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TVECM TO ANALYZE THE RELATIONSHIP BETWEEN NET FOREIGN ASSETS AND CURRENCY CIRCULATION

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ABSTRACT

In the analytical balance sheet of the base money monetary authority, Bank Indonesia explained that net foreign assets (NFA) affected the circulation of base money, including currency. This gives an assumption regarding the indication of a causal relationship between currency circulation and NFA. In addition to the causality test, the primary purpose of this study is to identify long-term equilibrium relationships between NFA and Currency Circulation. The cointegration test obtained r = 1, indicating cointegration (long-term equilibrium). Time series data plots of these two variables tend to have a trend and are not stationary. The Vector Error Correction Model (VECM) is applied as an analytical method used to correct long-term relationships between variables that are not stationary. However, in the concept of VECM deviation and short-term dynamics, the association is assumed to be linear. At the same time, in applying economics, the relationship between economic variables is not necessarily linear. The significance test for the presence of a threshold using a fixed regressor bootstrap shows a threshold effect or nonlinear VECM, so it is necessary to use an analytical method that can combine nonlinearity and cointegration through the Threshold Vector Error Correction Model (TVECM). In this study, modeling of TVECM 2 regimes and three regimes were carried out. TVECM 3 regimes obtain the best model with two threshold values of -310850 and -260156.

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1. INTRODUCTION

In its application to various economic and financial aspects, monetary policy by the central bank can provide sufficient influence and direction signs to achieve the objectives of economic and financial activity to create stability in the context of economic growth. According to [1], monetary policy, in general, affects the velocity of money, which is reflected in one how the money supply consists of currency (banknotes and coins) and demand deposits (cheques).

The focus of one of the variables used in this study is the amount of currency in circulation as one of the primary money categories or commonly referred to as base money. Cash used by the public as legal tender in circulation is supervised by Bank Indonesia (BI) as the realization of the function of the central bank. In the analytical balance published by BI, the monetary authority for base money, it is explained that net foreign assets (NFA) affect the circulation of base money, including currency. Linearity with the research results of [2] that net foreign assets significantly affect the circulation of base money in Indonesia.

On the monetary authority's balance sheet, the postal amount of NFA is the difference between claims to non-residents and liabilities to non-residents. One of the main factors influencing changes in base money includes currency, namely the pattern of transactions by foreign people, or known as net foreign assets [3].

Based on the presentation above, this supports the assumption that there is a relationship between the amount of currency circulation in Indonesia and the value of net foreign assets, as stated in the balance sheet of the base money monetary authority. One method that can be used in research on relationship analysis with a cointegration approach (long term) is the *Vector Error Correction Model* (VECM), which is the development of the *Vector Autoregression* (VAR) method. The concept of the VAR method considers all variables as endogenous variables, while the independent variables are lag and are designed for stationary variables that do not contain trends. In addition, VAR cannot be used to model time series data that has a long-term relationship or is cointegrated [4]. The VECM concept is different from the VAR model, where the VECM model can be used to model time-series data that has cointegration and is non-stationary.

According to [5], in applying the VECM concept, deviations, and short-term dynamics, the relationship is assumed to be linear (linear VECM). In contrast, in the application of economics, the relationship between economic variables is not always linear. Therefore, if there is a nonlinear relationship between deviations and short-term dynamics, the VECM model is no longer appropriate for interpreting the analysis results of short-term relationships between variables. An alternative to overcome this problem is the application of *threshold* cointegration which can combine nonlinearity and cointegration properties, namely through the Threshold Vector Error Correction Model (TVECM).

Several reviews of previous research that analyzed the relationship using the TVECM method include [6] regarding the analysis of the relationship between the elderly population and the dynamics of employment in China; [7] regarding the study of the relationship between yield spread, macroeconomic factors, and stock market volatility; [5] analyzed the relationship between the amount of Gross Domestic Product and Exports in Indonesia; and [8] regarding market integration analysis between international and domestic rice markets.

Based on the description of the relationship between currency circulation and net foreign assets, the availability of data, as well as the current solution opportunities, the authors are interested and consider it necessary to carry out research using the TVECM method to determine the relationship between currency circulation and net foreign assets in Indonesia during the period January 2015–December 2021 where data on currency circulation and net foreign assets shows a fluctuating pattern and tends to have a trend or nonlinearity.

2. RESEARCH METHODS

This research used a method with steps, formulas, and concepts.

2.1 Data Collection

The data used in this study is secondary data obtained from the Indonesian Economic and Financial Statistics (SEKI) published by Bank Indonesia. Research variables include currency circulation (CC) and net foreign assets (NFA) taken from the base money monetary authority balance sheet for January 2015–December 2021, which will be presented in a time series.

