Chapter 5

Forecasting

Forecasting models for the yield series will be considered in this chapter. The yield series is divided into two parts, the sample forecast range (1960: Q1 to 1996: Q4) and the post sample forecast range (1997: Q1 to 1997: Q4). The Sample Forecast Range (SFR) is used to fit the model, whereas, the Post Sample Forecasting Range (PSFR) is used to assess the forecasting performance of the fitted model.

The analysis of patterns of the yield (Y_t) series showed that the series has trend and seasonal components. The series also has an increasing variance of error terms. To achieve stationarity in variance the following transformations are applied. They were, logarithm (λ = 0), negative square root reciprocal (λ = -0.5) and negative reciprocal (λ = -1). The series given in Table 5.1 will be used in developing forecasting models.

Table 5.1: Series Used In Developing Forecasting Model

	Transformation	Series
Original Series		Y_t
Logarithm	Log Y_t	LY_t
Negative Square Root Reciprocal	$1/\sqrt{Y_t}$	$Y1_t$
Negative Reciprocal	$1/Y_t$	$Y2_t$

Holt-Winters trend and seasonality method which is based on three smoothing constants, one for level, one for trend and one for seasonality will sed. The Holt-Winters' Multiplicative Seasonality (HWMS) method will be tted to original series (Y_t). This method is suitable for increasing variance eries. Holt-Winters' Additive Seasonality(HWAS) method will be fitted to the ower-transformed series, LY_t , $Y1_t$ and $Y2_t$ which is sutiable for series aving constant seasonality. ARIMA methodology requires the series to ave constant variance. Therefore, ARIMA methodology will be only fitted to LY_t , $Y1_t$ and $Y2_t$.

5.1 Forecasting Models: By Holt-Winters Method

In order to fit this method, the method requires initial estimates of the three smoothing constants. EViews software determines the initial values of the three smoothing constants and then obtains the appropriate estimates of smoothing constant for level, α; trend, γ; and seasonal, δ. The EViews output of the optimal values of the three levels of the exponential smoothing parameters for Y_t, LY_t, $Y1_t$ and $Y2_t$ are given in Table B1, B2, B3 and B4 (Appendix B) respectively. Table 5.2 shows the summary output of the optimal values of the α (level), γ(trend) and δ(seasonal) for Holt-Winters' Multiplicative Seasonality (HWMS) method on the original series and Holt-Winters' Additive Seasonality (HWAS) method on each of the power-transformation series. The optimal smoothing trend parameter for all series is zero. The implication is that the updating trend equation becomes $T_t = T_{t-1}$ (see, Section 5.1)

The initial estimates and the optimal values of the exponential smoothing parameters which were determined earlier and together with the updating procedure is used for updating until quarter 4 of 1996. The outputs end values of the three levels of quarter 4 of 1996 for Y_t, LY_t, $Y1_t$ and $Y2_t$ e given in Table B1, B2, B3 and B4 (Appendix B) respectively.

