CHAPTER 4

METHODOLOGY

To achieve the first objective which is the possibility of the Bank of Thailand in dealing with bubble, the statistic and study of the relation of related variables in the past are used. This section is composed of two parts concerning about stock market and property market.

To investigate stock market, cointegration method is employed to study the relationship between Thai stock index and Dow Jones index to examine whether or not Thai stock depends on Dow Jones index. In addition, the effect from the bust of bubbles on stock market is examined. The last point of this part analyzes the intervention when stock index increases or decreases sharply.

To examine property market, it studies the effect of the bust of bubbles on property market which considers continuously the linkage to other economic sectors.

The second objective of this study is to find the threshold of the size and duration of bubble which the Bank of Thailand needs to take necessary actions. This section considers the boom-bust cycle in the U.S. by using empirical data and analyzes the factors in Thailand and those in the U.S. In addition, Granger causality test is employed to find the causality between stock index (land transactions) and aggregate demand.

To achieve the last objective which is to examine the effectiveness of monetary policy transmission channels in which the Bank of Thailand can implement its policy instrument to deflate the bubbles. The vector autoregressive model (VAR) is employed. This section compose of two parts, with the first one describing how to construct the VAR model. The second one discusses the methods of interpreting the VAR model, namely the Variance Decomposition and the Impulse Response Function and jointly analyzes in order to understand the monetary policy transmission channels, specifically, to judge which the monetary policy transmission channels are more relevant with asset prices.

4.1 Unit Root Test

If non-stationary time series are used in the regression model, the result may be biased or lead to spurious correlation. Any spurious regression has a high R-square and estimated residuals exhibit a high degree of autocorrelation (low Durbin-Watson statistics) and even sometimes show significant t-statistics. If the non-stationary exists, the transforming method, differencing or removing a trend, must be conducted.

Unit root test is employed to detect the properties of each series and to determine the order of integration. The unit root test is initially introduced on the basis of the first order autoregressive model.

$$X_t = \rho X_{t-1} + e_t$$

where X_t is times series variable at time t

X_{t-1} is lagged time series of X

T is time, t=1,2,3,…

ρ is the coefficient of the lag of time series

e_t is the disturbance term which is assumed to be identically independent distributed (iid) with zero mean and variance (σ^2)

If $|\rho|$<1 $\Rightarrow$ X_t will converge (as $t \to \infty$) to a stationary time series.

If $|\rho|$=1 $\Rightarrow$ X_t is non-stationary, specifically random walk, because the variance of X_t is $t\sigma^2$; the starting value (X_0) is assumed to be zero.

If $|\rho|$>1 $\Rightarrow$ X_t is non-stationary and the variance of X_t grows exponentially.

4.2 Engle-Granger Method of Cointegration

The Engle-Granger method of cointegration test[1] is straightforward in testing whether two I(1) (integrated of order 1) variables are cointegrated. Suppose

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[1] Enders (1995).

that two variables y_t and z_t are believed to be integrated of order 1 and one wants to determine whether there exists an equilibrium relationship between them as follows:

Step1: Pretest the variables for their order of integration. The unit root test is adopted to pretest each variable to determine its order of integration. If both variables are stationary, it is not necessary to proceed since standard time-series methods can be applied to stationary variables. If variables are integrated of different orders, it is possible to conclude that they are not cointegrated.

Step 2: Estimate the long-run equilibrium relationship. If the result of step 1 indicates that both y_t and z_t are I(1), the next step is to estimate the long-run equilibrium relationship in form of:

$$y_t = \beta_0 + \beta_1 z_t + e_t$$

If variables are actually cointegrated, the residual sequence from this equation (e_t) is the series of the estimated residuals of the long-run relationship. Then, e_t is tested by performing unit root test. If e_t is found to be stationary, the y_t and z_t sequences are cointegrated of order (1,1).

