Chapter 4

Patterns in Tea Yield Series

Agricultural productivity or yield can be measured in the form of partial or total factor productivity. Partial factor productivity refers to the productivity of one single factor input. It is calculated at the ratio of total production to total quantity of factor input such as land, labour or capital, Hussein and Kuperan (1985 and 1987). An increase in partial productivity, among other things, implies a saving in the use of the input, and vice versa. Therefore, growth in total production can be an improvement in land or expansion in the land area or both.

The trends of tea production discussed in Section 3.2, shows the production of tea has been increasing over the years and the trend of input factor, that is, average hectareage in production has been gradually decreasing over the same period. The study will use partial factor productivity by taking the input factor to be average hectareage in production. The partial factor productivity calculated at the ratio of total quarterly production to quarterly average hectareage in production for every quarter from 1960 to 1996 to develop a yield time series for this study. Table A1 (Appendix A) shows the quarterly yield for tea from 1960 to 1996.

This chapter examines the yield series plot for visual evidence of trend, seasonal variation, cycle and variation in the fluctuations. The series is then decomposed into the above-said components to determine behaviour and significance. If the yield series shows non-stationarity in variance, then appropriate transformation is carried out.

4.1 Descriptive Statistics of Yield Series

The descriptive statistics of quarterly yield of tea in Peninsular Malaysia for the period 1960 to 1996 is given in Table 4.1. The average quarterly yield is 0.3677 tonnes per hectare (3677 kg/h) with standard deviation of 0.1182 tonnes per hectare (1182 kg/h). The highest and lowest quarterly yield for the period 1960 to 1996 is 0.6407 tonnes per hectare (6407 kg/h) and 0.1752 tonnes per hectare (1752 kg/h) respectively.

Table 4.1: Descriptive Statistics Of Production Per Hectare

Series: PRODHEC
Sample 1960:1 1996:4
Observations 148

Mean	0.367727
Median	0.331292
Maximum	0.640682
Minimum	0.175227
Std. Dev.	0.118173

4.2 Plot of Quarterly Production of Made Tea Per Hectare

The plot in Figure 4.1 is the plot for quarterly production per hectare (yield). It can be seen clearly from the plot that fluctuations increase as one moves from the left to the right of the graph and higher fluctuations seem to be taking place after 1980. During the period of the nineties fluctuations are much higher than in any other period. Overall, the plot indicates a general upward trend or long run growth in the quarterly production per hectare. The series also indicates seasonal variations with second quarter showing highest yield. The first quarter registers the lowest yield and third quarter yield is in between second and fourth quarter. Hence, the quarterly tea production per hectare in Peninsular Malaysia exhibits increasing fluctuations, an upward trend, seasonal variation and irregular fluctuations. The strength and presence of these regular patterns will be further confirmed by the decomposition method.

4.3 Decomposition of Yield Time Series

The first step in the analysis of time series in this study is to identify for regular patterns and explain or account for the behaviour of these patterns. Since the yield series shows increasing fluctuations, then Multiplicative Decomposition method would be appropriate to decompose the series. The yield series will be decomposed into trend (Trend-Cycle), seasonal, cycle and irregular components and then the significance of these components will be determined. The graphical insights into behaviour of the yield components will also help in identifying the structure of the yield series.

4.3.1 Trend-Cycle Pattern

The trend-cycle (T_t) of Y_t (Yield) is computed using 4-quarter centred moving average and these computed values are given in Table A2 (Appendix A). The plot of this series is shown in Figure 4.2. The plot indicates an upward trend. Run Test is performed over the yield series to determine the significance of the trend. This is to test for the null hypothesis that the series has no trend with random errors.

