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Econometric modeling of the relationship among macroeconomic variables of Thailand: Smooth transition autoregressive regression model

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ABSTRACT

There is evidence of non-linear in macroeconomic variables of Thailand. To understand the behavior of this economic indicators, this paper used the smooth transition autoregressive model (STAR) that was developed by the contribution of Teräsvirta and Anderson (1992). This paper used quarterly data for the period of 1997:3 to 2012:1. The linearity test shows that almost all variables have non-linear behavior with logistic STAR (LSTAR) except in the investment growth rate. The results show that GDP growth rate have suddenly moved from negative to positive on a quarterly period and most of its observation remained in the upper regime. Moreover, inflation rate, unemployment rate, and interest rate are slow in adjustment to reducing their values, and most of them that was based on observation belonged in the lower regime. For investment growth rate, this paper used linear AR(2) model to estimate the parameter and prediction. The results showed that there is tremendous fluctuate movement in the percentile of -30% to 30%.

1. Introduction

Thailand's continuing macroeconomic problem has been caused from many crises that have occurred around the world. For this reason, we want to estimate the accurate parameters which indicate the behavior among macroeconomic variables to capture the business cycle of Thailand. Thus, this study seeks for the suitable methodologies where prediction is at its greatest in the growth rate among macroeconomic variables. Recently, many studies have found nonlinear relationship in macroeconomic variables in Thailand. Consequently, the economic model has a different regime in linear structure form.

The objective of this paper is to inspect the macroeconomic variables of Thailand for studying its behavior and to have a better understanding of this economic indicator, thus giving us a future reference based on the result of our work. Moreover, we want to find out the efficiency of nonlinearity in the macroeconomic variables of Thailand and then evaluate the STAR model to see if it is sufficient enough to be used in the macroeconomic variables. We separated this paper into two parts. First, we considered the model as linear or nonlinear model by linearity test. After that, we used the third order Taylor approximations for choosing between the LSTAR or the ESTAR models. Second, we estimated the model by LSTAR or the ESTAR. Moreover, we evaluated the nonlinear model by the misspecification test.

2. Literature review

The nonlinear models with an observable transition variable of the business cycle have been studied for many years. Tong (1978) and Tong and Lim (1980) suggested for the threshold autoregressive (TAR) model, whereas Chan and Tong (1986) considered in employing the smooth transition variant. Tsay (1989) recommended a threshold autoregressive models with systematic model building. However, Teräsvirta and Anderson (1992) put forward the smooth transition autoregressive (STAR) model as being the better model, because it can explain the variable switch between two regimes smoothly rather than a sudden jump. Tiao and Tsay (1994) rejected linearity against a threshold autoregressive model and then used a two regime threshold autoregressive (TAR) model with the data. Teräsvirta (1994) developed the smooth transition autoregressive (STAR) models. Eitrheim and Teräsvirta (1996) used the STAR model and derived misspecification tests for STAR models.

3. Smooth Transition Autoregressive Models

3.1 The baseline model

Since we found that there was evidence of asymmetries behavior movement in economic regimes, a linear autoregressive models may not be the appropriate model for prediction. Thus, the smooth transition autoregressive (STAR) model in Teräsvirta and Anderson (1992) were considered to examine these movements. Let

$$Y_t = A + B(L)Y_{t-l} + \left[C + D(L)Y_{t-l}\right]F\left(Y_{i,t-d}\right) + u_t \tag{1}$$

Where Y_t represents a time-series vector of macroeconomic variables. A and C are vectors of intercepts, $B(L)$ and $D(L)$ are polynomial matrices of p-th order lag, d is the delay parameter, and u_t follows an independent and identically distributed Gaussian process with zero mean and variance Ω. In addition, the transition function $F(\bullet)$ is the key component of this STAR. $F(\bullet)$ will control the regime switching and the value of $F(\bullet)$ is bounded between zero and one. In case, $F(\bullet)$ is zero, equation (1) becomes a linear AR with parameters A and $B(L)$. On the contrary, when $F(\bullet)$ is one, the model is a different linear AR with parameters $A+C$ and $B(L)+D(L)$. So, $F(\bullet)$ may be interpreted as a criteria function that separates the model between two extreme regimes. If we find the asymmetries movement that can be interpreted economically, we will refer to them as "first regime" and "second regime", respectively.

We consider the two different forms of transition function across these regimes. The first one is the logistic function, stated as:

$$F\left(Y_{i,t-d}\right) = \left\{1 + \exp\left[-\gamma\left(Y_{i,t-d} - c\right)/\sigma\right]\right\}^{-1} \tag{2}$$

Where c is the threshold between two regimes, and σ is the standard deviation of $Y_{i,t-d}$. The second one is the exponential transition function, stated as:

$$F\left(Y_{i,t-d}\right) = 1 - \exp\left[-\gamma\left(Y_{i,t-d} - c\right)^2/\sigma^2\right] \tag{3}$$

When we set the transition function, $F\left(Y_{i,t-d}\right)$ to be a logistic, the first regime changes monotonically to the second regime with transition value $Y_{i,t-d}$. In addition, the transition function becomes a constant when $\gamma \to 0$, and the transition is bounded from 0 to 1 is instantaneous at $Y_{i,t-d} = c$ when $\gamma \to +\infty$. For the exponential function, the system changes symmetrically relative to the threshold c with $Y_{i,t-d}$ but the model turns linear if either $\gamma \to 0$ or $\gamma \to +\infty$. In both models, the smoothness parameter γ, which is restricted to be positive between zero and one, controls the speed of adjustment across regimes.

3.2 Linearity tests and the transition function

The first step is to specify a linear AR model. Although, the true model is nonlinear, the linear specification obtains preliminary results that assist in specifying the maximum lag length p to include in the nonlinear model.

