Chapter 2

Econometric Modeling of the Relationship Among Macroeconomic Variables of Thailand : Threshold Cointegration Model

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There is an evidence of non-linear long-run equilibrium relationship between GDP and macroeconomic variables in Thailand. This paper examines the asymmetries dynamic evidence of Thailand's economy and estimated its relation by a threshold co-integration. We use quarterly data for the period of 1997:3 to 2012:1. The threshold co-integration test was developed by the contribution of Hansen and Seo (2002). The threshold co-integration model confirms the non-linear long-run equilibrium relationship between GDP and macroeconomic variables in Thailand. There exists significantly asymmetric dynamic adjusting processes between GDP and these variables, which has implied that an adjustment process of macroeconomic variables toward equilibrium is highly persistent when an appropriately threshold is reached. There is an adjustment behavior when the threshold is reached, making macroeconomic variables grow faster than GDP in Thailand.

1. Introduction

The objective of this paper is to find the relationship of the joint dynamics of output, unemployment rate, inflation, investment, and interest rate allowing for nonlinear co-integration in Thailand. In order to accomplish this paper, we used the Hansen and Seo (2002) test nonlinear co-integration among macroeconomic variables. From there, we used a threshold VECM (TVECM) model where the nonlinearity arises in the system. There are two reasons to study an asymmetric adjusting behavior among variables. First, there are less attention in the properties of asymmetric of the adjustment process, while the evidence of the asymmetric adjustment of most macroeconomic variables had been found in recent studies. Therefore, omitting an asymmetric adjustment among macroeconomic variables may provide to biased inferences and hence misleading results.

Second, many recent studies have found a nonlinear relationship in macroeconomic variables in Thailand. Consequently, the economy model has a different regime in linear structure form. Therefore, we should estimate the threshold of output in two regimes.

We separate this paper in two parts. First, we considered the model as linear co-integration or nonlinear co-integration. We used the method of the Hansen and Seo (2002) test to investigate the model. The test performed accounting for the nuisance parameter problem severely rejects the linear structure. Second, we estimated the model by TVECM if the test appears as a nonlinear co-integration and then investigate the response of macroeconomic variables as a function of error correction.

2. Literature review

There are many literature of nonlinear models have already been estimated. Several studies use a smooth transition method. Hansen (1997),who fitted a threshold autoregressive (TAR) used it as a model for US unemployment. Caner and Hansen (2001) consider a two-regime TAR(k) model with an autoregressive unit root. They developed an appropriate asymptotic theory, and showed that the joint application of the two tests – for a threshold and for a unit root – which enables one to distinguish between the nonlinear and nonstationary processes. They discovered that the US unemployment rate is a stationary nonlinear TAR. Beaudry and Koop (1993) estimated the GNP growth rates model as a function of the deviation of the current level of GNP. They displayed evidence that supported an asymmetric effect of deviations from the past output on to future economic growth. Pesaran and Potter (1997) showed that the model in Beaudry and Koop (1993) is a special case of a TAR model, and Pesaran-Potter (1997) used the TAR framework to exhibit that the US GNP is subjected to floor and ceiling effects. Koop, Pesaran and Potter (1996) developed methods for impulse response analysis in nonlinear multivariate models and used these methods to a US output and unemployment rate. Balke (1997) used a TVAR model for output growth, inflation, the Fed funds rate and a measure of credit market conditions. He came across that shocks have a larger impact on output when the credit measure is above a threshold, indicating that tight credit regimes multiply shocks more than normal regimes. Altissimo and Violante (2001) estimated a threshold VAR model of output and unemployment in the US. They found that only the unemployment rate behaves nonlinearity.

On a relationship studies between inflation rate and output, Dotsey and Sarte (2000) showed that there is a insignificant long-run inflation–output growth effects. Gylfason and Herbertsson (2001), showed the interaction of inflation and output growth. They found that, inflation via saving, financial development and the government budget deficit tends to impede growth in the long run. Klump (2003) found that inflation can reduce the elasticity of factor substitution. He advise several microeconomic to explain the negative relation between inflation and growth.

3. Testing for threshold co-integration with asymmetric adjustment

The threshold co-integration was introduced by Balke and Fomby (1997) they combine non-linearity and co-integration together. Balke and Fomby (1997) ,point out that the long-run equilibrium relationship should been analytical by a co-integration test while assuming asymmetric adjustment has been apparent. That we know, error-correction model (ECM) describes variables respond to deviations from the equilibrium relationship when variables are co-integrated. This is traditional approaches can be focused on a moving towards the long-run equilibrium for every time period.

