CHAPTER 5

FULL SAMPLE ANALYSIS

5.1 Introduction

This chapter presents the results for the entire sample period from January 1987 to December 2001. First, we examine the presence of unit root for establishing the order of integration of the data series. The following section presents the results of the cointegration test. This is followed by the presentation of the VEC model. The last section investigates the adjustments to disequilibrium and reporting the results of the causality test based on the VEC model.

5.2 Unit Root Tests

The ADF and PP unit root tests are conducted in the first part of this section. For robustness check on the results of the order of integration, we perform the unit root test with a breakpoint in the second part.

5.2.1 Augmented Dickey-Fuller and Phillips-Perron Unit Root Tests

Initially, we check for the presence of unit root in all the variables, which are the natural log of deseasonalized index of industrial production ($lnIIPS_t$), stock prices ($lnSP_t$), real money balances for M1 ($lnRB1_t$) and real money balances for M2 ($lnRB2_t$), and also the real interest rate (RIR_t).

We first conduct the ADF and PP unit root tests to test each variable for a unit root in levels, and then repeat the test in first differences for the variables that have a unit root in the level specification. As in equation (4.3), a constant term and deterministic time trend are included in the test regression. A constant term is included since all series have a non-zero mean, while the trend term allows for a deterministic trend.

We employ the ADF and PP tests with one, three and six lags to overcome the problem of serial correlation in residuals. Table 5.1 presents the results of the ADF and PP tests for a unit root in levels. The results of the ADF test show that the null hypothesis of a unit root cannot be rejected in all the series for all lags except the real interest rate at the 5 percent significance level with one lag and 10 percent significance level with three and six lags. However, the rejection of null hypothesis is not found at the 1 percent significance level.

The results of the PP test show similar findings at the ADF test where the null hypothesis of a unit root in real interest rate for one, three and six lags are marginally rejected at the 5 percent significance level. All other series are non-stationary in the levels at the 5 percent significance level.

Table 5.1: Tests for Unit Root (In Levels)

Variable	Lag (m)	ADF Test Statistic	PP Test Statistic
$lnIIPS_t$	1	-2.0158	3.0319
	3	-1.4581	-3.0910
	6	-1.7549	-3.3862*
$lnSP_t$	1	-2.1174	-2.1214
	3	-1.9977	-2.2431
	6	-1.4280	-2.1309
RIR_t	1	-3.6445**	-3.7369**
	3	-3.2383*	-3.7622**
	6	-3.3589*	-3.7282**
$lnRB1_t$	1	-2.1977	-2.0656
	3	-1.9032	-2.0112
	6	-1.8954	-1.9934
$lnRB2_t$	1	-1.1433	-1.0025
	3	-0.9329	-1.1109
	6	-0.8251	-1.1609

Notes: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

We then proceed with unit root tests for a second unit root in the series. Table 5.2 reports the results of the ADF and PP tests for two unit roots in levels, or a unit root in the first difference series. According to the results of ADF unit root test, the null hypothesis of a unit root in first differences is strongly rejected at the 1 percent significance level for all series with one, three and six lags in the test regressions. The results of the PP test for the first differences of the series also show similar findings. The null hypothesis of a unit root is strongly rejected at the 1 percent significance level, suggesting that the first difference series are I(0).

All the data series except real interest rate are first difference stationary and can be characterized as I(1). However, the conventional unit root tests do not take into consideration of the existence of any structural breaks in the time series. Subsequently, the results may be inaccurate if possible breakpoint is neglected.