able 5.2: Optimal Values Of Smoothing Parameters

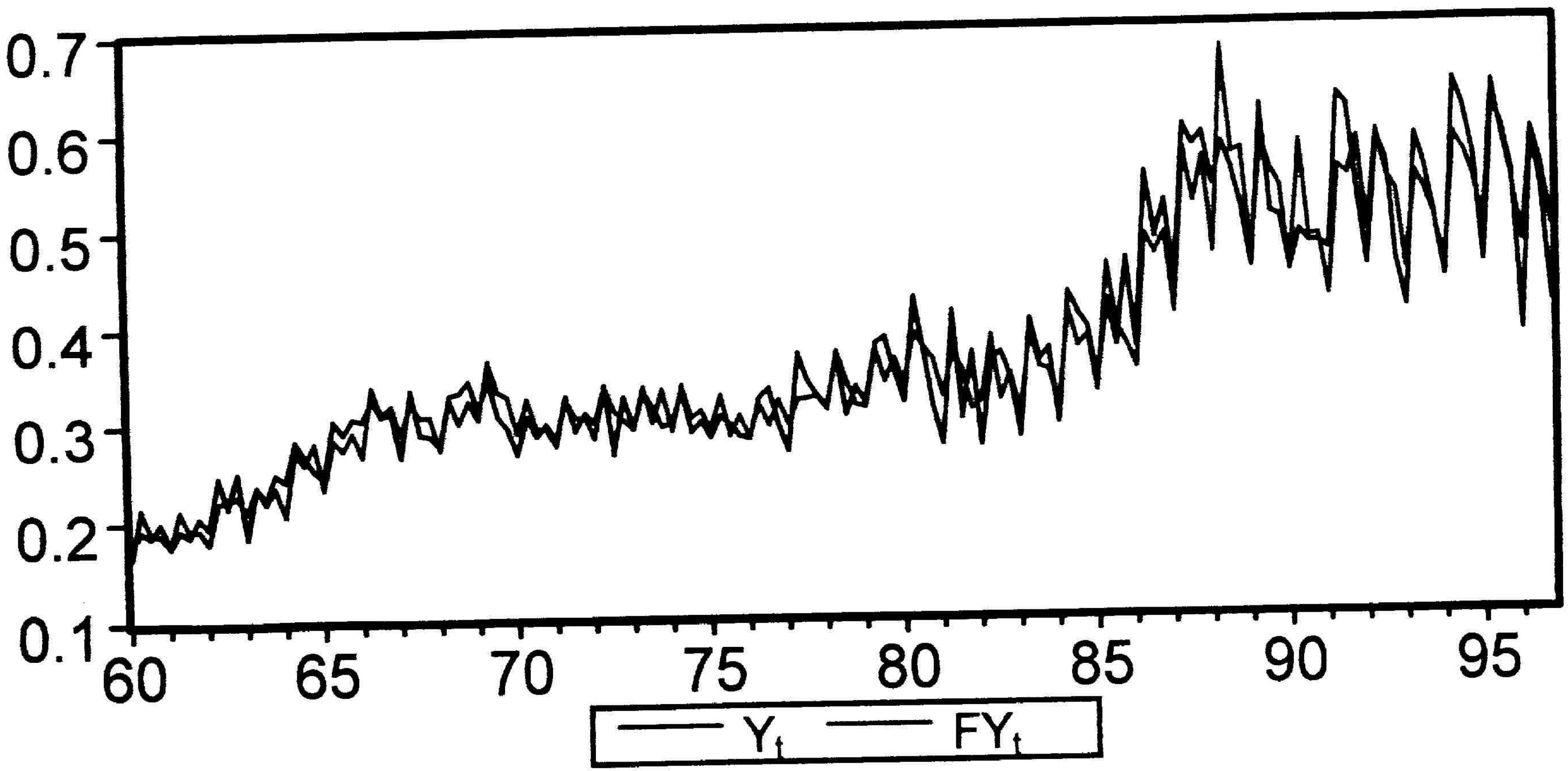
METHOD	HWMS	HWAS	HWAS	HWAS
SERIES	Y_t	LY_t	$Y1_t$	$Y2_t$
LEVEL (α)	0.4600	0.4500	0.4400	0.4700
TREND (γ)	0.0000	0.0000	0.0000	0.0000
SEASONAL (δ)	0.3901	0.3701	0.2300	0.0000

.1.1 Holt-Winters Multiplicative Seasonality (HWMS) Method on Y_t

Sample Forecast Range (SFR): Model is Fitted

Table B5 (Appendix B) shows the forecast (fitted) values in sample forecast range from the fitting of HWMS method. Figure 5.1 shows the plot of actual yield series (Y_t) and forecast yield series (FY_t). The correlogram of the residuals (Y_t - FY_t) is shown in Exhibit B1(Appendix B). Ljung-Box Q-statistic is Q_{36} = 42.146 with a p-value = 0.22, which is greater that 0.05. Therefore, it is reasonable to conclude that the fitted model is adequate and residuals of the fitted model follows white noise model. The root mean sum squared error and mean absolute percentage error from this fitted model is:

$RMSE_{psfr}$ = 0.033, $MAPE_{psfr}$ = 6.7


0.7
0.6
0.5
0.4
0.3
0.2
0.1
60
65
70
75
80
85
90
95
Y_t
FY_t

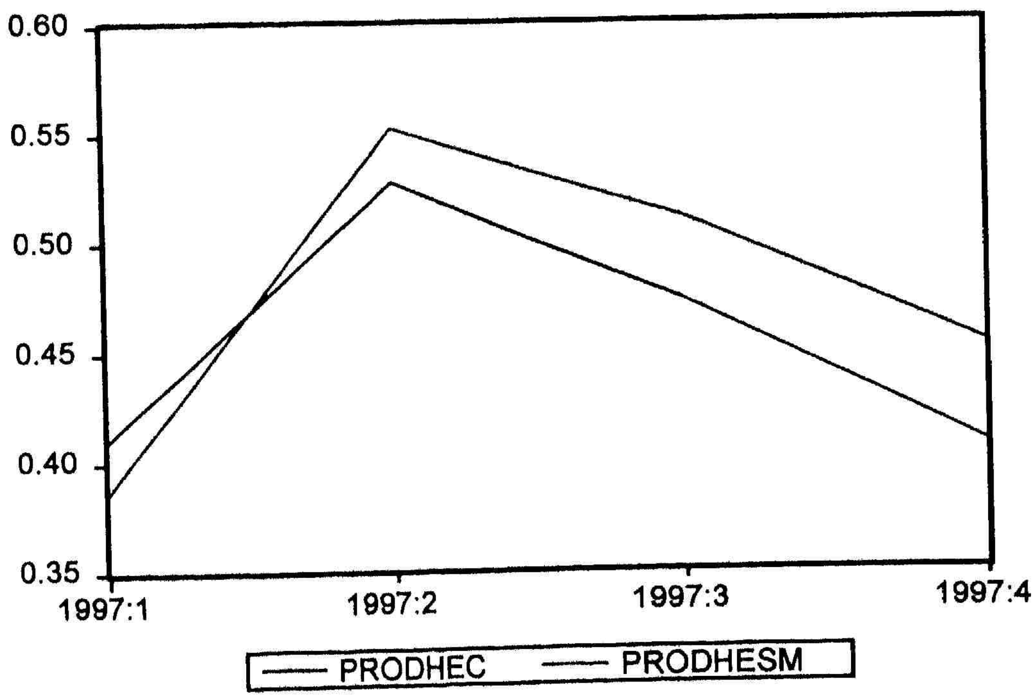
;t Sample Forecast Range (PSFR): Forecasting

The quarterly forecast values for 1997 are obtained by using updating ations to update the end values of the three levels of quarter 4 of 1996 ıer into the quarters of 1997. Table 5.3 shows the actual (Y_t) and cast values (FY_t) in post sample forecast range. Figure 5.2 shows the of Y_t and FY_t from 1997:Q1 to 1997:Q4. $MAPE_{sfr}$= 7.4 and $RSME_{sfr}$ = 43

ɔle 5.3: Actual (Y_t) And Forecast (FY_t) By HWMS: 1997:Q1 To 1997:Q4

		Q1	Q2	Q3	Q4
	1997	0.410390	0.527636	0.473456	0.407115
t	1997	0.386691	0.552312	0.511290	0.453109

Figure 5.2: Plot of Y_t And FY_t From 1997:Q1 To 1997:Q4 By HWMS



Holt-Winters Additive Seasonality (HWAS) Method on LY_t

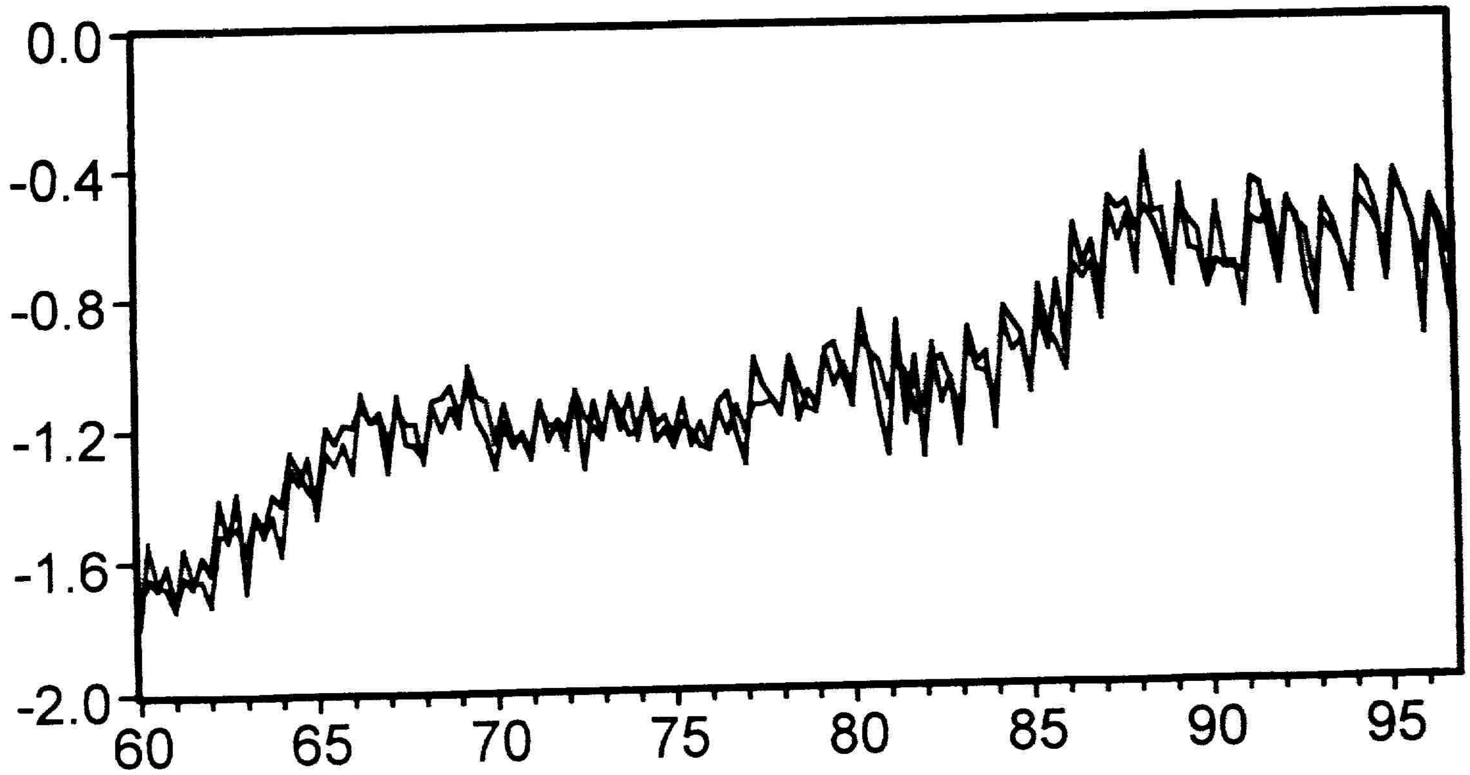
ple Forecast Range (SFR): Model is Fitted