2.2 Stationarity Time Series

Data is a chronological order or series of observations on the observed variables **[9]**. Static test on currency circulation and net foreign assets using the unit root test with the Augmented Dickey-Fuller (ADF) test. If the data is fixed, then a VAR model is formed in-level, but if the data is not stationary, then proceed with differencing the data so it is static. The equation *differencing* one is denoted as,

$$\Delta Y_t = Y_t - Y_{t-1} \tag{1}$$

The equation in the ADF test is formed from the addition of the lag value of the dependent variable ΔY_t. The current data with the previous data, which is denoted by:

$$\Delta Y_t = a_0 + \delta Y_{t-1} + \sum_{i=1}^{p} a_i \, \Delta Y_t + u_t \tag{2}$$

where u_t are the residual value of the ADF equation, and δ is the first lag parameter (Y_{t-1}). The ADF test hypothesis is written as,

H_0 : $= 0$ (non-stationary data)

H_1 : < 0 (stationary data)

with the test statistic used:

$$\tau_{statistic} = \frac{\hat{\delta}}{SE(\hat{\delta})} \tag{3}$$

where, $SE(\hat{\delta})$ The standard error. The test criteria are if the $\tau_{statistic} < \tau_{5\%}$ of the Mackinnon table or when the $p - value < \alpha = 0.05$ then reject H_0 which indicates the data is stationary **[5]** or if $\tau_{statistic} < -2.57$, then the decision results are also reject H_0 **[10]**.

2.3 Optimum Lag Selection Criteria

Determining the lag length in forming the VECM model is essential because it can affect the acceptance and rejection of H_0 accuracy of the resulting estimate. If the lag used is too short, the dynamic model cannot fully explain the model, but if the lag is too long, it results in an inefficient estimation because it lacks degrees of freedom. The formula for the four criteria **[5]** is as follows:

$$AIC_p = -2T\left[\ln\left(\hat{\sigma}_p^2\right)\right] + 2p \tag{4}$$

$$SIC_p = \ln\left(\hat{\sigma}_p^2\right) + \frac{[p \ln (T)]}{T} \tag{5}$$

$$HQ_p = \ln\left(\hat{\sigma}_p^2\right) + 2T^{-1} p \ln\, [\ln(T)] \tag{6}$$

$$FPE_p = \hat{\sigma}_p^2 (T-p)^{-1}(T-p) \tag{7}$$

Description:

p : length of the lag
$\hat{\sigma}_p^2$: $(T-p-1)^{-1} \sum_{t=1}^{T} \varepsilon_t^2$
ε_t : model residual
T : number of observations

2.4 Cointegration Test

After testing the static data at the first difference, it is re-tested to determine whether the data are cointegrated or not by cointegrating testing using the Johansen Cointegration Test. If the data are cointegrated, the VAR model formed is the VECM model. If the data is not cointegrated, a VAR in the first difference model will be created.

Test Cointegration test is conducted to determine whether there is a long-term relationship or *long-run equilibrium* between time series data and linear variables [11]. Cointegration testing uses the Johansen cointegration method with the following hypothesis [12]:

H_0 : *rank* cointegration $\leq k$ there is cointegration at the *rank* k)

H_1 : *rank* cointegration $> k$ (there is no cointegration in the *rank* k)

with test statistics using the feature root test (*trace statistic*) [13]:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{k} \ln(1 - \hat{\lambda}_i) \tag{8}$$

Description:
k : number of variables
T : number of observations
$\hat{\lambda}_i$: estimated eigenvalues
r : *rank* cointegration, where the possible sum r is from $r = 0$ to $r = k - 1$.

The test criteria if the value $\lambda_{trace}(r) > \lambda_{trace.5\%}$ then reject H_0, its means there is cointegration *rank* k.

2.5 Vector Error Correction Model (VECM)

At this stage, the estimation of the VECM model must be in a stationary state. The estimation model serves to determine the relationship between the short-term and long-term. VECM has an equation for each variable. The short-term dynamic relationship of a variable in the system is affected by deviations from the long-term balance called the *error correction term* (ECT) or commonly denoted as $W(\beta)$ in the form of the equation:

$$ECT = Y_{1t} - \beta_0 - \beta_1 Y_{2t} - \cdots - \beta_l Y_{lt}.$$

The VECM model in the equation with the change variable until the lag p *is* written with the equation:

$$\begin{bmatrix} \Delta Y_{1t} \\ \Delta Y_{2t} \\ \vdots \\ \Delta Y_{lt} \end{bmatrix}_{l\times 1} = \begin{bmatrix} a_{10} & a_{y1} & a_{11,1} & \cdots & a_{1l,p} \\ a_{20} & a_{y2} & a_{21,1} & \cdots & a_{2l,p} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_{l0} & a_{yl} & a_{l1,1} & \cdots & a_{ll,p} \end{bmatrix} \begin{bmatrix} 1 \\ W_{t-1}(\beta) \\ \Delta Y_{1t-1} \\ \vdots \\ \Delta Y_{lt-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{y1,t} \\ \varepsilon_{y2,t} \\ \varepsilon_{y3,t} \\ \vdots \\ \varepsilon_{yl,t} \end{bmatrix} \tag{9}$$

$$\Delta \boldsymbol{y_t} = \boldsymbol{A^T} \boldsymbol{y_{t-1}}(\boldsymbol{\beta}) + \boldsymbol{u_t} \tag{10}$$