Table 5.2: Tests for Unit Root (In First Differences)

Variable	Lag (m)	ADF Test Statistic	PP Test Statistic
$lnIIPS_t$	1	-14.5508***	-23.5080***
	3	-8.3482***	-24.9951***
	6	-4.6182***	-25.1630***
$lnSP_t$	1	-7.6488***	-11.7554***
	3	-7.7656***	-11.7885***
	6	-5.1016***	-11.6774***
RIR_t	1	-8.1398***	-12.8215***
	3	-7.6654***	-12.8389***
	6	-5.2470***	-12.8170***
$lnRB1_t$	1	-9.9810***	-12.6591***
	3	-6.9358***	-12.6501***
	6	-5.4257***	-12.6826***
$lnRB2_t$	1	-8.5589***	-12.5938***
	3	-6.6307***	-12.6227***
	6	-5.0328***	-12.6330***

Notes: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

5.2.2 Unit Root Test with a Structural Break

The conventional unit root tests (ADF and PP tests) could misinterpret a trend stationary series with a structural break as a random walk process. Therefore, allowance for a breakpoint in the specification of the unit root test seems more reasonable.

We treat the full sample period to have a breakpoint in which there is a significant change in the trend of the data series. In our analysis, we follow Perron's procedure, where the breakpoint is taken to be exogenous. We allow for a structural break in the time series since the period under consideration consists of two distinct sub-periods. The significant change in the trend is attributed to the implementation of selective capital controls on 1 September 1998 by the Malaysian government. Due to this, we fix the breakpoint at August 1998. There are a total of 140 observations before and on the breakpoint date, and 40 observations in post breakpoint date. The break fraction is $\lambda = T_B/n = 140/180 = 0.77 \approx 0.8$.

The specification of the regression equation (4.8) further augments the ADF regression by the inclusion of two dummy variables, DU and DT which capture the intercept and slope effects respectively. The unit root test with a breakpoint is conducted for all the variables in their levels. The results of the test are reported in Table 5.3. The test statistics (t_γ) are not significant for all data series with one, three and six lags at the 5 percent significance level. The rejection of the null hypothesis of a unit root is only found at the 10 percent significance level for real interest rate and real money balances for M2 with one lag. In general, we can say that all variables are non-stationary with at least one unit root in the series.

We then proceed to conduct the unit root test in the first differences of the data series. The results in Table 5.3 suggest that all variables are stationary after first difference and the null hypothesis of second unit root is strongly rejected at the 1 percent significance level for all variables.

Table 5.3: Unit Root Test with a Structural Break (In Levels and First Differences)

(A) Levels			(B) First Differences		
Variable	Lag (m)	Test Statistic	Variable	Lag (m)	Test Statistic
$lnIIPS_t$	1	-2.1797	$lnIIPS_t$	1	-14.6581***
	3	-1.0880		3	-8.6524***
	6	-1.3724		6	-4.8591***
$lnSP_t$	1	-0.5275	$lnSP_t$	1	-8.2875***
	3	-0.1069		3	-8.4687***
	6	1.0535		6	-5.7744***
RIR_t	1	-3.7704*	RIR_t	1	-8.2960***
	3	-3.3856		3	-7.9834***
	6	-3.5943		6	-5.6600***
$lnRB1_t$	1	-1.5420	$lnRB1_t$	1	-10.1375***
	3	-0.7375		3	-7.1576***
	6	-0.5821		6	-5.6068***
$lnRB2_t$	1	-3.8605*	$lnRB2_t$	1	-8.7422***
	3	-3.3725		3	-6.8228***
	6	-3.2988		6	-5.2594***

Notes: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Under the null hypothesis the 1%, 5% and 10% critical values of the unit root test (for $\lambda = 0.8$) are –4.70, -4.04 and –3.69, respectively (Perron, 1989).

Since unit root test with a structural break is more reliable than the standard ADF and PP tests, as a result, we can conclude that all variables in our analysis are characterized as first difference stationary or integrated of order one, written $lnIIPS_t \sim I(1)$, $lnSP_t \sim I(1)$, $RIR_t \sim I(1)$, $lnRB1_t \sim I(1)$ and $lnRB2_t \sim I(1)$.

5.3 Cointegration

The requirements for the Johansen cointegration test are that the variables are non-stationary and integrated of the same order. From the results of the unit root tests obtained from previous section, each series is first difference stationary. In this study, there are two four-variable systems. We treat $RB1_t$ and $RB2_t$ as alternative monetary aggregate variables. Thus, we have two multivariate models with four variables each.

