

CHAPTER 3

METHODOLOGY

3.1 Data

The following variables are used to examine the relationship between the bank lending and interest rate changes.

MM7	= Seven-day Money Market Interest Rate
MM1	= One-month Money Market Interest Rate
MM3	= Three-month Money Market Interest Rate
GDP	= Gross Domestic Product (base year 1987)
CPI	= Consumer Price Index (base year 1994)
LOAN	= Total Bank Lending (Commercial Bank)
DEP	= Total Deposit (Commercial Bank)
DUM	= Dummy variables (1 for fourth quarter of 1998 to second quarter of 2000; and 0 otherwise)
TIGHT_MM7	= Positive interest rate shock in the seven-day money market interest rate
TIGHT_MM1	= Positive interest rate shock in the one-month money market interest rate
TIGHT_MM3	= Positive interest rate shock in the three-month money market interest rate.

EASY_MM7 = Negative interest rate shock in the seven-day money market
interest rate

EASY_MM1 = Negative interest rate shock in the one-month money market
interest rate

EASY_MM3 = Negative interest rate shock in the three-month money market
interest rate.

The interest rate shock is explained further below.

Quarterly data from the first quarter of 1990 to the second quarter of 2000 are used. CPI is obtained from the IMF International Financial Statistics published by IMF. GDP, CPI, MM7, MM1, MM3 are obtained from the Bank Negara Malaysia Monthly and Quarterly Bulletin and the website of Bank Negara Malaysia (<http://www.bnm.gov.my>). LOAN and DEPOSIT are obtained from Money and Banking-SEACEN Financial Statistics.

3.2 Methodology

3.2.1 Unit Root Tests

Time series data can be stationary or non stationary. A stochastic process is stationary if its mean and variance are constant overtime and the value of covariance between two time periods depends only on the distance between these periods but not on the actual time at which the covariance is computed. Inclusion

of non-stationary time series in a regression model in their levels can lead to spurious regression if these series are not cointegrated.

The first step is to determine whether unit root is present in each of the variables. A series with a unit root contains a stochastic trend and is not stationary. The Augmented Dickey and Fuller test (ADF) and the Phillips-Perron unit root test (PP) are applied.

The ADF test and PP test depend crucially on the correct choice of deterministic components such as constant and trend terms, and sufficient lagged terms to ensure that the error terms behave like white noise.

The ADF tests for presence of unit root involves estimating:

$$\Delta Y_t = \mu + \beta t + \alpha Y_{t-1} + \sum \phi_i \Delta Y_{t-i} + \varepsilon_t$$

where $\varepsilon_t \sim \text{i.i.d}(0, \sigma^2)$

The hypothesis to be tested is

$$\begin{array}{ll} & H_0: \alpha = 0 \\ \text{against} & H_1: \alpha < 0 \end{array}$$

If $H_0: \alpha = 0$ is rejected, Y_t does not contain a unit root. So, Y_t is a stationary series and it is integrated of order zero or $I(0)$. If H_0 is not rejected, Y_t contains at least one unit root and Y_t is a non-stationary series. In this case the following is estimated:

$$\Delta^2 Y_t = \mu + \beta t + \alpha Y_{t-1} + \sum \phi_i \Delta^2 Y_{t-i} + \varepsilon_t$$

$$\text{where } \varepsilon_t \sim \text{i.i.d}(0, \sigma^2)$$

The same hypothesis is tested. If $H_0: \alpha = 0$ is rejected, ΔY_t does not contain a unit root. So, ΔY_t is a stationary series and it is integrated of order zero or $I(0)$. So, Y_t is integrated of order one and it is a difference-stationary process.

The test can be carried out by performing a t-test, but the t-statistic under the null hypothesis of a unit root does not have the conventional t-distribution. Dickey and Fuller (1979) showed that the distribution under the null hypothesis is nonstandard, and simulated the critical values for selected sample sizes. Besides that, MacKinnon (1991) implemented a much larger set of simulations than those by Dickey and Fuller. In addition, MacKinnon estimated the response surface using simulation, these permitting the calculation of critical values for any sample size and for any number of explanatory variables. In this study, the critical values provided by MacKinnon are used.

Very often the assumption of white noise disturbances is violated. The ADF and PP tests use different methods to control for higher-order serial correlation in the series. The ADF test makes a parametric correction for higher-order correlation by assuming that Y_t follows an AR(p) process.

The Phillips-Perron unit root test uses a non-parametric method for controlling the higher-order serial correlation in a series. The regression needed for the Phillips-Perron (PP) test assumed on AR(1) process. The Phillip-Perron test makes a correction to the t-statistic of the slope coefficient from the AR(1) regression to account for the serial correlation in the residuals. The correction is non-parametric since an estimate of the spectrum of residuals at frequency zero that is robust to heteroskedasticity and autocorrelation of unknown form is used.

