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Tax Revenue Forecasting: an Empirical Evidence Using Autoregressive-Distributed Lag (ARDL)

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Abstract

It is essential for the Directorate General of Taxes (DGT) to forecast tax revenue fast, accurately, and consistently, especially with high volatility in the current macroeconomics condition. This article tries to build an empirical forecasting model capturing global and local macroeconomic conditions as variables. The researcher found that most macroeconomic variables can be utilized to predict tax revenue in the short run. However, these variables are less likely to project tax revenue in the future for a particular type of tax revenue. Given these results, DGT, as a tax authority in Indonesia, may apply this approach to forecast tax revenue, both in the short run and the long run.

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1. Introduction

Tax revenue integrates with the national or global macroeconomic conditions. The current volatile global conditions, mainly due to the COVID-19 pandemic and geopolitical conditions, will bring tax revenue conditions to uncertainty. Thus, tax revenue forecasting is less accurate. It is essential to build a tax revenue forecasting model considering macroeconomic variables. With this model, the Directorate General of Taxes (DGT) may quickly and accurately predict and forecast tax revenue with several assumptions and scenarios.

The objective of building this model is to forecast tax revenue with several macroeconomics assumptions. However, there is no appropriate forecasting model empirically verified using statistical methodology. Since the tax revenue dataset is confidential, it is advantageous for DGT to access the tax revenue dataset to forecast tax revenue in more detail. The model will be more potent in projecting tax revenue by combining macroeconomic assumptions, including inflation,

exchange rate, and commodity price.

This paper applied time series analysis with the Autoregressive Distributed Lag Model (ARDL), assuming that only economic variables influence tax revenue. The economic variables are exogenous (or at least exogenous). One advantage of this model is that it is suitable with a small sample size but still produces robust results (Latif et al., 2015). The data used for this analysis is tax revenue by five groups (non-oil and gas, value-added tax (VAT), oil and gas, land and building tax (PBB), and other taxes). In addition, the researcher also collected economic datasets from 2000 to 2001. The results show that the lag variable of tax revenue for a particular group in a certain period influenced tax revenue for that specific period. In that case, inflation, the Fed rate, exchange rate, and oil price can be used as indicators to predict tax revenue in the future. On the contrary, the central bank rate (BI rate) was less meaningful in predicting tax revenue.

These results are valuable for DGT to build more accurate tax revenue forecasting. Updating this model with a more current dataset is essential to maintain its accuracy. Concerning this study presentation, the researcher will explain the literature review regarding the relationship between tax revenue and macroeconomic condition in the following section. Meanwhile, in the third chapter, the researcher will briefly explain the data and model of this study, while the fourth chapter will elaborate on the discussion. The last chapter, the fifth, will present the conclusion.

2. Literature Review

2.1. Factors affecting tax revenue

Tax revenue cannot be separated from macroeconomic conditions, in addition to microeconomic conditions. Tax revenue relies on the willingness to pay taxes and comply with tax regulations, which is part of microeconomics. Moreover, from a macroeconomic view, economic conditions locally and globally, including economic growth, inflation, and exchange rate, will influence economic conditions in a particular country. This mechanism will affect national revenue, particularly from the taxation sector that contributes significantly to this type of revenue of a country, including Indonesia. Below, the researcher will review several works of literature concerning the relationship between economic factors and tax revenue.

2.1.1. *Sectoral economy and tax revenue classification*

Regarding the sectoral economy, Ayenew (2016) found that this variable correlates with tax revenue in Ethiopia. The correlation was positive and significant. Concerning tax structure, the contribution of a particular tax to total tax revenue relies on the sectoral economy in a country. This mechanism happens because a specific sectoral economy may have distinct characteristics that differ from the other sectors. For instance, in the mining sector, withholding tax article 23 contributes highly to the tax revenue, mainly due to transportation costs. This type of tax will reduce corporate tax articles 25 and 29 in the following year. In the accommodation sector, including hotels and restaurants, there is no value-added tax (VAT) since this sector has been exempted from VAT. Karagoz (2013) revealed that tax revenue in Turkey is influenced by the agriculture and industry sectors.

Concerning economic growth, McNabb (2018) showed the relationship between economic growth and tax revenue using the data from OECD countries. He differentiated between income tax and consumption tax concerning this economic growth. Income tax relates to low economic growth in the long run, while consumption tax does not always have a positive relationship with economic growth. This tax classification is partly essential because the timing is different. VAT is a *real-time* tax because it is due when there is a transaction, while income tax will be due the following year after a tax year ends (income tax articles 25 or 29). In that case, the income tax paid the next year is the economic effect of the previous year (lag variable). Therefore, the researcher will discuss this effect on tax revenue for each classification.

2.1.2. *Inflation and exchange rate*

Several articles discuss the impact of inflation on tax revenue. Ayenew (2016) analyzed the consumer price index (CPI) as a proxy to measure inflation in Ethiopia. He assumed that inflation is associated negatively with tax revenue because inflation will reduce the purchasing power. He found that if inflation increased by one percent, it would reduce tax revenue by 0.68 percent in the long run. In other words, once inflation rises, the purchasing power will decrease, and finally, it will reduce the actual value of the amount of tax collected. Quite similarly, Tanzi (1989) explained that timing is vital. The difference between tax collection and tax payment, especially in a developing country, will reduce the value of tax revenue. Meanwhile, Ghure (1998) discussed that inflation will encourage people to evade tax and shift the economy from the formal sector toward the informal one, which is difficult to tax.

2.1.3. *Exchange rate*

Seade (1990) suggested analyzing the implication of the exchange rate on tax revenue for each tax basis. However, the calculation only from tax revenue sources will be biased and tends to mislead. Thus, the easiest way is to analyze across sectors that have similarities by looking at how the added value of productions contributes to those different fields. If devaluation succeeds, the price will decrease for nontradable goods relatively to tradable goods. In short, the effect of evaluation on tax revenue depends on the tax balance or structure.

2.1.4. *The commodity price*

Commodity prices might influence tax revenue in a particular country, and there is a spillover effect from the change in the commodity price. This effect will be even more significant if the economic structure in a country provides a subsidy to the commodity. Once the commodity price rises, the state budget will increase to subsidize those products. Then, the change in the commodity price will generate inflation that hikes the prices of goods and services and the demand for those commodities. When demand for the products and their prices significantly increase, the VAT will also be affected. In that case, the net effect of this scenario on tax revenue is interesting to be analyzed.

Related to this matter, Ehrhart and Guerineau (2013) found that, in developing countries, the volatility of commodity prices will influence tax revenue. Specifically, imported goods will affect tax revenue negatively, particularly from international trade.

3. Methodology

3.1. Data

Data used in this paper include the tax revenue dataset as a dependent variable, collected from the national tax revenue dataset from 2000 to May 2022 (monthly).[1] For the explanatory variables, the researcher used inflation, exchange rate, BI rate, The Fed rate, and commodity price.[2]

3.2. Method

The researcher applied a time series analysis with *Autoregressive Distributed Lag* (*ARDL*).[3] Below is the model specification:

$$\text{LogTax}X_t = \alpha + \beta_1 \text{infl}_t + \beta_2 \text{BI rate}_t + \beta_2 \text{The Fed rate}_t + \beta_3 \text{Exrate}_t + \beta_4 \text{Price}_{it} + \varepsilon$$

With:

- LogTax X_t : Log of tax revenue X classification time *t*.
- infl_t : inflation time *t*.
- BI rate $_t$: Bank Indonesia rate time *t*.
- The Fed rate $_t$: The Fed rate time *t*.
- Exrate : Exchange rate for US Dollar time *t*.
- Price_{it} : Commodity price *i* time *t*.

3.3. Correlation between variables

To analyze economic variables and tax revenue, one should check whether there is a correlation between variables (Table 1). In this case, the BI rate had no significant correlation with The Fed rate.

Table 1. Correlation between variables

	Inflation (BI)	Inflation (BPS)	Exrate	BI rate	The Fed rate	Gas	Oil	CPO	Wheat	Corn	Coal
Inflation (BI)	1										
Inflation (BPS)	0.1914	1									
Exrate	-0.2485	-0.1428	1								
BI rate	0.6392	0.1351	-0.4617	1							
The Fed rate	-0.5401	-0.1471	0.6752	-0.4233	1						
Gas	0.2435	0.1483	-0.5889	0.3526	-0.3073	1					
Oil	0.2689	0.1319	-0.6743	0.4388	-0.3446	0.9639	1				
CPO	0.2561	0.055	-0.8133	0.2709	-0.5477	0.6601	0.7212	1			
Wheat	0.5048	0.1153	-0.6435	0.5391	-0.4467	0.7985	0.8309	0.6684	1		
Corn	0.2583	0.1188	-0.6917	0.224	-0.3966	0.801	0.8062	0.7369	0.8737	1	
Coal	-0.1343	-0.0139	-0.4139	-0.0118	0.1291	0.4599	0.5288	0.5869	0.3516	0.4492	1

Meanwhile, as seen in Figure 1, only the first month of 2010, 2018, and 2019 show a similar trend between BI and The Fed rates.

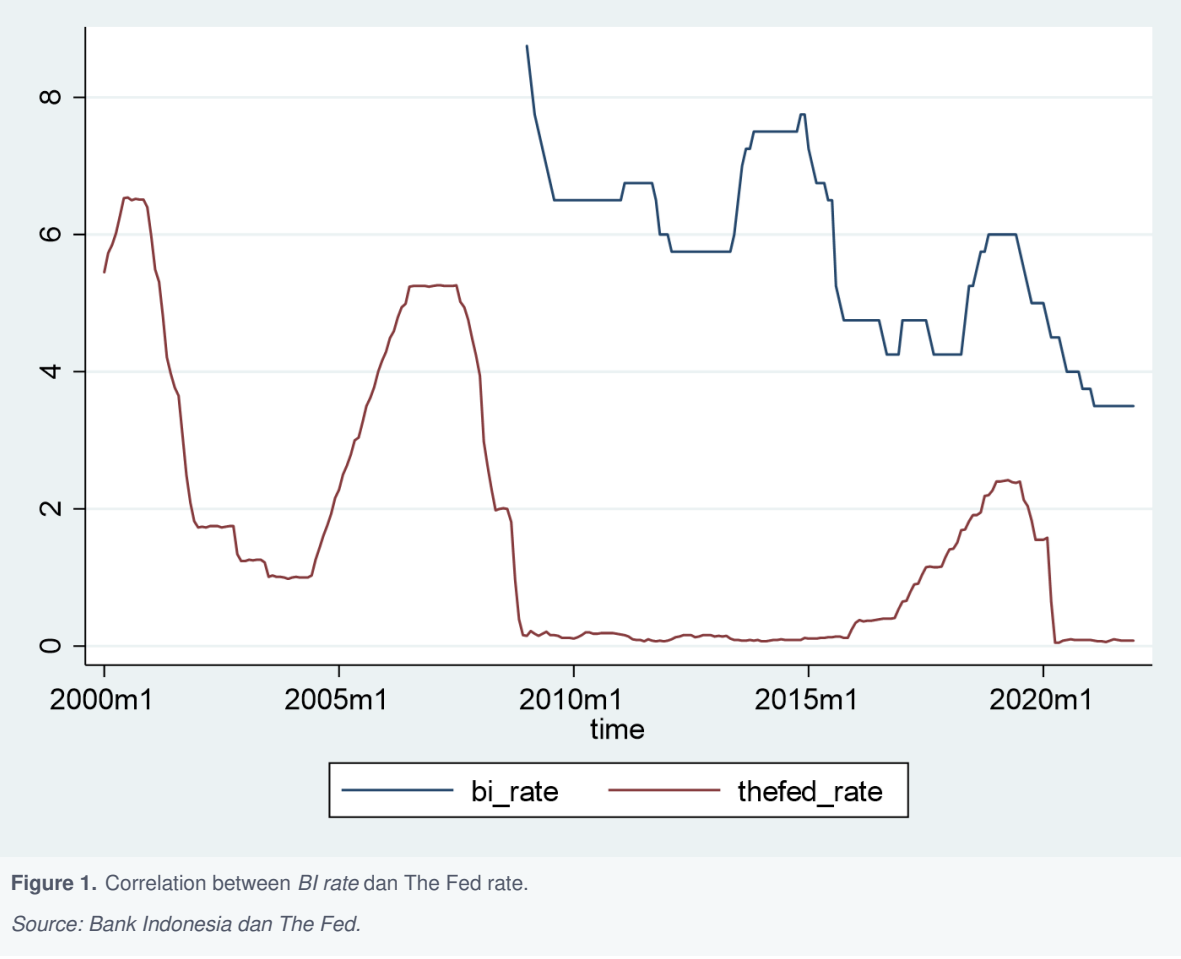


Figure 1. Correlation between *BI rate* dan The Fed rate.

