CHAPTER 5
LONG-TERM ANALYSIS

5.1 Introduction

In this chapter, the results of long-term analysis are discussed. Long-term refers to the entire sample period used in this study. The first section discusses the results of the unit root tests. It is followed by the results of cointegration tests. The vector error correction model is presented in Section 5.2.3. Using the model, we forecast the indices for the month of July 1999 and the results are presented in Section 5.2.4.

5.2 Results for the Entire Sample Period

5.2.1 Unit Root Tests

We first check for presence of unit roots in the sectoral indices to examine their stationarity. These series are referred to as the level of the data. A series which is not stationary in their levels and needs differencing to achieve stationarity simply means that it contains one unit root. It is said to be integrated of order one or, I(1). If it needs to be differenced twice to achieve stationarity, this means the series contain two unit roots, or is I(2). The augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) tests described in Section 3.2.2.1 are used to test for the presence of unit roots in the Composite, Finance, Industrial, Plantation, Mining and Property Index. A constant term and deterministic time trend are included in the equation to perform the test, as given by equation (3.5). The reason for including a constant term is to accommodate for series that has a non-zero mean level. The trend term permits us to test for the possibility of a deterministic trend apart from the stochastic trend.

The results for the ADF tests are shown in Table 5.1. We fitted equation (3.5) with lags of m=1 to m=12. The inclusion of lags in the equation is to take care of the problem of serial correlation. To choose the lag length, we used the Schwarz criterion defined in Section 3.2.2.1. However, if the problem of serial correlation is found to exist in the residuals of the equation with the chosen lag length, the next optimal lag is used. The final lag length included in the equation is given in Table 5.1.

The ADF test was run with m=1 for all the sectoral indices except for the Finance Index, which was run on m=3. By using these lags, the residuals are free from the serial correlation problem. This is shown by the results of the serial correlation LM test. However, based on the autoregressive conditional heteroscedasticity (ARCH) LM test and White test for heteroscedasticity, the results show that the residuals are heteroscedastic. To overcome the problem, the Phillips-Perron test is used. We will analyse the results later.

The ADF test statistics (t_α) are not significant for all the sectoral indices. The coefficients of α are not significantly less than 0. It is clear that all the sectoral indices contain at least a unit root. This means that the series are not stationary in their level. Constant terms for all the indices are significant at the 5 percent level. This indicates the presence of a drift in all the series. Significant deterministic trends are detected in all the indices as well. Based on these results, it is clear that each of the series is non-stationary with a drift and deterministic time trend. The first differences of the series need to be examined to establish the order of integration and the results are shown in Table 5.1.

The ADF test conducted on the first differences rejected the null hypothesis of a unit root in all the series. This shows that after taking the first difference, all the sectoral indices are stationary. Similar to the procedure for the levels, the equations estimated to conduct the ADF test for the first differences included the number of lags that is chosen by the Schwarz criterion. The equations for the Plantation and Mining Index used 1 lag, the Composite and Industrial Index used 4 lags, the Finance Index used 3 lags and the Property Index used 5 lags. The drift is not significant in all cases except for the Mining Index where it is significant at the 10 percent level. The deterministic trend is only mildly significant for the Plantation and Mining Index, but not in the other cases. The equations are free from the problem of serial correlation, as indicated by the LM test. However, the ARCH LM and White tests show that they are plagued by heteroscedasticity.