We first examine the first system, which are seasonally adjusted industrial production index ($lnIIPS_t$), stock prices ($lnSP_t$), real interest rate (RIR_t) and real money balances for M1 ($lnRB1_t$). We then examine the second system in which the variable of real money balances for M1 is replaced by real money balances for M2 ($lnRB2_t$). The results of the Johansen cointegration test are tabulated in Tables 5.4 and 5.5.

Table 5.4: Johansen Cointegration Test for the First System (M1)

Lag Length	Trace Statistic (Q_r)			
	r = 0	r = 1	r = 2	r = 3
1	58.6668**	34.0060**	14.9429	6.0452
2	66.3470**	36.6827**	16.2175**	5.6058**
3	49.4713**	28.9833	14.2950	6.6559
4	56.6855**	35.7353**	18.0224**	7.9344**
5	50.6264**	30.1510**	15.8975**	5.9714**
6	50.8988**	29.3768	12.9141	4.4515

** Significant at the 5% level.

Table 5.5: Johansen Cointegration Test for the Second System (M2)

Lag Length	Trace Statistic (Q_r)			
	r = 0	r = 1	r = 2	r = 3
1	66.0524**	36.3202**	13.1048	3.3206
2	67.7540**	35.8058**	17.6277**	3.4321
3	53.6464**	29.4663	15.2002	3.3926
4	61.0272**	36.9549**	18.3504**	3.7739**
5	55.8746**	35.0106**	17.7251**	4.3274**
6	65.1130**	37.5817**	17.8519**	4.6057**

** Significant at the 5% level.

The results in Tables 5.4 and 5.5 indicate that the null hypothesis of no cointegration among the variables is rejected for all lags for both the systems at the 5 percent significance level. However, there are some extreme cases where the null hypothesis of three cointegrating relations is rejected for the first system with two, four and five lags. Similar cases exist in the second system with four, five and six lags. In other words, the Π matrix in equation (4.10) has full rank. Nevertheless, the optimal lag length for the VEC model is determined with of BIC or SC.

The use of SC suggests that one lag is the optimal lag length for both systems. Based on the results of the cointegration test in Tables 5.4 and 5.5, there are two cointegrating vectors that exist for both the systems that define the long-run movements of the variables. In other words, two error correction terms should be included in each model.

5.4 Vector Error Correction Model

In the full sample period, all variables are cointegrated. As a result, they must have an error correction model representation. As reported in the previous section, there are two cointegrating relations which also imply that two error correction terms are present in the VEC model. The two error correction terms for the first system are:

$$\hat{z}_{11,t} = 4.1148 + \ln IIPS_t + 0.1066RIR_t - 1.0220\ln RB1_t \quad (5.1)$$

$$\hat{z}_{12,t} = 2.6551 + \ln SP_t - 0.3888RIR_t - 0.6653\ln RB1_t \quad (5.2)$$

Two error correction terms for the second system are:

$$\hat{z}_{21,t} = 3.1362 + \ln IIPS_t + 0.0036RIR_t - 0.7524\ln RB2_t \quad (5.3)$$

$$\hat{z}_{22,t} = -0.0337 + \ln SP_t - 0.2796RIR_t - 0.4098\ln RB2_t \quad (5.4)$$

The VEC models for the two systems are tabulated in Tables 5.6 and 5.7.

Table 5.6: The Vector Error Correction Model for the First System (M1)

Independent Variable	Dependent Variable			
	$\Delta lnIIPS_t$	$\Delta lnSP_t$	ΔRIR_t	$\Delta lnRB1_t$
Constant	0.0110*** (4.0066)	0.0003 (0.0414)	-0.0253 (-0.7671)	0.0073*** (2.7634)
$\Delta lnIIPS_{t-1}$	-0.4927*** (-6.7223)	0.2280 (1.2059)	-0.0585 (-0.0662)	-0.1380** (-1.9621)
$\Delta lnSP_{t-1}$	-0.0145 (-0.4803)	0.1302* (1.6746)	-0.3811 (-1.0491)	0.0119 (0.4106)
ΔRIR_{t-1}	0.0087 (1.4083)	-0.0063 (-0.3962)	0.0209 (0.2821)	0.0016 (0.2662)
$\Delta lnRB1_{t-1}$	0.0131 (0.1576)	0.2239 (1.0433)	-0.4610 (-0.4599)	0.1473* (1.8450)
$\hat{z}_{11,t-1}$	-0.0415 (-0.9045)	-0.2028* (-1.7119)	-0.1472 (-0.2661)	0.1593*** (3.6142)
$\hat{z}_{12,t-1}$	-0.0051 (-0.4245)	-0.0516* (-1.6799)	0.1787 (1.2458)	0.0416*** (3.6422)