Description:

$\Delta \boldsymbol{y_t}$ $= [\Delta Y_{1t} \Delta Y_{2t} \cdots \Delta Y_{lt}]^{\boldsymbol{T}}$

$W_{t-1}(\beta)$ $= ECT_{t-1}$Is the ECT of the previous period.

$\boldsymbol{y_{t-1}}(\boldsymbol{\beta})$: vector of size $k \times 1$

A : matrix of size $k \times l$

k $= 2 + lp$.

or it can be written as an equation as follows:

$$\begin{aligned} \Delta Y_{1t} &= a_{10} + a_{y1} W_{t-1} + \sum_{i=1}^{p} a_{11,i}\, \Delta Y_{1t-i} + \sum_{i=1}^{p} a_{12,i}\, \Delta Y_{2t-i} + e_{1t} \\ \Delta Y_{2t} &= a_{20} + a_{y2} W_{t-1} + \sum_{i=1}^{p} a_{21,i}\, \Delta Y_{1t-i} + \sum_{i=1}^{p} a_{22,i}\, \Delta Y_{2t-i} + e_{2t}. \end{aligned} \tag{11}$$

2.6 Granger Causality Test

This test aims to determine the causal relationship between currency circulation and net foreign assets. With $F_{statistic}$: [5]

$$F_{statistic} = \frac{(RSS_R - RSS_{UR})/_p}{RSS_R/(T-k)}$$

where, RSS_R (restricted residual sum of a square) $= \sum_{t=1}^{n} \varepsilon_{1t}^2$; RSS_{UR} (unrestricted residual sum of a square) $= \sum_{t=1}^{n} \varepsilon_{2t}^2$; p is the length of the lag; T is the number of observations; k is the number of parameters estimated in *unrestricted regression*; ε_{1t} is the residual of the restricted model; and ε_{2t} is the residual of the unrestricted model. Furthermore, the test criteria are determined if $|F_{statistic}| > |F_{a;(k-1);(n-k-p)}|$. Then the null hypothesis is rejected or indicates that there is a causality/cause-effect relationship.

2.7 Threshold Vector Error Correction Model (TVECM)

Before modeling TVECM, perform a significance test for the presence or absence of a threshold with the SupLagrange Multiplier (SupLM) Test. The p-value in the SupLM test was obtained using a fixed regressor bootstrap. If there is a threshold effect, TVECM is appropriate, and if the test threshold effect is insignificant, then the modeling is sufficient to use VECM.

As a method to detect the threshold, the Lagrange Multiplier test is used with the hypothesis [14]:

H_0 : The model is a linear VECM

H_1 : Model is the threshold VECM

The p $-$ value in this study was obtained by applying the concept of the fixed regressor bootstrap with many bootstrap 1000 replications [15] and received using the software RStudio package tsDyn. In describing the bootstrap fixed regressor, if (β, γ) is known, then the test statistic form of the Lagrange Multiplier is,

$$LM(\beta,\gamma) = vec\left(\widehat{\boldsymbol{A}}_{\boldsymbol{1}}(\beta,\gamma) - \widehat{\boldsymbol{A}}_{\boldsymbol{2}}(\beta,\gamma)\right)' \left(\widehat{\boldsymbol{V}}_{\boldsymbol{1}}(\beta,\gamma) + \widehat{\boldsymbol{V}}_{\boldsymbol{2}}(\beta,\gamma)\right)^{-1} \times vec\left(\widehat{\boldsymbol{A}}_{\boldsymbol{1}}(\beta,\gamma) - \widehat{\boldsymbol{A}}_{\boldsymbol{2}}(\beta,\gamma)\right) \quad (12)$$

If (β, γ) is not known, the test statistic cannot be used. As an alternative used, test statistics,

$$SupLM = \underset{\gamma_L \le \gamma \le \gamma_U}{SupLM}(\tilde{\beta}, \gamma) \quad (13)$$

where γ is the threshold, $\tilde{\beta}$ an estimator of the linear VECM cointegration coefficient, γ_L percentile π_0 of ECT_{t-1}, while γ_u percentile $1 - \pi_0$ of ECT_{t-1}. As the function of $LM(\tilde{\beta}, \gamma)$ have not γ known value. Maximize the test statistic equation, and it is necessary to evaluate the grid $[\gamma_L, \gamma_U]$ with the cointegration vector β fixed at a value $\tilde{\beta}$ and fixed regressor bootstrap, determined as follows:

$$SupLM^* = \underset{\gamma_L \le \gamma \le \gamma_U}{Sup}\, vec\left(\widehat{\boldsymbol{A}}_{\boldsymbol{1}}(\gamma)_b - \widehat{\boldsymbol{A}}_{\boldsymbol{2}}(\gamma)_b\right)'\left(\widehat{\boldsymbol{V}}_{\boldsymbol{1}}(\gamma)_b - \widehat{\boldsymbol{V}}_{\boldsymbol{2}}(\gamma)_b\right)^{-1} \times vec\left(\widehat{\boldsymbol{A}}_{\boldsymbol{1}}(\gamma)_b - \widehat{\boldsymbol{A}}_{\boldsymbol{2}}(\gamma)_b\right) \quad (14)$$

where $\hat{A}_1(\gamma)_b$ and $\hat{A}_2(\gamma)_b$ are the coefficient matrix estimates, $\hat{V}_1(\gamma)_b$ and $\hat{V}_2(\gamma)_b$ is called The Eicker-White covariance matrix estimator for $vec\hat{A}_1(\gamma)_b$ and $vec\hat{A}_2(\gamma)_b$.

According to [14], the approximation generated by the distribution $SupLM^*$ has valid results against the SupLM distribution. This distribution is unknown but can be calculated using the simulation then obtained $p - value$.

[14] proposed a likelihood to estimate the value β and threshold γ_j, where $j = 1$ to $l - 1$ and l is the number of TVECM model regimes with two variables, as follows:

$$L_n = -\frac{n}{2}\ln\left|\hat{\Sigma}(\beta, \gamma_j)\right| - \frac{2n}{2} \quad (15)$$

The general forms of TVECM 2 regimes and three regimes are as follows [14] and [16]:

1) TVECM 2 Regimes (16)

$$\Delta Y_{1t} = \begin{cases} \Delta Y_{1t} = a_{110} + a_{y11}(Y_{1t-1} - \beta_0 - \beta_1 Y_{2t-1}) + \sum_{i=1}^{p} a_{111,i}\Delta Y_{1t-i} + \sum_{i=1}^{p} a_{112,i}\Delta Y_{2t-i} + \varepsilon_{11,t}, jika\ W_{t-1}(\beta) \le \gamma \\ \Delta Y_{1t} = a_{210} + a_{y21}(Y_{1t-1} - \beta_0 - \beta_1 Y_{2t-1}) + \sum_{i=1}^{p} a_{211,i}\Delta Y_{1t-i} + \sum_{i=1}^{p} a_{212,i}\Delta Y_{2t-i} + \varepsilon_{21,t}, jika\ W_{t-1}(\beta) > \gamma \end{cases}$$

$$\Delta Y_{2t} = \begin{cases} \Delta Y_{2t} = a_{120} + a_{y12}(Y_{1t-1} - \beta_0 - \beta_1 Y_{2t-1}) + \sum_{i=1}^{p} a_{121,i}\Delta Y_{1t-i} + \sum_{i=1}^{p} a_{122,i}\Delta Y_{2t-i} + \varepsilon_{12,t}, jika\ W_{t-1}(\beta) \le \gamma \\ \Delta Y_{2t} = a_{220} + a_{y22}(Y_{1t-1} - \beta_0 - \beta_1 Y_{2t-1}) + \sum_{i=1}^{p} a_{221,i}\Delta Y_{1t-i} + \sum_{i=1}^{p} a_{222,i}\Delta Y_{2t-i} + \varepsilon_{22,t}, jika\ W_{t-1}(\beta) > \gamma \end{cases}$$

2) TVECM 3 Regimes (17)

$$\Delta Y_{1t} = \begin{cases} \Delta Y_{1t} = a_{110} + a_{y11}(Y_{1t-1} - \beta_0 - \beta_1 Y_{2t-1}) + \sum_{i=1}^{p} a_{111,i}\Delta Y_{1t-i} + \sum_{i=1}^{p} a_{112,i}\Delta Y_{2t-i} + \varepsilon_{11,t}, jika\ W_{t-1}(\beta) \le \gamma_1 \\ \Delta Y_{1t} = a_{210} + a_{y21}(Y_{1t-1} - \beta_0 - \beta_1 Y_{2t-1}) + \sum_{i=1}^{p} a_{211,i}\Delta Y_{1t-i} + \sum_{i=1}^{p} a_{212,i}\Delta Y_{2t-i} + \varepsilon_{21,t}, jika\ \gamma_1 < W_{t-1}(\beta) \le \gamma_2 \\ \Delta Y_{1t} = a_{310} + a_{y31}(Y_{1t-1} - \beta_0 - \beta_1 Y_{2t-1}) + \sum_{i=1}^{p} a_{311,i}\Delta Y_{1t-i} + \sum_{i=1}^{p} a_{312,i}\Delta Y_{2t-i} + \varepsilon_{31,t}, jika\ W_{t-1}(\beta) > \gamma_2 \end{cases}$$

