sub-Region, a one-way relationship existed from energy consumption to economic growth in East and Southern Africa. Using Hsiao's Granger causality test and data for the 1955-1996 period, Ageel and Butt (2001) examined the relationship between energy consumption and economic growth in Pakistan. The test results showed that there was a one-way relationship from economic growth to energy consumption. Finally, Lean and Smyth (2014) analyzed the disaggregate relationship between fuel consumption and economic growth in Malaysia using annual time series data from 1980 to 2011. The disaggregated fuel consumption referred to here is the consumption of diesel fuel and motor petrol. Using a multivariate regression model test, they discovered that fuel consumption had a long-term effect on economic growth.

The link between fuel consumption, economic growth, and other economic variables has been examined by, among others, Abosedra et al. (2015), Asafu-Adjaye (2000), and Sarkodie and Adom (2018). Abosedra et al. (2015) investigated the relationship between financial development, energy consumption and economic growth in Lebanon. To test the relationship, they employed a VAR model and monthly data covering the period from February 2000 to December 2010. Test findings revealed that economic growth was driven by financial development and energy use. In addition, financial development and economic growth influence the use of energy. Asafu-Adjaye (2000) estimated the causal relationship between energy consumption, energy prices and economic growth in Asian countries (India, Indonesia, Philippines, and Thailand) using the Granger causality test. The estimation results indicated a two-way relationship between energy consumption, energy prices and economic growth. In order to explore the relation between fossil fuels, non-fossil, and economic growth in 53 countries, Asafu-Adjaye et al. (2016) used Pooled Mean Group (covering oil-importing countries and oil-exporting countries) and the data from 1990 to 2012. The test results indicated that fuel demand and genuine GDP only had a two-way relationship in non-oil importing countries. Thus, fossil fuels had a negative causal link to economic development, meaning that conserving fossil fuels could hinder economic growth. Sarkodie and Adom (2018) examined the relationship between fossil fuel consumption, electricity consumption, and economic growth in Kenya using the NIPALS (nonlinear iterative partial minimum squares) test. The test results indicated that while economic growth impacted fossil fuel use, economic growth was influenced by electricity consumption.

Schryder and Peersman (2013) examined the relationship between the United States dollar exchange rate and oil demand in OECD countries. They observed that exchange rates affected oil demand. As the exchange rate increased, oil demand decreased. The decrease in demand for oil also reduced oil fuel consumption.

Aman et al. (2013), using data from 1976 to 2010, reviewed the relationship between exchange rates and economic growth in Pakistan. They used a simultaneous model of the equation to analyze the data. The findings of the test demonstrated a positive relationship between exchange rate and economic growth, which was due to exports, domestic investment and direct foreign investment variables. Using the VAR model and the Granger causality test, Selimi and Selimi (2017) analyzed the effect of exchange rates on economic growth in Macedonia. They used quarterly data from the first quarter of 1998 to the first quarter of 2015. The test results showed that exchange rates affected economic growth. Finally, Razzaque et al. (2017) examined exchange rate movements on economic growth in Bangladesh. They used yearly time series data between 1980 and 2012. To analyze the data, a VECM model was applied. The test results demonstrated that the exchange rates had a long-term impact on economic development.

3. DATA AND METHOD

3.1. Data

The data used for this study are time-series data consisting of 3-time series, namely exchange rates, the consumption of fuel and Southeast Sulawesi's gross regional domestic product (GRDP). The time-series data cover the period from 1988 through 2016. The IDR/USD exchange rate (after this abbreviated as the exchange rate) is used as a proxy for the exchange rate, on the ground that it is commonly used as an instrument for an international trade transaction. Meanwhile, GRDP is used as a proxy for economic growth. The data of exchange rate are sourced from the Central Bank of Indonesia.

3.2. Method

As explained in the introduction, there can be correlations between the three variables: fuel consumption, exchange rates and growth. The variable of fuel consumption is expressed in COF, exchange rates in EXC and the economic growth in GRO. COF, EXC, and GRO variables represent natural logarithmic forms. The Vector Autoregressive (VAR) model and Granger causality test are used to test the relationships between fuel usage, exchange rates and economic growth. The VAR model with a time lag length p, written as VAR (p) (Heij et al., 2004; Lutkepohl, 2009; Brooks, 2014), is as follows.

$$Z_t = C + \sum_{i=1}^{p} \mathrm{B}_i Z_{t-i} + \varepsilon_t \qquad (1)$$

where $Z_t=[COF,EXC,GRO]'$ is a vector of endogenous variables, $C=[C_1,C_2,C_2]'$ is a constant vector, B_i (i=1,2,…,p) is the coefficient matrix, and ε_t is error or white noise vector. The white noise vector $\varepsilon_t=[\varepsilon_{1t},\varepsilon_{2t},\varepsilon_{3t}]'$ is $\varepsilon_t \sim \mathrm{IID}(0,\Sigma)$ where the covariance of the matrix $\Sigma=\mathrm{E}(\varepsilon_t,\varepsilon_t')$ is a positive definite matrix.