3.2.2 Cointegration and Vector Error Correction (VEC) model

The fact that many macro time series may contain a unit root has spurred the development of the theory of non-stationary time series analysis. Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary series may be stationary. If such a stationary, or $I(0)$, linear combination exists, the non-stationary (with a unit root), time series are said to be cointegrated. The stationary linear combination is called the cointegrating equation and may be interpreted as a long-run equilibrium relationship between the variables. Variables can deviate from the equilibrium relationship in short run,

but equilibrium occurs in the long run. The Johansen cointegration test is used in this research.

Economic theory is often not rich enough to provide a tight specification of the dynamic relationship among variables. Furthermore, estimation and inference are complicated by the fact that endogenous variables may appear on both the left and right sides of the equations. These problems lead to alternative, non-structural, approaches to modeling the relationship between several variables. So, the vector error correction (VEC) model are employed to estimate the relationship among variables.

A vector error correction (VEC) model is a restricted vector autoregression (VAR) that has cointegration restrictions built into the specification, so that it is designed for use with non-stationary series that are known to be cointegrated. The VEC specification restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing a wide range of short-run dynamics. The cointegration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

The cointegration test is used to detect the existence of long-run relationship.

Johansen (1991) introduced a maximum likelihood test procedure that estimates

the cointegrating vectors in a multivariate framework. To discuss this procedure, consider a VEC model given by

$$\Delta \mathbf{x}_t = \boldsymbol{\mu} + \boldsymbol{\Pi} \mathbf{x}_{t-1} + \boldsymbol{\Gamma}_1 \Delta \mathbf{x}_{t-1} + \boldsymbol{\Gamma}_2 \Delta \mathbf{x}_{t-2} + \dots + \boldsymbol{\Gamma}_p \Delta \mathbf{x}_{t-p} + \boldsymbol{\varepsilon}_t$$

where

$$\mathbf{x}_t = \begin{bmatrix} X_{1t} \\ X_{2t} \\ \vdots \\ X_{kt} \end{bmatrix} \quad \boldsymbol{\mu} = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \vdots \\ \mu_k \end{bmatrix} \quad \boldsymbol{\Pi} = \begin{bmatrix} \Pi_{11} & \Pi_{12} & \dots & \Pi_{1k} \\ \Pi_{21} & \Pi_{22} & \dots & \Pi_{2k} \\ \vdots & \vdots & & \vdots \\ \Pi_{k1} & \Pi_{k2} & \dots & \Pi_{kk} \end{bmatrix} \quad \boldsymbol{\Gamma}_j = \begin{bmatrix} C_{11,j} & C_{12,j} & \dots & C_{1k,j} \\ C_{21,j} & C_{22,j} & \dots & C_{2k,j} \\ \vdots & \vdots & & \vdots \\ C_{k1,j} & C_{k2,j} & \dots & C_{kk,j} \end{bmatrix}$$

and $j = 1, 2, \dots, p$.

If the rank of $\boldsymbol{\Pi}$ is r , where $r < k$, then there exists r linear independent cointegrating vectors. Initially, the hypothesis to be tested is

$$H_0 : r = 0 \text{ (no cointegrating equation)}$$

$$\text{against} \quad H_1 : r > 0 \text{ (general alternative)}$$

If the null hypothesis is rejected, we proceed to test for existence of one cointegrating equation

$$H_0: r=1$$

$$\text{against} \quad H_1: r>1$$

If this null hypothesis is not rejected, it means that the system has one cointegrating equation. If the null hypothesis is rejected, the process is repeated until a non-rejection is found.

For this test, we use the likelihood ratio trace test statistic given by

$$Q_r = -N \sum_{j=r+1}^k \log(1 - \lambda_j)$$

where r is the hypothesized number of cointegrating vector under H_0 , and λ_j is the j -th largest eigenvalue for $C = 0$ where

$$C = \left[\lambda S_{11} - S_{10} S_{00}^{-1} S_{01} \right]$$

$$S_{00} = N^{-1} \sum r_{0t} r'_{0t}$$

$$S_{01} = N^{-1} \sum r_{0t} r'_{1t}$$

$$S_{10} = N^{-1} \sum r_{1t} r'_{0t}$$

$$S_{11} = N^{-1} \sum r_{1t} r'_{1t}$$

and r_{0t} and r_{1t} are the residuals from the regression of Δx_t and x_{t-1} on μ and the lags of Δx_t , respectively. Osterwald-Lenum (1992) have computed the critical values for the trace test. If the test indicates existence of r cointegrating vectors, the $k \times r$ matrix of eigenvectors corresponding to the r largest eigenvalues gives the long-run relationship. The relationship enters the VEC model through the term Πx_{t-1} .

3.2.3 The Two-step Procedure

The two-step procedure suggested by Cover (1992), and Dell’Ariccia and Garibaldi (1998) is used in this study.