4.3 Granger Causality

The basic idea is, if X causes Y, the changes in X should precede the changes in Y. However, if Y causes X, the changes in Y should precede the changes in X. In addition, the lagged value of a variable can explain the current value of that variable. Granger causality test can be performed as follows:

a) Null hypothesis is that X does not cause Y. $\Rightarrow$ H_0: $Y_t = \sum_{i=1}^{n} \alpha_i Y_{t-i} + u_t$

Alternative hypothesis is that X causes Y. $\Rightarrow$ H_a: $Y_t = \sum_{i=1}^{n} \alpha_i Y_{t-i} + \sum_{i=1}^{m} \beta_i X_{t-i} + u_t$

n = the optimal lag length of Y obtained from Akaike information criterion.

m= the optimal lag length of X (including the present period) obtained from Akaike information criterion.

b) Null hypothesis is that Y does not cause X. $\Rightarrow$ H_0: $X_t = \sum_{i=1}^{n} \lambda_i X_{t-i} + u_t$

Alternative hypothesis is that Y causes X. $\Rightarrow$ H_a: $X_t = \sum_{i=1}^{n} \lambda_i X_{t-i} + \sum_{i=1}^{m} \delta_i Y_{t-i} + u_t$

n = the optimal lag length of X obtained from Akaike information criterion.

m= the optimal lag length of Y (including the present period) obtained from Akaike information criterion.

There are four possible cases:

1. a: Reject H_0	$\Rightarrow$ X causes Y	Undirectional causality from X to Y
b: Do not reject H_0	$\Rightarrow$ Y does not cause X	
2. a: Do not reject H_0	$\Rightarrow$ X does not cause Y	Undirectional causality from Y to X
b: Reject H_0	$\Rightarrow$ Y causes X	
3. a: Reject H_0	$\Rightarrow$ X causes Y	Bilateral causality
b: Reject H_0	$\Rightarrow$ Y causes X	
4. a: Do not reject H_0	$\Rightarrow$ X does not cause Y	Independent between Y and X
b: Do not reject H_0	$\Rightarrow$ Y does not cause X	

4.4 Vector Autoregressive Model (VAR)

This study employs a VAR model because the inference drawn from a typical structural or simultaneous macroeconomic model is typically sensitive to the choice of specification and to the identification assumptions. Although one cannot determine which variables are causes and which are effects, we know all variables are supposed to be inter-connected in the monetary policy transmission mechanism theory as mentioned in Chapter 2. A VAR model can be constructed precisely to investigate this inter-connection.

All of the variables in a VAR system are assumed to be endogenous. They are linearly interaction with their own and another current and past value. In addition, VAR system employs historical data to determine the quantitative impact that each variable has on its own and other variable future values. Thus, all equations have the same set of regressors. Since all regressors in VAR are lagged variables, it can be assumed that they are contemporaneously uncorrelated with the disturbance.

Therefore, each equation can be estimated by ordinary least square (OLS) which yields consistent and efficient estimators[1] (unbiased estimator with the least variance).

4.4.1 Vector Autoregressive Modeling (VAR)

Considering the primitive multivariate system:

$$ZX_t = \Gamma_0 + \sum_{i=1}^{n} \Gamma_i X_{t-i} + u_i \quad (4.4.1)$$

where X_t is an $(n \times 1)$ vector of endogenous variables

Z_t is an $(n \times n)$ matrix of coefficients on endogenous variables

Γ_0 is an $(n \times 1)$ vector of intercept term in the original model

Γ_i is an $(n \times n)$ matrix of the coefficient of lag endogenous

n is the number of lags of the endogenous variables

u_t is an $(n \times 1)$ vector of error terms

Multiplying equation (4.4.1) by Z^{-1}

$$X_t = A_0 + \sum_{i=1}^{n} A_i X_{t-i} + e_t \quad (4.4.2)$$

Equation (4.4.2) is a simple unrestricted VAR model system.

where A_0 is an $(n \times 1)$ vector of intercept terms $\left(A_0 = Z^{-1}\Gamma_0\right)$

A_i is an $(n \times n)$ vector of coefficients that relates lagged values of the endogenous variables to current values of those variables $\left(A_i = Z^{-1}\Gamma_i\right)$

e_t is a white noise error term $\left(e_t = Z^{-1}u_t\right)$

This specification is an unrestricted reduced form relationship of a structural simultaneous equation which makes minimal theoretical demand on the structure of a model.