Figure 4.1: Time Series Plot of Quarterly Made Tea Per Hectare (Yield) In Peninsular Malaysia From 1960-1996

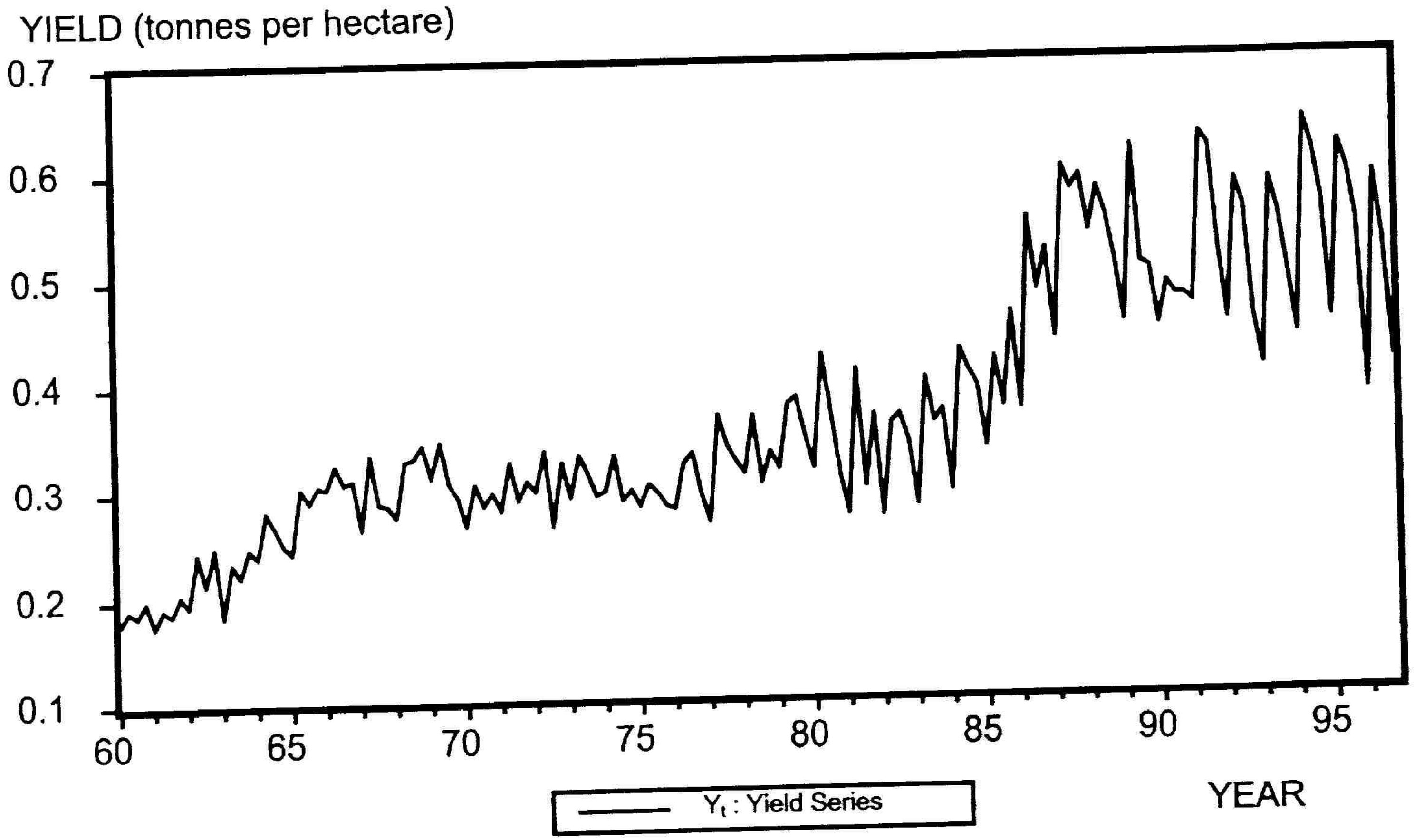
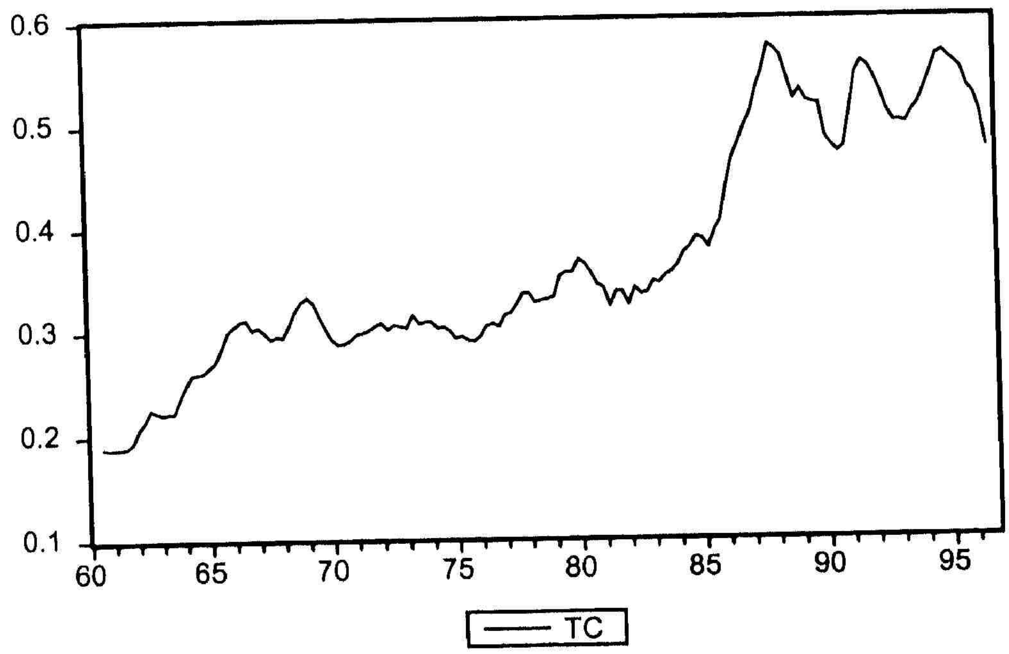