Table B6 (Appendix B) shows the forecast (fitted) values in sample cast range from the fitting of HWMS method. Figure 5.3 shows the plot ctual yield series (LY_t) and forecast yield series (FLY_t). The correlogram ie residuals (LY_t - FLY_t) is shown in Exhibit B2 (Appendix B). Ljung-Box statistic is Q_{36} = 33.452 with a p-value = 0.59, which is greater that 0.05. refore, it is reasonable to conclude that the fitted model is adequate and duals of the fitted model follows white noise model. The root mean sum iared error and mean absolute percentage error from this fitted model is: ISE_{psfr} = 0.083, $MAPE_{psfr}$ = 7.2.

ost Sample Forecast Range (PSFR): Forecasting

The quarterly forecast values for 1997 are obtained by using dating equations to update the end values of the three levels of quarter 4 1996 further into the quarters of 1997. Table 5.4 shows the actual (LY_t) id forecast values (FLY_t) in post sample forecast range. Figure 5.4 shows e plot of LY_t and FLY_t from 1997:Q1 to 1997:Q4. $MAPE_{sfr}$ = 9.7 and MSE_{sfr} = 0.082.

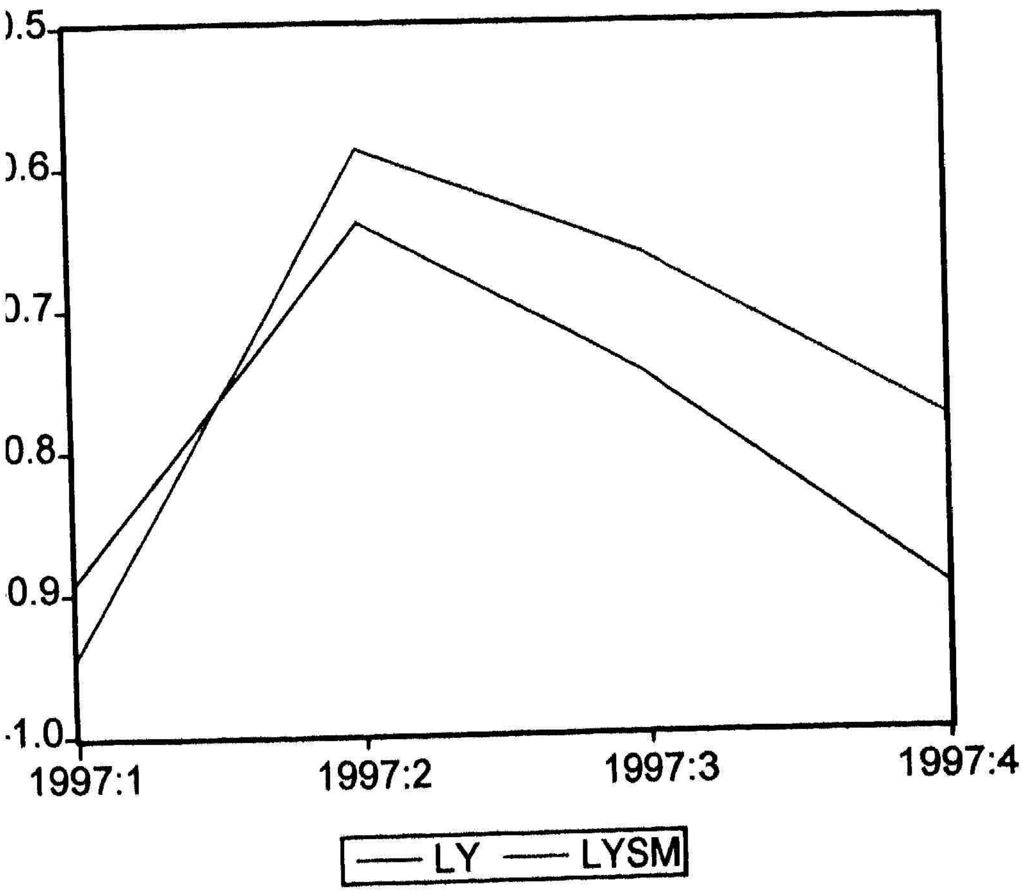
Figure 5.3: Plot of Yield Series (LY_t) and Forecast Series (FLY_t) by HWMS Method