Many studies have discussed co-integration with its corresponding error correction model as moving toward a long-run equilibrium. Balke and Fomby (1997) emphasize that the possibility of its movement toward the long-run equilibrium need not occur in every period. Thus, when the equilibrium move toward exceeds a critical threshold, it could be a discrete adjustment to long run equilibrium. Therefore, economic policy makers will use any policy to move the system back to equilibrium. Therefore, threshold co-integration could describe the discrete adjustment to the equilibrium where using the traditional co-integrating does not appropriately explanation.

Balke and fomby (1997) applied many univariate tests (e.g. Hansen, 1996; Tsay, 1998) to examine the co-integrating residual (i.e., the error-correction term) for testing a threshold effect in the model. Forbes et al. (1999), developed a Bayesian estimation for financial arbitrage. Lo and Zivot (2001) test a threshold effect in the model by using a multivariate threshold co-integration model with a known co-integration vector. Hansen and Seo (2002) examined an unknown co-integration vector. In particular, these authors developed a Lagrange multiplier (LM) test for the presence of a threshold effect based on the error-correction term. Hansen and Seo (2002) explained a two-regime threshold co-integration model in a non-linear VECM of order $l+1$ form. That is :

$$\Delta x_t = \begin{cases} A_1' X_{t-1}(\beta)+u_t & if\ w_{t-1}(\beta)\le\gamma \\ A_2' X_{t-1}(\beta)+u_t & if\ w_{t-1}(\beta)>\gamma \end{cases} \quad (1)$$

With

$$X_{t-1}(\beta)=\begin{pmatrix} 1 \\ w_{t-1}(\beta) \\ \Delta x_{t-1} \\ \Delta x_{t-2} \\ \vdots \\ \Delta x_{t-l} \end{pmatrix}$$

Denote x_t is a matrix of time series with p-dimensional I(1). In addition, there is co-integrated with one $p\times 1$ co-integrating vector β. Let $w_t(\beta)=\beta' x_t$ are the I(0) error-correction term. For coefficients matrices A_1 and A_2 explain the dynamics in each the regimes. And, γ is the threshold parameter, while u_t is an error term.

In the threshold model (1) separate to two regimes which the non-linear model depends on below or above the threshold parameter. For indentification of regimes, we have to impose β be normalized. And there is no cost to set one element of β equal to unity in the bivariate system (p=2) in case of one co-integrating vector. Moreover, in case of p>2, we imposes the restriction of corresponding element of x_t into the co-integrating relationship.

For test threshold co-integration, Hansen and Seo (2002) suggested the two heteroskedastic-consistent LM test statistics under linear co-integration in null against the alternative threshold co-integration. It means that no threshold co-integration under the null. So, model (1) become to linear VECM. In case known a priori of true co-integrating vector, the testing statistic is denoted as:

$$Sup\ LM^0 = \underset{\gamma_L \le \gamma \le \gamma_U}{Sup}\ LM\left(\beta_0,\gamma\right) \tag{2}$$

Where the known value β_0 is fixed at unity. And the other case that the test statistic of unknown the true co-integrating vector is denoted as:

$$Sup\ LM = \underset{\gamma_L \le \gamma \le \gamma_U}{Sup}\ LM\left(\tilde{\beta},\gamma\right) \tag{3}$$

Where $\tilde{\beta}$ is calculated from the null estimate of β. In both tests, let $[\gamma_L,\gamma_U]$ is the search region, γ_L is the percentile at π_0 of $\tilde{w}_{t-1}$, and γ_U is the percentile at $(1-\pi_0)$. Andrews (1993) suggests that the good setting π_0 should be belong the interval 0.05 and 0.15. Finally, using 5000 simulation replications of the bootstrap methods procedure to calculate the asymptotic critical values and p-values by Hansen and Seo (2002).

4. Data

All the data in this study are quarterly frequencies and cover the period from 1997Q2 to2011Q2. To find the long run relation of macroeconomic variable, we used a quarterly Thailand data set that include endogenous variables that are real GDP (GDP), inflation rate (inf), investment (INV : calculate from gross capital changing plus gross capital fixed), unemployment rate (un), 3-month interest rate (r). Every variables were collected from Reuter Ecowin. Before providing an analysis on the time series, we should determine integrated order for each variable. We used univariate methods to test for the unit roots and identified the properties of stationary in each time series variable. We investigated the order of integration of all variables by using the Augmented Dickey and Fuller (1979, ADF) and KPSS (Kwiatkowski et al., 1992) tests for examining the existence of unit roots. Note that in the ADF test, testing the hypothesis of unit root is carried out hard to ensure that the hypothesis is rejected. Then, we also used KPSS tests, which can distinguish variables that appear to be stationary and be integrated.