Figure 4.2: Trend-Cycle Of Quarterly Production Of Made Tea Per Hectare (Yield) From 1960-1996



Run Test: Yield Series

H_0: The quarterly yield series follows a no-trend series with independent errors.

H_1: The quarterly yield series has trend and/or autocorrelated errors.

Test Statistic: R = 30 and m=74 (m>20, large sample)

μ_R = expected number of runs = 75

σ_R = standard deviation of the number of runs = $\sqrt{\frac{m(m-1)}{(2m-1)}}$ = 6.06

$Z = \frac{(30-75)}{6.06} = -7.43$

Decision Rule: (α = 10%)

Reject H_o if $|Z| > Z_{0.05} = 1.645$

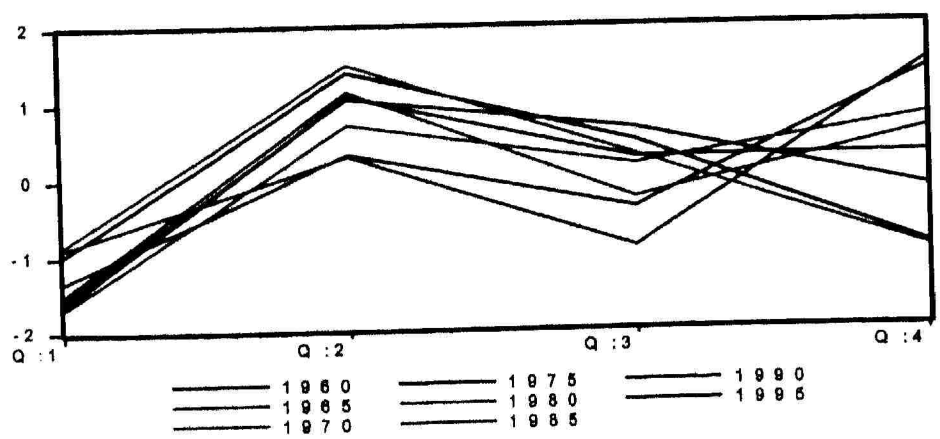
Otherwise do not reject H_o.

onclusion: Since |-7.43| > 1.645, the null hypothesis is rejected at 10% ·vel of significance and thus conclude that a no-trend model is ıappropriate.

l.3.2 *Seasonal Pattern*

To decide whether or not the yield series has seasonal pattern, he study starts by plotting the normalised quarterly yields of selected /ears at five year intervals (1960, 1965, 1970, 1975, 1980, 1985, 1990 and 1995) on the same diagram as shown in Figure 4.3. The plot shows that the yield peaks at second quarter and lowest for first quarter. Generally the periodic pattern from year to year indicates that first quarter registers the lowest yield and it peaks at second quarter and then third and fourth quarters show a decline.