Source: Bank Indonesia dan The Fed.

Subsequently, the researcher assessed the correlation between commodity prices, specifically the correlation of oil price with gas price, which reached 0.9 (Table 1). In addition, the prices of other commodities were similar to that of oil prices (Figure 2).

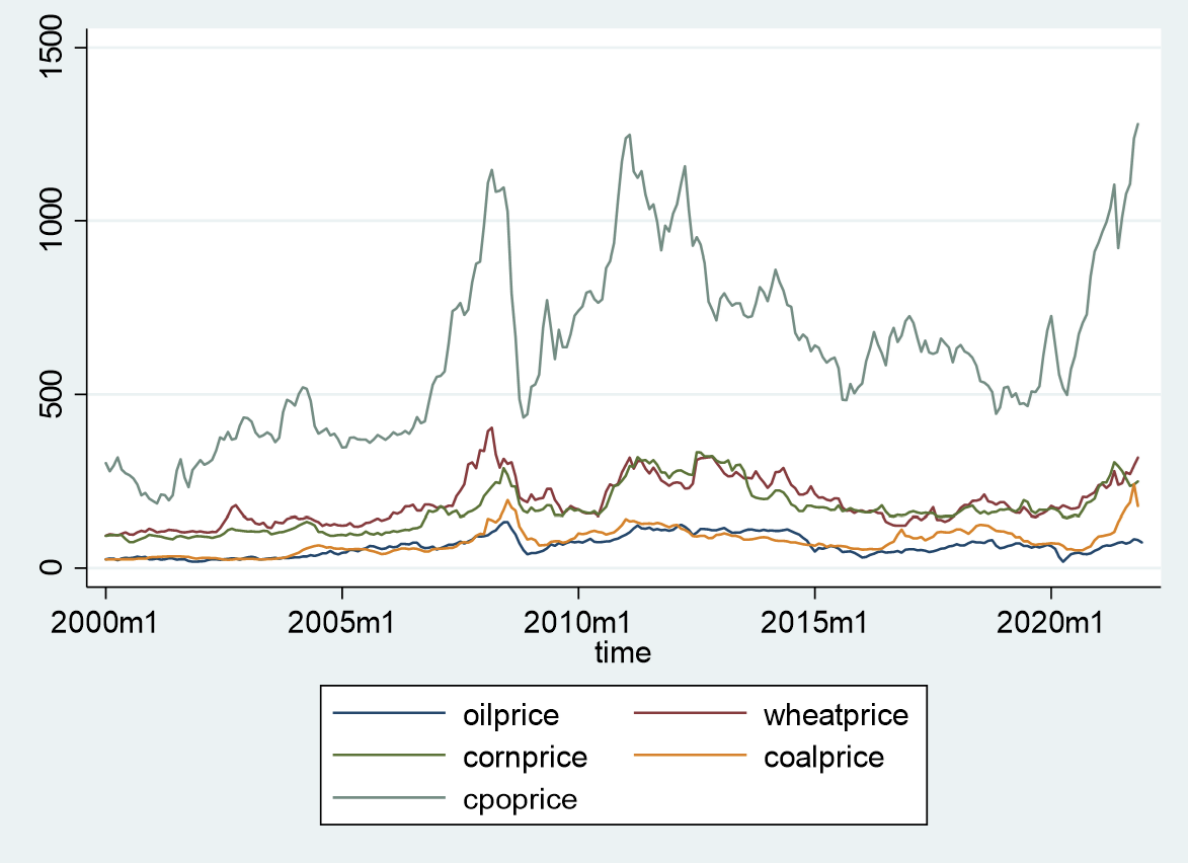


Figure 2. Correlation among commodity prices.

Source: The Fed.

Concerning this issue, ARDL only uses the dataset that has a low correlation with other variables.[4]

4. Results

To analyze tax revenue, the researcher mainly classified them into five categories, including 1) non-oil and gas income tax; 2) oil and gas income tax; 3) VAT; 4) other income tax; and 5) land and building tax (PBB). [5] Meanwhile, Table 2 provides the results from ARDL regression.[6] In general, each category of tax revenue is influenced by its lag variable, The Fed rate, and oil price. To be precise, the lag variable of the dependent variable (t-1) and (t-2) influenced tax revenue positively (columns 1, 2, and 5). Contrarily, only oil and gas income tax and other income tax showed a negative relationship. Therefore, tax revenue for the period (t) can be projected by the tax revenue of the previous period.

Regarding PBB, inflation had a negative correlation, yet, it was only at a 10 percent level. Meanwhile, the lag variable of inflation correlated positively with PBB at a 10 percent level. It means that an increase in goods and services will boost the

economy. However, the demand for goods and services will decrease if the price increases. The combination of this scenario will have a net effect on tax revenue in the short run. Yet, this net effect was relatively small in PBB and showed no effect on the other tax.

Furthermore, as expected, the effect of the exchange rate changes on tax was positive in VAT and PBB at a 5 percent level, but the coefficients were relatively small (0.00 point). If the US dollar value increases, the import goods become more expensive, and VAT from import goods will also increase. However, similar to inflation, the demand for import goods and services will decrease, automatically reducing VAT from import transactions. The changes in the BI rate would not influence all taxes revenue, but the changes in The Fed rate had a relatively high and positive effect only on VAT at 5 percent. The assumption is that The Fed rate also contributes to the change in demand and price of goods and services. Lastly, the changes in oil price influenced the other tax positively at a 5 percent level. Concerning this matter, the researcher assumed that there are particular types of taxes in other taxes category that is more sensitive to oil price volatility.

Table 2. *ARDL model (short-run)* for a log of tax revenue for each category

	Non-oil and gas income tax	VAT	Oil and gas income tax	Other tax	PBB
Log DV					
t-1	0.49*** (0.075)	0.68*** (0.06)	-0.24*** (0.09)	-0.26*** (0.08)	0.58*** (0.06)
t-2	0.31*** (0.76)		-0.13 (0.08)		
Inflation (BI) ***(t)***	-0.00 (0.02)	-0.02 (0.02)	-0.13 (0.16)	0.02 (0.02)	-0.41* (0.23)
t-1			0.21 (0.16)		0.39* (0.23)
t-2					
Diff.Exchange rate t	-0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	-0.00 (0.00)	0.00** (0.00)
t-1	0.00* (0.00)	0.00** (0.00)		0.00 (0.00)	
				-0.00*	

t-2				(0.00)	
Diff.BI rate *(t)*	0.06 (0.20)	0.03 (0.18)	0.35 (0.45)		-0.62 (0.67)
t-1					
Diff.The Fed rate	0.02 (0.31)	0.56** (0.28)	-0.04 (0.62)	-0.52 (0.36)	1.43 (0.96)
Diff.Oil Price *(t)*	-0.00 (0.00)	-0.00 (0.00)	0.01 (0.01)	0.02** (0.00)	-0.02 (0.02)
t-1				-0.01 (0.00)	
Cons	6.23*** (1.71)	10.11*** (1.94)	-0.23 (1.20)	-0.08 (0.12)	11.29*** (1.74)
N	164	157	145	170	164
Model	*ARDL*	*ARDL*	*ARDL*	*ARDL*	*ARDL*
Adj R-Squared	0.60	0.48	0.03	0.08	0.36

**** p<0.01, **p<0.05, *p<0.1*

Note: The dependent variable is a log of tax revenue for each category.

The researcher used the first difference for oil and gas income tax, the other taxes, the exchange rate, BI rate, The Fed rate, and oil price.

4.1. Forecasting

This research aims to build a forecasting model to predict tax revenue by considering several macroeconomic variables. To check whether the model can accurately portray the actual tax revenue, the researcher visualized and compared the prediction and the factual tax revenue from the year 2000 to May 2022 and extended this prediction until the end of 2022.[7]

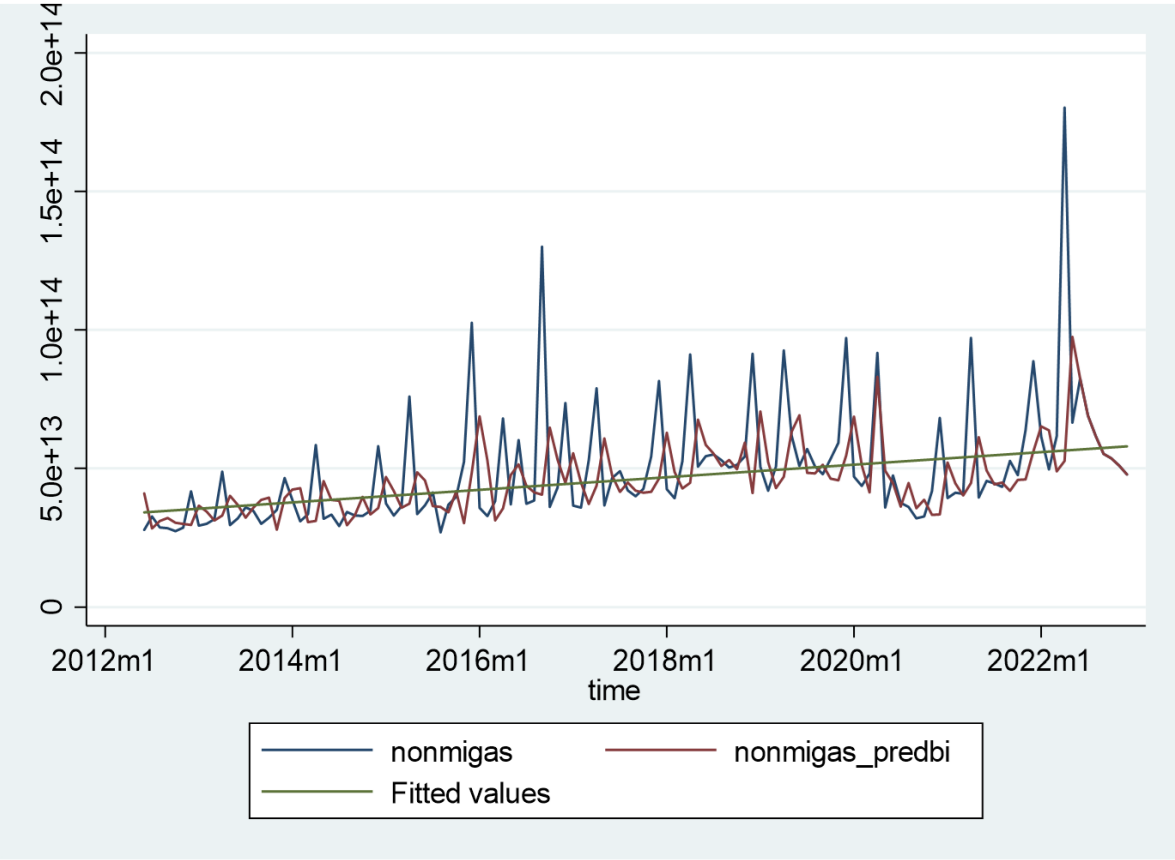


Figure 3. The comparison between non-oil and gas income tax (*actual value*) and the prediction with its fitted value.

Plot prediction and its actual value of non-oil and gas income tax (Figure 3) show that the model can predict relatively accurately.[8] The fitted values between the prediction and the actual one did not differ with 95% CI (Figure A1). Non-oil and gas income tax is shown to be influenced by its lags. Income tax article 25 has quite a large portion in this category. This income tax, which depends on the yearly income tax paid in March or April in a particular year, is based on the calculation of the financial statement in the previous year.[9] It means that the economy in a period will affect this income tax in the following year. Therefore, the lags variable significantly affects the income tax of a particular period. As shown in the figure, the shocks were the yearly income tax paid around March and April.