$$\Delta Y_{2t} = \begin{cases} \Delta Y_{2t} = a_{120} + a_{y12}(Y_{1t-1} - \beta_0 - \beta_1 Y_{2t-1}) + \sum_{i=1}^{p} a_{121,i}\Delta Y_{1t-i} + \sum_{i=1}^{p} a_{122,i}\Delta Y_{2t-i} + \varepsilon_{12,t}, jika\ W_{t-1}(\beta) \le \gamma_1 \\ \Delta Y_{2t} = a_{220} + a_{y22}(Y_{1t-1} - \beta_0 - \beta_1 Y_{2t-1}) + \sum_{i=1}^{p} a_{221,i}\Delta Y_{1t-i} + \sum_{i=1}^{p} a_{222,i}\Delta Y_{2t-i} + \varepsilon_{22,t}, jika\ \gamma_1 < W_{t-1}(\beta) \le \gamma_2 \\ \Delta Y_{2t} = a_{320} + a_{y32}(Y_{1t-1} - \beta_0 - \beta_1 Y_{2t-1}) + \sum_{i=1}^{p} a_{321,i}\Delta Y_{1t-i} + \sum_{i=1}^{p} a_{322,i}\Delta Y_{2t-i} + \varepsilon_{32,t}, jika\ W_{t-1}(\beta) > \gamma_2 \end{cases}$$

The last step of this research is to compare the smallest AIC and SSR values from TVECM with one threshold and TVECM with two thresholds to get the best model.

3. RESULTS AND DISCUSSION

As the initial step of the research, data collection was carried out for NFA and CC, which then visualized the data into a graph plot to make it easier to identify data patterns. The following is a graph of data on net foreign assets and currency circulation in Indonesia.

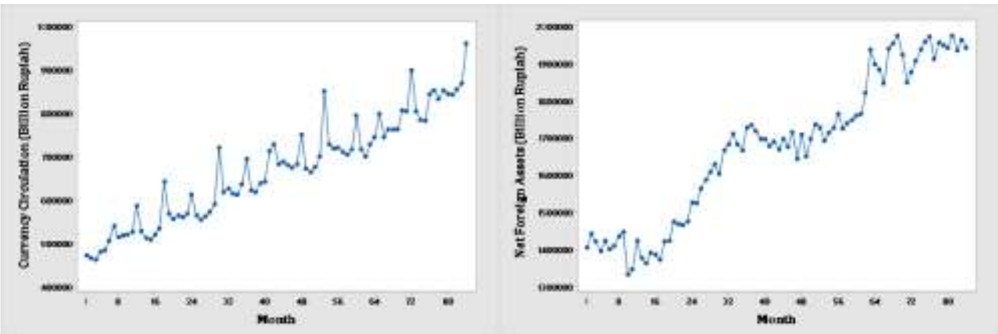

Figure 1. Data Plot of Time Series Currency Circulation (left) and Net Foreign Assets (right)

The currency circulation for the 2015–2021 period fluctuates monthly and tends to increase annually. Currency circulation data also shows a spike in certain months, such as the fasting month to the Eid Al-Fitr holidays, which occurred in July 2015, June in 2016–2018, and May in 2019–2021. In addition, data spikes occur in December every year due to Christmas and the end of the year. Meanwhile, net foreign assets data fluctuates monthly but tends to increase from 2015 to 2021. After knowing the data plots of the two variables, the next step is to test for stationarity using the ADF test, which is presented in **Table 1**.

Table 1. ADF Stationarity Test

Variable	Level		First Difference	
	$\tau_{statistic}$	$\tau_{5\%}$	$\tau_{statistic}$	$\tau_{5\%}$
Currency Circulation	1.144	-2.902	-4.147	-2.902
Net Foreign Assets	-0.568	-2.897	-11.329	-2.897

Based on **Table 1**, the two variables at the level are not stationary because $\tau_{statistic} > \tau_{table}$ or fail to reject H_0. While the results of the ADF test on *differencing* 1, the two research variables have met the stationarity of the data due to the $\tau_{statistic} < \tau_{table}$.

The lag of one variable affects other variables for how long. The next step is testing the optimum lag. The decision criteria for determining the optimum lag are based on the FPE, AIC, SC, and HQ requirements, and the optimum lag results from this test are lag two, as presented in **Table 2**.