Figure 4.3: Seasonal Plot Of Quarterly Production Of Made Tea Per Hectare.



ruskal-Wallis test for seasonality of the yield series

l_0: $S_1 = S_2 = S_3 = S_4 = 0$

l_1: $S_i \neq 0$

est Statistic:

$l = 12/n(n+1)\Sigma R_i /n_i \; - 3(n+1)$

$= 12/144(144+1)[4385^2/36 + 908^2/36 + 2493^2/36 + 2545^2/36] -$

$\text{\textbrokenbar}(144+1)$

$= 96.0307$

)ecision Rule: Reject H_0 if $H > \chi^2_{5\%}$ (L-1), i.e.

$H > \chi^2_{5\%}(3) = 7.81$,

Conclusion: Since H = 96.0307 > 7.81, null hypothesis is rejected at 5% level of significance and thus conclude that there is seasonality in the yield series of tea in Peninsular Malaysia.

Calculation of Seasonal Indices

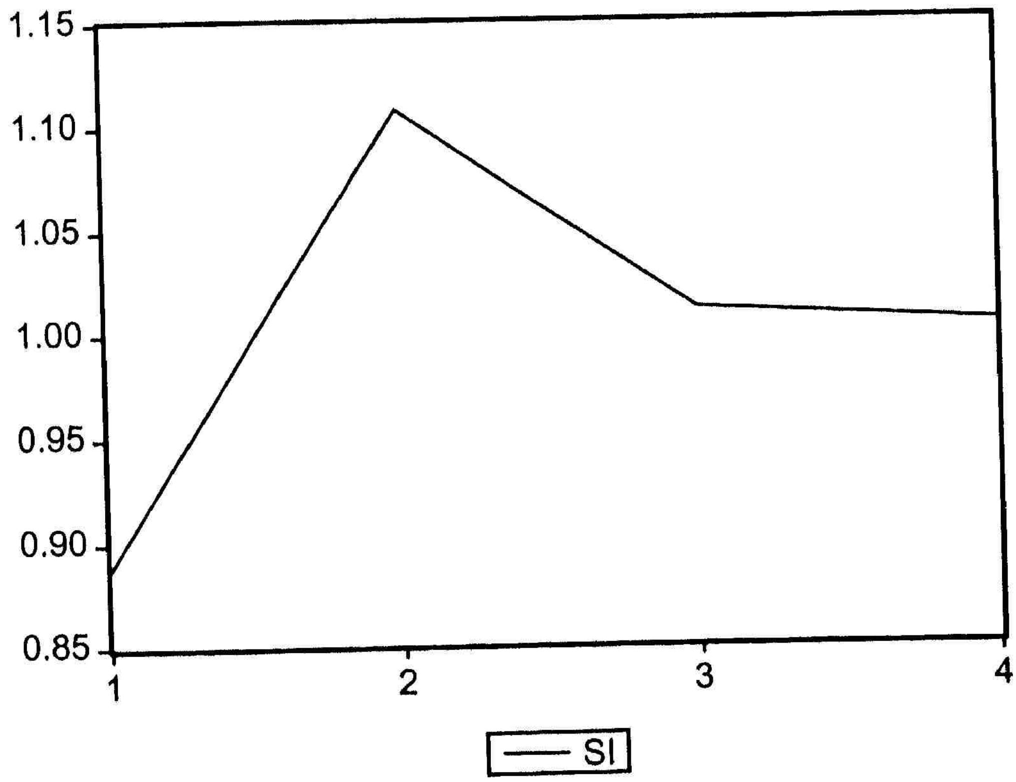
The de-trended series is computed by taking the ratio of actual-to-moving average, that is, $S_tE_t = Y_t / T_t$ followed by the calculation of seasonal indices. The seasonal index for this yield series is given in Table 4.2 and the seasonal plot is shown Figure 4.4. The seasonal pattern in Figure 4.4 shows that first quarter has the lowest yield and second quarter has the highest yield. The yield for third quarter is between first quarter and second quarter yield. The yield for fourth shows a slight decline from third quarter.