Table 5.1: The Augmented Dickey - Fuller Test for the Presence of a Unit root

(a)Logarithm of Sectoral Indices

Index	Lag	μ	t_μ	β	t_β	α	t_α	Serial Correlation LM Test (p-value) Lag 1	Lag 2	Lag 3	ARCH LM Test (p-value)	White Test (p-value)
Composite	1	0.0307**	2.23	-2.45×10^{-6}**	-1.74	-0.0042	-2.17	0.4531	0.7418	0.8661	0.0000***	0.0000***
Finance	3	0.0290**	2.28	-2.22×10^{-6}*	-1.58	-0.0031	-2.19	0.3778	0.6715	0.1071	0.0000***	0.0000***
Industrial	1	0.0284**	2.12	-2.06×10^{-6}**	-1.73	-0.0036	-2.05	0.4740	0.7307	0.8804	0.0000***	0.0000***
Plantation	1	0.0463***	3.02	-2.94×10^{-6}***	-2.41	-0.0057	-2.89	0.3370	0.4914	0.3737	0.0000***	0.0000***
Mining	1	0.0465***	3.23	-7.00×10^{-6}***	-2.92	-0.0069	-3.08	0.1789	0.3227	0.3231	0.0000***	0.0000***
Property	1	0.0321***	2.43	-5.00×10^{-6}***	-2.50	-0.0038	-2.35	0.3742	0.5845	0.3315	0.0000***	0.0000***

t_μ is the t-test statistic for testing Ho: $\mu = 0$.
t_β is the t-test statistic for testing Ho: $\beta = 0$.
t_α is the ADF test statistic for Ho : $\alpha = 0$ and the critical values are -3.9692, -3.4152 and -3.1295 at the 1%, 5% and 10%, respectively (MacKinnon, 1991)
*** Significant at the 1% level.
** Significant at the 5% level.
* Significant at the 10% level.

(b) First-Difference of Logarithm of Sectoral Indices

Index	Lag	μ	t_μ	β	t_β	α	t_α	Serial Correlation LM Test (p-value) Lag 1	Lag 2	Lag 3	ARCH LM Test (p-value)	White Test (p-value)
Composite	4	0.0008	0.70	-8.01×10^{-7}	-0.66	-0.9735***	-17.57	0.1811	0.3040	0.4215	0.0000***	0.0000***
Finance	3	0.0013	1.11	-1.21×10^{-6}	-0.91	-0.8003***	-18.17	0.5911	0.1109	0.1337	0.0000***	0.0000***
Industrial	4	0.0009	0.91	-1.01×10^{-6}	-0.92	-0.9753***	-17.18	0.3450	0.6403	0.5713	0.0000***	0.0000***
Plantation	1	0.0020	1.90	-2.28×10^{-6}**	-1.89	-0.9645***	-27.61	0.1405	0.2664	0.2796	0.0000***	0.0000***
Mining	1	0.0026*	1.44	-2.97×10^{-6}*	-1.49	-1.0465***	-28.92	0.2498	0.4400	0.6404	0.0000***	0.0000***
Property	5	0.0009	0.76	-1.45×10^{-6}	-1.03	-0.8773***	-15.97	0.6258	0.2833	0.3713	0.0000***	0.0000***

t_μ is the t-test statistic for testing Ho: $\mu = 0$.
t_β is the t-test statistic for testing Ho: $\beta = 0$.
t_α is the ADF test statistic for Ho : $\alpha = 0$ and the critical values are -3.9692, -3.4152 and -3.1295 at the 1%, 5% and 10%, respectively (MacKinnon, 1991)
*** Significant at the 1% level.
** Significant at the 5% level.
* Significant at the 10% level.

The Phillips-Perron test allows for dependent and heterogeneously distributed error term (Phillips and Perron, 1988). The ADF test statistic is adjusted to take into consideration the effect of serially correlated and heteroscedastic errors. The Phillips-Perron test has the same asymptotic power properties as the Dickey-Fuller test.

Table 5.2 gives the results for the Phillips-Perron unit root test for both the level and first difference of the sectoral indices. The truncation lag used for the Phillips-Perron test follows the lag length chosen for the ADF test as reported in Table 5.1. Besides that, truncation lag of 5, 10 and 20 were also used to examine the sensitiveness of the test to the truncation lag.