Equation (4.4.2) can be expressed in a more explicit form as follows:

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[1] Pindyck and Rubinfeld (1998).

$$\begin{bmatrix} X_{1t} \\ X_{2t} \\ \vdots \\ X_{nt} \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \\ \vdots \\ a_{n0} \end{bmatrix} + \begin{bmatrix} a_{11}(L) & a_{12}(L) & a_{13}(L) & \dots & a_{1n}(L) \\ a_{21}(L) & a_{22}(L) & a_{23}(L) & \dots & a_{2n}(L) \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{n1}(L) & a_{n2}(L) & a_{n3}(L) & \dots & a_{nn}(L) \end{bmatrix} \begin{bmatrix} X_{1,t-i} \\ X_{2,t-i} \\ \vdots \\ X_{n,t-i} \end{bmatrix} + \begin{bmatrix} e_{1,t} \\ e_{2,t} \\ \vdots \\ e_{n,t} \end{bmatrix} \qquad (4.4.3)$$

where $a(L)$ is lag operator. And each row in equation (4.4.3) describes one equation for one variable from an $(n \times 1)$ vector of joint endogenous variables $[X_t]$. In addition, each variables in an $(n \times 1)$ of X_t is a linear function of its own lagged values, the lagged value of all other regressors in the system and a white noise error term.

With a VAR, one needs to specify only two properties:

(i) The set of variables that is believed to be interacted and hence should be included as part of the economic system.

(ii) The largest number of lags that are needed to capture most of the effect that variables have on one another.

4.4.2 Set of Variables

The set of endogenous variables which are included in the VAR are pre-selected in accordance with relevant economic theories, mentioned in the theoretical background of monetary transmission mechanisms. According to studies about monetary policy transmission channels, it is found that interest rate channel and credit channel are the main transmission channels. Therefore, in this study, repurchase rate and monetary base are used as proxies of above channels. Moreover, the mentioned monetary policies influence on the GDP growth as well. The model, thereafter, uses manufacturing production index as a proxy of GDP.

According to the previous theoretical framework, the GDP change is positively related with the change of people income. People will increase demand of property leading to the rise of asset prices in the end. Thus, stock index and land transactions are employed as proxies to represent the asset prices.

However, to examine the transmission mechanism of monetary policy, this study imposes a set of exogenous variable which is Dow Jones Industrial Average

Index since the U.S. stock index tends to relate with Thai stock index. So it can be used as exogenous variable.

Therefore, the VAR system consists of the two sets of variable which are described as follows:

4.4.2.1 Set of Endogenous Variables

1) Log of the Repurchase Rate (RP)

Following the objective of study, interest rate is one of the monetary policies included in the system. In addition, in conducting monetary policy under the inflation-targeting framework, monetary policy stance is signaled through the policy interest rate. (The 14-day RP rate was used as the policy interest rate up until January 16th, 2007.)

2) Log of the Monetary Base (MB)

To study the relationship between credit channel and asset prices, monetary base is included in the system. Monetary base is part of operating target of monetary policy. As monetary base and money supply have a positive relationship to one another, money supply tends to more in the same direction with private sector loanable fund. Therefore, it is very likely that monetary base will correlate with the private sector loanable fund.

3) Log of the Stock Index (SI) and Log of the Land Transactions (Land)

In this study, the stock index and land transactions are proxy for the asset prices because, during 1987-1997, stock and real estate markets experienced a larger boom-bust cycle than any other sectors of the economy.