5.4: Actual (LY_t) And Forecast (FLY_t) From 1997:Q1 To 1997:Q4
By HWAS

	Q1	Q2	Q3	Q4
1997	-0.890647	-0.639349	-0.747696	-0.898660
1997	-0.943764	-0.587635	-0.663022	-0.779643

re 5.4: Plot Of LY_t And Forecast FLY_t From 1997:Q1 To 1997:Q4
By HWAS:



lolt-Winters Additive Seasonality (HWAS) Method
ın $Y1_t$

le Forecast Range (SFR): Model is Fitted

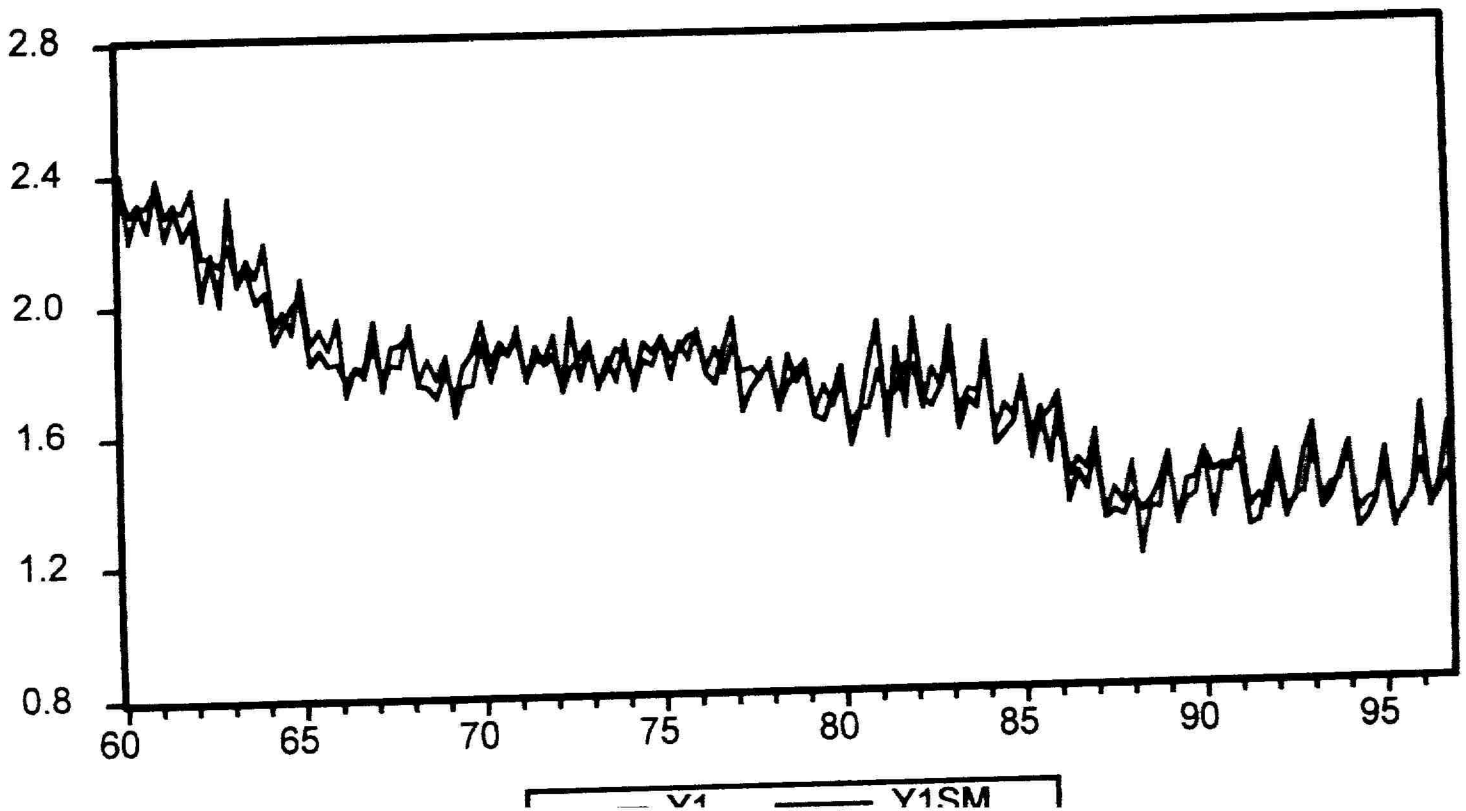
Table B7 (Appendix B) shows the forecast (fitted) values in sample st range from the fitting of HWMS method. Figure 5.5 shows the plot ual yield series (Y_t) and forecast yield series ($FY1_t$). The correlogram residuals (Y_t – $FY1_t$) is shown in Exhibit B1(Appendix B). Ljung-Box atistic is Q_{36} = 37.65 with a p-value = 0.394, which is greater that 0.05. fore, it is reasonable to conclude that the fitted model is adequate and uals of the fitted model follows white noise model. The root mean sum red error and mean absolute percentage error from this fitted model is:

E_{psfr} = 0.071, $MAPE_{psfr}$ = 3.3

t Sample Forecast Range (PSFR): Forecasting

The quarterly forecast values for 1997 are obtained by using ating equations to update the end values of the three levels of quarter 4 996 further into the quarters of 1997. Table 5.5 shows the actual ($Y1_t$) forecast values ($FY1_t$) in post sample forecast range. Figure 5.6 shows plot of $Y1_t$ and $FY1_t$ from 1997:Q1 to 1997:Q4. $MAPE_{sfr}$ = 3.4 and SE_{sfr} = 0.061.

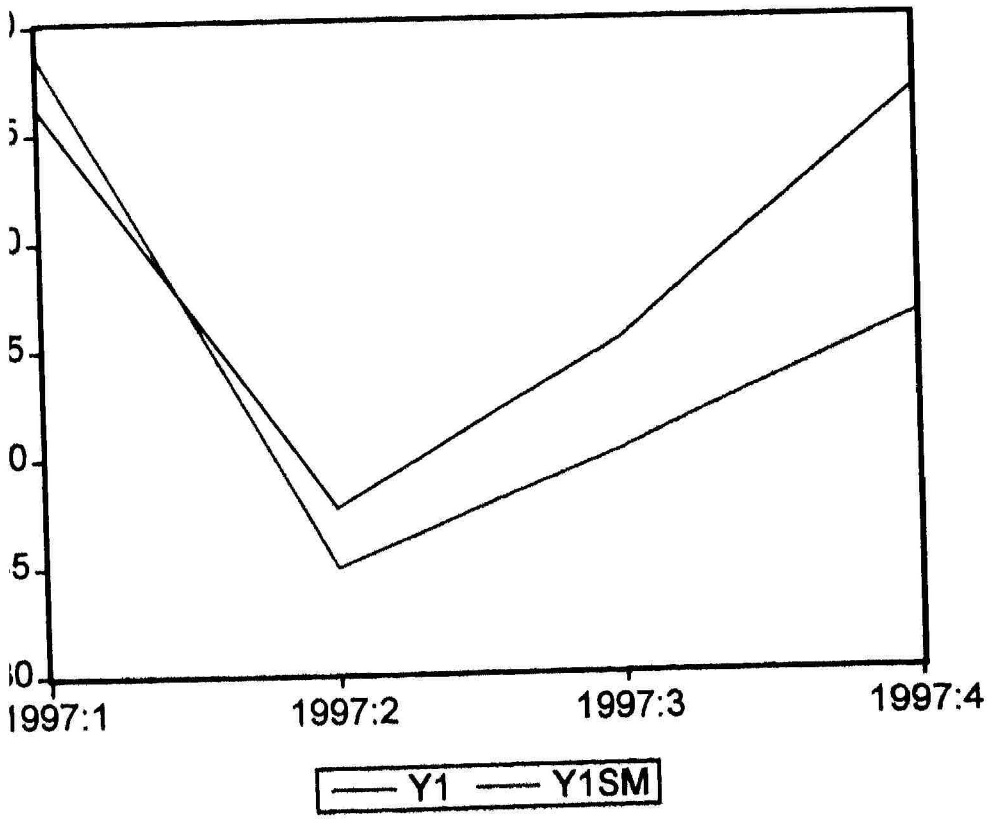
Figure 5.5: Plot of Yield Series ($Y1_t$) and Forecast Series ($Y1_t$) by HWAS Method