Next, for testing some linearity and model selection, we used Lagrange Multiplier (LM)-type test to test linearity. This value will follow asymptotically a χ^2 distribution with degrees of freedom equal to the number of restrictions that are imposed under the null. Luukkonen, Saikkonen and Teräsvirta (1988), suggest in managing this problem by 'suitable third order Taylor approximations' of the transition function. The problem of testing linearity is reduced to estimating the following auxiliary regression:

$$Y_t = g + G_0 Y_{t-1} + G_1 Y_{t-1} Y_{i,t-d} + G_2 Y_{t-1} Y_{i,t-d}^2 + G_3 Y_{t-1} Y_{i,t-d}^3 + \varepsilon_t \tag{4}$$

The null hypothesis is

$$H_0 : G_1 = G_2 = G_3 = 0 \tag{5}$$

Normally, d is usually restricted to be less than or equal to p. If the null hypothesis is rejected for at least one d , then to find out the appropriate $\hat{d}$ value. We choose the one with the smallest p-value, which also gives the greatest power for the test.
After determining the delay parameter d, the third step is to choose between a logistic and an exponential function. The tests are sequentially applied to the auxiliary regression which has the null hypothesis as the following:

$$\begin{aligned} &H_{01} : G_3 = 0 \\ &H_{02} : G_2 = 0 \mid G_3 = 0 \\ &H_{03} : G_1 = 0 \mid G_3 = G_2 = 0 \end{aligned} \tag{6}$$

The 3 hypotheses are tested with a sequence of F-tests named F1, F2 and F3, respectively. If the rejection of the hypothesis H_{02} is the strongest, Teräsvirta (1998) advises choosing the exponential transition function model. In the case of the strongest rejection of the hypotheses H_{01} or H_{03} , the logistic function will be chosen as the appropriate model. This decision rule is based on expressing the parameter vectors G_1 , G_2 and G_3 from auxiliary regression (6) as functions of the parameters γ , c and the first three partial derivatives of the transition function $F(\bullet)$ at the point $\gamma = 0$.

4. Data

The research operation was conducted at Chiang Mai University, Chiang Mai, Thailand. The data was downloaded from DataStream, Ecowin, and the Internet.

In smooth transition AR models, all the data are quarterly frequencies and cover the periods from 1997Q2 to 2011Q2. We consider the data set of macroeconomic variables that includes the growth rate of GDP (gdp), inflation rate (inf), unemployment rate in difference term (un), growth rate of investment (inv) and 3-month interest rate in difference term (r). Moreover, we checked the unit root of all variables by conducting an ADF-test which show that the results all had a variable that was neither a unit root or I(0). Then, we checked the order on lag of variables by the LR test statistic (each test at 5% level) and Hannan-Quinn information criterion. The result indicates that lag 2 is significant in all variables. Moreover, we used linear AR model to find the maximum lag length *p* that no serial correlation by AIC. The results show the same as the above.

5. Results

We considered the model as linear or nonlinear model from the linearity test. After that, we chose between the LSTAR (logistic smooth transition AR) or the ESTAR (exponential smooth transition AR) models by using the third order Taylor approximations from table 1.

TABLE 1. Results of linearity test and optimal delay parameter

	GDP		inf		un	
Null Hypothesis	d=1	d=2	d=1	d=2	d=1	d=2
H_0	23.1332	19.0641	21.7604	18.8763	16.8040	16.4669
	(0.0008)	(0.004)	(0.0013)	(0.0043)	(0.0007)	(0.0115)
H_{01}	1.1700	-	1.0500	-	1.7900	-
	(0.3194)		(0.3612)		(0.1774)	
H_{02}	2.8700	-	2.3300	-	1.4100	-
	(0.0327)		(0.0686)		(0.2438)	
H_{03}	5.2700	-	4.8700	-	3.3200	-
	(0.0003)		(0.0005)		(0.0079)	

Note : the number in parentheses is p-value

Table 1. (cont.)

Null Hypothesis	inv d=1	inv d=2	r d=1	r d=2
H0	0.9228 (0.63)	4.79 (0.187)	13.501 (0.003)	18.9588 (0.0002)
H01	-	-	-	2.4200 (0.099)
H02	-	-	-	2.1800 (0.085)
H03	-	-	-	3.8700 (0.0031)

Note: the number in parentheses is p-value

From Table 1, the linearity test of all variables indicates that almost all variables except growth rate of investment (inv) have nonlinearity behavior and are mostly significant at d=1 but with an interest rate (r) that is significant at d=2. Furthermore, after performing the sequence of tests H_{01}, H_{02}, and H_{03}. H_{01} is not rejected in all variables. H_{02} is rejected for GDP, inf and r. But if we compare p-value of H_{02} and H_{03} in all variables (except inv), we found that H_{03} in all variable (except inv) is the smallest for p-value. Thus, it indicates that the LSTAR model is an appropriate model for prediction. Then, we estimated the parameters in the LSTAR model which provide the results that are shown below. In the estimated model, Teräsvirta (1994) had suggested standardizing the logistic of $F(\bullet)$by dividing it by $\hat{\sigma}$ (standard deviation of y_t) to make γ scale free. So, the starting value of the standardized γ is been easier to select. For inv variable, we used linear AR model to estimate the parameters. In calculating the characteristic roots of polynomials and modulus for lower ($F(\bullet)=0$) and upper ($F(\bullet)=1$) regimes, we can calculate its value by solving this

$$z^p - \left[\hat{B}(L) + \hat{D}(L)F(\bullet)\right]z^{p-j} = 0 \quad ; \quad F = 0,1 \tag{7}$$