Moreover, land transactions are used to represent the property price since there is no data on monthly basis about housing price index. The land transactions are the prominent factor which the Bank of Thailand uses to analyze the property market. In addition, test on the relationship between annual land transactions and annual housing price index found that these factors had the correlation of 0.6.

4) Log of the Manufacturing Production Index (MPI)

Manufacturing production index is used to indicate the condition of productivity of industrial sectors in the short run, and is also used as a measurement to estimate the trend in the long run. Therefore, manufacturing production index is used to represent the impact of asset price on the economic activities.

4.4.2.2 Set of Exogenous Variables

Log of the Dow Jones Industrial Average Index (DJIA)

In this study, the Dow Jones Industrial Average Index is a proxy for the U.S. stock index since it is an index of 30 "blue-chip" U.S. stocks. At 100-plus years, it is the oldest continuing the U.S. market index. It is called an "average" because it is originally computed by adding up stock prices and dividing by the number of stocks. It is the best-known market indicator in the world, partly because it is old enough that many generations of investors have become accustomed to quote it, and partly because the U.S. stock market is the global's biggest.

4.4.3 Lag Length Selection

The lag length selection requires judgment on the trade-off between obtaining a general model and having sufficient degrees of freedom for estimation purpose. Since the longer lags make the greater number of parameters to be estimated, causing fewer degrees of freedom left. However, the shorter lags may cause a misspecification of the model.

To specify the optimal lag length, the statistical criterion used in this study is Akaike Information Criterion (AIC). The test is characterized as follows:

$$\ln AIC = \left(\frac{2k}{n}\right) + \ln\left(\frac{RSS}{n}\right) \qquad (4.4.4)$$

where $\ln AIC$ = natural log of AIC

k = number of regressors (including the intercept)

n = number of observations

$\frac{2k}{n}$ = penalty factor

RSS = residual sum of squares

Equation (4.4.4) shows that AIC relates with RSS. Therefore, the model with the lowest value of AIC is preferred because it has the lowest value of RSS as well. The advantage of AIC is that it is useful for not only in-sample but also out-of-sample forecasting performance of a regression model.

The VAR model is then specified in form of equation as follows:

$$RP_t = a_{10} + \sum_{i=1}^{n} a_{11,i} RP_{t-i} + \sum_{i=1}^{n} a_{12,i} MB_{t-i} + \sum_{i=1}^{n} a_{13,i} SI_{t-i} + \sum_{i=1}^{n} a_{14,i} Land_{t-i} + \sum_{i=1}^{n} a_{15,i} MPI_{t-i} + \sum_{i=1}^{n} a_{16,i} DJIA_{t-i} + e_{RP,t}$$
$$MB_t = a_{20} + \sum_{i=1}^{n} a_{21,i} RP_{t-i} + \sum_{i=1}^{n} a_{22,i} MB_{t-i} + \sum_{i=1}^{n} a_{23,i} SI_{t-i} + \sum_{i=1}^{n} a_{24,i} Land_{t-i} + \sum_{i=1}^{n} a_{25,i} MPI_{t-i} + \sum_{i=1}^{n} a_{26,i} DJIA_{t-i} + e_{MB,t}$$
$$SI_t = a_{30} + \sum_{i=1}^{n} a_{31,i} RP_{t-i} + \sum_{i=1}^{n} a_{32,i} MB_{t-i} + \sum_{i=1}^{n} a_{33,i} SI_{t-i} + \sum_{i=1}^{n} a_{34,i} Land_{t-i} + \sum_{i=1}^{n} a_{35,i} MPI_{t-i} + \sum_{i=1}^{n} a_{36,i} DJIA_{t-i} + e_{SI,t}$$
$$Land_t = a_{40} + \sum_{i=1}^{n} a_{41,i} RP_{t-i} + \sum_{i=1}^{n} a_{42,i} MB_{t-i} + \sum_{i=1}^{n} a_{43,i} SI_{t-i} + \sum_{i=1}^{n} a_{44,i} Land_{t-i} + \sum_{i=1}^{n} a_{45,i} MPI_{t-i} + \sum_{i=1}^{n} a_{46,i} DJIA_{t-i} + e_{Land,t}$$
$$MPI_t = a_{50} + \sum_{i=1}^{n} a_{51,i} RP_{t-i} + \sum_{i=1}^{n} a_{52,i} MB_{t-i} + \sum_{i=1}^{n} a_{53,i} SI_{t-i} + \sum_{i=1}^{n} a_{54,i} Land_{t-i} + \sum_{i=1}^{n} a_{55,i} MPI_{t-i} + \sum_{i=1}^{n} a_{56,i} DJIA_{t-i} + e_{MPI,t}$$