TABLE 1. Test for unit root

Variables	ADF		KPSS	
	Level	First difference	Level	First difference
GDP	2.10021	-3.550753***	0.93269***	0.147753
inf	6.11872***	-	0.07957	-
un	-1.70666	-3.626722***	0.84675***	0.196782
INV	-1.51187	-5.626973***	0.62141**	0.271569
r	-2.55278	-9.52731***	0.58134**	0.055135

Note: 1 '***', '**' denotes significance at 1% level and 5% level respectively.

Table 1 shows the results of the stationary tests in the level and in first difference for all variables. We include a constant and a trend term in these tests. The optimal lag length of each case for the ADF tests is chosen by the Schwarz information criterion (SIC) after testing for first and higher order serial correlation residuals. From table 3, the results of testing for unit roots in the level variables with the ADF test well against the alternative with the KPSS test. For the ADF tests, almost all of them, except for the inflation rate (inf), indicates that accepting the null hypothesis contains a unit root in level, but it appears rejected when the null hypothesis or variables become stationary after taking the first differences. Moreover, the results of the KPSS, null hypothesis is stationary, tests show that the null hypothesis in the level reject most of the variables (except inflation rate) at the 5% significance level, which is a unit root, while the stationary under the null hypothesis is accepted after having the differencing once. Consequently, we suggest that most of the variables are integrated by order I(1) and the inflation rate is integrated by order I(0). Then, we checked the order of lag of variables by LR test statistic (each test at 5% level) and Hannan-Quinn information criterion. The results are shown in table 2.

5. Results

5.1. Results of asymmetric threshold co-integration tests

To examines macroeconomic variables are linear or non-linear co-integrated. We used $Sup\,LM^0$ and $Sup\,LM$ that proposed by Hansen and Seo (2002) for tests of threshold co-integration. We used 5000 simulation replications of bootstrap method to calculate p-values in both of the two tests. We check the lag length of the VAR model by the Akaike and Bayesian information criteria, that the results is lag 1 on the case for co-integration in GDP v.s. interest rate. For co-integration in GDP v.s. inflation, GDP v.s. unemployment, GDP v.s. investment have lag 3. Table 2 reports these tests.

From table 2, the results in testing of threshold co-integration show that at the 10% significant level of the $Sup\,LM$ test (i.e., when the co-integrating vector is estimated), both have co-integration in model GDP and inflation, and model GDP and unemployment. All the while, there is a 5% significant level of the $Sup\,LM$ test for co-integration in GDP and investment, and GDP and interest rate. Therefore, the null hypothesis of linear co-integration is rejected. We would prefer the estimating co-integration vector β rather than fixed it at unity, because of less sufficiently economic information to obtain the co-integration vector of the prior known.

Table 2. Hansen-Seo test of threshold cointegration

Model	lag	sup LM_0	sup LM
GDP v.s. inflation	3		
Test satistic value		25.46863	25.46863
Bootstrap p-values		0.0722	0.0702
Threshold value		0.143303	0.143303
Cointegrating vector estimate		1	0.012197
GDP v.s. unemployment	3		
Test satistic value		24.89094	24.89094
Bootstrap p-values		0.121	0.0938
Threshold value		-0.31681	-0.31681
Cointegrating vector estimate		1	0.058098
GDP v.s. investment	3		
Test satistic value		19.42455	19.42455
Bootstrap p-values		0.6894	0.0434
Threshold value		-0.29819	-0.29819
Cointegrating vector estimate		1	0.041607
GDP v.s. interest rate	1		
Test satistic value		19.65255	19.65255
Bootstrap p-values		0.0132	0.0044
Threshold value		-2.31374	-2.31374
Cointegrating vector estimate		1	-0.07614

Note: 1 '***', '**' denotes significance at 1% level and 5% level respectively.

5.2. Results of the two regime error correction models

From the results of the co-integration tests, we have to estimate two-regime VECM in order to investigate the asymmetric dynamic movement between GDP and macroeconomic variables. The threshold vector error-correction models differ from the vector error-correction models by allowing asymmetric adjustments toward the long-run equilibrium. The result for estimation of the two-regime vector error-correction models for the four combinations between GDP and different macroeconomic variables are given below. In each TVECM equations, the optimal lag orders in each TVECM model are determined by Akaike information criterion (AIC). ObsR1 and ObsR2 represent the percentages of sub-sample on total sample size when the error-correction term is below and above the certain threshold value, respectively. The p-value is reported in parentheses. Moreover, SSR are sum square residual of the model. When we have no formal distribution theory for the parameter estimates and standard errors, these should be interpreted somewhat cautiously.