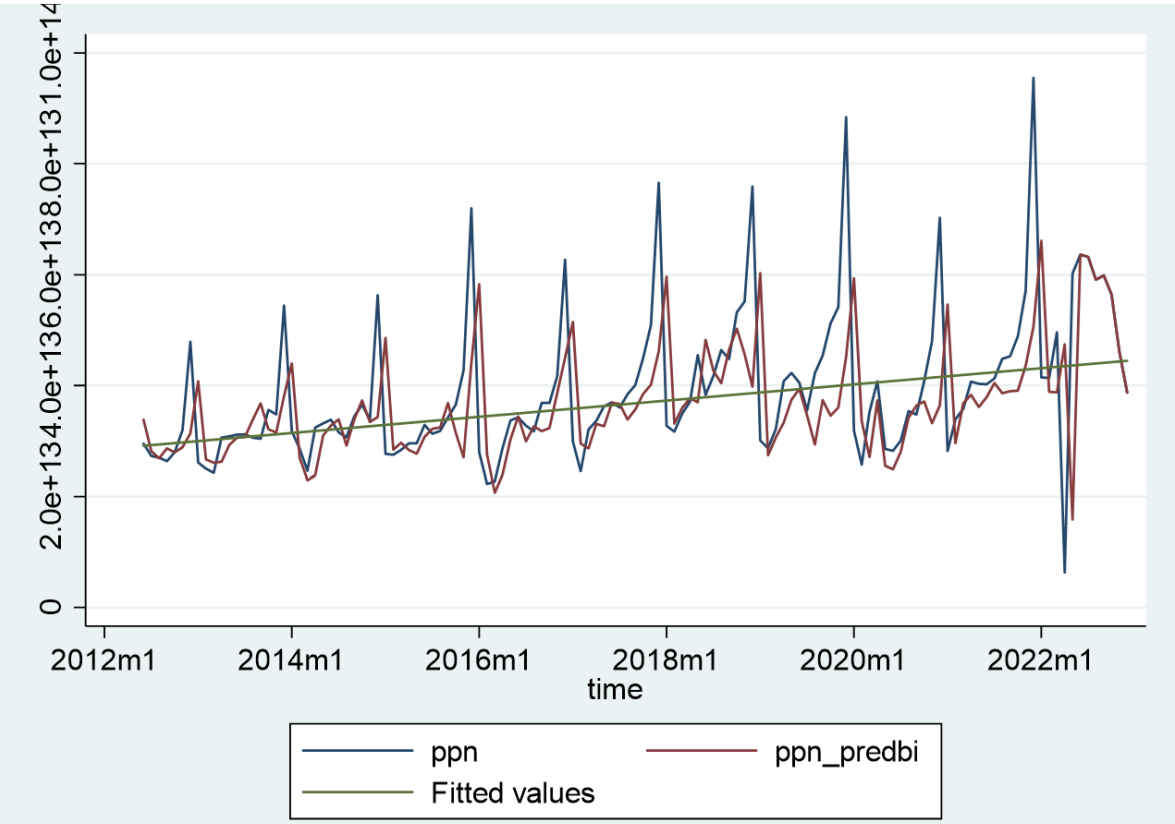


Figure 4. The comparison between VAT (*actual value*) and the predictionwith its fitted value.

For VAT (Figure 4), there was no difference between the actual value and the prediction. The plot shows an increasing trend over the years. In that case, the lag variable, the exchange rate, and oil price change will affect VAT. Assuming that there are no changes drastically in the consumption of goods and services, the VAT of the previous period can predict the VAT in the following period. Besides that, exchange rate and oil price can be used to predict the VAT. The changes in the exchange rate and oil price will influence the prices of goods and services. The shocks of the VAT mainly come from the government transaction at the end of each year.

Meanwhile, Figure 5 plots the oil and gas income tax. This model is considered less precise, with an Adjusted R-squared of 0.03. Only the lag variable influenced the tax revenue in one period. In oil and gas income tax, the payment depends on the governmental invoice and the ability of the taxpayers to pay tax reflected in their budgets. In addition, the lifting oil and gas assumption should also be considered as the factors influencing this tax revenue.

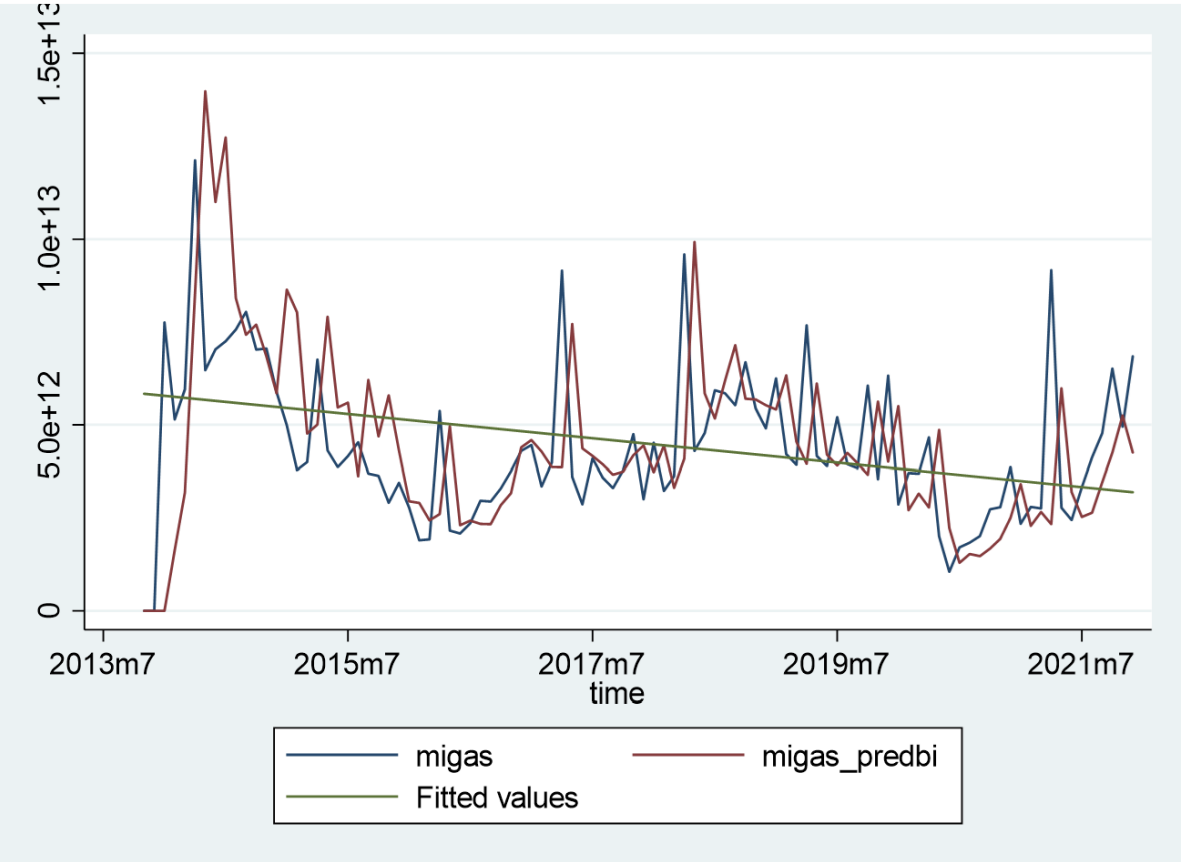


Figure 5. The comparison between oil and gas income tax (*actual value*) and the predictionwith its fitted value.

Figure 6 plots the prediction for other taxes. However, this model cannot predict accurately, with the Adjusted R-squared of 0.08. One possible reason is that several taxes in this category have different characteristics. In this case, a more detailed classification is required for a more accurate analysis. Despite the small R-squared value, the prediction's line can follow the actual value's line.

At the same time, there was no increasing trend for PBB (Figure 6). The Adjusted R-squared of 0.36 shows that this model is relatively accurate. The change in the exchange rate and the lag variable of PBB significantly influenced PBB in a certain period. The exchange rate matters because the tax due is calculated using foreign currencies for several PBB categories, including oil and gas. The shock itself was due to the payment in a particular month.

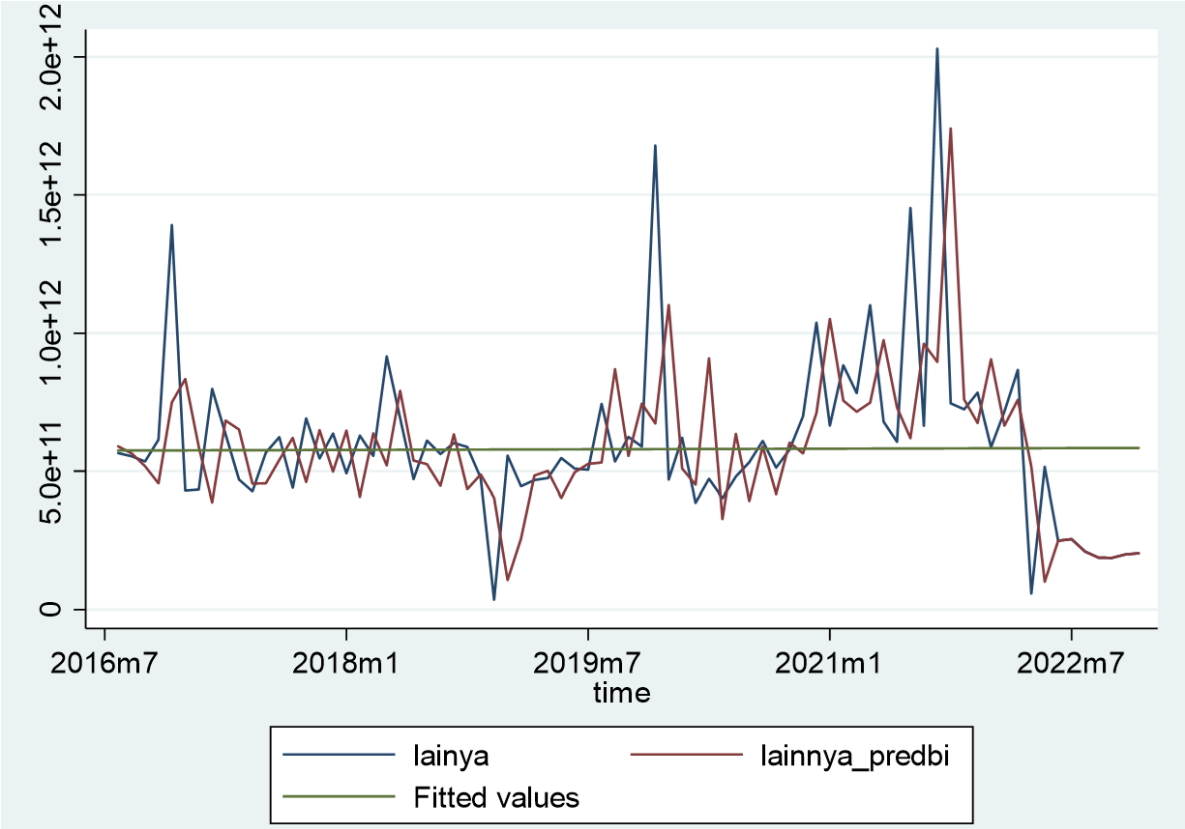


Figure 6. The comparison between the other tax (*actual value*) and the predictionwith its fitted value.

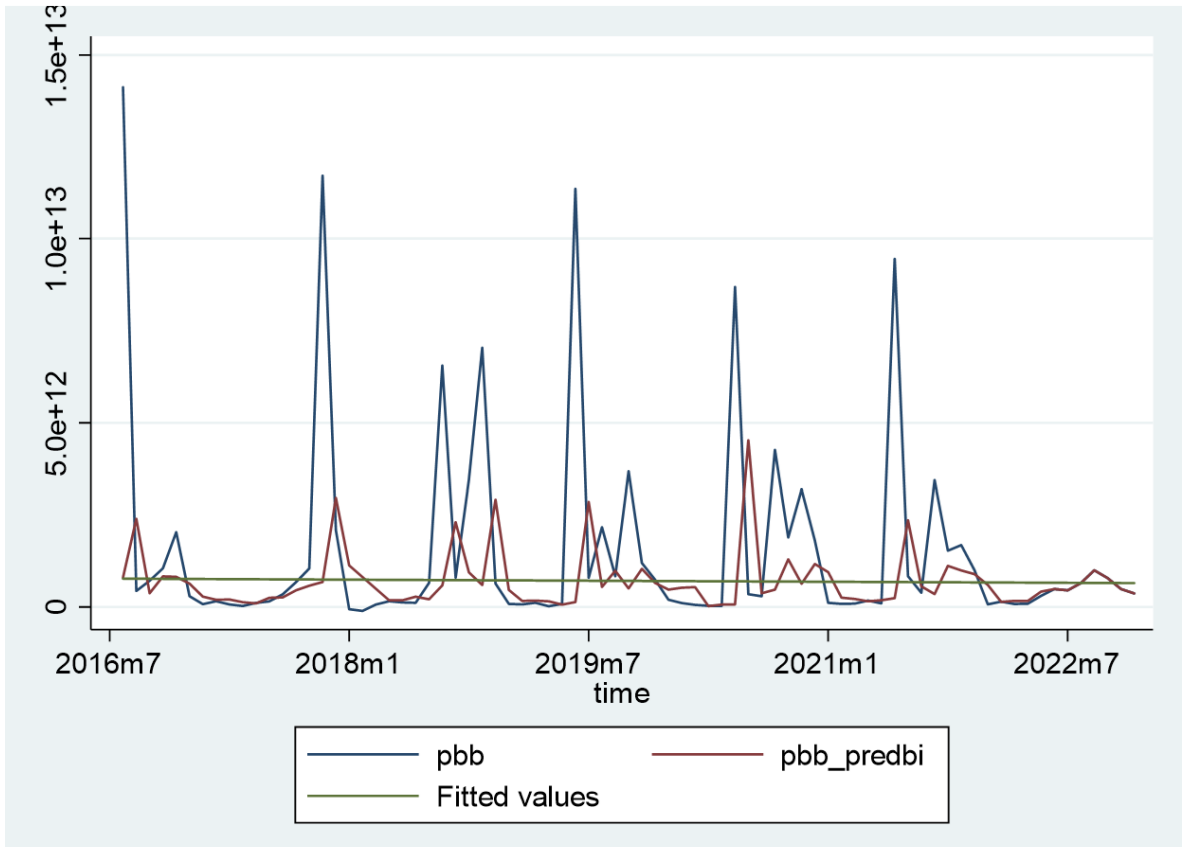


Figure 7. The comparison between PBB (*actual value*) and the predictionwith its fitted value.