where n is the optimal lags selected from AIC. The right hand side of each equation above contains only predetermined variables and the error terms are assumed to be serially uncorrelated with finite variance. So, each equation can be estimated using the OLS.

The estimation of VAR is originated from the theory of stationary processes. Therefore, variables used in VAR should be tested for unit root and transformed to the stationary series. Otherwise, one has to evaluate and compare the forecast ability of each model (the level VAR and the stationary VAR).

4.5 Impulse Response Function and Variance Decomposition

Impulse Response Function and Variance Decomposition are employed to interpret the estimated results of relationship among variables.

4.5.1 Impulse Response Function

Impulse response function traces the effect of shock in one innovation of each endogenous variable on current and future values of other variables. To make an interpretation of VAR model by impulse response function, equation (4.4.3) should be written in form of vector moving average (VMA). In VMA, the variables are expressed in terms of the current and past values of residuals. A VMA can be expressed as follows:

$$X_t = \overline{X}_t + \sum_{i=0}^{\infty} A_i e_{t-i} \qquad (4.5.1)$$

where $\overline{X_t}$ is the unconditional mean value of X_t. So, the unconditional mean value of RP, MB, SI, Land and MPI are denoted by $\overline{RP_t}, \overline{MB_t}, \overline{SI_t}, \overline{Land_t}$ and $\overline{MPI_t}$.

From equation (4.4.2), e_t is equal to $Z^{-1}u_t$. It means that e_t, the shock to VAR, cannot be directly interpreted because these shock are linear combinations of the shocks in the initial system. So, we substitute $Z^{-1}u_t$ into equation (4.5.1), and then get the equation (4.5.2) as shown below:

$$X_t = \overline{X}_t + \sum_{i=0}^{\infty} A_i Z^{-1} u_{t-i} \qquad (4.5.2)$$

Let $\phi_i = A_i Z^{-1}$;

$$X_t = \overline{X}_t + \sum_{i=0}^{\infty} \phi_i u_{t-i} \qquad (4.5.3)$$

Equation (4.5.3) can be expressed in the explicit system as:

$$\begin{bmatrix} RP_t \\ MB_t \\ SI_t \\ Land_t \\ MPI_t \end{bmatrix} = \begin{bmatrix} \overline{RP_t} \\ \overline{MB_t} \\ \overline{SI_t} \\ \overline{Land_t} \\ \overline{MPI_t} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \phi_{11}(i) & \phi_{12}(i) & \phi_{13}(i) & \phi_{14}(i) & \phi_{15}(i) \\ \phi_{21}(i) & \phi_{22}(i) & \phi_{23}(i) & \phi_{24}(i) & \phi_{25}(i) \\ \phi_{31}(i) & \phi_{32}(i) & \phi_{33}(i) & \phi_{34}(i) & \phi_{35}(i) \\ \phi_{41}(i) & \phi_{42}(i) & \phi_{43}(i) & \phi_{44}(i) & \phi_{45}(i) \\ \phi_{51}(i) & \phi_{52}(i) & \phi_{53}(i) & \phi_{54}(i) & \phi_{55}(i) \end{bmatrix} \begin{bmatrix} u_{RP_{t-i}} \\ u_{MB_{t-i}} \\ u_{SI_{t-i}} \\ u_{Land_{t-i}} \\ u_{MPI_{t-i}} \end{bmatrix}$$