5.2.1. Model of GDP vs. inflation rate

$$\Delta GDP_t = \begin{cases} 0.627_{(0.5)} - 2.57_{(0.00)}\, w_{t-1} + 0.598_{(0.17)}\, \Delta GDP_{t-1} + 0.36_{(0.14)}\, \Delta \inf_{t-1} + 2.02_{(0.00)}\, \Delta GDP_{t-2} + 0.326_{(0.28)}\, \Delta \inf_{t-2} \\ +1.769_{(0.02)}\, \Delta GDP_{t-3} - 0.485_{(0.2)}\, \Delta \inf_{t-3} + u_{1t},\ w_{t-1} \le 0.143 \\ 0.629_{(0.49)} - 0.86_{(0.17)}\, w_{t-1} + 0.023_{(0.94)}\, \Delta GDP_{t-1} + 0.38_{(0.25)}\, \Delta \inf_{t-1} + 0.266_{(0.25)}\, \Delta GDP_{t-2} + 0.236_{(0.43)}\, \Delta \inf_{t-2} \\ +0.097_{(0.66)}\, \Delta GDP_{t-3} + 0.149_{(0.5)}\, \Delta \inf_{t-3} + u_{1t},\ w_{t-1} \ge 0.143 \end{cases}$$

$$\Delta \inf_t = \begin{cases} -1.54_{(0.05)} - 0.33_{(0.33)}\, w_{t-1} + 0.07_{(0.77)}\, \Delta GDP_{t-1} - 0.63_{(0.00)}\, \Delta \inf_{t-1} + 0.11_{(0.69)}\, \Delta GDP_{t-2} - 1.04_{(0.00)}\, \Delta \inf_{t-2} \\ +0.79_{(0.07)}\, \Delta GDP_{t-3} - 0.4_{(0.07)}\, \Delta \inf_{t-3} + u_{2t},\ w_{t-1} \le 0.143 \\ -0.5_{(0.32)} + 0.47_{(0.17)}\, w_{t-1} - 0.16_{(0.4)}\, \Delta GDP_{t-1} - 0.66_{(0.00)}\, \Delta \inf_{t-1} - 0.095_{(0.45)}\, \Delta GDP_{t-2} - 0.26_{(0.12)}\, \Delta \inf_{t-2} \\ -0.055_{(0.66)}\, \Delta GDP_{t-3} - 0.3_{(0.03)}\, \Delta \inf_{t-3} + u_{1t},\ w_{t-1} \ge 0.143 \end{cases}$$

$ObsR_1$ = 23.2% ; $ObsR_2$ = 76.8%; SSR = 227.4756

The estimated VECM results between GDP and inflation rate are presented above. The estimation of the error-correction term in the VAR, w_{t-1}, indicate the behavior of the gap between GDP and in. From the results, in the first regime of GDP equation, error-correction effects are maximum both in terms of significance and size of the coefficients. On the contrary, it does not appear at the significant level of error-correction. The effects appear in the second regime in GDP equation and both regime in the inflation rate equation.