The results show that Phillips-Perron test cannot reject the null hypothesis of a unit root for the levels of all sectoral indices. This shows non-stationarity in the series. However, the test statistics for the first difference of all the series are significant at the 1 percent level. This indicates that the sectoral indices have one unit root or they are I(1). For both the levels and first differences, the higher lag order of 5, 10 and 20 give the same results as the first set of truncation lag chosen. Thus, the results are robust to the truncation lag used. The results are also consistent with the findings of the ADF test.

Table 5.2: The Phillip-Perron Test Statistics for Testing the Presence of a Unit Root

(a) Logarithm of Sectoral Indices

Index	Lag Length			
	Same as the ADF Test	5	10	20
Composite	-2.1520(1)	-2.1565	-2.1383	-2.1752
Finance	-2.2019(3)	-2.2110	-2.2157	-2.2532
Industrial	-2.0576(1)	-2.0517	-2.0478	-2.0669
Plantation	-2.8725(1)	-2.8857	-2.8989	-2.9058
Mining	-3.0679(1)	-3.0689	-3.0798	-3.1044
Property	-2.2941(1)	-2.3270	-2.3339	-2.3632

Table 5.2 (Continued)

(b) First-Difference of Logarithm of Sectoral Indices

Index	Lag Length			
	Same as the ADF Test	5	10	20
Composite	-37.7024(4)***	-37.6995***	-37.6816***	-37.7085***
Finance	-34.3031(3)***	-34.3939***	-34.3913***	-34.9250***
Industrial	-38.0858(4)***	-38.0866***	-38.0841***	-38.0935***
Plantation	-37.0246(1)***	-37.0844***	-37.1813***	-37.2339***
Mining	-39.6550(1)***	-39.6538***	-39.6648***	-39.7532***
Property	-36.0523(5)***	-36.0523***	-36.0794***	-36.3434***

PP test statistic for Ho : $\alpha = 0$ and the critical values are -3.9692, -3.4152 and -3.1295 at the 1%, 5% and 10%, respectively (MacKinnon, 1991).

The figures in parentheses show the lag length used in Table 5.1

*** Significant at the 1% level.

** Significant at the 5% level.

* Significant at the 10% level.

5.2.2 Cointegration

The unit root tests show that all the sectoral indices contain a stochastic trend. We now examine whether any common stochastic trend exists among these indices. The cointegration test is used for this purpose. The concept of cointegration means that there is at least one long-run equilibrium relationship among the different series, which links them together. Cointegration also implies that at least one linear combination of the sectoral indices are stationary although the series are not individually stationary. One requirement before testing for cointegration is that the individual series must have the same number of unit root, which must be more than zero. As discussed in the previous section, this requirement is met.

When performing the ADF test, we see that the sectoral indices contain a deterministic trend. Therefore, the cointegration test is performed by taking the presence of deterministic trend in these series into account. It is further assumed that intercepts are present in the cointegrating vector. Our aim is to test if there is any common stochastic trend among the five sectoral indices. If r cointegrating vector is found, this means 5-r common stochastic trends exist. We fitted the VEC model defined in equation (3.12). One to twelve lags were included, and the Schwarz criterion given by Section 3.2.2.1 is used to select the optimal lag length. In this case, lag 1 gives the smallest Schwarz value. The statistics for the cointegration test are reported in Table 5.3. We see that one cointegrating vector is found because $H_0: r = 0$ is rejected, but $H_0: r = 1$ cannot be rejected.

Table 5.3: The Cointegration Test

Eigenvalue	Likelihood Ratio Trace Statistics	5 percent critical value	1 percent critical value	Hypothesized Number of CE(s)
0.0201	78.4841	68.52	76.07	0 ***
0.0144	47.0663	47.21	54.46	1
0.0115	24.5879	29.68	35.65	2
0.0029	6.6391	15.41	20.04	3
0.0014	2.2133	3.76	6.65	4

Note: CE refers to cointegrating equation.
*** Significant at the 1% level.