The elements $\phi_{jk}(0)$ are impact multipliers which represent the immediate responses of the system to unit innovations. And the set of coefficients $\phi_{jk}(i)$ is called the impulse response functions. For example, the coefficient $\phi_{31}(0)$ is the instantaneous impact of an autonomous change in repurchase rate at time t $(u_{RP,t})$ on stock index at time t(SI_t). The coefficient $\phi_{31}(1)$ is the instantaneous impact of an autonomous change in repurchase rate at time t-1 $(u_{RP,t-1})$ on stock index at time t(SI_t). Updating by one period indicates that $\phi_{31}(1)$ represents the effect of an autonomous change in repurchase rate at time t $(u_{RP,t})$ on stock index at time t+1(SI_{t+1}). Plotting the impulse response function is a practical way to visually interpret the behavior of the variables in response to various shocks.

If the error terms are uncorrelated with one another, the ordering of variables imposed in VAR model does matter. However, if the errors are correlated, so the ambiguity to identify shocks with specific variables will increase.

One therefore needs to know correlation among the error terms. If the correlation coefficient between residuals is low, the ordering is not likely to be important. However, in a VAR with several variables, it is unlikely that all correlations will be small. After all, in selecting the variables to be included in a model, one is likely to choose variables that exhibit strong co-movements. Under the null hypothesis that the cross-correlation are all zero, the sample variance of cross-correlation coefficient i asymptotically converges to $(T-i)^{-1}$, where T= number of usable observations. Let $r_{yz}(i)$ denotes the sample cross-correlation coefficient between y and z_{t-i}.

$$Var\, r_{yz(i)} = (T-i)^{-1} \qquad (4.5.4)$$

Then, the standard deviation of the cross-correlation coefficient between y and z_{t-i} is $(T-i)^{-1/2}$. If the calculated value $r_{yz}(i)$ exceeds $2*(T-i)^{-1/2}$ (two standard deviations), null hypothesis can be rejected.[1]

4.5.2 Variance Decomposition

Variance Decomposition provides understanding about the properties of the forecast error variance and interrelationship among variables in the system. The forecast error variance decomposition is to decompose the forecast error variance of each variable into a portion attributable to its own innovations and innovations of the other variables in the system.

Given that all of constant terms (A_0) and coefficients (A_i) in equation (4.4.2) are known, one wants to forecast the various value of X_{t+h} conditional on observed value of X_t. The variance decomposition is also based on the vector moving average (VMA) represented in equation (4.5.1).

For example, the h-period ahead forecast error of the X_1 is one variable in the system $[X_t]$. The forecast error system can be represented as:

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[1] Enders (1995).

$$\begin{aligned} X_{1,t+h} - E_t X_{1,t+h} = {} & \phi_{11}(0) u_{x_{1,t+h}} + \phi_{11}(1) u_{x_{1,t+h-1}} + \ldots + \phi_{11}(h-1) u_{x_{1,t+1}} + \\ & \phi_{12}(0) u_{x_{2,t+h}} + \phi_{12}(1) u_{x_{2,t+h-1}} + \ldots + \phi_{12}(h-1) u_{x_{2,t+1}} + \\ & \vdots \qquad\qquad \vdots \qquad\qquad\qquad \vdots \\ & \phi_{1n}(0) u_{x_{n,t+h}} + \phi_{1n}(1) u_{x_{n,t+h-1}} + \ldots + \phi_{1n}(h-1) u_{x_{n,t+1}} \end{aligned} \tag{4.5.5}$$