4.2. Robustness check

To check the robustness of the results, the regression using ARDL with VAR was compared, as seen in Table 3.[10] Using the T-test, the forecasting results of two models from June 2022 until December 2022 show no significant differences at a 1 percent level.[11]

Since no significant difference between these two models exists, analyzing how the dependent variable responds to the shock of independent variables, which can be evaluated from a VAR model, is challenging. Therefore, the researcher discusses the impulse response function and variance decomposition in the following section.[12]

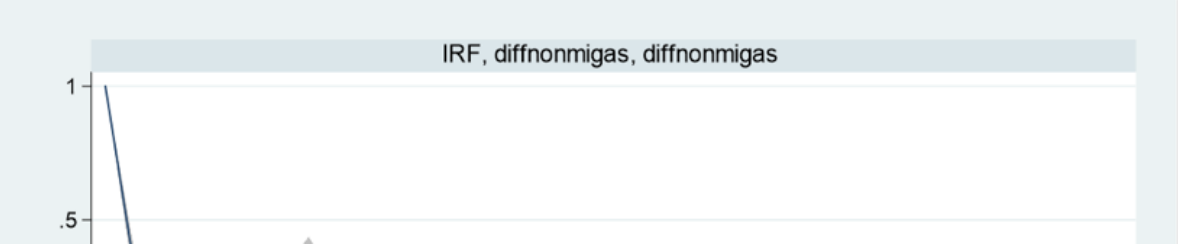
Table 3. The difference between ARDL and VAR

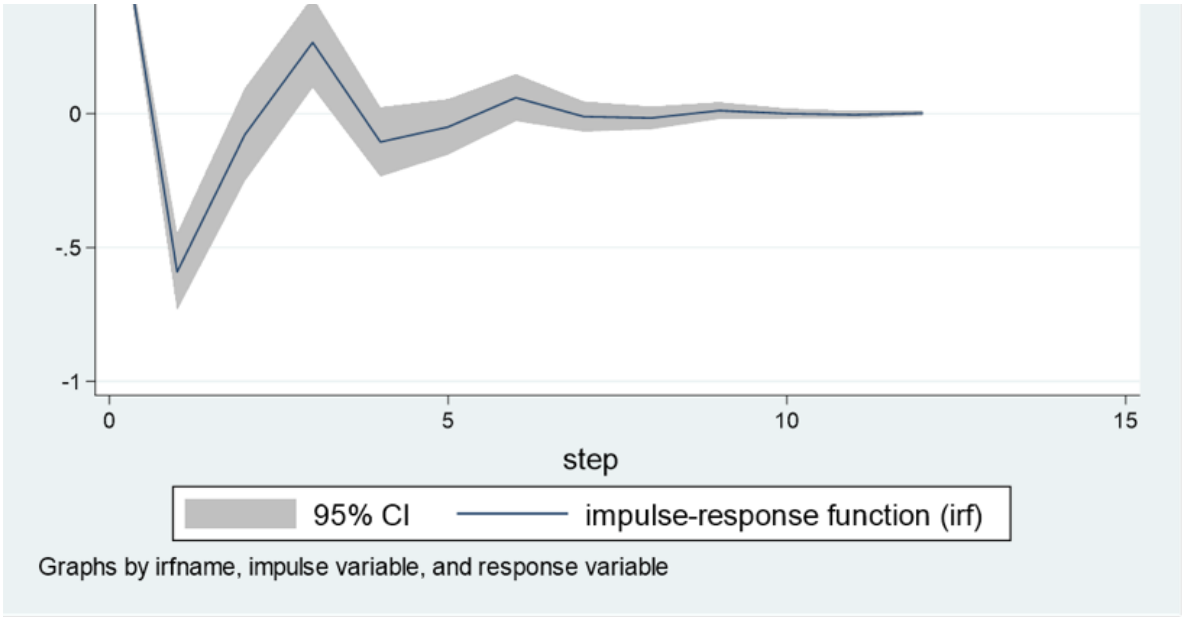
	Oil and gas	VAT
Mean (in Billion)	115,429	117,629
Observations	7	7
df	6	6
F	1.98	
P(F<=f) one-tail	0.21	
F Critical one-tail	4.28	

4.3. Impulse response function and variance decomposition

4.3.1. *Non-oil and gas tax*

The interpretation of the impulse response function is not straightforward since the researcher used the first difference for tax and other variables. From the impulse response function, non-oil and gas tax was influenced by the tax and The Fed rate. If one standard deviation of the change in non-oil and gas tax increases, the changes of non-oil and gas will decrease significantly in the first period after shock but increase in the second period. However, there is no significant effect after the second period. Meanwhile, regarding The Fed rate changes, the effect the increase of one standard deviation, was only found in the first period. The other variables did not impact on non-oil and gas taxes. These results reconfirm the ARDL's results that only non-oil and gas taxes influence the tax.

