Chapter 4

Time Series Analysis

This chapter covers the statistical modelling that is used to analyse the data, which includes the following components.

1. Time series analysis of economic indicators in Thailand
2. Time series analysis of economic indicators in Malaysia
3. Comparison of the results for the two countries.

The data analysed in this study are economic indicators measured at monthly intervals, so time series methods are used to analyse them. This study used the program Asp (see McNeil, 1998a) developed using Matlab Version 5. The Asp time series analysis command tsplot is used for the analyses.

The model fitted to a time series is called the signal, and the residual series after subtracting this signal is called the noise. As described in Chapter 2, the noise may be modelled as an autoregressive process.

Figures 4.1 to 4.12 graphically present the time series analyses. There are four pictures in each figure. The picture at the top left of each figure shows the data plotted as a time series with the fitted model superimposed. The picture on the top right comprises a plot of the scaled periodogram, with the theoretical curve corresponding to the fitted model superimposed. This graph shows the proportionate contribution to the total squared error from each frequency. The bottom right picture shows the base 10 logarithm of the periodogram values, because the variance of the periodogram is stabilised by taking logarithms. This makes it easier to compare values of the periodogram at different frequencies. The lower left picture shows the sample autocorrelation function of the residuals, together with p-values for the Ljung-Box test. P-values greater than 0.05 are denoted by circles and p-values less than 0.05 are denoted by crosses. If circles denote most p-values, the results are consistent with the time series being a white noise process, that is, a process of mutually uncorrelated observations.

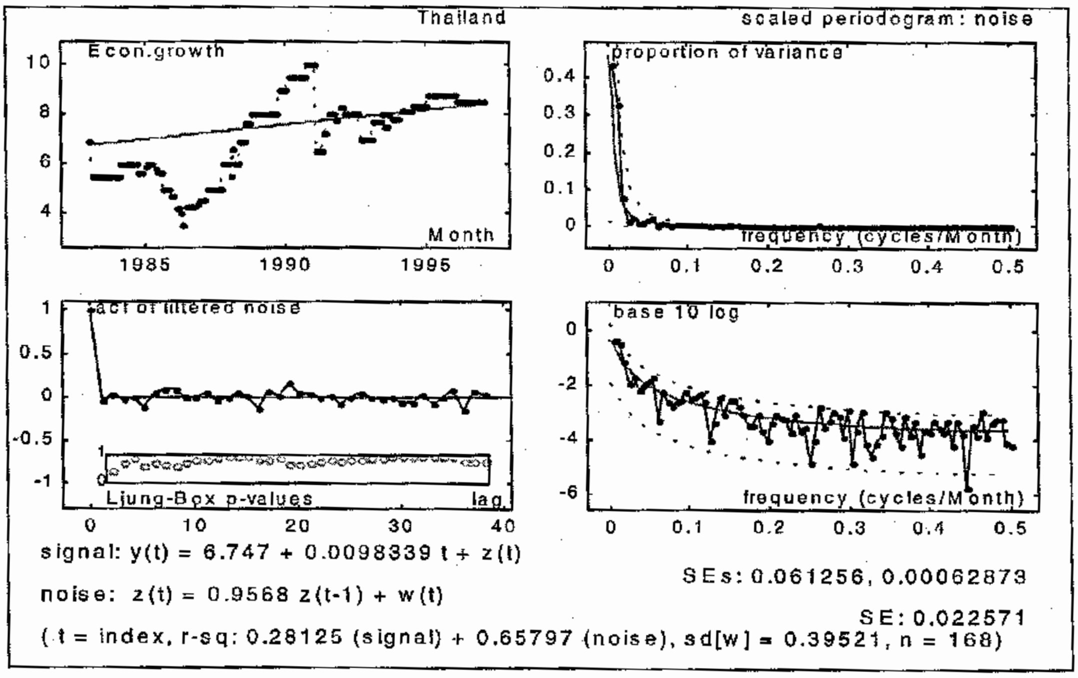
The data are clearly not stationary because the means change with time. As seen in the preliminary analysis, the international reserves, money supply, exports and imports need to be transformed by taking logarithms. The economic growth and trade balance are not transformed because they take both positive and negative values. The results are described in the following sections.

Time Series Analysis of Economic Indicators in Thailand

1. Economic Growth

Figure 4.1 shows the fitted model for the economic growth rate in Thailand using time series analysis. The signal is assumed to follow a linearly increasing trend, with value 6.6% at the beginning of 1983, increasing to 9.4% at the end of 1996 (an increase of almost 0.01% per month), while the noise is modelled as a first order autoregressive process with fitted parameter 0.957.