ible 4.2: Seasonal Indices Of Yield Series

ample: 1960:1 1996:4
cluded observations: 148
djustment Method: Multiplicative
riginal Series: PRODHEC (Y_t)

Quarter	Seasonal Index
1	0.887925
2	1.107887
3	1.011908
4	1.004587

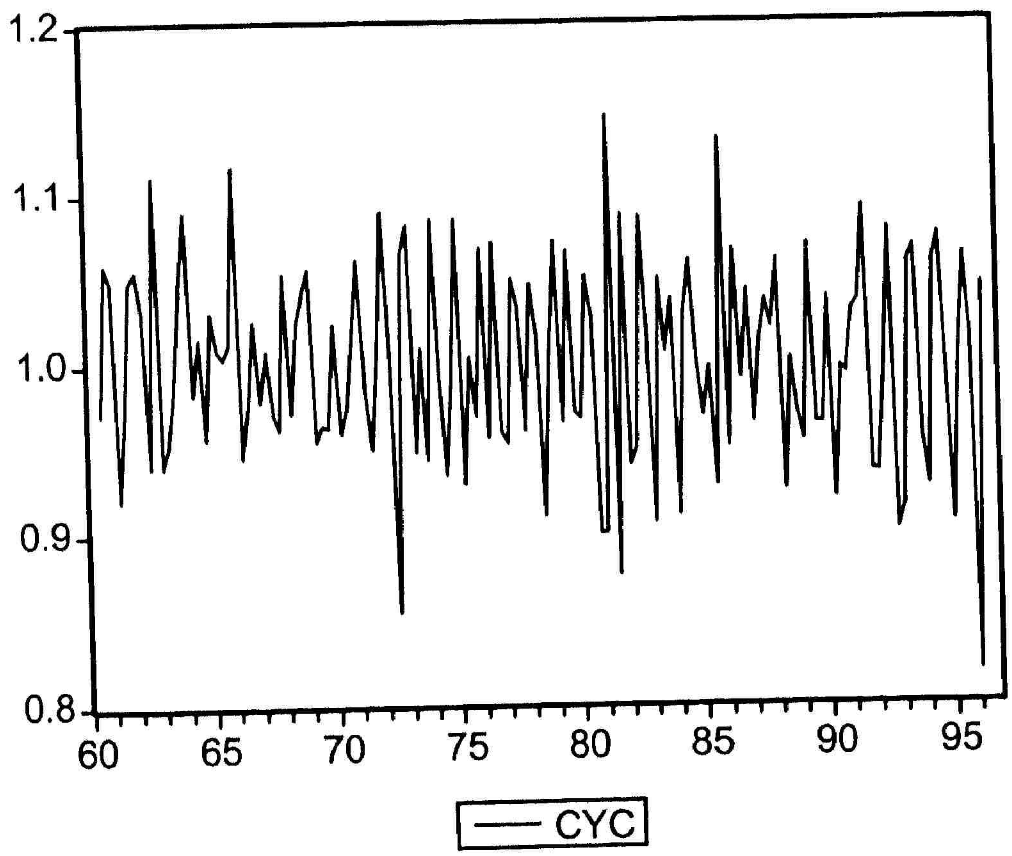
Figure 4.4: Seasonal Indices Plot Of Yield Series



3.3 Cyclical Pattern

Detrended-deseasonalized (Irregular) term is computed and it is ven in the last column of Table A5. Figure 4.5 shows the plot of etrended- deseasonalized series versus time. The plot shows a random ehaviour indicating that noise dominates the cycles.