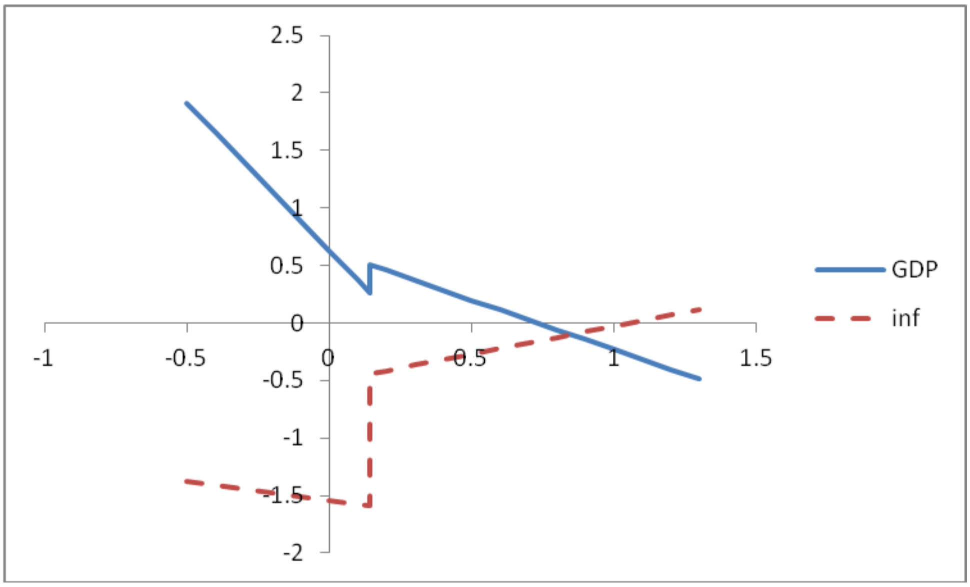

Fig.1 Response of GDP and inflation rate to error correction, 1997:3-2012:1

Figure 1 plots the error-correction effect, the estimated regression response of ΔGDP_t and $\Delta \inf_t$ as a function of w_{t-1} in the previous period when holding the other variables constant. In the figure 1, when the error-correction term is below the threshold value, we can see that there is a sharply error correction effect on the left side of the threshold in GDP equation but a flat error correction effect for inflation rate equation. The speed of adjustment in the error-correction to the response of inflation rate would lead to a stronger positive response when the deviation of inflation rate is below the threshold value. Nevertheless, on the right side of the threshold, the responses of the inflation rate will increase when the error-correction exceeds than a threshold value, while GDP is significant less sharply decreasing than before.

These findings show that the error-correction terms respond more to the inflation rate than GDP when the error-correction exceeds a threshold; thus making the inflation rate efficiency. Under such a regime, inflation rate will diverge from the mean level: this is due to exogenous shocks, such as a debt crisis in Europe market shocks or disaster events. Hence, the government should be careful on how to use a policy for solving or stimulating an economic problem.

5.2.2. Model of GDP vs. unemployment rate

$$\Delta GDP_t = \begin{cases} -\underset{(0.01)}{6.6} - \underset{(0.00)}{12.01} w_{t-1} + \underset{(0.00)}{8.4} \Delta GDP_{t-1} + \underset{(0.02)}{12.53} \Delta un_{t-1} + \underset{(0.00)}{9.95} \Delta GDP_{t-2} - \underset{(0.01)}{8.17} \Delta un_{t-2} \\ + \underset{(0.00)}{10.19} \Delta GDP_{t-3} + \underset{(0.7)}{0.43} \Delta un_{t-3} + u_{1t}, \quad w_{t-1} \le -0.316 \\ -\underset{(0.94)}{0.052} - \underset{(0.36)}{0.527} w_{t-1} - \underset{(0.69)}{0.13} \Delta GDP_{t-1} - \underset{(0.37)}{0.75} \Delta un_{t-1} + \underset{(0.15)}{0.36} \Delta GDP_{t-2} - \underset{(0.82)}{0.1} \Delta un_{t-2} \\ + \underset{(0.75)}{0.067} \Delta GDP_{t-3} - \underset{(0.7)}{0.143} \Delta un_{t-3} + u_{1t}, \quad w_{t-1} \ge -0.316 \end{cases}$$

$$\Delta un_t = \begin{cases} 0.34_{(0.47)} + 0.327_{(0.58)} w_{t-1} - 0.213_{(0.66)} \Delta GDP_{t-1} - 0.7_{(0.47)} \Delta un_{t-1} - 0.29_{(0.61)} \Delta GDP_{t-2} - 0.64_{(0.26)} \Delta un_{t-2} \\ -0.77_{(0.13)} \Delta GDP_{t-3} - 0.22_{(0.45)} \Delta un_{t-3} + u_{2t}, \; w_{t-1} \le -0.316 \\ -0.09_{(0.48)} - 0.066_{(0.53)} w_{t-1} + 0.07_{(0.24)} \Delta GDP_{t-1} - 0.3_{(0.04)} \Delta un_{t-1} - 0.004_{(0.92)} \Delta GDP_{t-2} - 0.77_{(0.00)} \Delta un_{t-2} \\ +0.043_{(0.27)} \Delta GDP_{t-3} - 0.29_{(0.05)} \Delta un_{t-3} + u_{2t}, \; w_{t-1} \ge -0.316 \end{cases}$$

$ObsR_1$ = 16.1% ; $ObsR_2$ = 83.9 %; SSR = 184.0205

The estimated VECM results between GDP and the unemployment rate are presented above. The estimation of the error-correction term in the VAR, w_{t-1}, indicates the behavior of the gap between GDP and in. From the results, only in the first regime of GDP equation, error-correction effects are maximum both in terms of significance and size of the coefficients. On the contrary, it does not appear at the significant level of error-correction. The effects appear in the second regime in GDP equation and both regime in the unemployment rate equation.