Figure 4.1 Time series of economic growth of Thailand

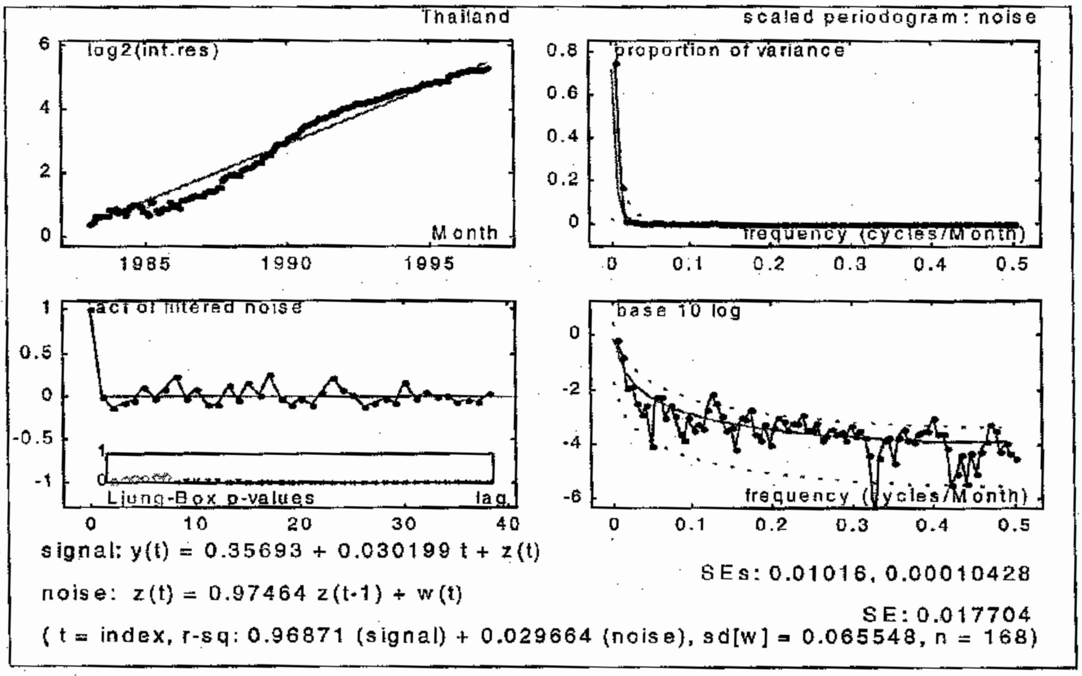


Most of the periodogram values are inside the 95% confidence limits based on the fitted model, indicating that the model fits the data adequately. The r-squared of the signal is 0.281, demonstrating that only 28.1% of variation in the data is explained by the linear trend. The r-squared associated with the fitted autoregressive model is 0.658, giving a total r-squared of 0.939. The Ljung-Box p-values are all greater than 0.05, as indicated by circles on the graph. Thus there is evidence that the filtered noise, after removing the autoregressive component, is a white noise process. Since the parameter in the fitted autoregressive model is close to 1, the time series closely resembles a random walk. For such processes, the noise, rather than the signal, accounts for most of the variation in the data.

2. International Reserves

Figure 4.2 shows the model for the international reserves in Thailand after log- transforming the data. In this case the fitted signal is a linearly increasing trend. This trend increased from 1.31 billion US$ per month at the beginning of 1983 to 43.1 billion US$ per month at the end of 1996.

Figure 4.2 Time series of log2 (international reserves) of Thailand

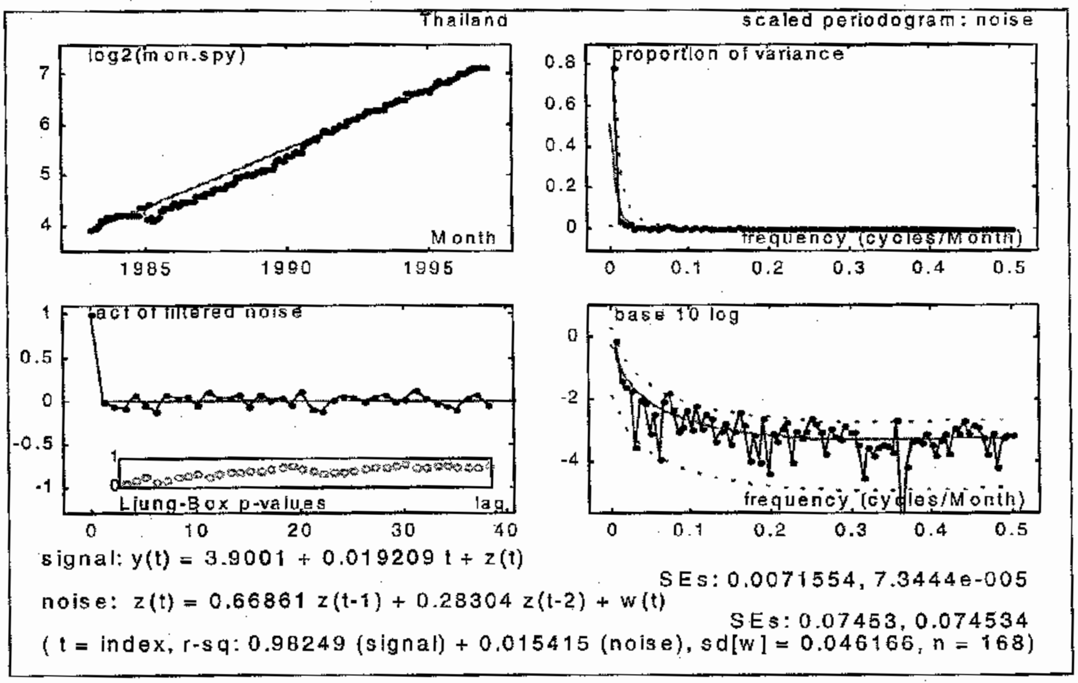


The noise is modelled as a first order autoregressive process with fitted parameter 0.975. The r-squared of signal is 96.9%. The r-squared associated with the fitted autoregressive model is 0.03, giving a total r-squared of 0.999. The Ljung-Box p-values are mostly less than 0.05. This shows that the periodogram does not look much like the periodogram of a white noise process.

3. Money Supply

Figure 4.3 shows the model for the money supply in Thailand. The values increased from 15.13 billion US$ per month at the beginning of 1983 to 139.81 billion US$ per month at the end of 1996.