5.1 LSTAR of gdp model

$$\begin{aligned} gdp_t &= -0.036 - 0.000595t + 1.5gdp_{t-1} - 2.05gdp_{t-2} + \\ &\quad (0.08) \quad (0.11) \qquad (0.0002) \quad (0.066) \\ &\quad (0.0584 + 0.000813t - 2.21gdp_{t-1} + 1.75gdp_{t-2}) \times \\ &\quad (0.0536)\ (0.0004) \quad (0.000) \qquad (0.018) \\ &\quad \left\{1 + \exp\left[-9.55(gdp_{t-1} + 0.00115)/0.027049\right]\right\}^{-1} \end{aligned} \tag{8}$$

$$\hat{\sigma} = 0.0271,\ s = 0.02034, AIC = \text{-}451,\ \text{JB}{=}1.163(0.56),\ {}^{se}\!/\!_{se_{linear}} = 0.74$$
$$Root(low) = 0.75 \pm 1.22i, \quad Modulus(low) = 1.43$$
$$Root(up) = -0.35 \pm 0.421i, \ Modulus(up) \ = 0.548$$

The number in parentheses are p-value, $\hat{\sigma}$ is the standard deviation of y_t. s is the standard error of the estimated model. The Jarque-Bera (JB) test does not reject the null hypothesis of residual normality. And ${}^{s_{LSTAR}}\!/\!_{s_{linear}}$ is the ratio of residuals standard error of LSTAR model to residuals standard error of linear AR model which indicates that we can reduce 26% of standard error by transforming the linear AR model into nonlinear LSTAR model.

The threshold value (c) is -0.00115 that lie less than 1st-quartile of its variable. This indicates that most of the observation are in the upper regime of logistic transition function. Additionally, $\hat{\gamma} / \hat{\sigma} = 353.7$, this value indicates that the transition from lower regime to upper regime is very fast: as shown in figure 1. From threshold value that is -0.115%, if the growth rate of GDP in this quarter does not increase, then in the next quarter there are policy to make a sudden adjustment to have the economy increase its GDP. Because most of the observation belongs in the upper regime, it implies only to some few events that displays the GDP growth rate as being negative.

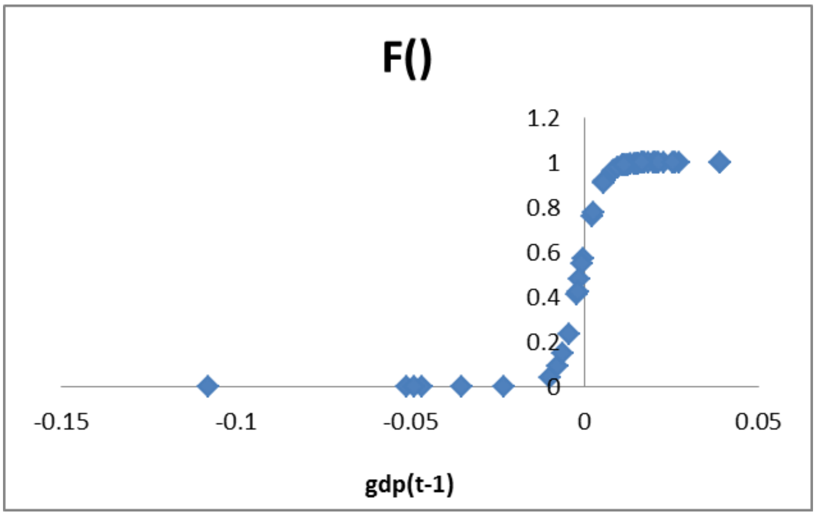


Figure 1: The transition function of estimated LSTAR model against gdp_{t-1}

For roots of characteristic polynomials and modulus, the lower regime show an unstable dynamic model, but the upper regime show a stable dynamic model. This implies that the LSTAR model lacks stability and is limited in forecasting for the long run. But in the short run, it can predict a few quarter in ahead of time.

Additionally, figure 2 shows ACF and PACF of residual which indicate no autocorrelation and partial autocorrelation.

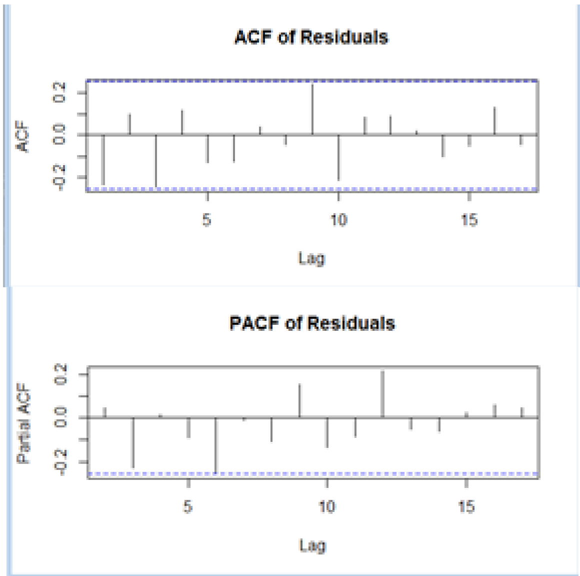


Figure 2: ACF and PACF of residual of gdp variable

Figure 3 shows the estimated LSTAR model being compared with the original data. We found that the LSTAR model fails to fit the data when original data have fallen or occurring in the large exogenous shock to growth rate of GDP; however, we see that the model fits with the original data in the normal period.