Notes: The numbers in parentheses are t-ratios. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

The VEC model in Table 5.6 implies that given a unit deviation from the first long-run relationship, the industrial production adjusts by a reduction of 4 percent in the following month. The adjustment is a decrease of 0.5 percent in response to a unit deviation from the second long-run relationship one month before. The adjustment of stock prices in response to one unit deviation from the first and second long-run relationships one month before is a reduction of 20.3 percent and

5.2 percent, respectively. Correspondingly, the real interest rate adjusts by a decrease of 14.7 percent and an increase of 17.9 percent. Real money balances for M1 adjust by an increase of 15.9 percent and 4.2 percent, respectively.

Table 5.7: The Vector Error Correction Model for the Second System (M2)

Independent Variable	Dependent Variable			
	$\Delta lnIIPS_t$	$\Delta lnSP_t$	ΔRIR_t	$\Delta lnRB2_t$
Constant	0.0117*** (4.1159)	-0.0891 (-0.1913)	-2.3724 (-1.1126)	-0.0086 (-0.1093)
$\Delta lnIIPS_{t-1}$	-0.3943*** (-5.7205)	0.1773 (0.9308)	0.3401 (0.3900)	0.0170 (0.5312)
$\Delta lnSP_{t-1}$	-0.4344 (-1.4987)	0.1476* (1.8437)	-0.4604 (-1.2556)	0.0107 (0.7925)
ΔRIR_{t-1}	0.0112* (1.9083)	-0.0112 (-0.6900)	0.0280 (0.3768)	-0.0010 (-0.3528)
$\Delta lnRB2_{t-1}$	-0.1448 (-0.8588)	-0.0891 (-0.1913)	-2.3724 (-1.1126)	-0.0086 (-0.1093)
$\hat{z}_{21,t-1}$	-0.2443*** (-4.5029)	0.0753 (0.5025)	-0.8414 (-1.2258)	0.0261 (1.0331)
$\hat{z}_{22,t-1}$	0.0252*** (4.0449)	-0.0110 (-0.6374)	0.3154*** (3.9990)	0.0042 (1.4438)

Notes: The numbers in parentheses are t-ratios. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table 5.7 shows the VEC model in the second system. The results suggest that industrial production adjusts downward by 24.4 percent for a unit deviation from the first long-run relationship. However, industrial production adjusts upward by 2.5 percent for a unit deviation from the second long-run relationship. For stock prices, for one unit deviation from the first long-run relationship, the adjustment is a rise of 7.5 percent and the adjustment is a reduction of about 11 percent for one unit deviation from the second long-run relationship. The adjustment of real interest rate in the second system is much faster than the adjustment in the first system in response to one unit deviation from both the long-run relationships. Nevertheless, real money balances for M2 only adjust 0.4 percent and 3 percent, respectively. The adjustment of real interest rate is the fastest while the real money balances for M2 are the slowest in the second system.

If we look at the individual t-statistics, the error correction terms in the first system are significant for the equations of real money balances for M1 and stock prices at the 1 percent and 10 percent significance level, respectively. In comparison, the second system of VEC model shows different results in which both the error correction terms for the equation of industrial production are highly significant while only the second error correction term of the equation of real interest rate is significant.

Note that there are two error correction terms in each system. As a result, we carry out joint tests of the error correction terms to establish which variable adjusts to disequilibrium in the system in the next section.