Figure 4.3 Time series of log2(money supply) of Thailand



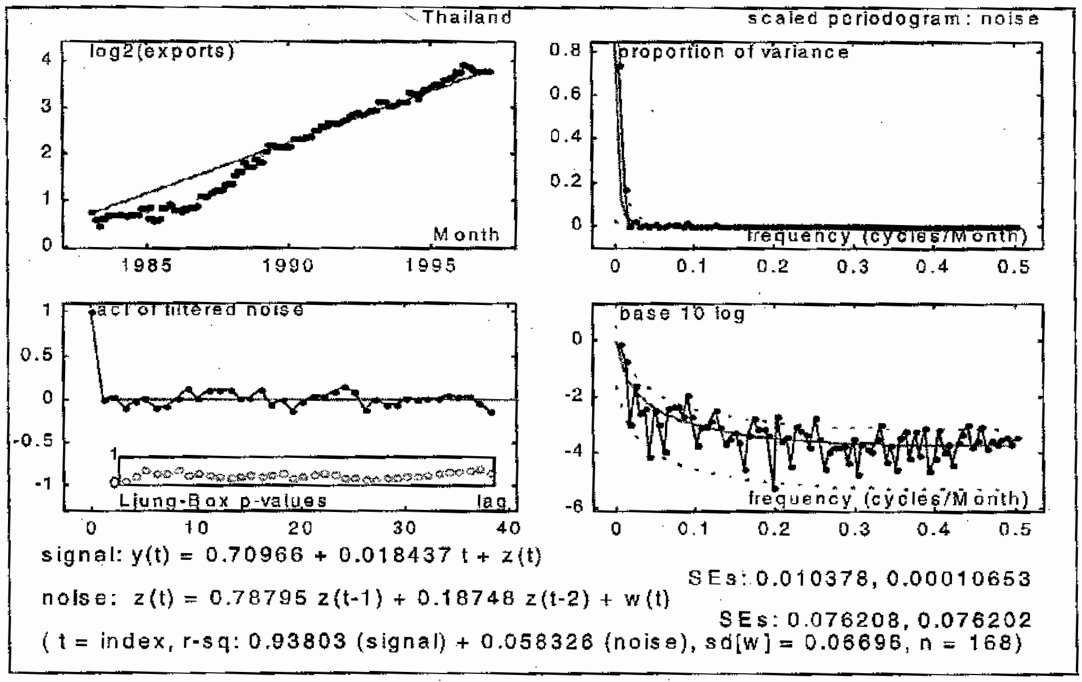
The noise is modelled as a second order autoregressive process with fitted parameters 0.669 and 0.283. Most of the periodogram values are inside the 95% confidence limits based on the fitted model, indicating that the model fits the data adequately. The r-squared of the signal is 98.3%.

The r-squared associated with the fitted autoregressive model is only 0.015, giving a total r-squared of 0.998. The Ljung-Box p-values are all greater than 0.05, as indicated by circles on the graphs. Thus there is evidence that the fitered noise, after removing the autoregressive component, is a white noise process.

4. Exports

Figure 4.4 shows the model for the value of exports in Thailand. The flow of exports increases from a monthly average of 1.65 billion US$ at the beginning of the period to 14 billion US$ at the end of the period.

Figure 4.4 Time series of log2 (exports) of Thailand

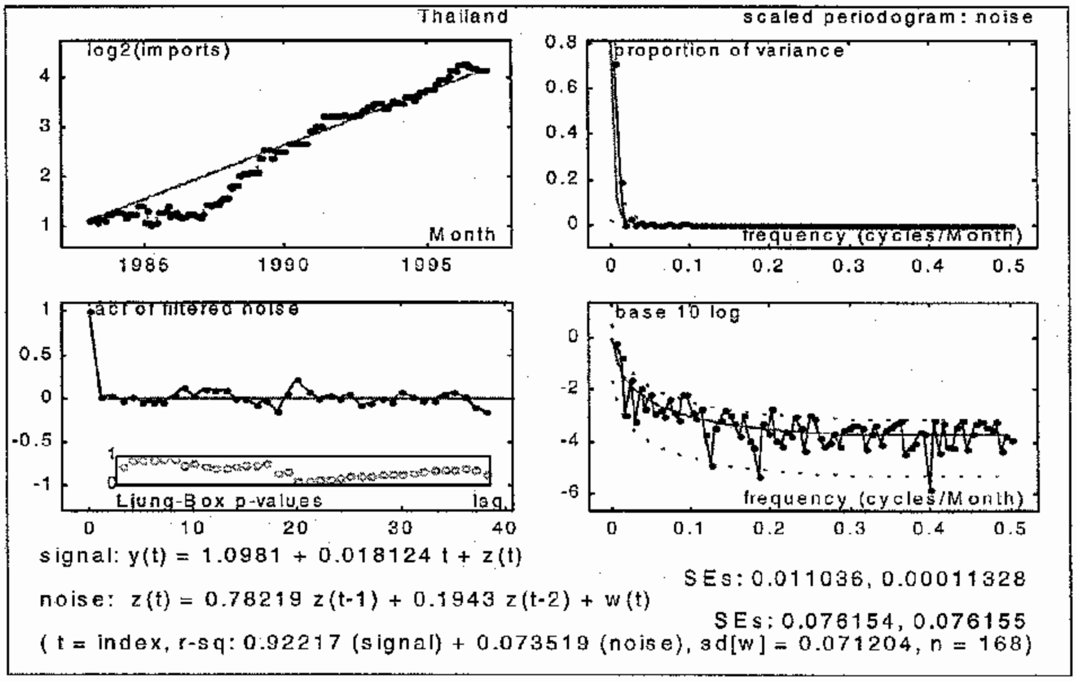


The noise is modelled as a second order autoregressive process with fitted parameters 0.788 and 0.187. Most of the periodogram values are inside the 95% confidence limits based on the fitted model, indicating that the model fits the data adequately. The r-squared of the signal is 93.8%. The r-squared associated with the fitted autoregressive model is 0.058, giving a total r-squared of 0.996. The Ljung-Box p-values are all greater than 0.05. Thus there is evidence that the fitered noise, after removing the autoregressive component, is a white noise process

5. Imports

Figurc 4.5 shows the model for the valuc of imports in Thailand. The value of this trend increased from 2.17 billion US$ per month at the beginning of 1983 to 17.7 billion US$ per month at the end of 1996.

Figure 4.5 Time series of log2 (imports) of Thailand



The noise is modelled as a second order autoregressive process with fitted parameters 0.783 and 0.193. Most of the periodogram values are inside the 95% confidence limits based on the fitted model, indicating that the model fits the data adequately. The r-squared of the signal is 92.2%.