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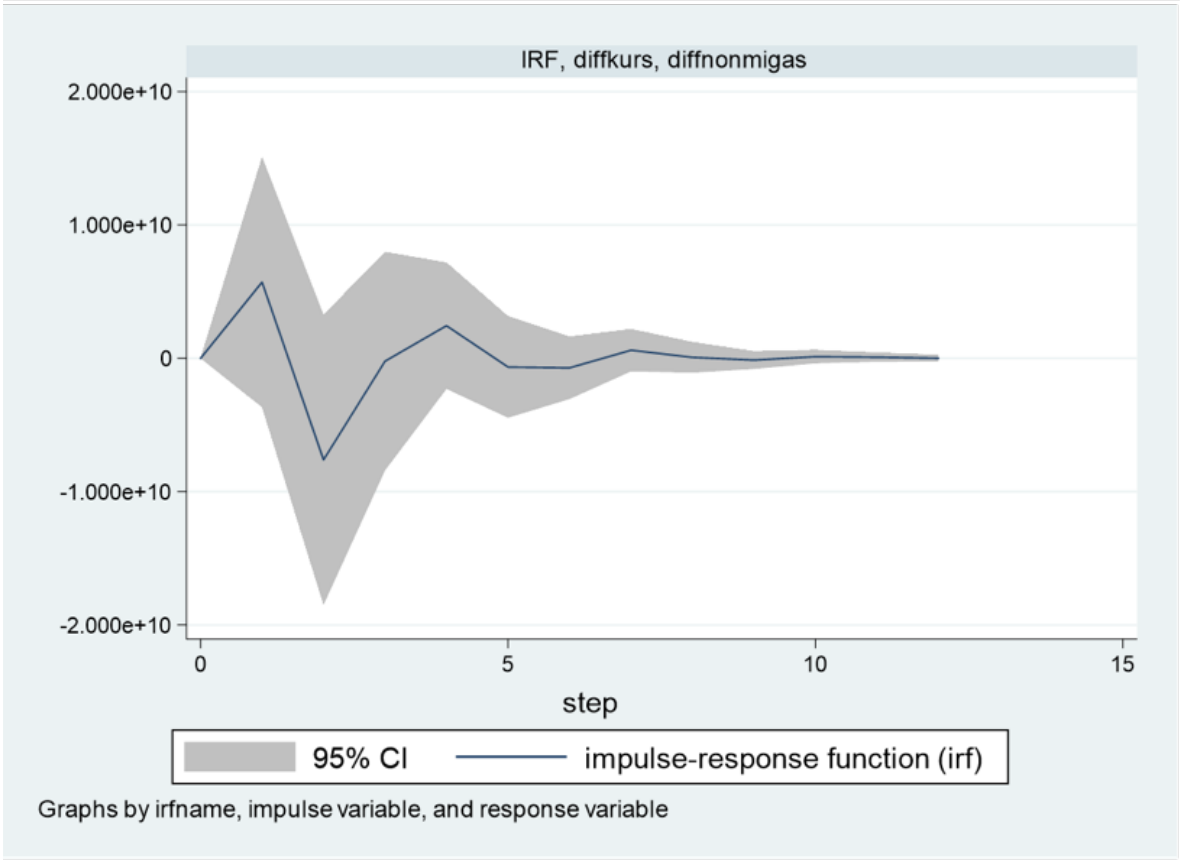
Graphs by irfname, impulse variable, and response variable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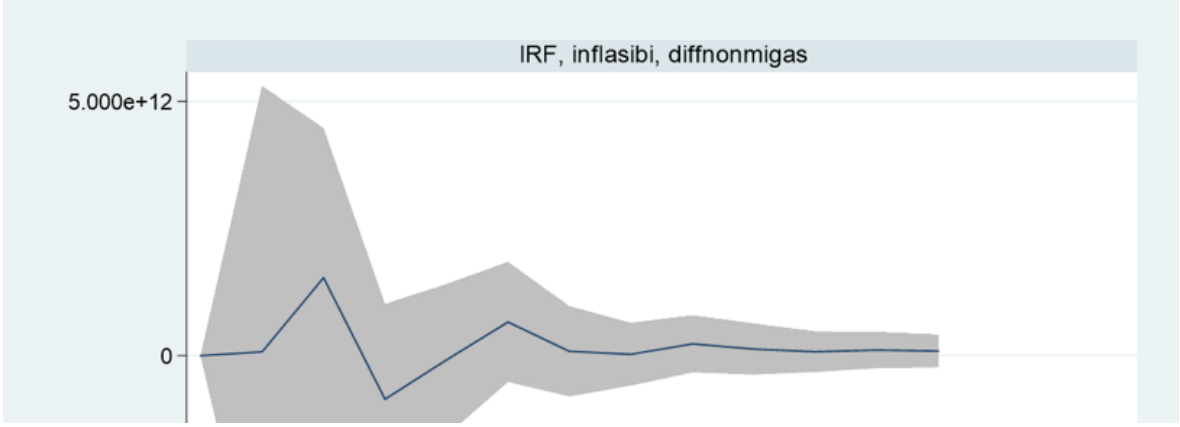
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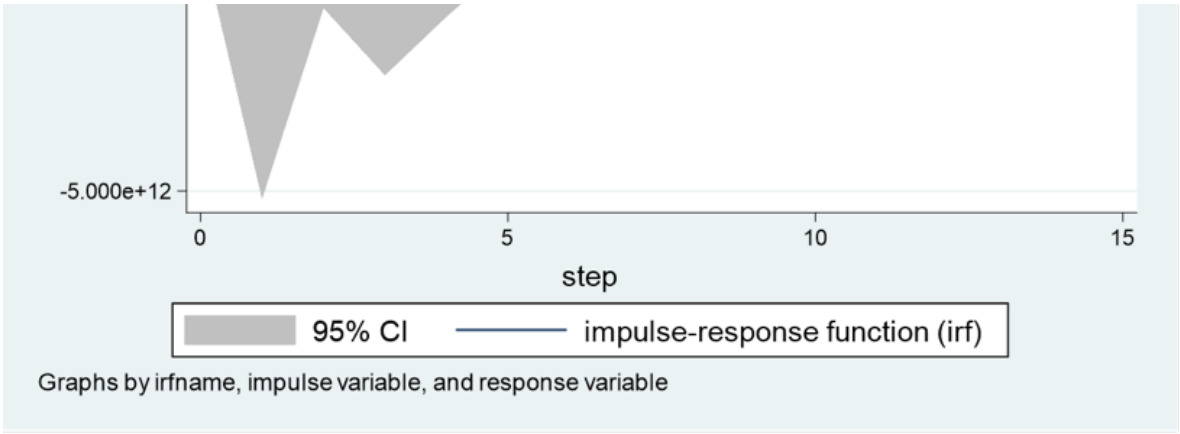
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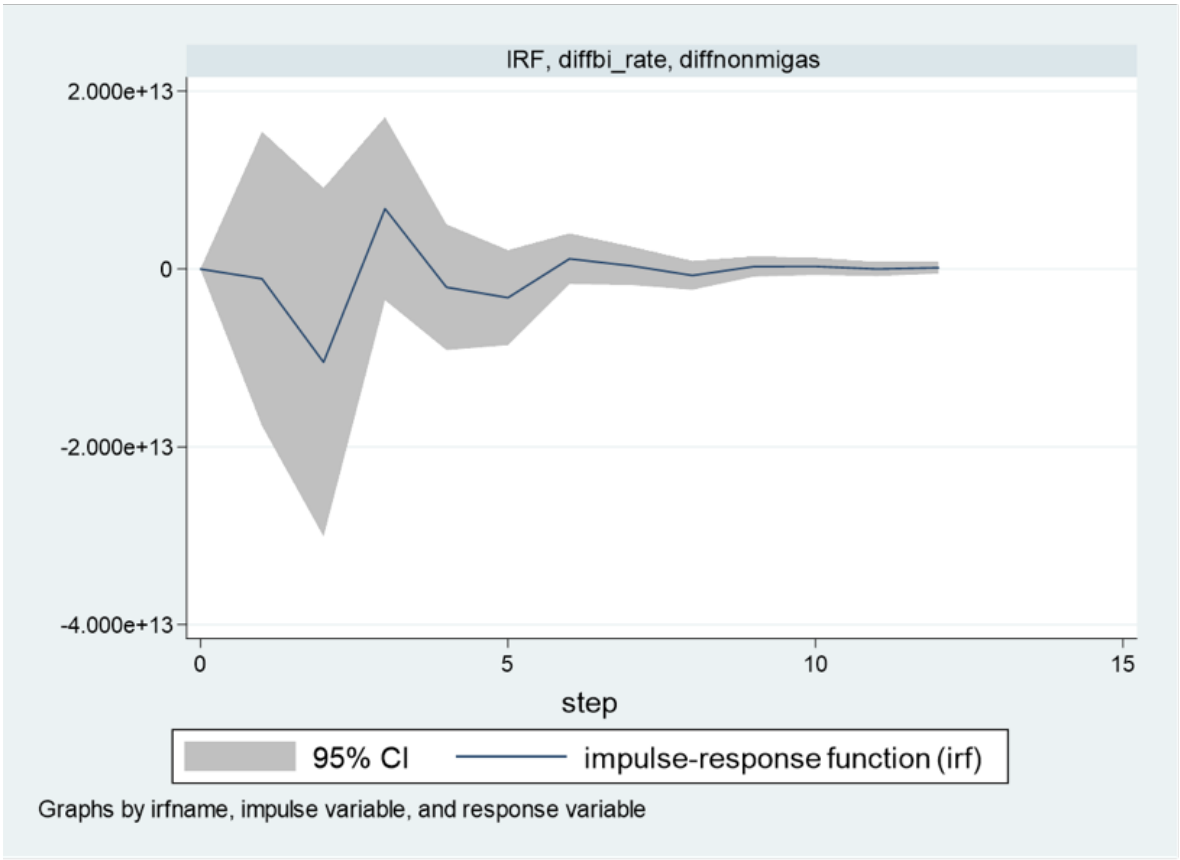
Graphs by irfname, impulse variable, and response variable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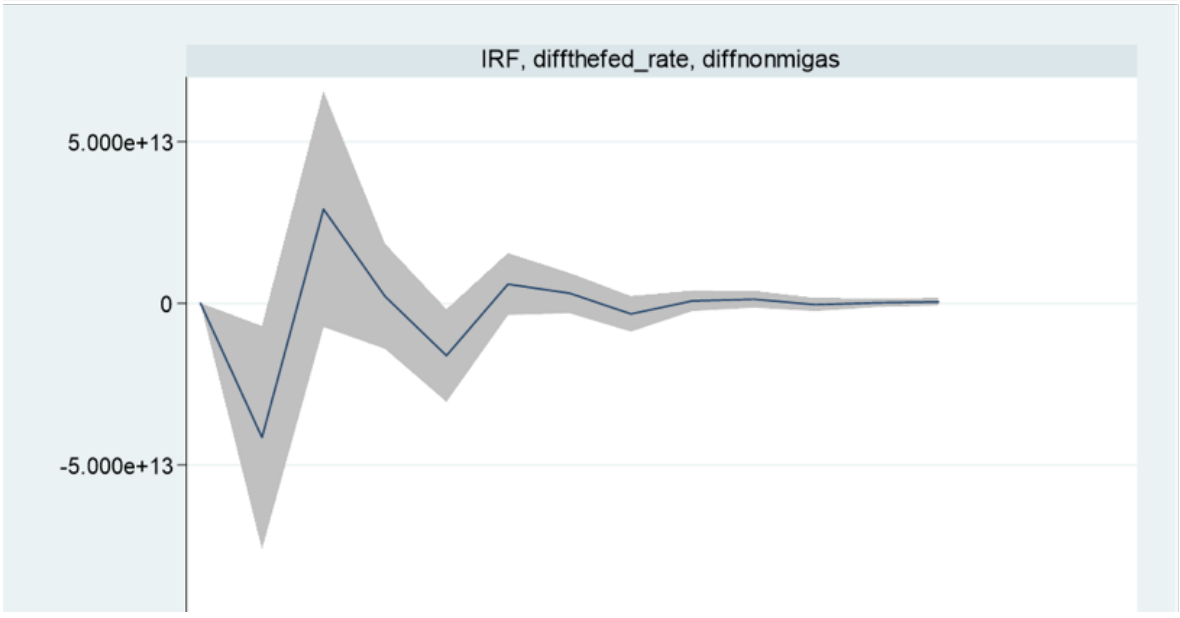
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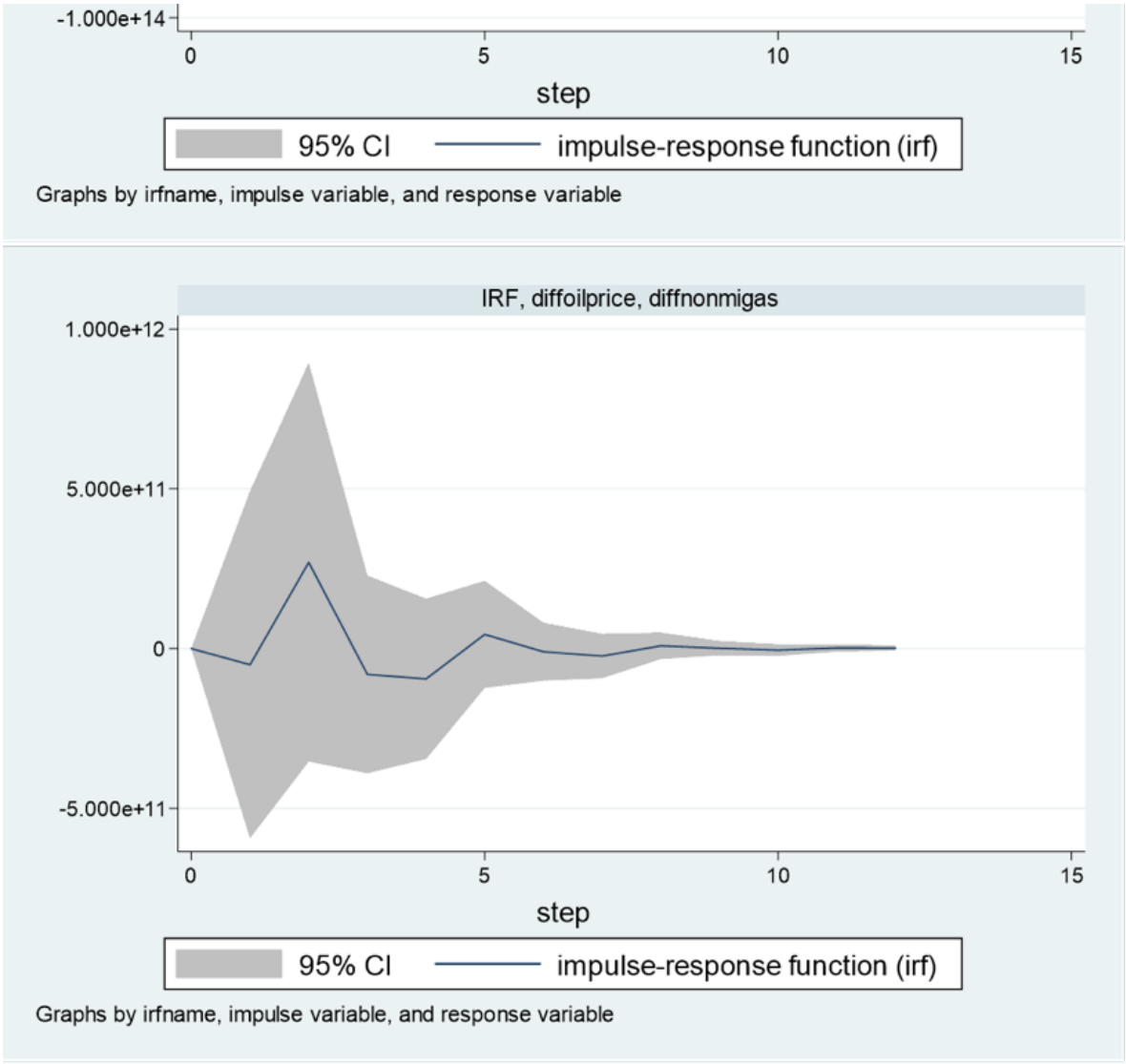


Figure 8. Impulse response function of non-oil and gas tax.

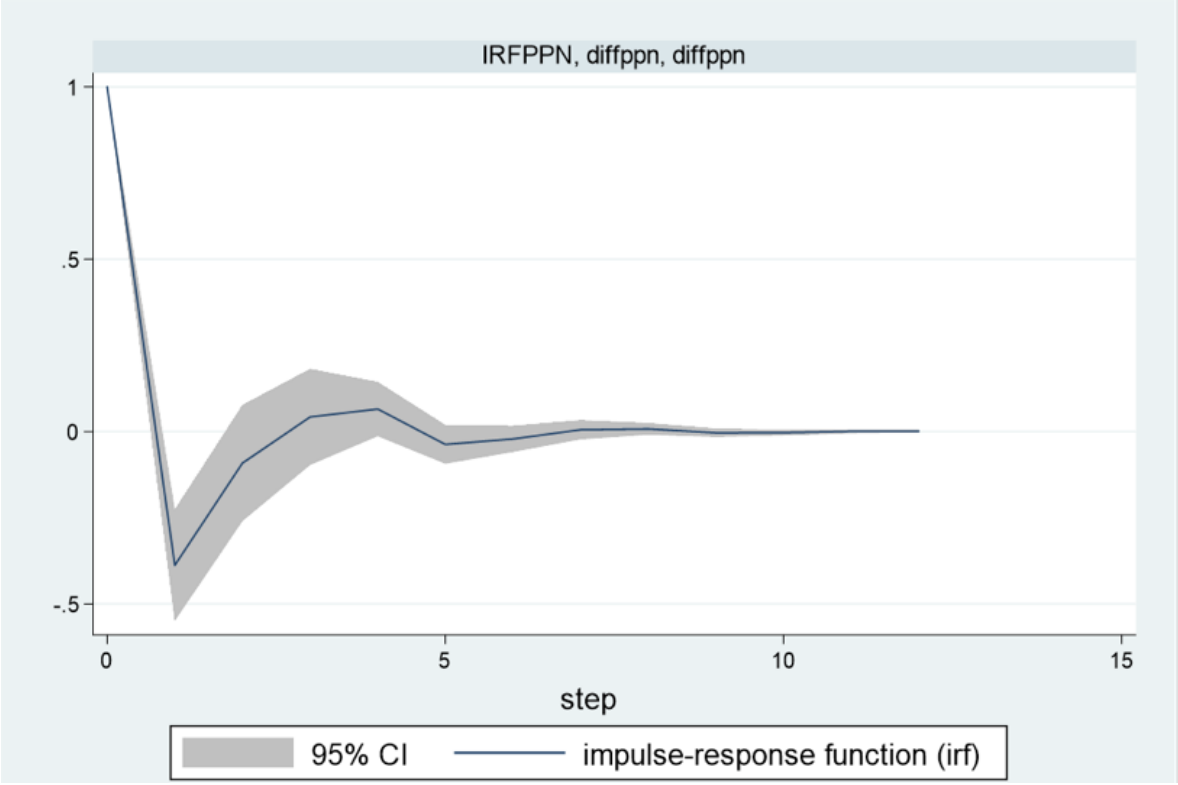
The variance decomposition presents similarly to ARDL's results. The tax on non-oil and gas was 89%, explained by the tax itself. The other variables explain non-oil and gas tax at maximum of 5%.