Figure 4.5: Plot Of Detrended-Deseasonalized Yield Series



lculation of Quarterly Cyclical Dominance (QCD) of The Yield Series Peninsular Malaysia

The computations of percentage change in Trend-Cycle and egular term for all the quarters is given in Table A5 and Table A6 ppendix A) respectively. The average absolute percentage change in end-Cycle and Irregular term for all quarters is given in Table A7 and able A8.

$$!CD = \frac{\text{Average absolute \% change in irregular term}}{\text{Average absolute \% change in irregular term in trend-cycle}}$$

- Quarter Spans: 7.59/2.22 = 3.42

- Quarter Spans: 7.37/3.88 = 1.90

;- Quarter Spans: 6.66/5.34 =1.25

|- Quarter Spans: 5.72/6.85 = 0.83

The values for QCD are: First Quarter Spans=3.42; Second Quarter-Spans=2.57; Third Quarter Spans=1.25; Fourth Quarter Spans=0.8348. Since QCD is more than 1, it indicates a weak cyclical movement. Hence, the cyclical-irregular term is being primarily noise and has zero value in forecasting.

4.4 Data Transformation

The plot of the yield series shows that the variance of the data tends to increase as the level increases. Thus, the variance is not reasonably constant over time. Therefore, stationarity transformations are carried out to achieve stationarity in variance before time series ecasting models are developed using this yield series, Y_t. Standard d interpretable transformations such as logarithmic, square root, 'erse square root and inverse are used to transform the yield series. e plots of these series are shown in Figure 4.6. By visual comparison the plots in Figure 4.6, it is clear that negative square root reciprocal ;hieves high degree of stationarity in variance. Victor's (1993) method select the exact value of variance stabilising parameter, λ of power ansformation is applied. The second approach of his method is applied find the appropriate value for the parameter λ of the power ansformation. To keep homogeneity between the subseries, the size of ıe subseries were taken to be yearly with four quarterly observations.

hen, the mean and standard deviation ($\bar{Z}_h$,S_h) are computed for all the ubseries. These computed means and standard deviations are given in 'able A10 (Appendix A). The linear regression is fitted to the logarithm ›f means and standard deviations. The regression output is given in Table A11 (Appendix A). The estimated relationship is

$\text{Log}(S_h)$	=	-6.298 +	$1.665762\text{Log}(\bar{Z}_h)$,	h=1, ...,37
t-statistic		-6.112374	6.726318	
p-value		0.0000	0.0000	
standard errors		(0.2692)	(0.2476)	

with $R^2 = 0.5638$ and Durbin-Watson's d = 1.609. Durbin-Watson's test indicates residuals are not correlated. The estimated λ is -0.67[3] and the 95% confidence interval for λ is (-1.2, -0.6). Relatively simple or