5.4.1 Adjustments to Disequilibrium

We conduct join tests to determine which are the variables that respond to disequilibrium in the error correction model. For a variable that adjusts to disequilibrium, the error correction terms in concern should be jointly significant. The F-test is performed and the results of the test are reported in Table 5.8.

Table 5.8: F-Test for Adjustments to Disequilibrium

First System (M1)		
Variable	F-Statistic	P-Value
$lnIIPS_t$	1.129	0.326
$lnSP_t$	1.489	0.228
RIR_t	9.067***	0.000
$lnRB1_t$	6.803***	0.001
Second System (M2)		
Variable	F-Statistic	P-Value
$lnIIPS_t$	11.063***	0.000
$lnSP_t$	0.208	0.813
RIR_t	10.000***	0.000
$lnRB2_t$	4.754***	0.009

*** denotes significance at the 1% level.

The results of the first system suggest that real interest rate and real money balances for M1 adjust to disequilibrium at the 1 percent significance level. The second system shows an additional variable that adjusts to disequilibrium that is industrial production when the monetary aggregate is defined in a broader definition of money. The findings imply that the interest rate and monetary variable are used as active tool in influencing the economic activity in the country for the whole sample period. Interestingly, stock prices are not adjusting to disequilibrium in the economic system.

5.4.2 Granger Causality

Engle and Granger (1987) showed that at least one direction of Granger causality is entailed by cointegration. Individual t-statistics may not accurately determine the lead-lag relationships among the variables due to the presence of error correction terms in the equations. The F-statistics are calculated under the null hypothesis of no causality based on the VEC models reported in Tables 5.6 and 5.7. The results of the Granger causality test for the first and second systems are reported in Tables 5.9 and 5.10, respectively.

The results in Table 5.9 indicate that all variables are Granger-caused by themselves. The lagged changes in stock prices, real interest rate and real money balances have no predictive ability for the movements in industrial production. If stock prices reflect fundamentals, there should be a close relation to expected future real activity. These results do not support that stock prices are leading indicators of economic activity. However, the extension of monetary aggregate from M1 to M2 in Table 5.10 has suggested that apart from its own lag, industrial production is also Granger-caused by stock prices, real interest rate and real money balances at the 1 percent significance level. The predictive ability of stock prices for real economic activity implies that the stock market is a passive informant of future real activity as stock prices react immediately to new information about future real activity before it occurs. Real interest rate and availability of credit also influence the decision in business or production expansion.

There is a bi-directional causality between real interest rate and real money balances in both the systems. The results are consistent with the fact that both interest rate and money are treated as monetary tools and they should be closely related with each other. Moreover, stock prices tend to lead real interest rate in the second system. The results in Table 5.9 also show that industrial production and stock prices Granger-cause real money balances and these may reflect the importance of the stock market and economic activity on the currency in circulation and demand deposits. However, there is no causality from industrial production and stock prices to real money balances in the second system. In the second system, the null hypothesis of stock prices do not Granger-cause real interest rate is rejected at the 1 percent significance level. No variable seems Granger-causes stock prices. The movements of stock prices tend to be independent.

Table 5.9: Granger Causality Test for the First System (M1)

Causal Variable	Dependent Variable			
	$IIPS_t$	SP_t	RIR_t	$RB1_t$
$IIPS_t$	28.134***	1.693	0.049	6.857***
SP_t	0.249	2.393*	1.132	7.202***
RIR_t	1.397	1.116	6.132***	4.710***
$RB1_t$	0.862	1.887	6.044***	4.770***

Notes: F-statistics are reported in the table. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table 5.10: Granger Causality Test for the Second System (M2)

Causal Variable	Dependent Variable			
	$IIPS_t$	SP_t	RIR_t	$RB2_t$
$IIPS_t$	38.994***	0.796	0.751	0.954
SP_t	8.303***	1.715	8.029***	1.757
RIR_t	8.100***	0.286	6.767***	3.169***
$RB2_t$	7.453***	0.165	6.707***	4.770***

Notes: F-statistics are reported in the table. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.