Table 4. Variance decomposition of non-oil and gas tax

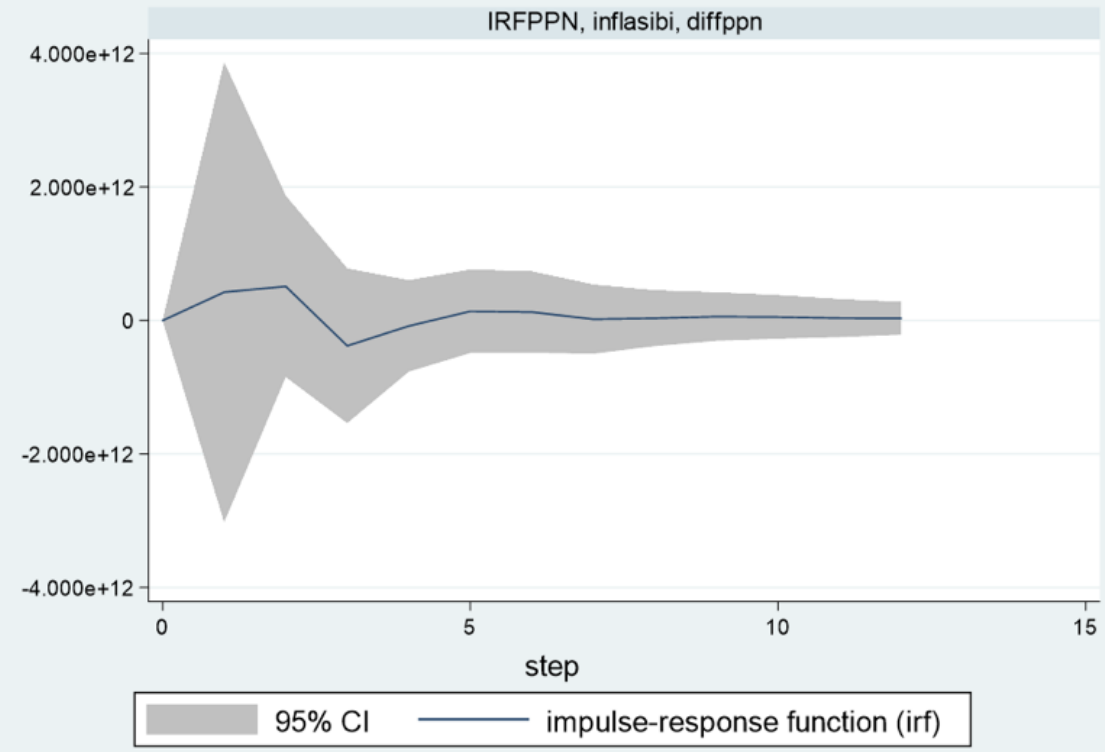
Period	Non-Migas	Inflation	Exchange rate	BI rate	The Fed rate	Oil price
0	0	0	0	0	0	0
1	1	0	0	0	0	0
2	0.949	0.000	0.023	0.000	0.027	0.000
3	0.901	0.000	0.047	0.005	0.043	0.004
4	0.903	0.000	0.044	0.007	0.041	0.004
5	0.896	0.000	0.048	0.007	0.044	0.004
6	0.895	0.001	0.048	0.007	0.045	0.004
7	0.894	0.001	0.048	0.007	0.045	0.004
8	0.894	0.001	0.048	0.007	0.045	0.004
9	0.894	0.001	0.048	0.007	0.045	0.005
10	0.894	0.001	0.048	0.007	0.045	0.005
11	0.894	0.001	0.048	0.007	0.045	0.005
12	0.894	0.001	0.048	0.007	0.045	0.005

4.3.2. ***Value-added tax***

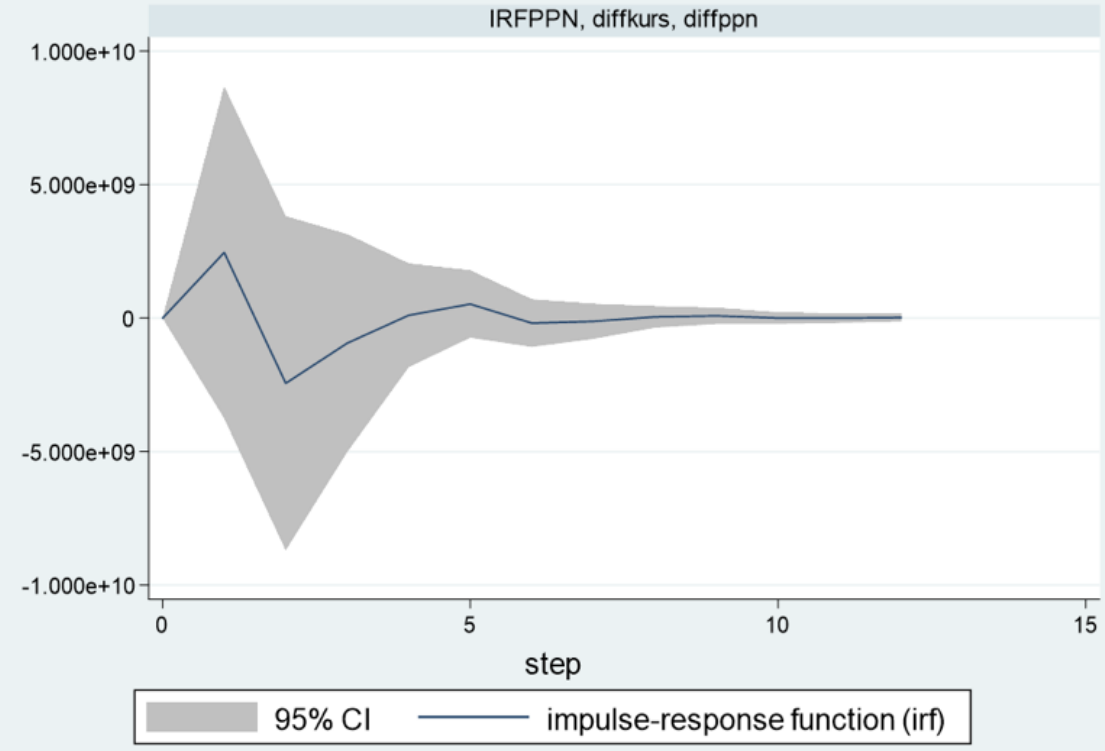
Similar to non-oil and gas, the results show that only VAT's shock influenced the VAT itself. The increase of one standard deviation of the change in VAT decreased the change of VAT only in the first period, which was quite different from non-oil and gas tax, where the effect of the tax remained until the second period. The graph reconfirms the ARDL model that only the first lag of VAT matters for VAT at a certain period. Similarly, the Fed rate also confirms the ARDL results, and the other variables did not affect VAT in the following periods.



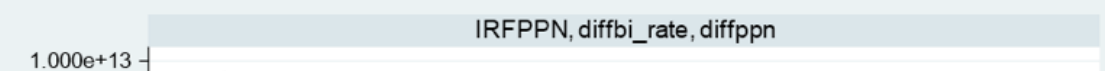
Graphs by irfname, impulse variable, and response variable

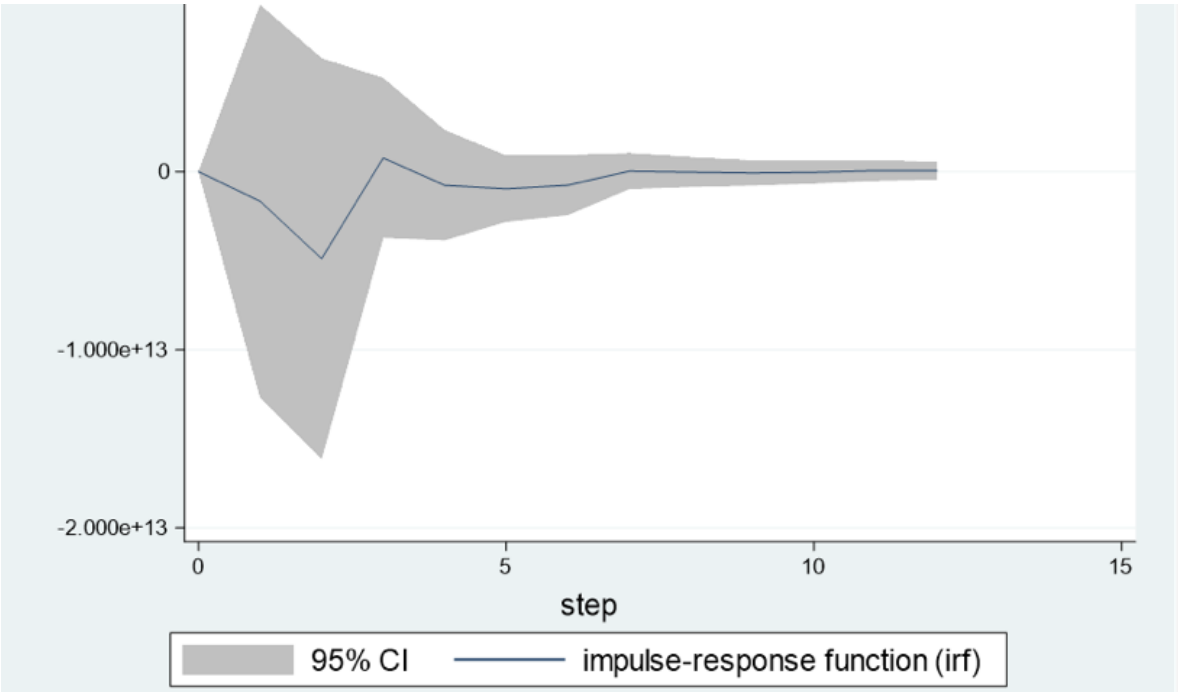


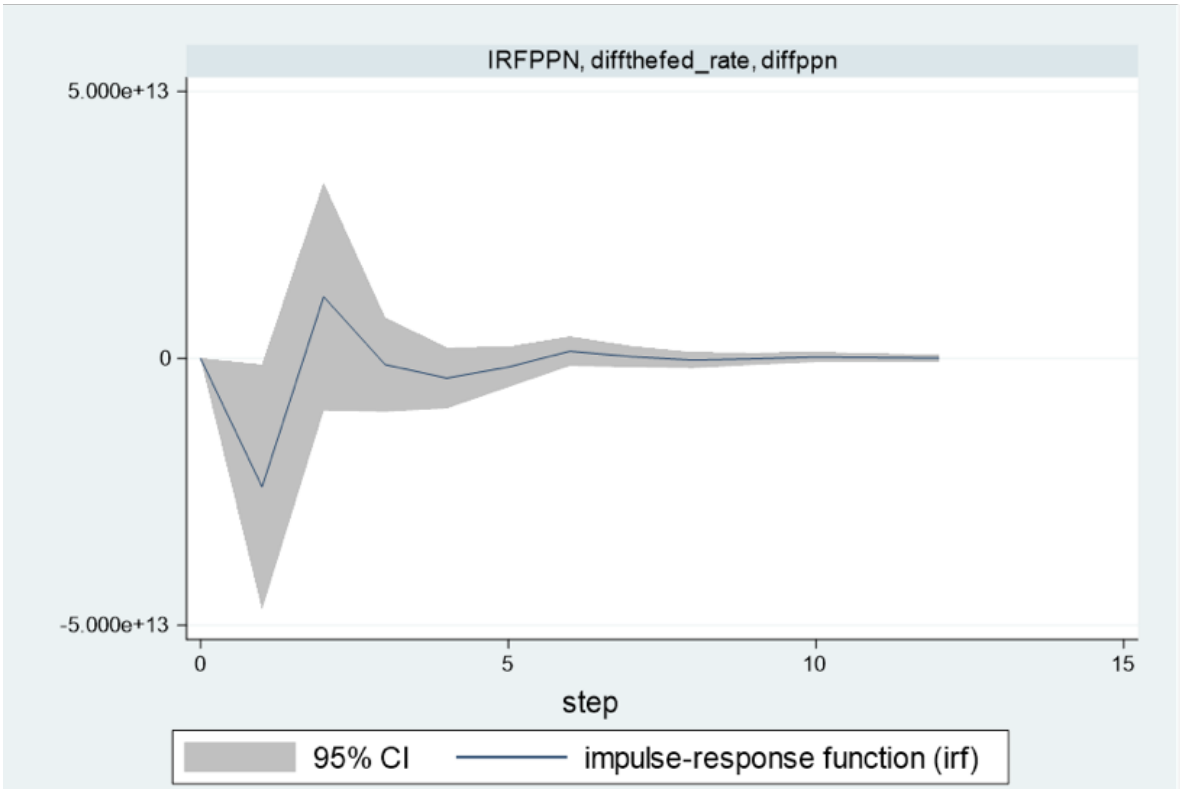
Graphs by irfname, impulse variable, and response variable