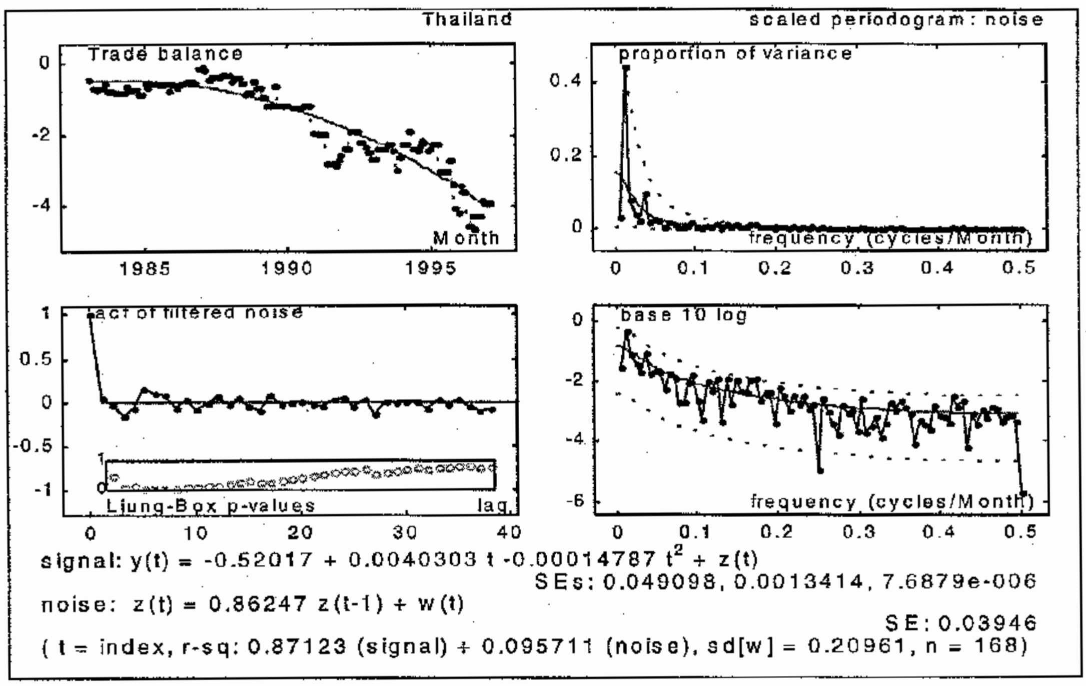
The r-squared associated with the fitted autoregressive model is only 0.073, giving a total r-squared of 0.995. The Ljung-Box p-values are mostly greater than 0.05, confirming that the fit of model is satisfactory.

6. Trade Balance

Figure 4.6 shows the model for the trade balance in Thailand. The signal is quadratic with decreasing trend during the study pcriod. The slope of this trend decreased from 0.004 billion US$ per month at the beginning of 1983 to -0.046 billion

US$ per month at the end of 1996. Thus the flow of the trade balance deteriorated from a monthly surplus of 4 million US$ at the beginning of the period to a monthly deficit of 46 million US$ at the end of the period.

Figure 4.6 Time series of trade balance of Thailand



The noise is modelled as a first order autoregressive process with fitted parameter 0.862. Most of the periodogram values are inside the 95% confidence limits based on the fitted model, indicating that the model fits the data adequately. The r-squared of the signal is 87.1%.

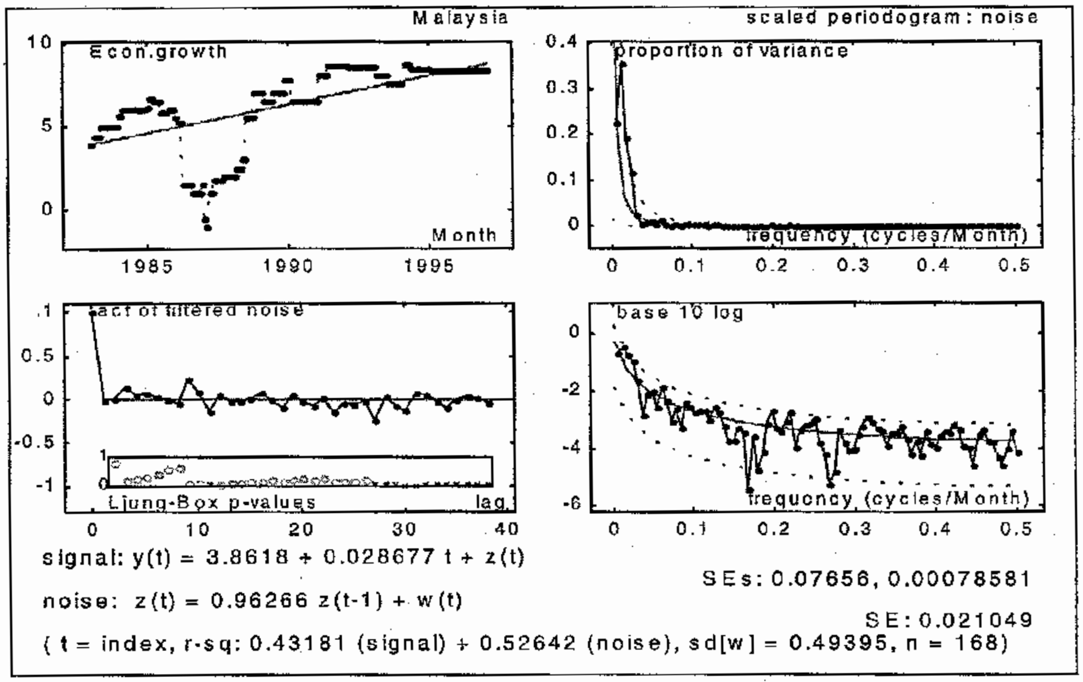
The r-squared associated with the fitted autoregressive model is 0.096, giving a total r-squared of 0.967. The Ljung-Box p-values are mostly greater than 0.05, confirming that the fit of the model is satisfactory. The residual series thus resembles a random walk.