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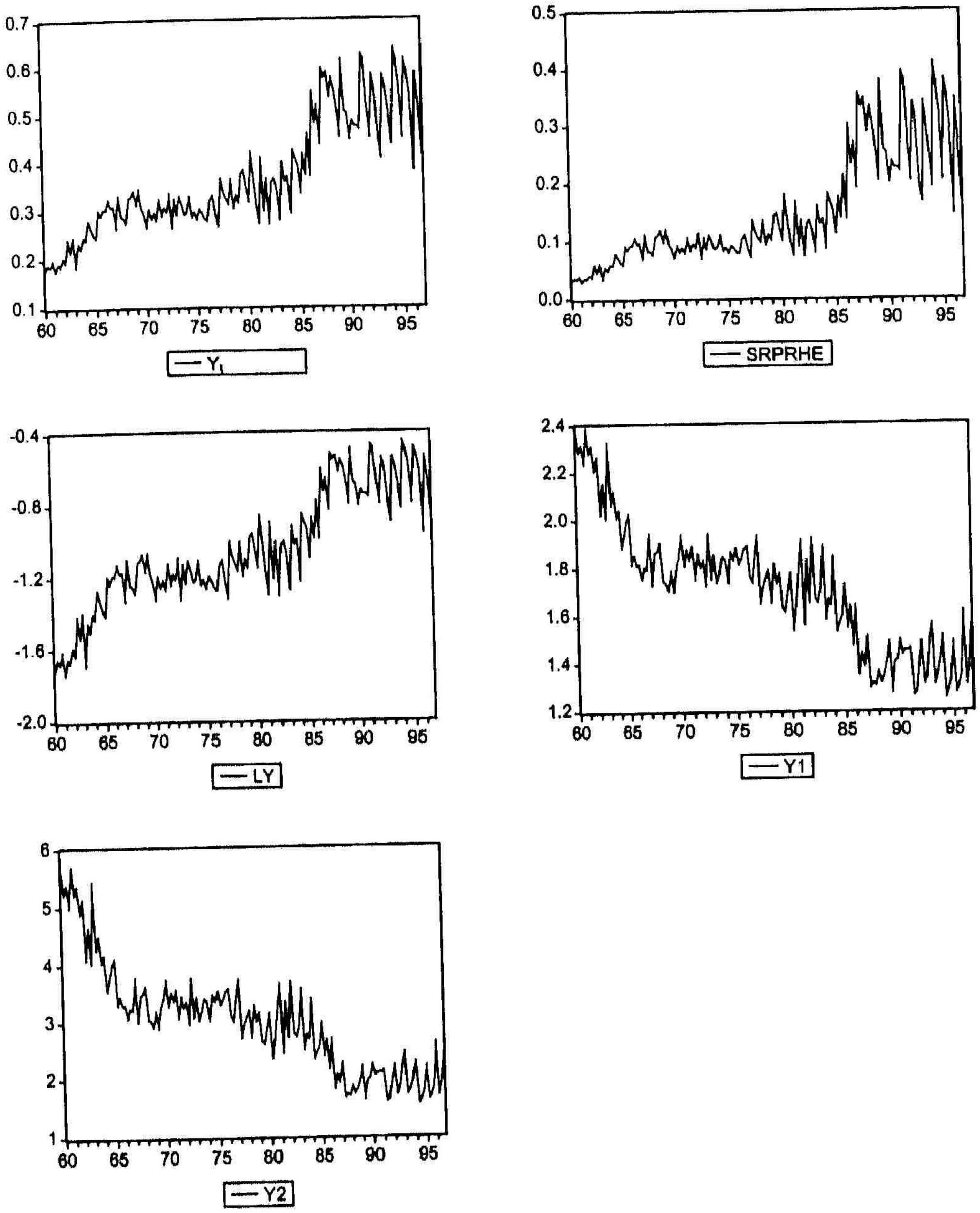
[3] $1-\lambda = 1.665762 \Rightarrow \lambda = -0.665762$

ːrpretable transformations are preferred; thus, we take λ= -0.5 instead λ= -0.67. An interesting point is that the transformations for λ =0 is : included in the 95% confidence interval for λ. Although, the visual of ıt of log transformed is able to reduce the increasing variance of error ms but it is not as good as inverse square root and inverse ınsformed series.

5 Summary

The original yield series Y_t shows a significant upward trend ıd a significant seasonal pattern. The cyclical component is weak and ominated by irregular terms or noise. The original yield series also ıdicates non-stationarity in variance. Standard and interpretable ·ansformations such as log, inverse and inverse square root are applied ın Y_t. Visual inspection of the plots shows that inverse square root ransformation is able to stabilise the increasing variance. The best /alue for variance stabilising parameter, λ of power transformation that will be able to stabilise the increasing variance in the yield series is – 0.67. It is then decided that λ = -0.5 instead of λ = -0.67 should be taken for the reason of easy interpretation. The log and inverse transformations will also be considered in this study along with inverse square root transformation for developing forecasting models. The log, inverse square root and inverse transformed series are given in Table A12, Table A13 and Table A14 respectively.

gure 4.6: Plots Of Original Yield Series And Transformed Series



Y_t : Original Yield Series; SRPRHE = $Y_t^{1/2}$; $LY_t = \text{Log}Y_t$; $Y1_t = 1/\sqrt{Y_t}$; $Y2_t = 1/Y_t$