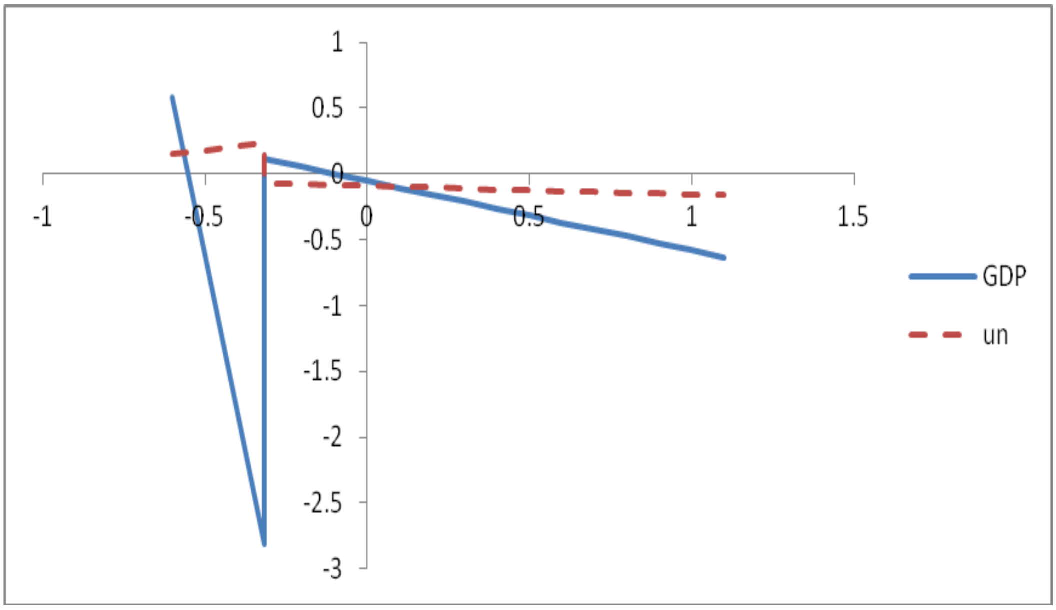

Fig.2 Response of GDP and unemployment rate to error correction, 1997:3-2012:1

Figure 2 plots the error-correction effect, the estimated regression response of ΔGDP_t and Δun_t as a function of w_{t-1} in the previous period when holding the other variables constant. In this figure, when the error-correction term is below the threshold value, we can see that there is a sharp error correction effect in the GDP equation but a very flat error correction effect for unemployment rate equation. Nevertheless, on the right side of the threshold, there is less responses of unemployment rate when the error-correction exceeds than a threshold value. These findings show that the error-correction terms respond less to the unemployment rate when it's in both two regimes. Under such a regime, unemployment rate would be less effected to exogenous shock. So, the management of government policy for decreasing the unemployment rate should concentrate not only on the GDP but also in the labor market.

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5.2.3. Model of GDP vs. investment

$$\Delta GDP_t = \begin{cases} 2.55_{(0.18)} - 3.43_{(0.00)}\, w_{t-1} + 1.76_{(0.00)}\, \Delta GDP_{t-1} - 0.21_{(0.03)}\, \Delta INV_{t-1} + 3.8_{(0.00)}\, \Delta GDP_{t-2} - 0.148_{(0.13)}\, \Delta INV_{t-2} \\ + 2.4_{(0.05)}\, \Delta GDP_{t-3} + 0.133_{(0.39)}\, \Delta INV_{t-3} + u_{1t}, \; w_{t-1} \le -0.298 \\ 0.78_{(0.31)} - 1.05_{(0.09)}\, w_{t-1} + 1.76_{(0.67)}\, \Delta GDP_{t-1} - 0.045_{(0.1)}\, \Delta INV_{t-1} + 0.44_{(0.09)}\, \Delta GDP_{t-2} - 0.42_{(0.06)}\, \Delta INV_{t-2} \\ + 0.25_{(0.29)}\, \Delta GDP_{t-3} - 0.019_{(0.21)}\, \Delta INV_{t-3} + u_{1t}, \; w_{t-1} \ge -0.298 \end{cases}$$