Graphs by irfname, impulse variable, and response variable




0
-1.000e+13
-2.000e+13
0
5
10
15
step
95% CI
impulse-response function (irf)
Graphs by irfname, impulse variable, and response variable


IRFPPN, diffthefed_rate, diffppn
5.000e+13
0
-5.000e+13
0
5
10
15
step
95% CI
impulse-response function (irf)
Graphs by irfname, impulse variable, and response variable


IRFPPN, diffoilprice, diffppn
5.000e+11

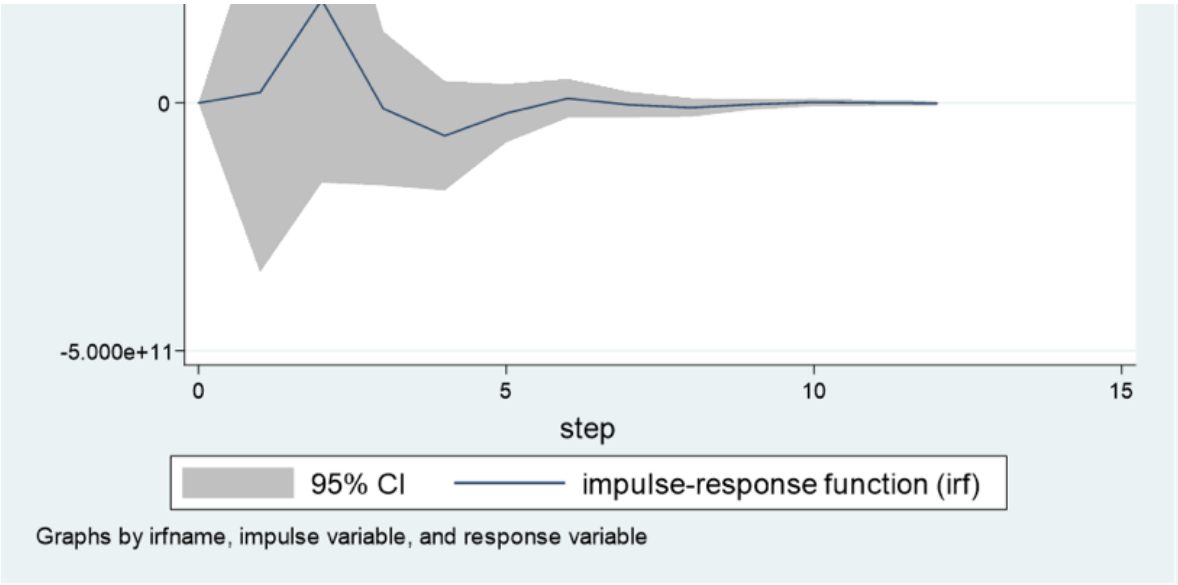


Figure 9. Impulse response function of VAT.

From the variance decomposition, VAT can be explained by the VAT itself by 93 percent and by the Fed rate by 3%. On the other hand, the other variables are less meaningful for VAT.

Table 5. Variance decomposition of VAT

Period	VAT	Inflation	Exchange rate	BI rate	The Fed rate	Oil price
0	0	0	0	0	0	0
1	1	0	0	0	0	0
2	0.963	0.000	0.014	0.000	0.023	0.000
3	0.937	0.000	0.021	0.003	0.031	0.007
4	0.937	0.001	0.022	0.003	0.031	0.007
5	0.935	0.001	0.022	0.003	0.032	0.007
6	0.934	0.001	0.022	0.003	0.032	0.007
7	0.934	0.001	0.022	0.003	0.032	0.007
8	0.934	0.001	0.022	0.003	0.032	0.007
9	0.934	0.001	0.022	0.003	0.032	0.007
10	0.934	0.001	0.022	0.003	0.032	0.007
11	0.934	0.001	0.022	0.003	0.032	0.007
12	0.934	0.001	0.022	0.003	0.032	0.007

5. Conclusion, Implication, And Limitation

The government, particularly DGT, should build a forecasting model accurately, fast, and consistently. Thus, it is necessary to have a model that captures the macroeconomic condition globally and locally.

This paper aims to build a forecasting model using ARDL and VAR methodology, incorporating macroeconomic assumptions. The results show empirical evidence that some macroeconomic variables can be utilized to predict tax revenue, particularly in the short run. In addition, tax revenue itself is considered the most practical variable to explain a particular tax revenue.

These results imply that DGT, as a tax authority in Indonesia, can apply this model to forecast tax revenue accordingly. However, several limitations exist, including the gaps in the dataset, which may influence the model structure and the forecasting results. Thus, an update is required to improve its accuracy.

Appendix

1. **Validation test.**

    1. Stationary test.

        a. Log Non-oil and gas income tax: stationary at level.
        b. Log Oil and gas income tax: stationary at first difference
        c. Log VAT: stationary at level.
        d. Log the other tax: stationary at first difference.
        e. Log PBB: stationary at level.
        f. Exchange rate: stationary at first difference.
        g. Inflation: stationary at level.
        h. BI rate: stationary at first difference.
        i. The Fed rate: stationary at first difference.
        j. Oil price: stationary at first difference.

    2. Optimal lag test.

        To get the optimal lag, AIC criteria was used.

    3. Boundtest.

        This test was used to know whether the variables were cointegrated.

        a. Non-oil and gas income tax model: No cointegration.
        b. VAT model: cointegrated.
        c. Oil and gas model: cointegrated.
        d. The other tax model: cointegrated.
        e. PBB model: cointegrated.

            If the results were cointegrated, the model used was the simple ARDL because this model was to predict only in the short run.

    4. Serial correlation and heteroskedaticity test.

a. Non-oil and gas income tax model: no serial correlation; homoskedasticity.
b. VAT model: no serial correlation; heteroskedasticity.
c. Oil and gas model: no serial correlation; homoskedasticity.
d. The other tax model: no serial correlation; heteroskedasticity.
e. PBB model: no serial correlation; heteroskedasticity.

There was no serial correlation in all models. However, VAT, the other tax, and the PBB model suffered from heteroskedasticity.

Almost all of the models were free from heteroskedasticity and serial correlation. Therefore, as the researcher assumed, the model is considered reliable.

2. **Fitted value between the actual value and the prediction.**

1. Non-oil and gas income tax.

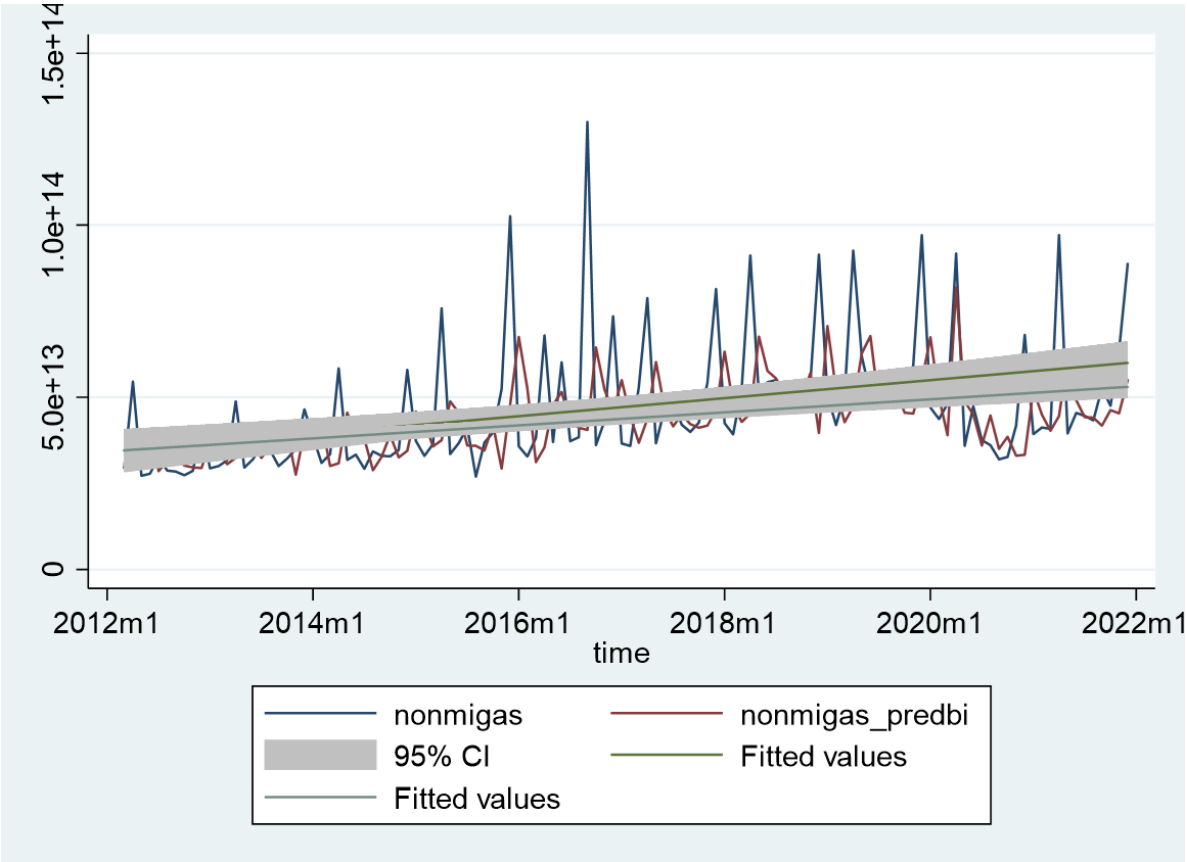


Figure A1. Non-oil and gas income tax (actual value and the prediction). The straight lines are the fitted value with CI 95%.

2. VAT.

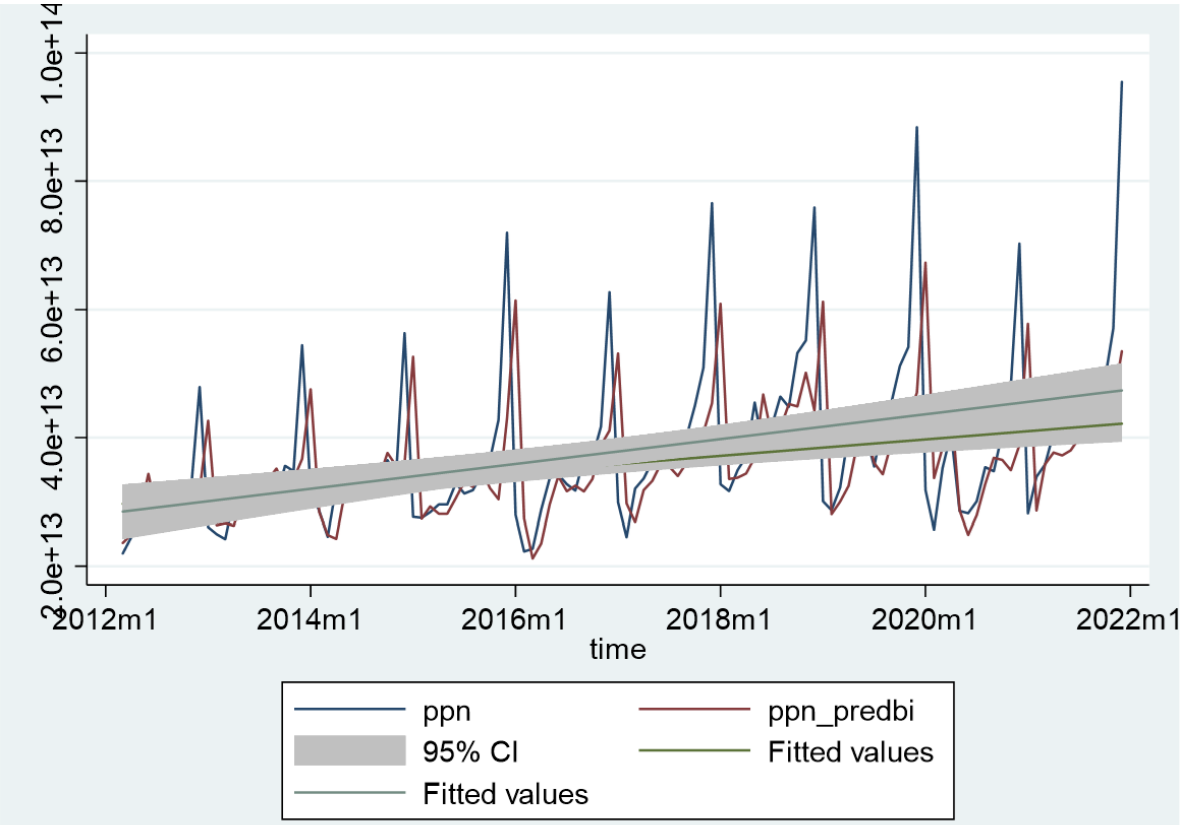


Figure A2. VAT (actual value and the prediction). The straight lines are the fitted value with CI 95%.