Table 2. Summary of Optimum Lag Test Results based on FPE, AIC, SC, HQ

Lag	FPE	AIC	SC	HQ
0	9.35×10^{19}	51.66056	51.72054	51.68459
1	2.90×10^{18}	48.18691	48.36687	48.25901
2	2.56×10^{18}*	48.06133*	48.36126*	48.18149*
3	2.59×10^{18}	48.07146	48.49136	48.23969
4	2.67×10^{18}	48.10297	48.64285	48.31926
5	2.57×10^{18}	48.06357	48.72341	48.32792

Note:*minimum value

Before doing VECM modeling, it is necessary to carry out a cointegration test through a trace test which the cointegration test results are presented in **Table 3**.

Table 3. Summary Cointegration Test Results for CC and NFA Variables

$H_0: r$	$H_1: r$	Trace Statistic Value	Critical value (5%)	P-Value
There is no cointegration ($r = 0$)	There is cointegration ($r \neq 0$)	19.23466	15.49471	0.0130
$r \leq 1$	$r > 1$	0.026345	3.841466	0.8710

Based on the first test, the statistical trace value is 19.23466 greater than the critical value of 15.49471, so that H_0 rejected, indicating that there is cointegration of the tested variables. Then proceed to test the second hypothesis, where the *trace* is 0.026345 smaller than the critical value of 3.841466 so that H_0 accepted, indicating that the cointegration rank is 1. This result concludes that currency circulation and net foreign assets have a cointegration or long-run equilibrium relationship. Therefore, identification can be continued using the VECM (2) model parameter estimation with the parameter coefficient results presented in **Table 4** and **Table 5**.

Table 4. VECM (2) Parameter Coefficient Estimation Results for Currency Circulation

ΔCC_t				
Variable	**Coefficient**	**T-statistics**	**Critical Value T-Test**	**Statement**
ECT_{t-1}	-0.493	-3.958	1.989	Significant
ΔCC_{t-1}	-0.154	-1.232	1.989	Not Significant
ΔCC_{t-2}	-0.104	-0.910	1.989	Not Significant

		ΔCC_t		
Variable	**Coefficient**	**T-statistics**	**Critical Value T-Test**	**Statement**
ΔNFA_{t-1}	-0.396	-3.129	1.989	Significant
ΔNFA_{t-2}	-0.219	-1.711	1.989	Significant
C	11381.82	2.425		
$ECT_{t-1} = CC_{t-1} - 0{,}5722NFA_{t-1} + 289123{,}2$				

Table 5. VECM (2) Parameter Coefficient Estimation for Net Foreign Assets

		ΔNFA_t		
Variable	Coefficient	T-statistics	Critical Value T-Test	Statement
ECT_{t-1}	0.243	2.134	1.989	Significant
ΔCC_{t-1}	-0.342	-3.006	1.989	Significant
ΔCC_{t-2}	-0.143	-1.370	1.989	Not Significant
ΔNFA_{t-1}	-0.195	-1.682	1.989	Not Significant
ΔNFA_{t-2}	-0.101	-0.869	1.989	Not Significant
C	10760.56	2.507		
$ECT_{t-1} = CC_{t-1} - 0{,}5722NFA_{t-1} + 289123{,}2$				

so that the VECM equation is obtained,

$$\Delta CC_t = 11381.82 - 0.493ECT_{t-1} - 0.153\Delta CC_{t-1} - 0.104\Delta CC_{t-2} - 0.396\Delta NFA_{t-1} - 0.219\Delta NFA_{t-2} + e_{1t}$$

$$\Delta NFA_t = 10760.56 + 0.243ECT_{t-1} - 0.195\Delta NFA_{t-1} - 0.101\Delta NFA_{t-2} - 0.342\Delta CC_{t-1} - 0.143\Delta CC_{t-2} + e_{2t}$$

The model results show that the ECT_{t-1} significant at ΔCC_t and ΔNFA_t the model indicates the long-term equilibrium [17] between currency circulation and net foreign assets. The coefficient of ECT_{t-1} in the ΔCC_t is -0.493 means that if there is an imbalance in the short term, the circulation of currency will tend to decrease to respond to the inequality that appears, where 0.493 billion rupiahs of imbalance will be corrected per month [5] by currency circulation [17]. While the ECT_{t-1} on the ΔNFA_t is 0.243 means that if an imbalance appears in the short term, the NFA tends to increase to respond to the inequality, and as much as 0.243 billion rupiahs of imbalance will be corrected monthly.

Each ΔCC_t and ΔNFA_t have to lag coefficient, which indicates whether or not the short-term dynamics of currency circulation and net foreign assets are affected by the dynamics of the previous several months [5]. Based on **Table 4**, it is interpreted that every one billion rupiah increase in the rate of change in net foreign assets 1 and 2 in the previous month significantly affects the current decline in currency circulation by 0.396 and 0.219 billion rupiah, respectively. Meanwhile, based on **Table 5**, an increase of one billion rupiahs in the rate of change in currency circulation in the previous period significantly affected the current decline in net foreign assets of 0.342 billion rupiahs. Because there is a variable lag change in net foreign assets, which significantly affects the dynamics of currency circulation and vice versa, the causal relationship is a two-way relationship. The causality relationship of the VECM model follows the results of the Granger Causality test using Eviews 10, which results in the conclusion that the currency circulation variable and net foreign assets have a two-way causality relationship.