$$\Delta INV_t = \begin{cases} 39.65_{(0.00)} - 8.22_{(0.15)}\, w_{t-1} + 10.77_{(0.01)}\, \Delta GDP_{t-1} - 2.66_{(0.00)}\, \Delta INV_{t-1} + 24.32_{(0.00)}\, \Delta GDP_{t-2} - 2.61_{(0.00)}\, \Delta INV_{t-2} \\ + 18.13_{(0.03)}\, \Delta GDP_{t-3} - 0.44_{(0.67)}\, \Delta INV_{t-3} + u_{2t}, \; w_{t-1} \le -0.298 \\ -6.52_{(0.22)} + 4.5_{(0.29)}\, w_{t-1} + 0.54_{(0.84)}\, \Delta GDP_{t-1} - 0.93_{(0.00)}\, \Delta INV_{t-1} + 4.54_{(0.01)}\, \Delta GDP_{t-2} - 0.93_{(0.00)}\, \Delta INV_{t-2} \\ + 1.9_{(0.21)}\, \Delta GDP_{t-3} - 0.63_{(0.00)}\, \Delta INV_{t-3} + u_{2t}, \; w_{t-1} \ge -0.298 \end{cases}$$

$ObsR_1$ = 17.9% ; $ObsR_2$ = 82.1%; SSR = 809.87

The estimated VECM results between GDP and investment are presented above. From the results, in both regime of GDP equation, error-correction effects are maximum both in terms of significance and size of the coefficients. But the investment equation in both regime error-correction effect are large in effect but does not have much of a significance.

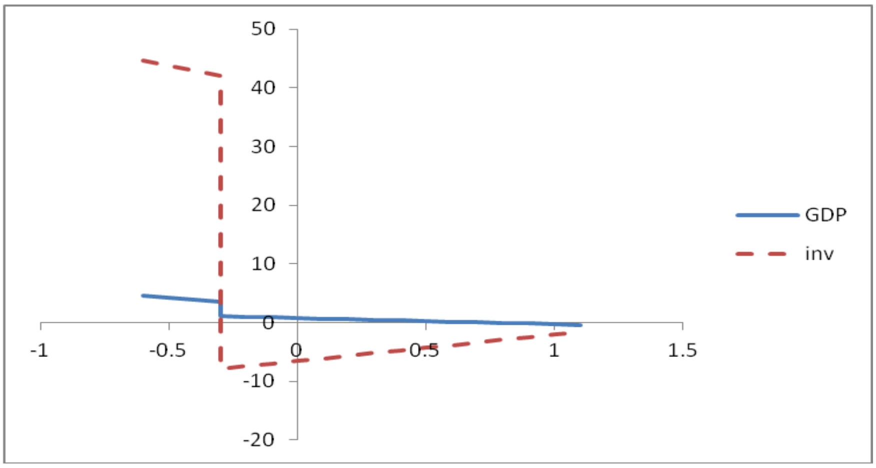

Fig.3 Response of GDP and investment to error correction, 1997:3-2012:1

Figure 3 plots the error-correction effect. The estimated regression has a response of ΔGDP_t and ΔINV_t as a function of w_{t-1} in the previous period when holding the other variables constant. In this figure, when the error-correction term is below the threshold value, we can see that there is a negative direction of error correction effect on both GDP and investment equation. After the threshold value, the speed of adjustment in the error-correction to the response of investment would lead to a stronger positive response. Nevertheless, on the right side of the threshold, the responses of the investment will increase when the error-correction exceeds the threshold value, while GDP is significant less sharply decreasing than before.

These findings show that the error-correction terms respond more to investment than GDP when the error-correction exceeds a threshold, thus making the investment having more efficiency. Under such a regime, investment will converge from the mean level. When there is an of an adjustment converse. Therefore, there are long run equilibrium in investment and GDP.

5.2.4. Model of GDP vs. interest rate

$$\Delta GDP_t = \begin{cases} -31.17_{(0.01)} - 14.85_{(0.03)} w_{t-1} + 8.925_{(0.08)} \Delta GDP_{t-1} - 7.948_{(0.1)} \Delta r_{t-1} + u_{1t}, & w_{t-1} \le -2.313 \\ 0.915_{(0.09)} - 0.855_{(0.00)} w_{t-1} + 0.042_{(0.84)} \Delta GDP_{t-1} - 0.1_{(0.52)} \Delta r_{t-1} + u_{1t}, & w_{t-1} \ge -2.313 \end{cases}$$

$$\Delta r_t = \begin{cases} 42.44_{(0.00)} + 23.74_{(0.00)} w_{t-1} - 17.78_{(0.00)} \Delta GDP_{t-1} + 15.14_{(0.00)} \Delta r_{t-1} + u_{2t}, & w_{t-1} \le -2.313 \\ -0.008_{(0.98)} - 0.078_{(0.73)} w_{t-1} + 0.089_{(0.56)} \Delta GDP_{t-1} - 0.002_{(0.98)} \Delta r_{t-1} + u_{2t}, & w_{t-1} \ge -2.313 \end{cases}$$

$ObsR_1$ = 8.6% ; $ObsR_2$ = 91.4%; SSR = 362.9736

The estimated VECM results between GDP and interest rate are presented above. From the results, both the first regime of GDP and interest rate equation, error-correction effects are large both in terms of significance and size of the coefficients. On the contrary, it is not at the significant level of error-correction effects in the second regime in the interest rate equation.