Based on the results, a single cointegrating vector is found to exist. This implies that the price series are bound together by a long-run equilibrium relationship. The normalized cointegrating relation is given by

$$Ln\hat{F}_t = 6.97LnI_t - 14.61LnL_t + 10.54LnM_t - 6.29LnP_t + 54.46$$
$$(19.87) \quad (51.19) \quad (36.17) \quad (21.55)$$

where Ln refers to the natural logarithm, figures in parentheses are standard errors and F_t, I_t, L_t, M_t and P_t represent the Finance, Industrial, Plantation, Mining and Property Index, respectively.

The existence of this long-run equilibrium shows the tendency to move together among the five sectoral indices. Hence, in the long run, they do not drift apart from each other.

5.2.3 Vector Error Correction Model

The VEC model takes into account both the short and long-run dynamics of the process to explain movements in the sectoral returns. Since there is one cointegrating relationship among the series, only one error correction term (ECT) is used in the subsequent VEC model. The ECT is given by:

$$Z_t = LnF_t - 6.97LnI_t + 14.61LnL_t - 10.54LnM_t + 6.29LnP_t - 54.46$$

The ECT shows the error correcting adjustments that maintain the long-run equilibrium relationship. When a series deviates from the long-run equilibrium, it will adjust back to the long-run path according to this error correcting mechanism. For example, if lnF_{t-1} drops below all the other series, a positive error correcting adjustment will take place to bring it back to the long-run relationship. If the series increase above all the other series, a negative adjustment will take place to reduce its value. In short, the ECT is included in the model to ensure that the sectoral indices do not drift far apart from the equilibrium relationship.

Table 5.4: The Vector Error Correction Model

Independent Variable	Dependent Variable				
	ΔLnF_t	ΔLnI_t	ΔLnL_t	ΔLnM_t	ΔLnP_t
Constant	0.0004 (0.0006)	0.0001 (0.0005)	0.0003 (0.0005)	0.0001 (0.0009)	-0.0002 (0.0006)
ΔLnF_{t-1}	0.2449*** (0.0558)	0.1166** (0.0460)	0.0968* (0.0506)	0.1823** (0.0836)	0.1668*** (0.0586)
ΔLnI_{t-1}	-0.0820 (0.0636)	-0.0934* (0.0524)	-0.0708 (0.0577)	-0.0125 (0.0953)	-0.0158 (0.0668)
ΔLnL_{t-1}	0.0006 (0.0526)	0.0066 (0.0433)	0.0068 (0.0477)	0.0691 (0.0789)	-0.0921* (0.0553)
ΔLnM_{t-1}	-0.0555** (0.0270)	-0.0064 (0.0222)	-0.0101 (0.0245)	-0.1019** (0.0404)	-0.0569** (0.0284)
ΔLnP_{t-1}	-0.0072 (0.0507)	0.0004 (0.0417)	0.0350 (0.0460)	-0.0451 (0.0759)	0.0784 (0.0532)
Z_{t-1}	-0.0016*** (0.0004)	-0.0007*** (0.0003)	-0.0010*** (0.0003)	-0.0009** (0.0005)	-0.0015*** (0.0004)

See text in Section 5.2.2 for definition of variables.
Figures in parentheses are standard errors.
*** Significant at the 1% level.
** Significant at the 5% level.
* Significant at the 10% level.

Table 5.4 shows the VEC model with 1 lag included as determined by the Schwarz criterion. We see that all the ECT's are significantly negative at the 1 percent level except that for the mining, which is significant at the 5 percent level. Given a 1 percent deviation from the long-run equilibrium path, the Finance, Industrial, Plantation, Mining and Property Index adjust by 0.16 percent, 0.07 percent, 0.10 percent, 0.09 percent and 0.15 percent in a day, respectively, to return to the long-run relationship. The adjustment is the fastest in the finance and property sectors and the slowest in the industrial sector.