The variables in equation (1) are assumed to be stationary at the level or integrated of order d, I(d), $d\geq 0$. However, if the three variables of fuel consumption (COF), exchange rate (EXC), and economic growth (GRO) are stationary at first difference and are co-integrated, then the relationship between fuel consumption, exchange rate, and economic growth is tested with a vector error correction model (VECM), as follows.

$$D(Z_t) = C + \Pi Z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i D(Z_{t-i}) + \varepsilon_t \qquad (2)$$

where $\Pi = \sum_{i=1}^{p} B_i - I$, I represents identity matrix, and $\Gamma_i = -\sum_{j=i+1}^{p} B_i$ for i=1,2,…,p-1. The matrix Π in equation (2) is called the long-term coefficient matrix. Meanwhile, the Γ_i (i=1,2,…,p−1) matrix is called the short-term coefficient matrix.

We followed several steps to test the causal link between fuel consumption, exchange rates, and economic growth. The first step was to check the stationarity of variables. To this end, the Augmented Dickey-Fuller (ADF) test developed by Dickey and Fuller (1981) was applied. The ADF test used the t-ratio statistic. The null hypothesis of the ADF test is H_0: The time series is not stationary againts the hypothesis H_1: The time series is stationary.

The following step was to perform a test for cointegration between fuel consumption, exchange rates and economic growth. This kind of test is carried out if the three endogenous variables are not stationary at level but stationary at first difference. The cointegration test used was the Johansen cointegration test developed by Johansen (1988). This cointegration test can be used if all endogenous variables are integrated in the same order, I(d) (Acaravci and Ozturk, 2012). There are two types of tests used in the Johansen cointegration test: the trace test and the Max-Eigen test. Trace test using test statistics.

$$\lambda_{trace}(r) = -T\sum_{i=r+1}^{g} \log(1-\lambda_i), r = 0,1,\ldots,g-1 \qquad (3)$$

The λ_i value in (3) is the largest eigen value of the matrix Π in equation (2), and T is the number of observations. The formula for the null hypothesis in the trace test is H_0: The number of cointegrating vectors is less or equal to r, versus the alternative hypothesis H_1: The number of cointegrating vectors is more than r. The max-eigen test statistic is

$$\lambda_{max}(r, r+1) = -T\log(1-\lambda_{r+1}), r = 0,1,\ldots,g-1 \qquad (4)$$

The null hypothesis of the max-eigen test in (4) is H_0: The number of cointegrating vectors is r, and the alternative hypothesis is H_1: The number of cointegrating vectors is r+1 (Brooks, 2014).

The last step was to estimate the VAR model and perform a Granger causality test. Initially, the lag length is established. Besides, in estimating the VAR model, the residual requirements, the impulse response function (IRF), and the variance decomposition (VD) are checked. While checking IRF is aimed at determining the impact of changes in one variable on other variables in the model, checking the VD is intended to determine the size of the contribution of each variable to the other variables.

4. RESULTS

In the first place, we conducted a stationary test for the research variables. The results of the ADF test are summarized in Table 1. It can be seen from Table 1 that fuel consumption, exchange rates, and economic growth are stationary at first difference, or integrated of order 1, I(1).

The results of the Johansen cointegration test are shown in Table 2. By comparing the statistical test values with their critical values at the 5% significance level, it is concluded that there is no cointegration between fuel consumption, exchange rates, and economic growth.

As fuel consumption, exchange rate, and economic growth do not co-integrate, the VAR model to be estimated is that of first difference. Therefore, the first step in the VAR estimation is to determine the lag length. The lag length is determined based on the lowest statistical value among the criteria: FPE (Final prediction error), AIC (Akaike information criterion), SC (Schwarz information criterion), and HQ (Hannan-Quinn information criterion). Of the criteria, FPE has the lowest statistical value, and thus the lag length is Table 3.

As mentioned above, the VAR(3) model at first difference is that to be estimated. Table 4 sums up the estimated results for VAR (3). It can be seen that D(COF (-3)) is the only significant variable for the case the dependent variable is D(GRO). The D(COF(-3)) variable coefficient is shown significant at 1%. Koop (2013) suggests that an independent variable is the Granger cause of the dependent variable if the coefficient of any one of the independent variables is significant, shown by the t-statistic. Thus, D(COF) Granger causes D(GRO).