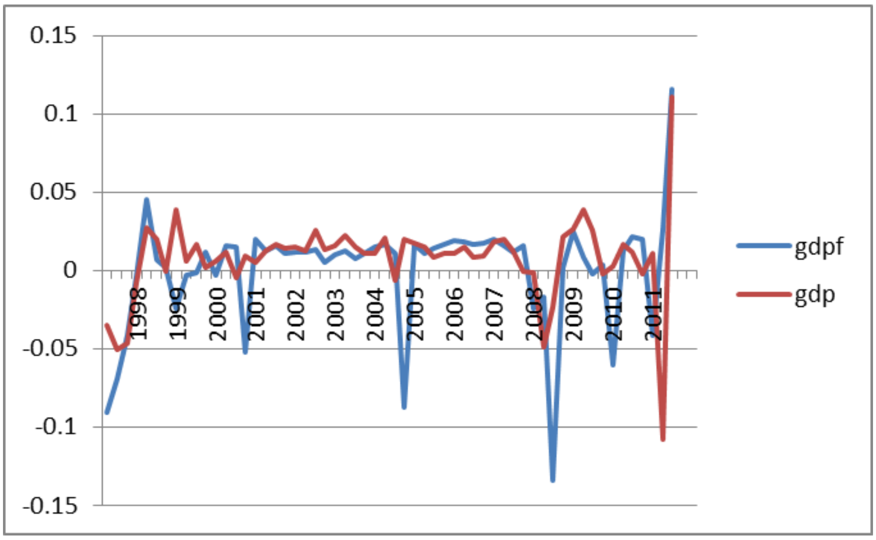


Figure 3: The estimated LSTAR model compared with the original data.

5.2. LSTAR of inf model

$$
\begin{aligned}
inf_t = \; & \underset{(0.504)}{0.206} - \underset{(0.053)}{0.0185}t + \underset{(0.268)}{0.175}\inf_{t-1} - \underset{(0.066)}{0.4655}\inf_{t-2} + \\
& \left(\underset{(0.000)}{3.906} - \underset{(0.0177)}{0.04243}t - \underset{(0.000)}{1.13989}\inf_{t-1} + \underset{(0.018)}{0.4935}\inf_{t-2}\right)\times \\
& \left\{1+\exp\left[-8.765\left(\inf_{t-1}-1.3731\right)/1.308\right]\right\}^{-1}
\end{aligned} \qquad (9)
$$

$$
\begin{aligned}
& \hat{\sigma} = 1.308,\; s = 0.99,\, AIC = 16,\; \text{JB}=2.91(0.23),\; {}^{se}\!/\!{}_{se_{linear}} = 0.79 \\
& Root(low) = 0.08 \pm 0.67i, \quad Modulus(low) = 0.683 \\
& Root(up) = -0.991 \pm 0.027i, \; Modulus(up) = 0.99
\end{aligned}
$$

The number in the parentheses are p-value. The Jarque-Bera (JB) test does not reject the null hypothesis of residual normality. And ${}^{s_{LSTAR}}\!/\!{}_{s_{linear}}$ is equal to 0.79, thus indicating that we can reduce 21% of the standard error by transforming the linear AR model into a nonlinear LSTAR model.

The threshold value (c) is 1.3731 that lies near the 3st-quartile of its variable. This indicates that most of the observation is in the lower regime of logistic transition function. Additionally, $\hat{\gamma}/\hat{\sigma} = 6.7$, this value indicates that the transition from lower regime to upper regime is slow: as shown in figure 4. For a threshold that is 1.373 %, if the inflation rate in this quarter increases over 1.373% then there are policies to reduce its value to a mean value (0.7%). But the policy is not quite fast for adjusteding the inflation rate. This can be attributed to where most of the observation belongs in the lower regime, thus implying that with some few events the inflation rate is large.

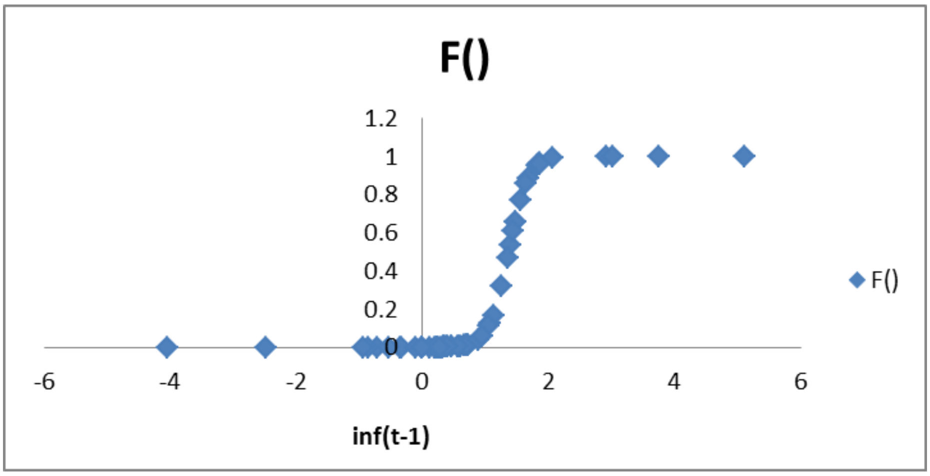


Figure 4: The transition function of estimated LSTAR model against $\inf_{t-1}$

For roots of characteristic polynomials and modulus, the lower regime is stable but the upper regime is unstable. This implies that the LSTAR model can be predicted when $\inf_{t-1}$ is less than the threshold value but is not suitable for prediction when $\inf_{t-1}$ is greater than the threshold value. So, the LSTAR model lacks stability and is limited for forecasting in the long run. But in the short run, it can predict a few quarter in ahead of time.

Additionally, figure 5 shows ACF and PACF of residual which indicate no autocorrelation and partial autocorrelation.