3. Oil and gas income tax.

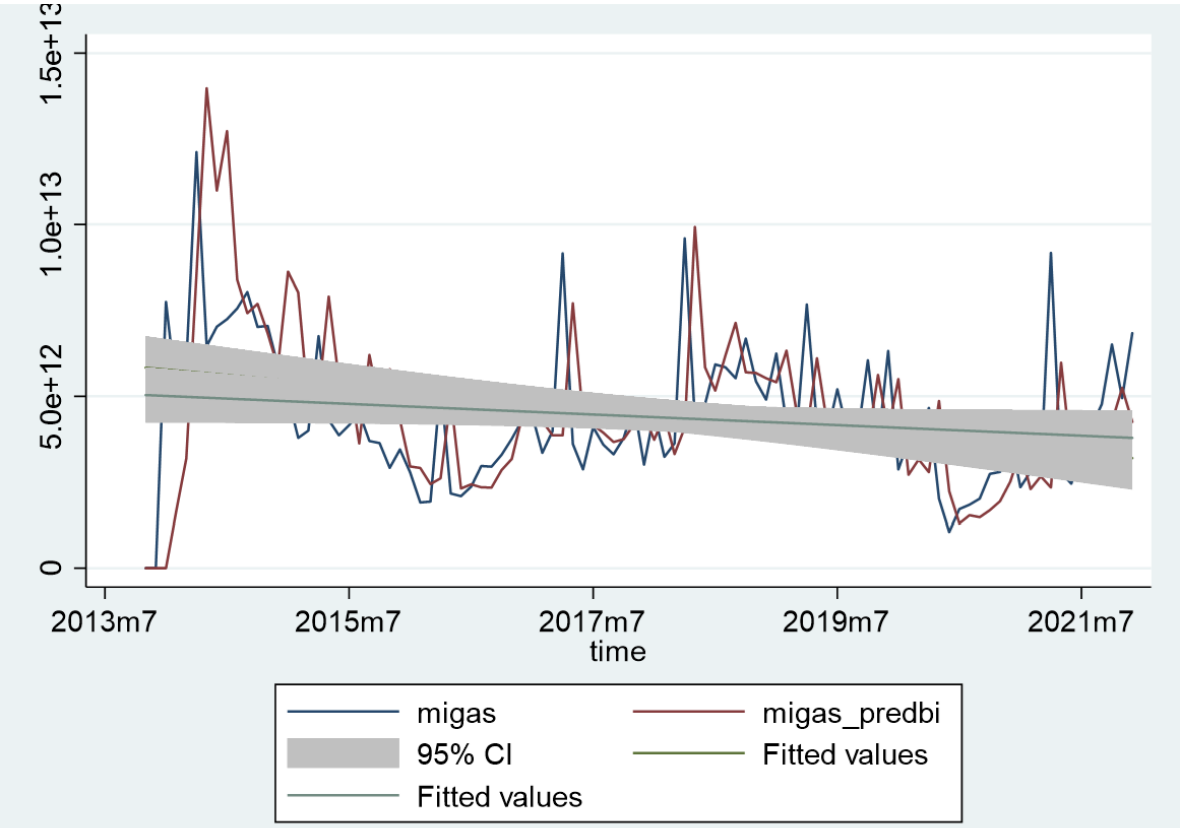


Figure A3. Oil and gas income tax (actual value and the prediction). The straight lines are the fitted value with CI 95%.

4. The other tax

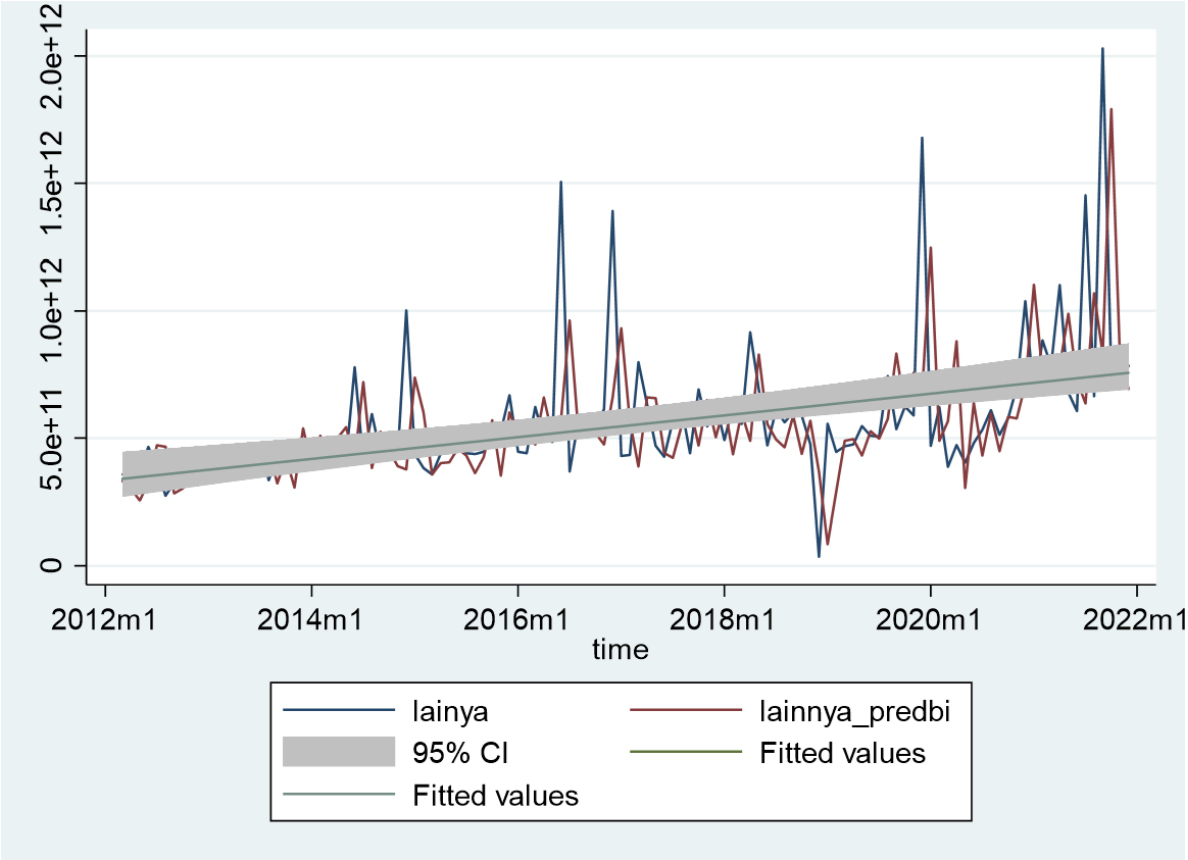


Figure A4. The other income tax (actual value and the prediction). The straight lines are the fitted value with CI 95%.

5. PBB

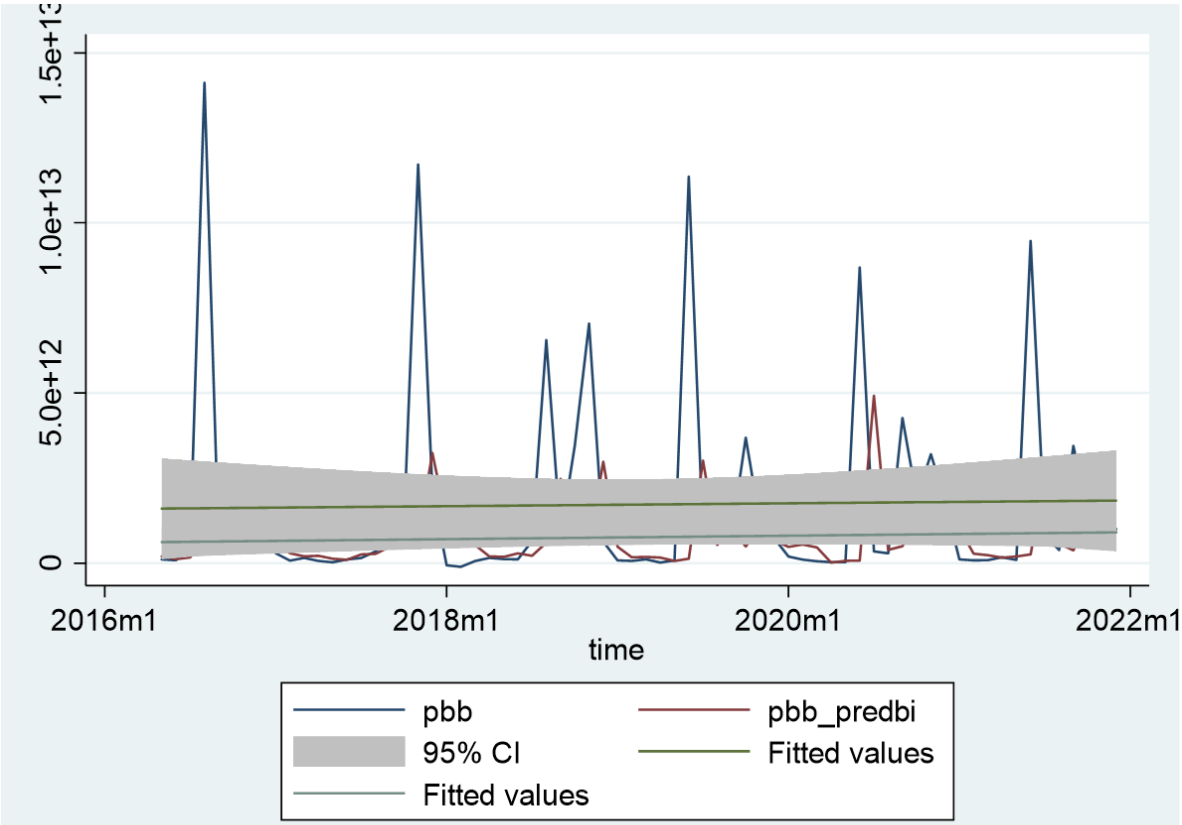


Figure A5. PBB (actual value and the prediction). The straight lines are the fitted value with CI 95%.

Footnotes

[1] Tax revenue was collected from the tax revenue monitoring system of DGT. The dataset was unavailable for certain periods, (exchange rate, inflation, and BI rate); therefore, the observations were only around 130-160 observations.

[2] Inflation and BI rate were from Bank Indonesia (monthly). The data can be downloaded at www.bi.go.id.

Exchange rate (IDR to USD) was from the statistical agency (BPS) (monthly). The data can be downloaded from www.bps.go.id.

The Fed rate and commodity price can be downloaded from https://fred.stlouisfed.org/.

[3] To test whether there was a cointegration or not, a boundtest was applied. The researcher also used Error Correction Model (ECM), should a cointegration in the data exist.

[4] For commodity price, only oil price, as the commodity price variable, was used.

[5] Tax revenue was converted to the logarithm form.

[6] Simple ARDL was used without considering cointegration as the regression was used to predict tax revenue in the short run. However, to test the validity of the results, a stationary test, a boundtest, a serial/autocorrelation test, and

heteroskedasticity test, were applied. Cum test was not available due to the gaps in the dataset. The results of the test can be found in appendix 1.

[7] The fitted value of actual tax revenue and the forecasting is provided in Appendix 2.

[8] The prediction incorporated periods from 2008 due to missing variables in the previous years.

[9] Several types of corporations might have a different methodology to calculate income tax article 25.

[10] The validity of the VAR model was checked. Meanwhile, other variables, such as the stationarity of the variables, the optimum lag, autocorrelation, and the stability of the model, were also analyzed. The results show that this model is stable and does not suffer from autocorrelation.

[11] Only non-oil and gas tax and VAT between the two models were compared. The forecasting difference between these two models was Rp.15,400 Billion; in other words, VAR model predicts 2% higher than the ARDL model.

[12] The researcher conducted tests only on non-oil and gas tax and VAT for impulse response function and variance decomposition as the other tax does not seem to correlate with the other variables.

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