The VAR Granger Causality/block Exogeneity Wald Tests can also test the direction of the causal relationship. This causality test uses the Chi-Square distribution of Wald-statistics. The results of the causal relationship test are shown in Table 5. The results of the VAR Granger Causality/Block Exogeneity Wald Tests test show that D(COF) Granger causes D(GRO), and thus, it can be concluded that while a short-term, one-way relationship exists from fuel consumption to economic growth, and there is no short-term relationship, from exchange rates to economic growth.

Since the significant variable coefficients are only the coefficient of D(COF) for the case the dependent variable is D(GRO), then checking the IRF is only the responses of economic growth to fuel consumption and economic growth to the exchange rate. Figure 1 shows the results of the IRF check. It can be seen that the response of economic growth to fuel consumption in the first ten periods was fluctuating. However, the response in the first period was positive. Meanwhile, the response of economic growth to the exchange rate also fluctuated during the first ten periods. However, the response in the first period was negative.

The periods for checking the Variance Decomposition are selected for 3 years, 6 years, 9 years, and 12 years. The statistical values of VD are summarized in Table 6. The impact of fuel consumption on economic growth is greater than the impact of exchange rates on economic growth. Compared to fuel consumption and exchange rates contribution, the contribution of economic growth in the past to current economic growth is the largest one. For example, the impact of past economic growth on current economic growth in the first 12 periods was 47.12%, while the effects of fuel consumption and exchange rates were 31.44% and 21.44%.

Table 1: Results of ADF test

Variable	Level		First difference	
	Constant	Constant and trend	Constant	Constant and trend
COF	-1.3920	-1.0287	-8.5430*	-8.5583*
EXC	-1.3074	-2.0218	-5.6877*	-5.6235*
GRO	-2.0080	-2.8448	-4.4594*	-4.2914**

* or ** means significant at 1 or 10%

Table 2: Result of Johansen cointegration test

Null Hypothesis (H_0)	Trace Test		Max-Eigen Test	
	Trace Statistic	5% Critical Value	Max-Eigen Statistic	5% Critical Value
$r=0$	18.0188	29.7971	11.7041	21.1316
$r\leq1$	6.3147	15.4947	4.8960	14.2646
$r\leq2$	18.0188	29.7971	1.4188	3.8415

Table 3: Statistical values of the information criteria

Lag	FPE	AIC	SC	HQ
0	0.0492	5.5025	5.6512	5.5375
1	0.0394	5.2672	5.8623	5.4074
2	0.0156	4.2830	5.3245	4.5284
3	0.0082*	3.4978	4.9856	3.8483
4	0.0232	4.2194	6.1535	4.6750
5	0.0376	4.0579	6.438399	4.6187
6	0.0127	1.4828*	4.3096*	2.1487*

* shows the lowest statistical values of the information criteria: FPE, AIC, SC and HQ

Table 4: Estimates of Model VAR(3)

Dependent Variables and Constant	Independent Variables and their Coefficient		
	D(GRO)	D(COF)	D(EXC)
D(GRO(-1))	0.1141	-0.4362	0.0112
	[0.8674]	[-0.4698]	[0.0793]
D(GRO(-2))	-0.0195	0.1753	-0.0849
	[-0.1503]	[0.1910]	[-0.6057]
D(GRO(-3))	0.0170	-0.1205	-0.0581
	[0.1295]	[-0.1302]	[-0.4113]
D(COF(-1))	0.0565	-0.4432	0.1037
	[1.4072]	[-1.5644]	[2.3978]
D(COF(-2))	0.0569	0.0538	0.0689
	[1.0662]	[0.1444]	[1.2106]
D(COF(-3))	-0.1219*	-0.0555	0.0174
	[-2.3153]	[-0.1493]	[0.3074]
D(EXC(-1))	-0.2553	0.5628	-0.4059
	[-0.9980]	[0.3118]	[-1.4722]
D(EXC(-2))	0.3546	0.7189	-0.3858
	[1.3837]	[0.3976]	[-1.3969]
D(EXC(-3))	-0.0451	0.9224	-0.0752
	[-0.2116]	[0.6132]	[-0.3275]
C	0.0840	0.15412	0.1306
	[1.1071]	[0.2880]	[1.5970]

value of statistic-t in [ ]. * means significant at 1% P-value of Portmanteau Tests (lag 4) is 13.53155, P-value of White joint test is 0.1938

5. DISCUSSION

The purpose of this research is to examine the causal link between fuel consumption, exchange rates and economic development. The