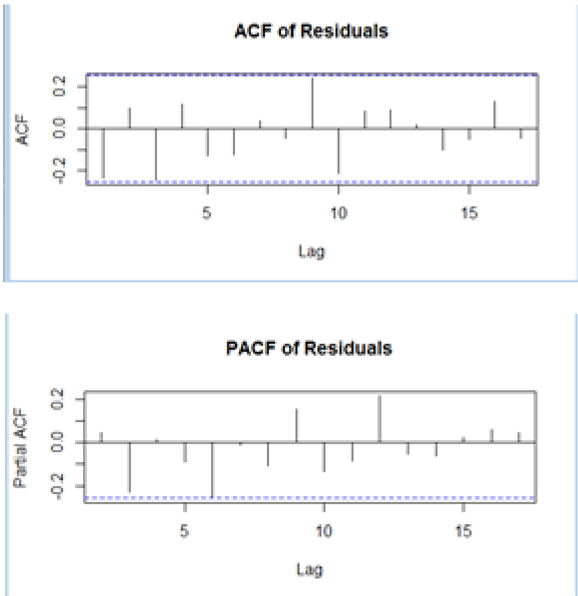


Figure 5: ACF and PACF of residual of inf variable.

Figure 6 shows the estimated LSTAR model compared with the original data. We found that the LSTAR model fits with the data when the original data has a normal period, but the model does not fit with the original data in a crisis period.

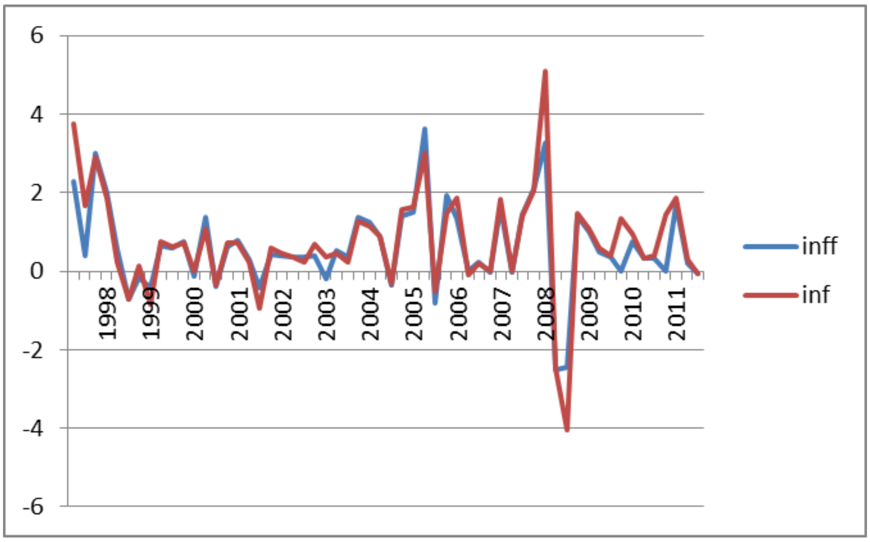


Figure 6: The estimated LSTAR model compared with the original data.

5.3. LSTAR of un model

$$
\begin{aligned}
un_t = & -0.2321 + 0.0025t - 0.293un_{t-1} - 0.7862un_{t-2} + \\
& (0.205) \quad (0.584) \quad (0.018) \qquad (0.000) \\
& (0.0101 - 0.04625t + 1.1497un_{t-1} + 0.2206un_{t-2}) \times \\
& (0.988) \; (0.009) \quad (0.0125) \qquad (0.1873) \\
& \{1 + \exp[-6.899(un_{t-1} - 0.7667)/0.8]\}^{-1}
\end{aligned} \qquad (10)
$$

$$
\begin{aligned}
& \hat{\sigma} = 0.8, \; s = 0.466, AIC = \text{-}75, \text{ JB}=1.39(0.49), \; {}^{se}\!/\!_{se_{linear}} = 0.79 \\
& Root(low) = -0.14 \pm 0.87i, \quad Modulus(low) = 0.88 \\
& Root(up) \; = 0.428 \pm 0.6183i, \; Modulus(up) \; = 0.752
\end{aligned}
$$

The numbers in the parentheses are p-value. The Jarque-Bera (JB) test does not reject the null hypothesis of residual normality. And ${}^{s_{LSTAR}}\!/\!_{s_{linear}}$ is equal to 0.79, which indicates that we can reduce 21% of the standard error by transforming the linear AR model into a nonlinear LSTAR model.

The threshold value (c) is 0.7667 that lies over 3st-quartile of its variable. This indicates that most of the observations are in the lower regime of the logistic transition function. Additionally, $\hat{\gamma}/\hat{\sigma} = 8.6$, this value indicates that the transition from the lower regime to the upper regime is slow; as shown in figure 7. For a threshold that is 0.7667, if the change of unemployment rate in this quarter is greater than 0.7667%, then there are policies to reduce unemployment rate; but the policy is not active enough to reduce it. Because most of the observation belongs in the lower regime, this implies only to few events that the unemployment rate is large.