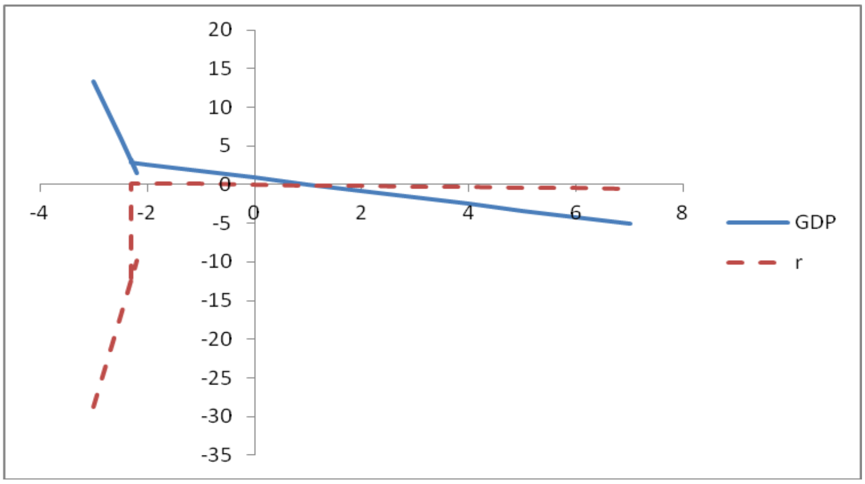

Fig.4 Response of GDP and interest to error correction, 1997:3-2012:1

Figure 4 plots the error-correction effect. The estimated regression has a response of ΔGDP_t and Δr_t as a function of w_{t-1} in the previous period when holding the other variables constant. In this figure, when the error-correction term is below the threshold value, we can see that there is a negative sharply error correction effect in the GDP equation but there is a positive sharply error correction effect for the interest rate equation. After the threshold value, the speed of adjustment in the error-correction to the response of interest rate would lead to a near zero response and less negative response in GDP. These findings show that the error-correction terms respond more to the interest rate than GDP when the error-correction exceeds a threshold, thus making the interest rate having more efficiency. Under such a regime, interest rate will converge from the mean level. When occurrence has exogenous shocks, interest rate responds more than GDP and having more adjustment converse to equilibrium. Thus, using monetary policy to the management of economics should be done with cautious when the economy belongs in the second regime.

6. Concluding remarks

This study examines the non-linear long-run equilibrium relationship between GDP and macroeconomic variables in Thailand, in order to exhibit unfavorable evidence of linear co-integration in the literature. Updated quarterly data for the period of 1997:3 to 2012:1 were analyzed. The threshold co-integration test was developed by the contribution of Hansen and Seo (2002), who concentrated on the possibility of an asymmetric adjusting process among time series variables.

The results from the test reject the null hypothesis of linear co-integration between GDP and among macroeconomic variables. The threshold co-integration model confirms the non-linear long-run equilibrium relationship between GDP and macroeconomic variables in Thailand. There exists a significantly asymmetric dynamic adjusting processes between GDP and these variables in Thailand, thus implying the importance of using a policy. Inflation rate, investment and interest rate are inefficient periods in which these variables have the gap of growing faster than the GDP. It can be captured when these variables exceed a certain threshold level. Policy-makers should create an effective policy system to improve efficiency under disequilibrium regime.
The Thai economy is facing the challenge of making a sustainable management policy to become a disequilibrium of these variables. Fiscal and monetary policy management is a possibly tool to entail actions that influence the quantity or patterns of them for a long run equilibrium.

To promote efficiency of speed adjusting, the bank of Thailand should use the monetary policy to adjust the interest rate and aggregate demand to solve or stimulate the economic growth for equilibrium in the long run. But, for the unemployment rate, it had been less affected by the policy shock. Thus, government should apply caution in the policy for reducing the unemployment rate; not only fiscal and monetary policy but also on creating the attitude towards working behavior for improving productivity. Therefore, investment in education, and research and development are the keys for reducing the unemployment rate. Further study should be added the policy variables such as fiscal policy, monetary policy and trade policy for analysis of these shock effect to macroeconomic variables.

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