Table 5: VAR Granger Causality/Block Exogeneity Wald Tests

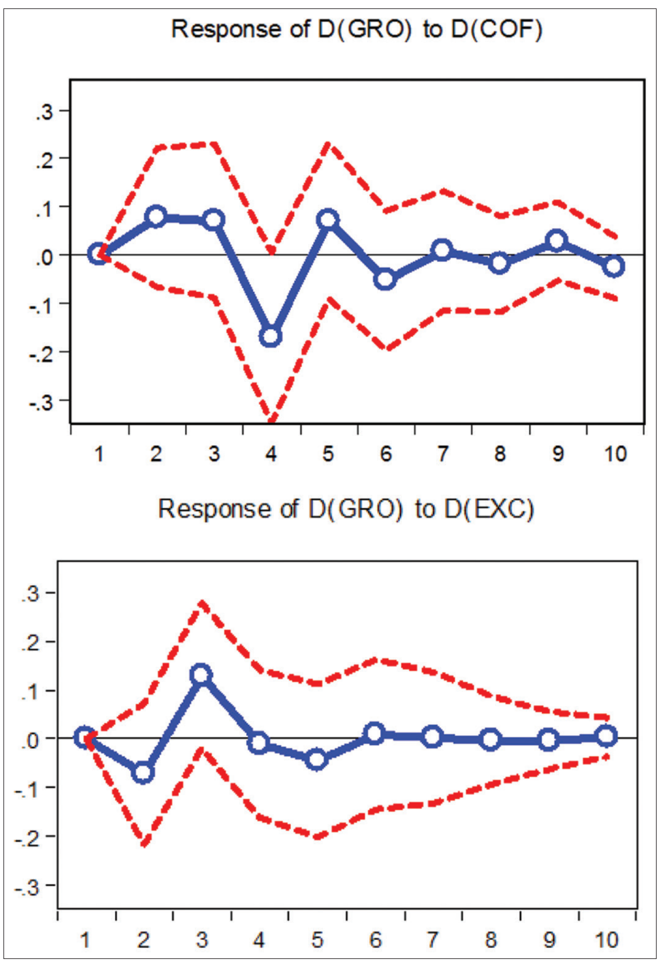
Dependent Variable	Independent Variable	Chi-square test statistics	Prob
D(GRO)	D(COF)	13.1581*	0.0043
	D(EXC)	4.5030	0.2120
	D(COF) and D(EXC)	13.4353	0.0366
D(COF)	D(GRO)	0.2933	0.9613
	D(EXC)	0.4265	0.9347
	D(GRO) and D(EXC)	0.8149	0.9917
D(EXC)	D(GRO)	0.53177	0.9119
	D(COF)	6.2427	0.1004
	D(GRO) and D(COF)	7.4517	0.2811

* means Chi-square statistic is significant at 1%

Table 6: Variance decomposition of D(GRO)

Period	D(GRO)	D(COF)	D(EXC)
3	62.7567	10.7589	26.4844
6	47.7467	30.7079	21.5455
9	47.3905	31.0847	21.5249
12	47.1242	31.4358	21.4402

Figure 1: Responses of economic growth to fuel consumption (left), and exchange rate (right)



estimated results of the VAR(3) model and the Granger causal test demonstrate that only fuel consumption and economic growth have a short-term relationship, namely from fuel consumption to economic growth. This result is consistent with those of Nondo et al. (2010) and Lean and Smyth (2014). However, on the other hand, it is in disagreement with the results shown by many studies: Chen and Chou (2015), Owoundi (2015), Fatai (2014), Ageel and Butt (2001), Asafu-Adjaye (2000), Asafu Adjaye et al. (2018). This disparity can occur because of variations in data period, cultural circumstances, and/or social and economic factors (Ozturk, 2010).

As far as the exchange rate and economic growth relationship are concerned, the present study does not find a short-term causal link between these variables. Hence, this study does not match the previous studies: Aman et al. (2013), Selimi and Selimi (2017), and Razzaque et al. (2017).

Given these results, South East Sulawesi's provincial government is advised to implement a gas and oil policy while maintaining a steady oil and gas price. With this steady oil price, there will be a rise in demand for oil and gas, thereby raising oil and gas. It means that economic growth will improve.

6. CONNCLUSION

In the economy, fuel and gas play a major part. Companies and households require, for instance, these two commodities to fulfil the requirements of industry and households. Meanwhile, the exchange rate also serves as a medium for oil imports, especially crude oil. This study focuses on the causal link among fuel consumption, exchange rates and economic growth in South East Sulawesi Indonesia. The annual time series data on fuel, exchange rate and GRDP as a proxy for economic growth were analyzed in this present study. The time series data covers the periods between 1988 and 2016.

The analysis show that the 3 time series: fuel consumption, exchange rates, and economic growth are stationary in the first deference. As shown by Johansen cointegration test, the variables of fuel consumption, exchange rates, and economic growth are not cointegrated. Meanwhile, the estimation results of the VAR(3) model and the Granger causality test at first difference indicate that there is a significant short-term relationship from fuel consumption to the economic growth of Southeast Sulawesi Province.

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