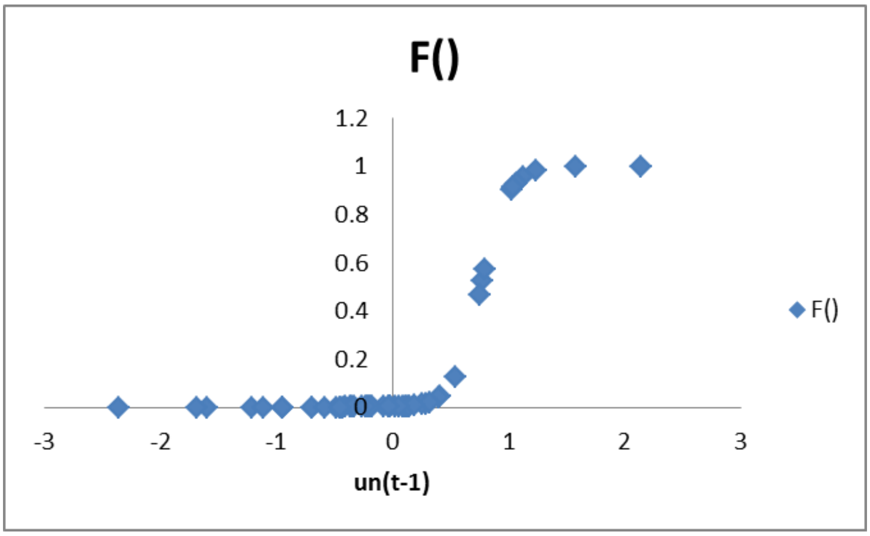
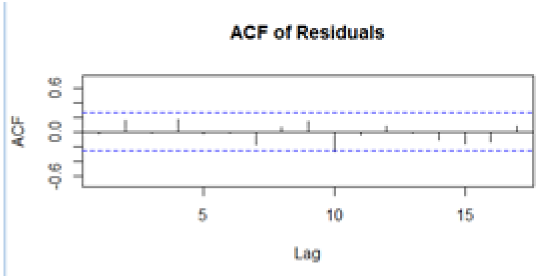


Figure 7: The transition function of estimated LSTAR model against un_{t-1}

For roots of characteristic polynomials and modulus, both of the regimes show a stable dynamic model. This implies that the LSTAR model has stability in long run.

Additionally, figure 8 shows ACF and PACF of residual which indicate no autocorrelation and partial autocorrelation.



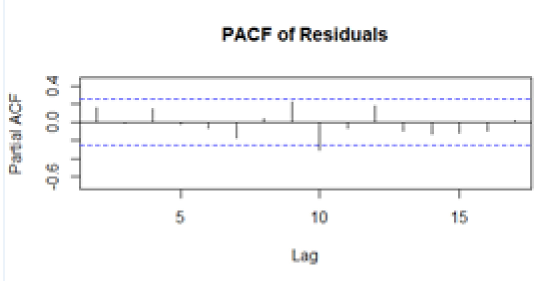


Figure 8: ACF and PACF of residual of un variable.

Figure 9 shows the estimated LSTAR model compared with the original data. We found that the LSTAR model fits with the data when the original data have normal period but model is a little bias with original data in a crisis period.

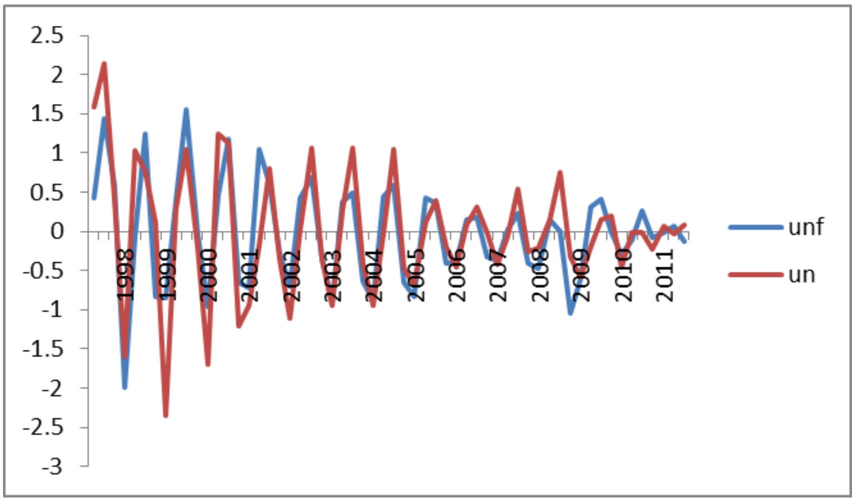


Figure 9: shows the estimated LSTAR model compared with the original data.

5.4. Linear AR of inv model

$$inv_t = \underset{(0.26)}{0.0017} - \underset{(0.04)}{0.266} inv_{t-1} - \underset{(0.055)}{0.256} inv_{t-2} \qquad (11)$$

$$\hat{\sigma} = 0.178,\ s = 0.171, AIC = \text{-}0.638,\ \text{JB}=2.409(0.299)$$
$$Root = -0.14 \pm 0.49i, \quad Modulus(low) = 0.5$$

We used AR(2) model from the smallest AIC criteria. The number in the parentheses is p-value. The Jarque-Bera (JB) test does not reject the null hypothesis of residual normality. For roots of characteristic polynomials and modulus, its value show that linear AR(2) model is a stable dynamic model. Additionally, figure 10 shows ACF and PACF of residual which indicate no autocorrelation and partial autocorrelation.

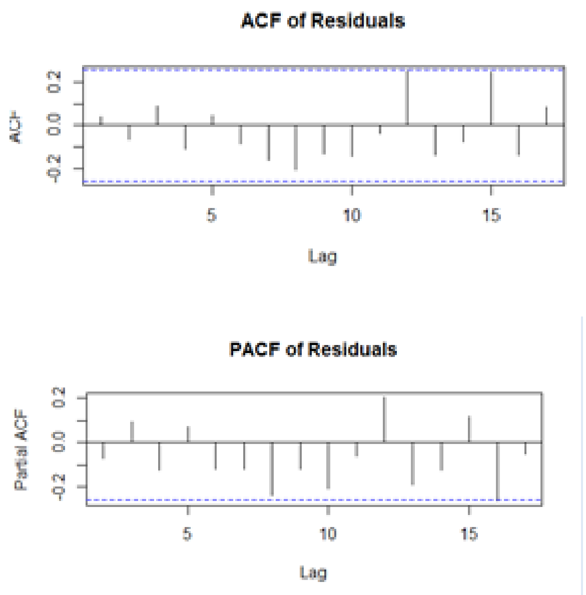


Figure 10: ACF and PACF of residual of inv variable.