Besides being bound by this long-run, equilibrium relationship, it is clear that the lagged sectoral returns are also important in explaining the sectoral performance. Since the equations in the system are based only on one lag of the sectoral returns, the individual t-statistics of the reported coefficients of lagged returns in Table 5.4 can be used to study the lead-lag relationship between returns of different sectors. This follows the principle of the Granger causality test discussed in Section 3.2.2.4. Since our results indicate the existence of cointegration among the sectors, there must be Granger causality in at least one direction for some of the sectors. A significant coefficient of a particular first lagged sectoral return means that this sector leads the sector implied by the dependent variable of the equation.

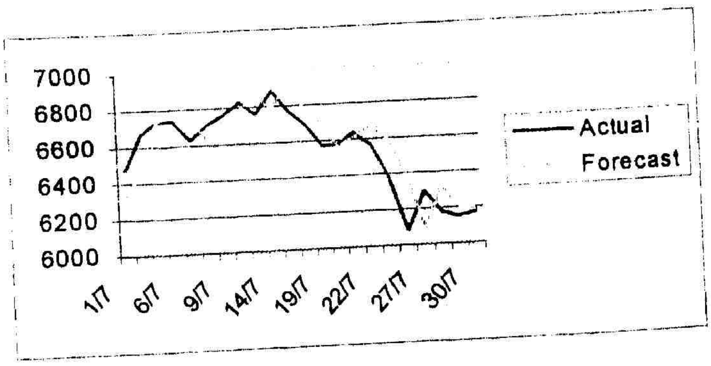
The results show that the lagged return of the mining sector Granger cause the returns in the finance sector. The finance sector seems to lead all the other sectors. The results also show that the plantation and mining sectors Granger cause the property sector. The property sector does not have any causality effect on all the other sectors. The returns in all the respective sectors are explained by their past returns except for the plantation and property sectors. These results show that over the entire sample period, the finance sector is the most significant in leading the other sectors. This is expected as any changes in the finance policy will have direct effect on the performance of the other sectors. However, as said earlier, the entire sample period covers different market behaviour. A more detailed study that examines the lead-lag relationship under different market conditions is discussed in Chapter 6.

5.2.4 Forecasting

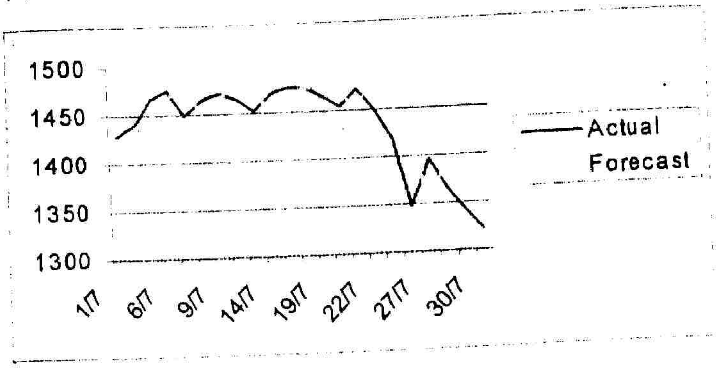
To evaluate the usefulness of the VEC model, its forecasting ability is examined. The VEC model fitted using daily data for the period 29 March 1993 to 30 June 1999 is used to forecast the daily indices of the five sectors for the month of July 1999. A one-period ahead forecast is carried out. Figure 5.1 plots the actual indices of the respective sectors with the forecast indices from the VEC model. Overall, the forecast indices track the actual series rather closely. There are certain days where the forecasts are identical to the actual values.

Figure 5.1: One-Period Ahead Forecasts for Daily Indices of July 1999 Based on the VEC Model