The first step involves the estimation of a model that explains the money market interest rate processes. The interest rate is postulated to be a function of GDP and CPI. First, it is tested whether cointegration exists among LMM7, LGDP and LCPI (L denotes the logarithm of the variable). If cointegration is present, then the Error Correction Model (ECM) is used. It is reported in Chapter 4, that one cointegrating relation is found for the case of MM7. The ECM is given by:

$$\begin{aligned}\Delta LMM7_t &= \mu + \theta Z_{1t-1} + \sum \alpha_i \Delta LMM7_{t-i} + \sum \beta_i \Delta LGDP_{t-i} + \sum \gamma_i \Delta LCPI_{t-i} \\ &+ \lambda DUM_t + \varepsilon_{7t} \\ Z_t &= \Phi_0 + \Phi_1 LMM7_t + \Phi_2 LGDP_t + \Phi_3 CPI_t\end{aligned}\quad (3.1)$$

The process is repeated for MM1. In this case, two cointegrating relations are found. The ECM is given by:

$$\begin{aligned}\Delta LMM1_t &= \mu + \theta_1 Z_{1t-1} + \theta_2 Z_{2t-1} + \sum \alpha_i \Delta LMM1_{t-i} + \sum \beta_i \Delta LGDP_{t-i} \\ &+ \sum \gamma_i \Delta LCPI_{t-i} + \lambda DUM_t + \varepsilon_{1t} \\ Z_{1t} &= \Phi_0 + \Phi_1 LMM1_t + \Phi_2 LGDP_t \\ Z_{2t} &= \Phi_3 + \Phi_4 LCPI_t + \Phi_5 LGDP_t\end{aligned}\quad (3.2)$$

For MM3, one cointegrating relation is found and the ECM is given by:

$$\begin{aligned}\Delta LMM3_t = & \mu + \theta Z_{1t-1} + \sum \alpha_i \Delta LMM3_{t-i} + \sum \beta_i \Delta LGDP_{t-i} \\ & + \sum \gamma_i \Delta LCPI_{t-i} + \lambda DUM_t + \varepsilon_{3t}\end{aligned}\quad (3.3)$$

$$Z_t = \Phi_0 + \Phi_1 LMM3_t + \Phi_2 LGDP_t - \Phi_3 LCPI_t$$

The associated residuals (ε_{7t} , ε_{1t} and ε_{3t}) from the ECMs are used for constructing the interest rate shocks for the money market.

The positive shocks to the money market for the three different interest rates are as below:-

$$TIGHT_MM7_t = \max(\varepsilon_{7t}, 0) \quad (3.4)$$

$$TIGHT_MM1_t = \max(\varepsilon_{1t}, 0) \quad (3.5)$$

$$TIGHT_MM3_t = \max(\varepsilon_{3t}, 0) \quad (3.6)$$

The negative shocks to the money market for the three different interest rates are as below:-

$$EASY_MM7_t = \min(\varepsilon_{7t}, 0) \quad (3.7)$$

$$EASY_MM1_t = \min(\varepsilon_{1t}, 0) \quad (3.8)$$

$$EASY_MM3_t = \min(\varepsilon_{3t}, 0) \quad (3.9)$$

The second step involves estimating the effect of interest rate shocks in the money market on the aggregate commercial bank lending. LOAN is a function of DEP. First, the possibility of these two variables being cointegrated is tested. In this test, the interest rate shocks are kept exogenous. It is reported in Chapter 4, that LOAN is cointegrated with DEP. The ECM is then used to explain the movements in LOAN. Three models are estimated, each for capturing the different shocks in the three interest rate series. The models are:

$$\Delta \text{LLOAN}_t = \mu + \theta Z_{t-1} + \sum \delta_i \Delta \text{LLOAN}_{t-i} + \sum \phi_i \Delta \text{DEP}_{t-i} + \sum \varphi_i \text{EASY_MM7}_{t-i} + \sum \tau_i \text{TIGHT_MM7}_{t-i} + \Phi \text{TREND} + \eta_t \quad (3.10)$$

$$Z_t = \Phi_0 + \Phi_1 \text{LLOAN} + \Phi_2 \text{LDEP}$$

$$\Delta \text{LLOAN}_t = \mu + \theta Z_{t-1} + \sum \delta_i \Delta \text{LLOAN}_{t-i} + \sum \phi_i \Delta \text{DEP}_{t-i} + \sum \varphi_i \text{EASY_MM1}_{t-i} + \sum \tau_i \text{TIGHT_MM1}_{t-i} + \Phi \text{TREND} + \eta_t \quad (3.11)$$

$$Z_t = \Phi_0 + \Phi_1 \text{LLOAN} + \Phi_2 \text{LDEP}$$

$$\Delta \text{LLOAN}_t = \mu + \theta Z_{t-1} + \sum \delta_i \Delta \text{LLOAN}_{t-i} + \sum \phi_i \Delta \text{DEP}_{t-i} + \sum \varphi_i \text{EASY_MM3}_{t-i} + \sum \tau_i \text{TIGHT_MM3}_{t-i} + \Phi \text{TREND} + \eta_t \quad (3.12)$$

$$Z_t = \Phi_0 + \Phi_1 \text{LLOAN} + \Phi_2 \text{LDEP}$$

A deterministic trend variable (TREND) is added into the ECM models. This is because the LOAN variable clearly exhibits a trend, as is shown in Figure 1.1 and Figure 1.2.