Time Series Analysis of Economic Indicators in Malaysia

1. Economic Growth

Figure 4.7 shows the fitted model for the economic growth in Malaysia using time series analysis. The signal is assumed to follow a linearly increasing trend, with value 3.8% at the beginning of 1983, increasing to 8.6% at the end of 1996 (an increase of almost 0.03% per month), while the noise is modelled as a first order autoregressive process with fitted parameter 0.963.

Figure 4.7 Time series of economic growth of Malaysia



Most of the periodogram values are inside the 95% confidence limits based on the fitted model, indicating that the model fits the data adequately. The r-squared of the signal is 0.432, demonstrating that only 43.2% of variation in the data is explained by this trend.

The r-squared associated with the fitted autoregressive model is 0.526, giving a total r-squared of 0.958. The Ljung-Box p-values are all greater than 0.05, as indicated by circles on the graph. Thus there is evidence that the filtered noise, after removing the autoregressive component, looks like a white noise process, as in

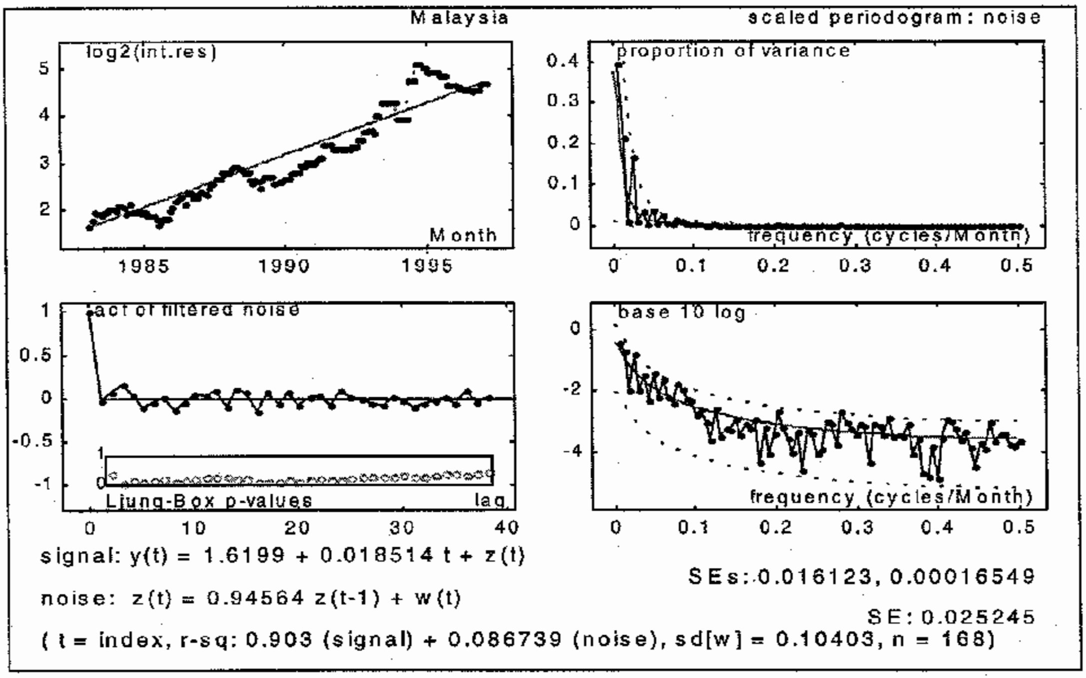
Thailand. For such processes, the noise, rather than the signal, accounts for most of the variation in the data. The time series itself resembles a random walk with positive drift.

2. International Reserves

Figure 4.8 shows the model for the international reserves in Malaysia as for the corresponding Thai data, the logarithm transformation is used. In this case the fitted signal is a linear trend. The inflow of international reserves from a monthly average of 3.1 billion US$ at the beginning of the period to 26.5 billion US$ at the end of the period.

The noise is modelled as a first order autoregressive process with fitted parameter 0.946. Most of the periodogram values are inside the 95% confidence limits based on the fitted model, indicating that the model fits the data adequately. The r-squared of the signal is 90.3%.

Figure 4.8 Time series of log2 (international reserves) of Malaysia



The r-squared associated with the fitted autoregressive model is 0.087, giving a total r-squared of 0.99. The Ljung-Box p-value are all circles in the box. Indicating that the filtered noise for the international reserves model is white.

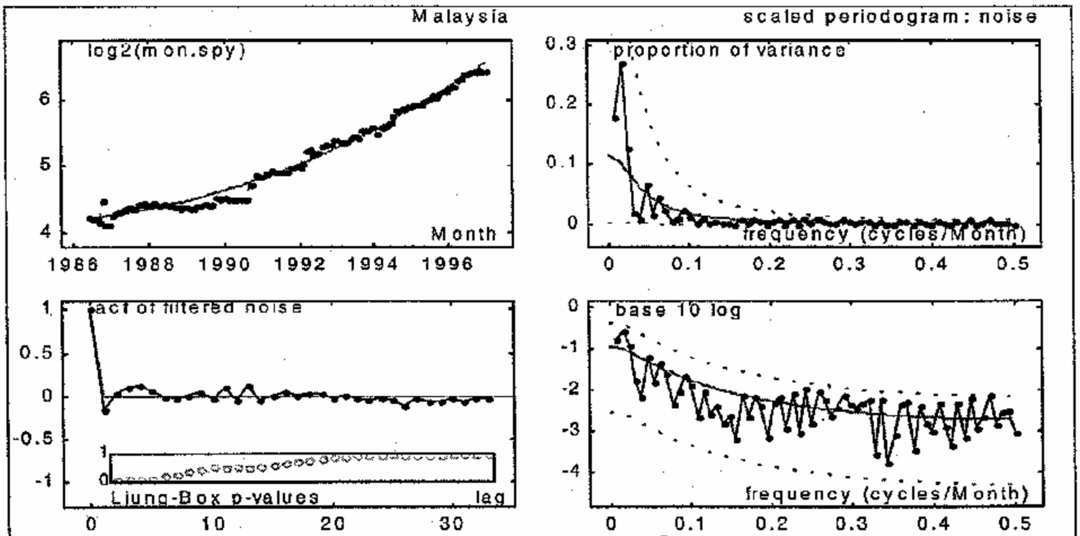
3. Money Supply

Figure 4.9 shows the model for the money supply in Malaysia. The fitted signal is quadratic. There were outliers from 1983 to mid-1986, the study omitted outliers before analyses time series. The flow of the money supply improved after omit outliers from a monthly average of 24.08 billion US$ at the 41st month of the period to 256.11 billion US$ at the end of the period.