The next step, to identify the existence of a threshold on the resulting VECM model, tested the presence of a threshold using the fixed regressor bootstrap. The test results at a significance level of 5% *software*, the test statistic value is 20.599 and with a critical value of 20.081 and $P - value = 0.38 < 5\%$ or rejects H_0. This indicates a significant threshold effect on modeling with CC and NFA variables so that TVECM modeling can be carried out. The modeling carried out in this study consists of TVECM using one threshold (TVECM 2 Regime) and TVECM using two thresholds (TVECM 3 Regime). The presentation in **Table 6** results from data processing using the TVECM 2 regime.

Table 6. Summary of Parameter Coefficient Estimation Results TVECM 2 Regime

Variable	Regime 1		Regime 2	
	ΔCC_t	ΔNFA_t	ΔCC_t	ΔNFA_t
ECT_{t-1}	-0.251	0.07	-0.62	0.079
ΔCC_{t-1}	0.168	-0.629***	-0.58	-0.029
ΔCC_{t-2}	0.016	-0.199	-0.673	0.032
ΔNFA_{t-1}	-0.153	-0.129	-0.434*	-0.412
ΔNFA_{t-2}	0.017	-0.105	-0.477*	-0.165
C	-61381.61	23536,85	-129294.68	30543.43
Threshold value (γ) = -267476,5				

Note:*significant 10%; **significant 5%; ***significant 1%

The division of the regime is based on a threshold value of -267476.5. Regime 1 describes the adjustment behavior of the CC and NFA variables when the deviation in the previous period is ≤ -267476.5. While regime 2 represents the adjustment behavior of the CC and NFA variables when the deviation in the previous period is> -267476.5.

Based on **Table 6**, the results show that there is no significant coefficient of ECT_{t-1}Thus, there is no significant effect of the movement or response of currency circulation and net foreign assets on the long-term balance. In regime 1, the dynamics of currency circulation were not significantly affected by the dynamics of currency circulation and net foreign investments in the previous months. Meanwhile, the dynamics of net foreign assets were only considerably affected by the currency dynamics during the last one-month period. In regime 2, the dynamics of currency circulation are significantly affected by net foreign assets one until 2 of the previous month. Meanwhile, the dynamics of net foreign assets were not greatly influenced by currency circulation and net foreign investments during the last months.

Furthermore, an analysis of the relationship using the TVECM 3 Regime was carried out on the CC and NFA variables, and the results were summarized in **Table 7**.

Table 7. Parameter Coefficient Estimation Results for TVECM 3 Regime

Variable	Regime 1		Regime 2		Regime 3	
	ΔCC_t	ΔNFA_t	ΔCC_t	ΔNFA_t	ΔCC_t	ΔNFA_t
ECT_{t-1}	0.12	1.278**	-0.62	1.288**	-0.923	0.235
ΔCC_{t-1}	0.492	-0.536*	-0.036	-0.626***	-0.45	-0.131
ΔCC_{t-2}	0.233	-0.294	-0.234	0.062	-0.658	-0.056
ΔNFA_{t-1}	-0.054	0.077	-0.271	0.032	-0.354	-0.425*
ΔNFA_{t-2}	-0.038	0.02	0.159	-0.195	-0.425*	-0.15
C	70102.54	438593.14**	-171228.61	365120.68**	-197410.15	70742.58
Threshold value (γ) = -310850 dan -260156						

Note:*significant 10%; **significant 5%; *** significant 1%

Meanwhile, Regime 1 in TVECM 3 Regime explains the adjustment pattern of the research variables during deviations in the previous period ≤ -310850. Meanwhile, Regime 2 presents the adjustment pattern of the research variables when the variation from the last period is > -310850 and ≤ -260156.1. Regime 3 explains the adjustment pattern of research variables when the deviation from the previous period is > -260156.1.

Furthermore, the best model between TVECM with one threshold and TVECM with two thresholds is done by comparing the AIC and SSR values from the two models and presented in **Table 8**.