Figure 11 shows the estimated linear AR(2) model compared with the original data. We found that the linear AR(2) model almost fits the data when the original data has a normal period; but this model is not suitable with original data in a crisis period. From this figure, investment growth rate has tremendous fluctuation between 30 % to -30 %. Investment is very sensitive when it comes to an economic policy adjustment.

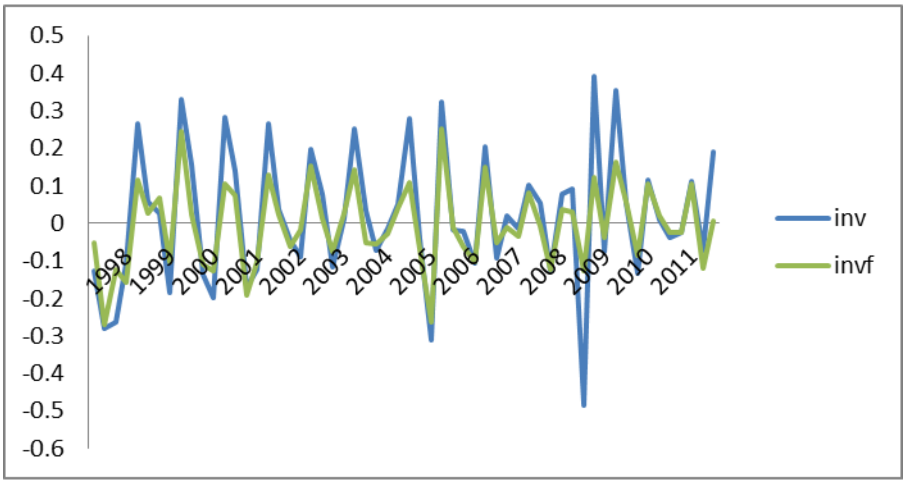


Figure 11: The estimated linear AR(2) model compared with the original data.

5.3. LSTAR of r model

$$
\begin{aligned}
r_t = & -0.372 + 0.00842t + 0.0115r_{t-1} + 0.0585r_{t-2} + \\
& (0.42) \quad (0.494) \quad (0.9207) \quad (0.4725) \\
& (-8.111 + 0.269t + 0.222r_{t-1} - 0.427r_{t-2}) \times \\
& (0.000) \quad (0.000) \quad (0.000) \quad (0.0052) \\
& \{1 + \exp[-8.776(r_{t-2} - 1.075)/2.22]\}^{-1}
\end{aligned} \qquad (12)
$$

$$
\begin{aligned}
& \hat{\sigma} = 2.22,\ s = 1.3,\ AIC = 49,\ \text{JB}=3.6(0.16),\ {}^{se}\!/\!_{se_{linear}} = 0.63 \\
& Root(low) = 0.25 \pm 0.23i, \quad Modulus(low) = 0.34 \\
& Root(up) = 0.117 \pm 0.595i,\ Modulus(up) = 0.6
\end{aligned}
$$

The number in the parentheses is p-value. The Jarque-Bera (JB) test does not reject the null hypothesis of residual normality. And ${}^{s_{LSTAR}}\!/\!_{s_{linear}}$ is equal to 0.63, which indicates that we can reduce 37% of standard error by transforming the linear AR model into a nonlinear LSTAR model.

The threshold value (c) is 1.075 that lies over 3st-quartile of its variable. This indicates that most of the observations are in the lower regime of the logistic transition function. Additionally, $\hat{\gamma}/\hat{\sigma} = 3.95$, this value indicates that the transition from the lower regime to the upper regime is slow; as shown in figure 12. For a threshold that is 1.075, if the change in interest rate in this quarter is greater than 1.075%, then there are policies to reduce the interest rate but the policy is not active enough to reduce it. Because most of the observation stays in the lower regime, this implies to few events that the interest rate is large.

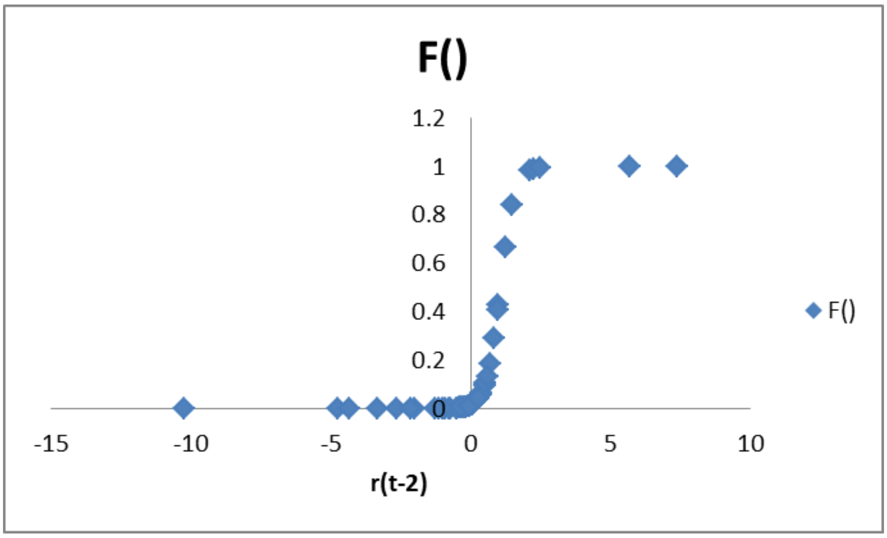


Figure: 12 The transition function of estimated LSTAR model against r_{t-1}

For roots of characteristic polynomials and modulus, both regimes show a stable dynamic model. This implies that the LSTAR model has stability in the long run.