The noise is modelled as a first order autoregressive process with fitted parameter 0.765. Most of the periodogram values are inside the 95% confidence limits based on the fitted model. The r-squared of the signal is 98.5%.

The r-squared associated with the fitted autoregressive model is 0.009, giving a total r-squared of 0.994. The Ljung-Box p-values are all circles in the box. Indicating that the filtered noise for the money supply model is white noise process.

Figure 4.9 Time series of log2 (money supply) of Malaysia



signal: $y(t) = 4.2127 + 0.0048917\,t + 0.00010509\,t^2 + z(t)$
SEs: 0.015343, 0.00054909, 4.1234e-006

noise: $z(t) = 0.76495\,z(t-1) + w(t)$
SE: 0.058591

(t = index, r-sq: 0.9851 (signal) + 0.0085953 (noise), sd[w] = 0.056961, n = 128)

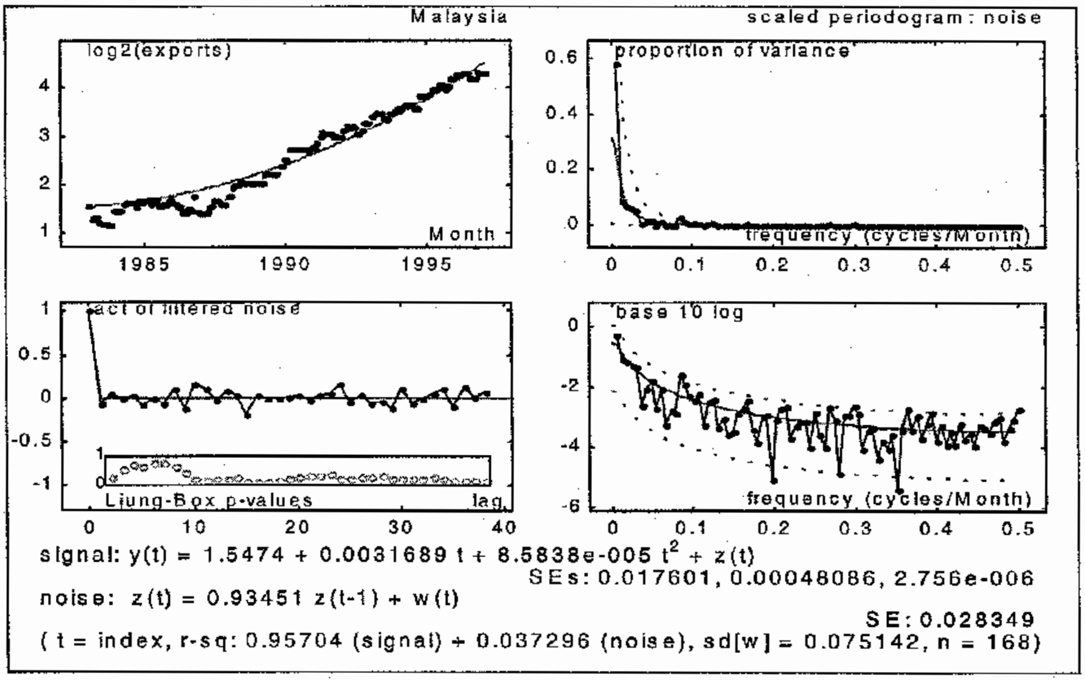
4. Exports

Figure 4.10 shows the model for the value of exports in Malaysia as for Thailand. In this case the fitted signal is quadratic with increasing trend during the study period. The valuc increased from 2.93 billion US$ per month at the beginning of period to 22.67 billion US$ per month at the end of period.

The noise is modelled as a first order autoregressive process with fitted parameter 0.934. Most of the periodogram values are inside the 95% confidence limits based on the fitted model, indicating that the model fits the data adequately.

The r-squared of the signal is 0.957, demonstrating that 95.7% of variation is explained by this trend. The r-squarcd associated with the fitted autoregressive model is 0.037, giving a total r-squared of 0.994. The Ljung-Box p-values are all greater than 0.05, showing that it is a white noise process.