Table 8. AIC and SSR values of TVECM

Model	AIC	SSR
TVECM 2 Regime	3424.18	180465789055
TVECM 3 Regime	3421.256	151729712066

Based on **Table 8**, the results of the AIC and SSR values in the TVECM 3 Regime model are smaller than TVECM 2 Regime, so it can be concluded that the use of the TVECM 3 Regime model for interpretation of relationship analysis is better than TVECM 2 Regime. The TVECM 3 Regime models produced based on **Table 7** are,

$$\Delta CC_t = \begin{cases} 70102{,}54 + 0{,}12ECT_{t-1} + 0{,}492\Delta CC_{t-1} + 0{,}233\Delta CC_{t-2} - 0{,}054\Delta NFA_{t-1} - 0{,}038\Delta NFA_{t-2} + \varepsilon_{21,t}, \\ ECT_{t-1} \leq -310850 \\ -171228{,}6 - 0{,}62ECT_{t-1} - 0{,}036\Delta CC_{t-1} - 0{,}234\Delta CC_{t-2} - 0{,}271\Delta NFA_{t-1} + 0{,}159\Delta NFA_{t-2} + \varepsilon_{21,t}, \\ -310850 < ECT_{t-1} \leq -260156 \\ -197410{,}15 - 0{,}923ECT_{t-1} - 0{,}45\Delta CC_{t-1} - 0{,}658\Delta CC_{t-2} - 0{,}354\Delta NFA_{t-1} - 0{,}425\Delta NFA_{t-2} + \varepsilon_{21,t}, \\ ECT_{t-1} > -260156 \end{cases}$$

$$\Delta NFA_t = \begin{cases} 438593{,}14 + 1{,}278ECT_{t-1} - 0{,}536\Delta CC_{t-1} - 0{,}294\Delta CC_{t-2} + 0{,}077\Delta NFA_{t-1} + 0{,}02\Delta NFA_{t-2} + \varepsilon_{21,t}, \\ ECT_{t-1} \leq -310850 \\ 365120{,}68 + 1{,}288ECT_{t-1} - 0626\Delta CC_{t-1} + 0{,}062\Delta CC_{t-2} + 0{,}032\Delta NFA_{t-1} - 0{,}195\Delta NFA_{t-2} + \varepsilon_{21,t}, \\ -310850 < ECT_{t-1} \leq -260156 \\ 70742{,}58 + 0{,}235ECT_{t-1} - 0{,}131\Delta CC_{t-1} - 0{,}056\Delta CC_{t-2} - 0{,}425\Delta NFA_{t-1} - 0{,}15\Delta NFA_{t-2} + \varepsilon_{21,t}, \\ ECT_{t-1} > -260156 \end{cases}$$

From the TVECM model with three regimes, it can be concluded that in regime one and regime two, the coefficient value of ECT_{t-1} in the ΔNFA_t model is significant at a significance level of 5%. The coefficient ECT_{t-1} model ΔNFA_t regime 1 is 1.278, meaning that if an imbalance appears in the short term is ≤-310850, the NFA tends to increase to respond to the inequality that appears. While the coefficient ECT_{t-1} at ΔNFA_t model in regime 2 is 1.288, meaning that if in the short term an imbalance appears >-310850 and ≤-260156.1, then NFA will tend to increase to respond to an imbalance. The coefficient ECT_{t-1} in the ΔCC_t model is insignificant, meaning that the given reaction does not significantly affect the creation of long-term equilibrium.

In regime 1 and regime 2, the dynamics of currency circulation were not significantly affected by the dynamics of currency circulation and net foreign assets in the previous months. Meanwhile, the dynamics of net foreign assets in regimes 1 and 2 were significantly influenced by currency 1 for the last month. This shows that in regime 1, every one billion rupiah increase in the rate of change in currency 1 in the previous period significantly affects the current decrease in net foreign assets by 0.536 billion rupiahs and 0.626 billion rupiahs in regime 2. So if there is an imbalance in Regimes 1 and 2, the short-term causality is that changes in currency circulation affect changes in net foreign assets.

In regime 3, the lag variable that significantly affects the dynamics of currency circulation is the change of NFA in the two previous month periods. This shows that every one billion rupiah increase in the rate of change in net foreign assets over the last two periods significantly affects the current currency decline of 0.425 billion rupiahs. Meanwhile, the lag variable that significantly affects the dynamics of the NFA is the change in the NFA in the previous one-month period, which means that every one billion rupiah increase in the rate of change in the NFA during the last period significantly affects the current NFA decrease of 0.425 billion rupiahs. Therefore, it can be concluded that the short-run causality that appears in Regime 3 is that net foreign assets affect currency circulation.

4. CONCLUSIONS

The TVECM 3 regime model (two thresholds) is better due to the lower AIC and SSR values than the TVECM 2 regime (one threshold). The TVECM 3 Regime modeling resulted in a threshold value of -310850 and-260156. A negative sign in the threshold value means that the resulting threshold value is under the balanced state (ECT<0), where ECT is the disequilibrium error value. The existence of these two thresholds divides the region into three regimes. Based on the results of the significance test of the coefficient of ECT_{t-1}, in Regime 1 and Regime 2 NFA will tend to increase to respond to the inequality in the short term. In Regime 1 and Regime 2, the short-term causal relationship is that changes in currency circulation affected changes in net foreign assets. Meanwhile, in Regime 3, the short-term causality that occurs is that net foreign assets affect the currency.

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