Additionally, figure 13 shows ACF and PACF of residual which indicate no autocorrelation and partial autocorrelation.

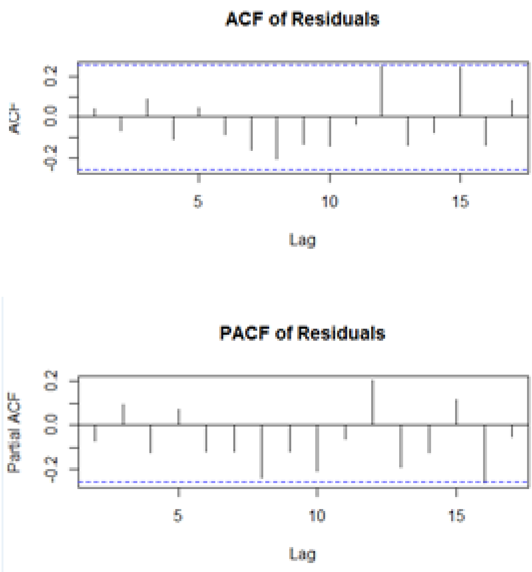


Figure :13 shows ACF and PACF of residual of r variable.

Figure 14 shows the estimated LSTAR model compared with the original data. We found that the LSTAR model fits the data when the original data has a normal period where the mean interest rate change a few value; but the model is a little bias with the original data that was in a crisis period before 2002.

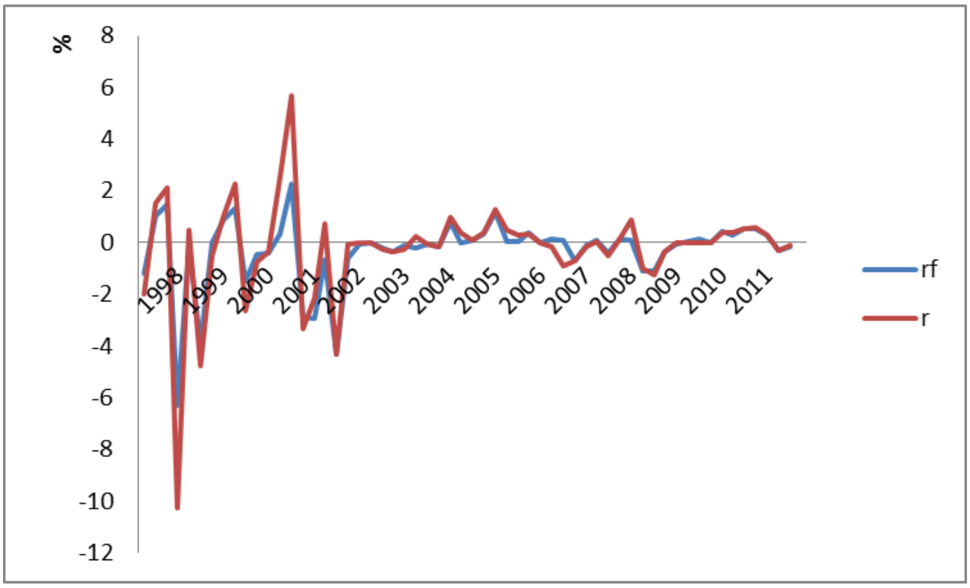


Figure :14 show the estimated LSTAR model compare with the original data.

6. Concluding remarks

This study conducted an inspection into the macroeconomic variables of Thailand for the purpose of learning its behavior and to have a better understanding of this economic indicator: updated quarterly data for the period of 1997:3 to 2012:1 were analyzed. The smooth transition autoregressive model was developed by the contribution of Teräsvirta and Anderson (1992), who concentrated on the possibility of an asymmetric adjusting process among time series variables.

The results from the linearity test rejected the null hypothesis of linear AR model in almost all of macroeconomic variables except for the growth of investment. When considering the delay parameter, with exception to the difference of interest rate, we found that the smallest p-value indicated that d=1. And the delay value for difference of interest rate is 2. Furthermore, we used a sequence of tests H_{01}, H_{02}, and H_{03} , the results show that the logistic transition function is appropriated than the exponential transition function. So, the LSTAR model is applied into all variables except for the growth rate of investment. The results show that the GDP growth rate has suddenly moved from the negative to the positive on a quarterly basis. Moreover, inflation rate, unemployment rate, and interest rate are slow in adjustment to reduce their value. Additionally, most of the observation in them belong in the lower regime which implies to some affective occur shock in their time series. From these results, the government should have an effective policy to make some adjustment to reduce large shocks in macroeconomic variables. For investment growth rate, it has an incredible fluctuation movement in the percentile of -30% to 30%. This shows that there is a high sensitive investment growth rate towards a policy adjustment. Therefore, the government should carefully concentrate in issuing an investment policy. Also, the government should have some rules to capture the investment movement for reducing its fluctuation.

To promote efficiency of adjusting speed, the bank of Thailand should quickly issue a monetary policy to adjust the interest rate and inflation rate when economy is occurring towards a large shock. For unemployment rate, the government should create an attitude towards the working behavior for improving productivity such as education, research and development, and up-skilling labor. Whenever a large shock hits the economy, the labor sector should be effectively prepared to find a new job. Further study should be considered in developing a joint relationship among these variable, such as the TVAR or STVAR model. In addition, some policy variables should be added, such as a fiscal policy, monetary policy, and trade policy into the model.

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