Figure 4.10 Time series of log2(exports) of Malaysia



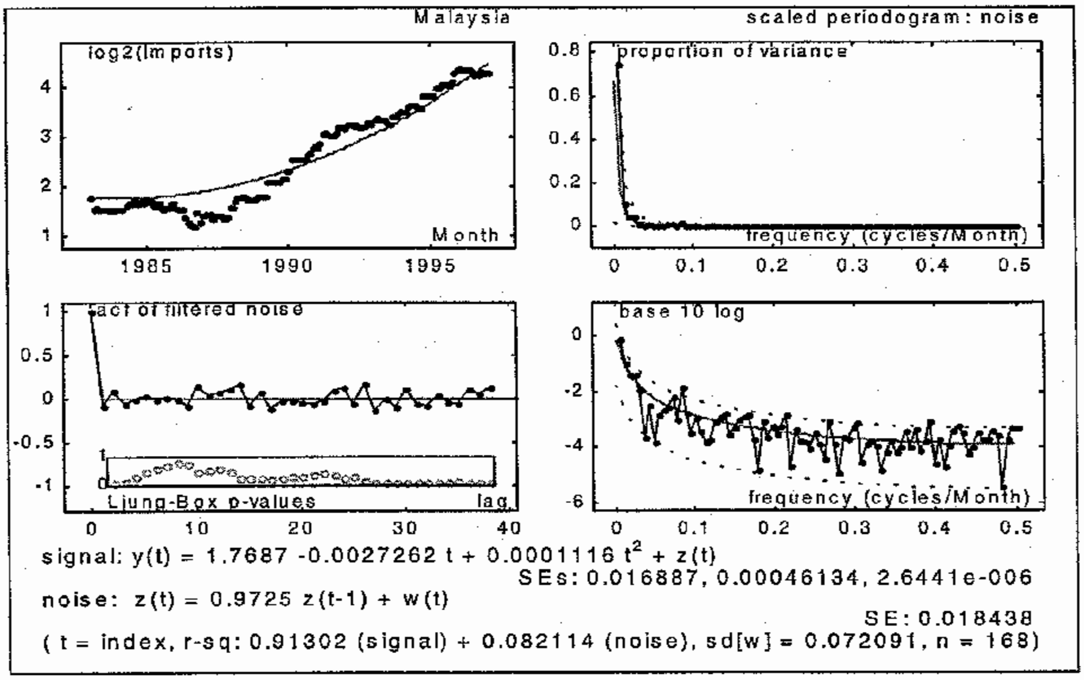
5. Imports

Figure 4.11 shows that the time series of imports from Malaysia. The data arc again log-transformed. The signal is quadratic with increasing trend during the study period. The value increased from 3.4 billion US$ per month at the beginning of 1983 to 22.01 billion US$ per month at the end of 1996.

The noise is modelled as a first order autoregressive process with fitted parameters 0.972. Most of the periodogram values are inside the 95% confidence limits based on the fitted model, indicating that the model fits the data adequately. The r-squared of the signal is 91.3%.

The r-squared associated with the fitted autoregressive model is 0.082, giving a total r-squared of 0.995. The Ljung-Box p-values are all greater than 0.

Figure 4.11 Time series of log2 (imports) of Malaysia



6. Trade Balance

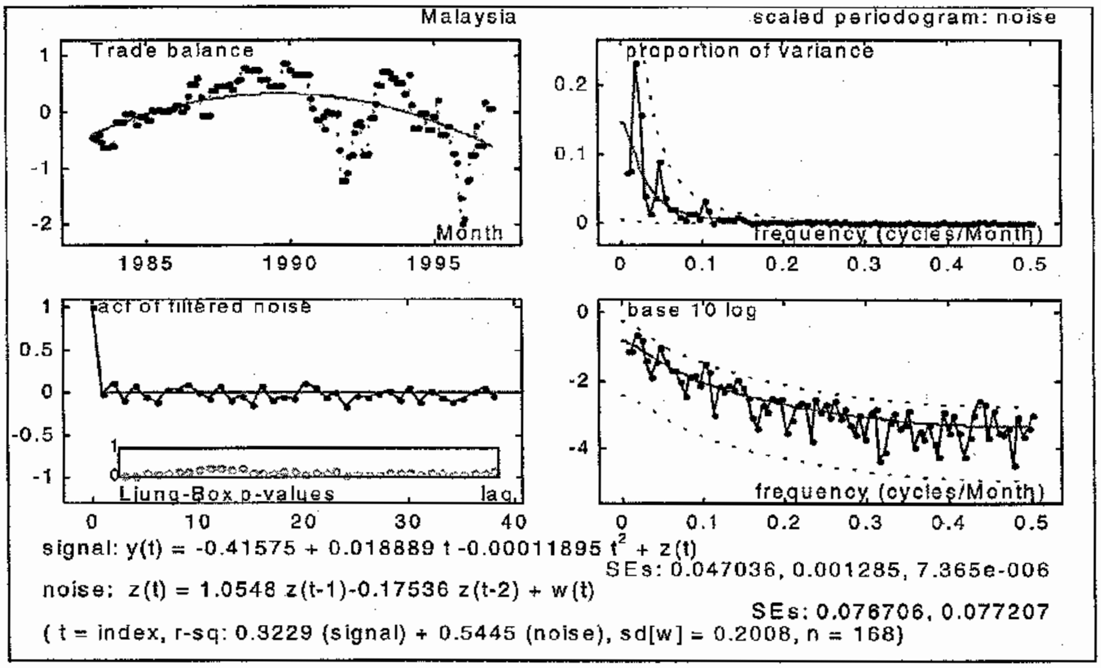
Figure 4.12 shows the trade balance of Malaysia. The signal is again quadratic with decreasing trend during the study period. The slope of this trend decreased from 0.019 billion US$ per month at the beginning of 1983 to –0.021 billion US$ per month at the end of 1996. Thus the flow of the trade balance improved from a monthly surplus of 19 million US$ at the beginning of the period to a monthly deficit of 21 million US$ at the end of the period.

The noise is modelled as a second order autoregressive process with fitted parameters 1.054 and –0.175. Most of the periodogram values are inside the 95% confidence limits based on the fitted model, indicating that the model fits the data adequately. The r-squared of the signal is only 32.3%.

The r-squared associated with the fitted autoregressive model is only 0.526, giving a total r-squared of 0.958. The Ljung-Box p-values are all greater than 0.05, as indicated by circles on the graph. Thus there is evidence that the filtered noise, after removing the autoregressive component, is a white noise process, confirming that the fit of the model is satisfactory.

Since the parameter in the fitted autoregressive model is close to 1, the time series resembles a random walk. For such processes, the noise, rather than the signal, accounts for most of the variation in the data.