Equation (4.5.5) can be written in general form as:

$$X_{i,t+h} - E_t X_{i,t+h} = \sum_{j=1}^{n} \sum_{s=0}^{h-1} \phi_{ij,s} u_{j,t+h-s} \tag{4.5.6}$$

where $E_t X_{i,t+h}$ is the linear-least square forecast of $X_{i,t+h}$ given the information $X_{i,t}$, $X_{i.t-1}$, and so on. The h-period ahead forecast error variance of $X_{i,t+h}$ is given by

$$E\left[\left(X_{i,t+h} - E_t X_{i,t+h}\right)\left(X_{i,t+h} - E_t X_{i,t+h}\right)\right] = \sum_{j=1}^{n} \sum_{s=0}^{h-1} \phi_{ij,s}^2 \tag{4.5.7}$$

where $\phi_{ij,s}$ is the ij^{th} component of the matrix ϕ_s . From equation (4.5.7), part of the expected h-period-ahead squared prediction error of $X_{i,t+h}$ produced by the innovation in variable $X_{j,t+h}$ is

$$\sum_{s=0}^{h-1} \phi_{ij,s}^2 \tag{4.5.8}$$

The percentage of the h-period forecast error variance of variable $X_{i,t+h}$ accounted by innovation in variable $X_{j,t+h}$ is

$$\frac{\sum_{s=0}^{h-1} \phi_{ij,s}^2}{\sum_{j=1}^{n} \sum_{s=0}^{h-1} \phi_{ij,s}^2} \times 100 \tag{4.5.9}$$

Note that the variance decomposition contains the same problem inherent in the impulse response function analysis in that the different ordering of variables included in the system generate different variance decompositions. We therefore need to analyze the correlation among the error terms.

Nevertheless, impulse response analysis and variance decompositions can be useful tools to examine relationship among economic variables. If the correlations among various innovations are small, the identification problem is not likely to be especially significant. The alternative orderings should yield similar impulse responses and variance decompositions. Of course, if the contemporaneous movements of many economic variables are highly correlated, one must impose an additional restriction on the VAR system. One possible identification restriction is to use Choleski decomposition.

4.6 Measuring Size of Bubble

In this study, Hodrick-Prescott (HP) Filter is employed to define the size of the bubble. It is a mathematical tool used in macroeconomic model, especially in real business cycle theory. It is used to determine the long term trend of a time series by discounting the importance of short term price fluctuations. The adjustment of the sensitivity of the trend to short-term fluctuations is achieved by modifying a multiplier λ.

The reasoning for the formula is as follows:

Let y_t for $t = 1,2,...,T$ denotes the logarithms of a time series variable. The series y_t is made up of a trend component, denoted by τ and a cyclical component, denoted by c such that $y_t = \tau + c$. Given an adequately chosen, positive value of λ, there is a trend component that will minimize.

$$\min \sum_{t=1}^{T} (y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} [(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2$$

The first term of the equation is the sum of the squared deviations $d_t = y_t - T_t$ which penalizes the cyclical component. The second term is a multiple λ of the sum of the squares of the trend component's second differences. This second term penalizes variations in the growth rate of the trend component. The larger value of λ, the higher is the penalty.

4.7 Sources of Data

This study uses the monthly data from 1995 to 2007 and the annual data from 1990-2008. Data series of housing price index, repurchase rate, monetary base, land transactions and manufacturing production index are obtained from the Bank of Thailand. Housing price is from Agency for Real Estate Affairs. Income per capita data is collected from Office of the Nation Economic and Social Development Board. In addition, the stock index is obtained from the Stock Exchange of Thailand. Lastly, the Dow Jones Industrial Average is accessed from Dow Jones Index website.

The following chapter aims to demonstrate empirical results about the relationship between asset prices and monetary policy in order to study the possibility of the Bank of Thailand in regulating asset price bubbles in stock market and property market, to find the threshold of size and duration of bubbles which the Bank of Thailand should take necessary actions and to examine the effectiveness of monetary policy transmission channels which the Bank of Thailand can implement its policy instrument to deflate the asset prices or the bubbles.