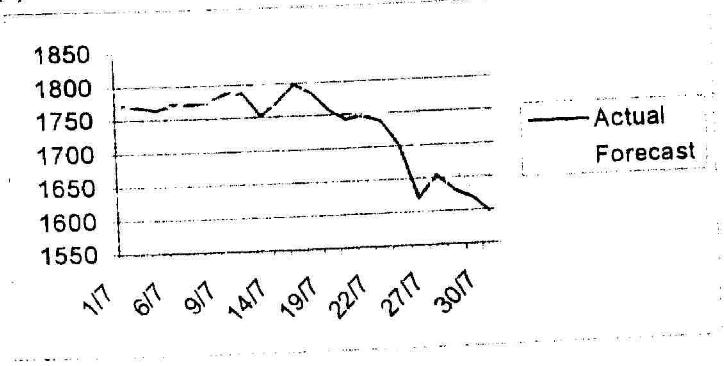
(a) Finance Sector



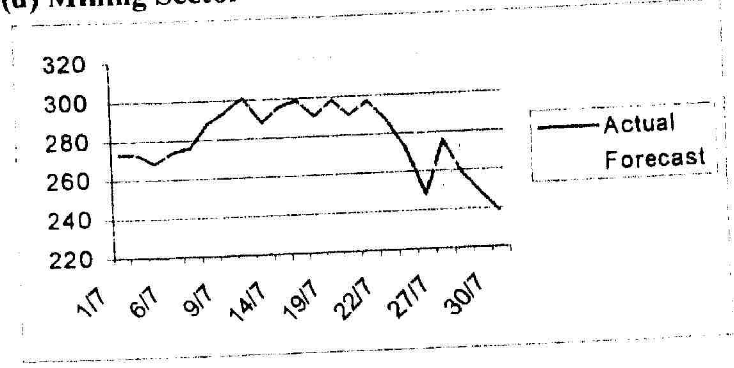
(b) Industrial Sector



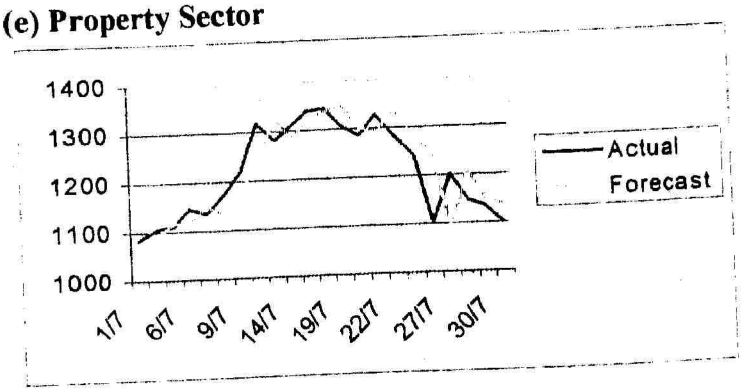
(c) Plantation Sector



(d) Mining Sector



(e) Property Sector



le 5.5 presents four measures to evaluate the forecasting errors of the VEC model. y are the Mean Absolute Deviation (MAD), Root Mean Squared Error (RMSE), an Absolute Percent Error (MAPE) and Theil's U Inequality Coefficient. These asures are defined in Section 3.2.2.5. Based on the MAD and RMSE, the smallest erage error per day is found for the mining sector. This is followed by the ntation, industrial, property and finance sector. To take into consideration of the els of the sectoral indices, we examine the MAPE. The sector with the smallest recast error is plantation, which has an error of 1.17 percent. This is followed by the dustrial and finance sectors with mean percent errors of 1.51 percent and 1.57 ercent, respectively. The property and mining sectors have the largest errors of 3.45 ercent and 3.57 percent, respectively. The figures indicate that the VEC model has easonably good forecasting power.

The Theil's U results indicate whether the model used for forecasting performs better, worse or no different from the no change model. We observe that all the U's values are slightly above 1. This shows that the VEC model does not perform better than the no change model.

Table 5.5: Evaluation of Forecasting Errors

Measure	Index				
	Finance	Industrial	Plantation	Mining	Property
Mean Absolute Deviation	101.27	21.21	19.76	9.72	41.50
Root Mean Squared Error	126.55	27.13	27.03	11.68	52.69
Mean Absolute Percent Error (%)	1.57	1.51	1.17	3.57	3.45
Theil's U	1.05	1.09	1.08	1.01	1.02