Figure 4.12 Time series of trade balance of Malaysia



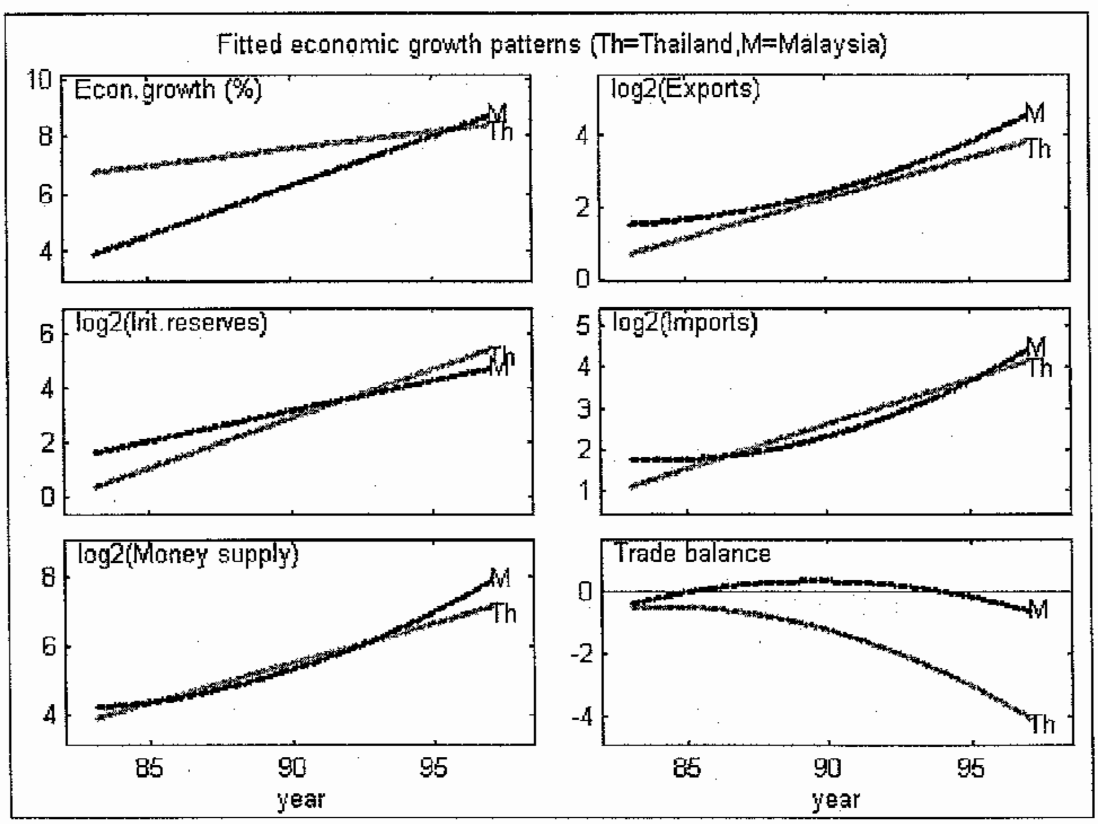
Summary

Figure 4.13 summarises the signals fitted to the various economic time series in the preceding sections. This graph may be used to visually compare the economic indicators in Thailand and Malaysia. The following conclusions are evident.

1. The economic growth in Thailand was higher than in Malaysia for most of the period of study. However, the trend of economic growth in Thailand increased slightly while in Malaysia the economic growth increased substantially. In 1996 the economic growth in Malaysia caught up to that in Thailand.

2. From 1983 to 1993, the international reserves of Thailand were slightly lower than Malaysia. But this tend was reverse after 1993, the international reserves in Thailand surpassed those in Malaysia, and increased more than those in Malaysia afterwards.

Figure 4.13 Fitted economic indicators pattern



3. From 1985 to early 1994 the money supply in Malaysia less than in Thailand. After 1995, the money supply in Malaysia tended to increase more than in Thailand.

4. The value of exports in Malaysia increased more than in Thailand. From 1987 to 1992 the value of exports in Thailand and Malaysia nearly the same. After that the value of exports in Malaysia tended to increase more than in Thailand.

5. From 1986 to early 1996 the value of imports in Malaysia was less than in Thailand. After 1996, the value of imports in Malaysia tended to increase more than in Thailand.

6. In 1983 the values of the trade balance in Thailand and Malaysia were the same. Afterwards, the trade balance in Thailand declined substantially, while in Malaysia the trade balance remained close to zero, but declined slightly during the second half of the study period.

Table 4.1 shows the fitted parameter associated with the noise, and the r-squared for the signal, the r-squared for the noise and the total r-squared.

In Thailand, the residual series of money supply, exports and imports (after fitting the signal) is well fitted by a second order autoregressive process. In Malaysia the residual series of trade balance (after fitting the signal) is well fitted by a second order autoregressive process the same as in Thailand. For most of the economic indicators the r-squared total is over 90%. The exception is the trade balance in Malaysia. The international reserves and money supply in Thailand have very high total r-squared.

Table 4.1 Noise parameters and r-squared of economic indicators

Indicators	Country	a_1	a_2	r-sq (signal)	r-sq (noise)	r-sq (total)
log2(International reserves)	Thailand	0.975	-	0.969	0.03	0.999
	Malaysia	0.946	-	0.903	0.087	0.99
log2(Money supply)	Thailand	0.669	0.283	0.983	0.015	0.998
	Malaysia	0.765	-	0.985	0.009	0.994
log2(Export)	Thailand	0.788	0.187	0.938	0.058	0.996
	Malaysia	0.934	-	0.957	0.037	0.994
log2(Import)	Thailand	0.783	0.193	0.922	0.073	0.995
	Malaysia	0.972	-	0.913	0.082	0.995
Trade balance	Thailand	0.862	-	0.871	0.096	0.967
	Malaysia	1.054	-0.175	0.323	0.544	0.867
Economic growth	Thailand	0.957	-	0.281	0.658	0.939
	Malaysia	0.963	-	0.432	0.526	0.958

Noise: $z(t) = a_1z(t-1) + a_2z(t-2)$; where i is country (Thailand and Malaysia)