.5: Actual ($Y1_t$) And Forecast ($FY1_t$) From 1997:Q1 To 1997:Q4 By HWAS

	Q1	Q2	Q3	Q4
1997	1.560995	1.376679	1.453316	1.567261
1997	1.584868	1.348984	1.402161	1.463507

ıre 5.6: Plot Of $Y1_t$ And $FY1_t$ From 1997:Q1 To 1997:Q4 By HWAS



ılt-Winters Additive Seasonality (HWAS) Method
$Y2_t$

ı Forecast Range (SFR): Model is Fitted

Table B8 (Appendix B) shows the forecast (fitted) values in sample t range from the fitting of HWMS method. Figure 5.7 shows the plot al yield series ($Y2_t$) and forecast yield series ($FY2_t$). The correlogram esiduals ($Y2_t - FY2_t$) is shown in Exhibit B4 (Appendix B). Ljung-Box istic is Q_{36} = 39.459 with a p-value = 0.318, which is greater that 0.05. ore, it is reasonable to conclude that the fitted model is adequate and als of the fitted model follows white noise model. The root mean sum ɔd error and mean absolute percentage error from this fitted model is:

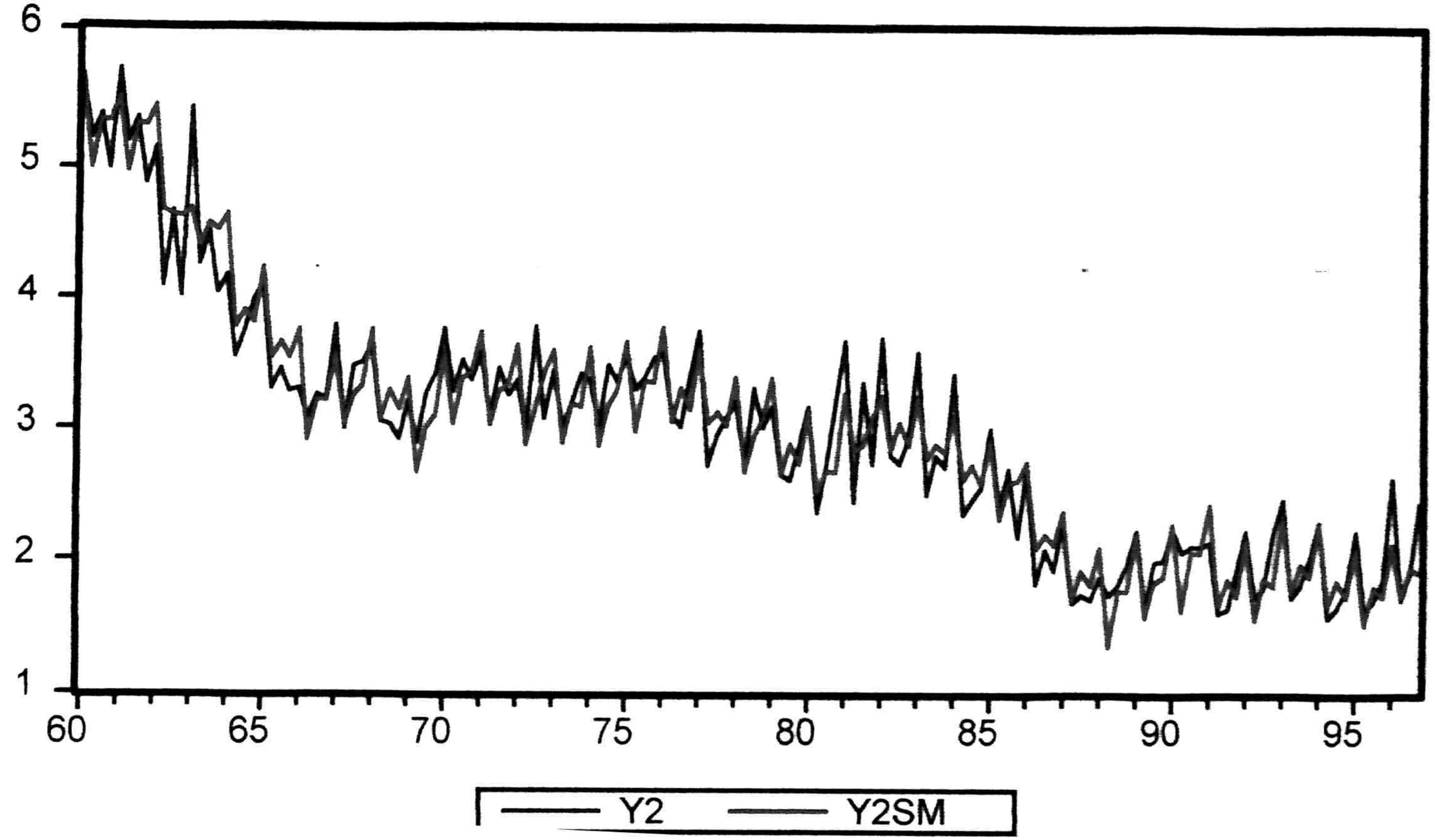
$:_{psfr}$ = 0.254, $MAPE_{psfr}$ = 6.7

Sample Forecast Range (PSFR): Forecasting

The quarterly forecast values for 1997 are obtained by using ting equations to update the end values of the three levels of quarter 4 ı96 further into the quarters of 1997. Table 5.6 shows the actual ($Y2_t$) forecast values ($FY2_t$) in post sample forecast range. Figure 5.8 shows plot of $Y2_t$ and $FY2_t$ from 1997:Q1 to 1997:Q4. $MAPE_{sfr}$ = 5.3 and

$;E_{sfr}$ = 0.197

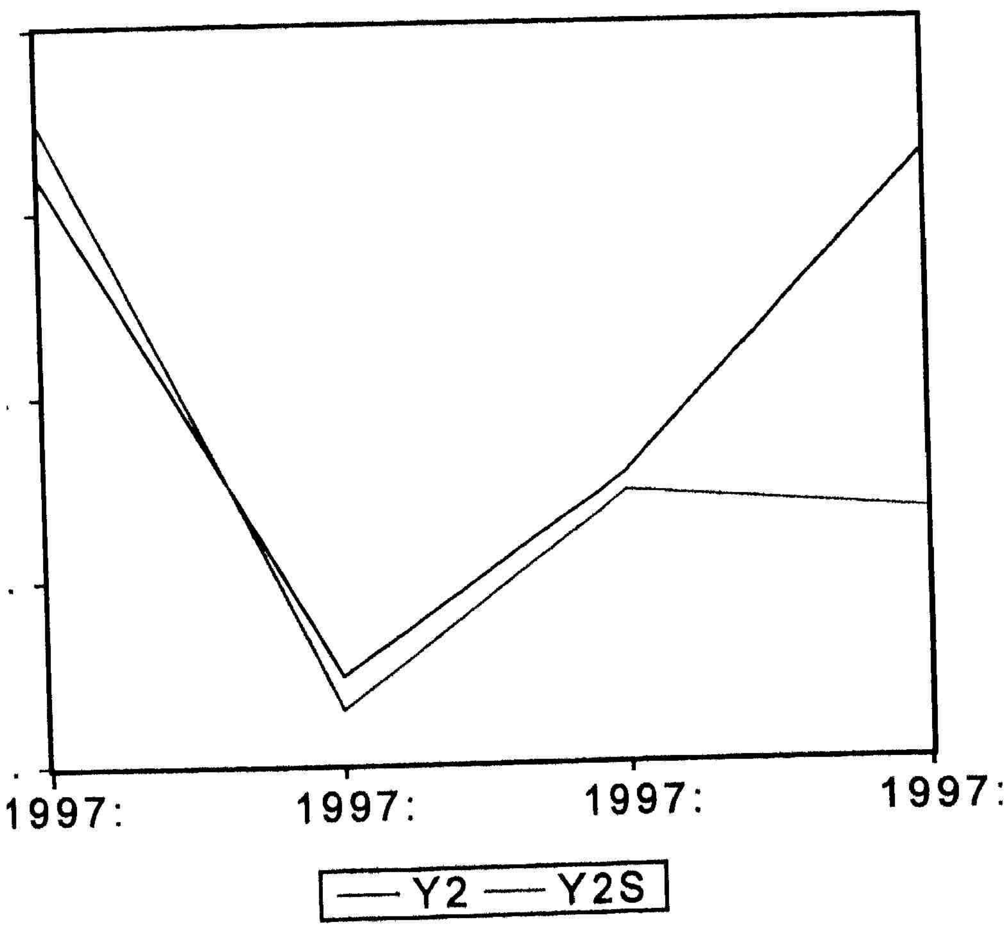
Figure 5.7: Plot of Yield Series ($Y2_t$) and Forecast Series($Y2_t$) by HWAS Method



.6: Actual ($Y2_t$) And Forecast ($FY2_t$) From 1997:Q1 To 1997:Q4 By HWAS

	Q1	Q2	Q3	Q4
1997	2.436707	1.895246	2.112129	2.456308
1997	2.495474	1.858865	2.091943	2.068142

5.8: Plot Of $Y2_t$ And $FY2_t$ From 1997:Q1 To 1997:Q4 By HWAS



recast Yield From Holt-Winters Method

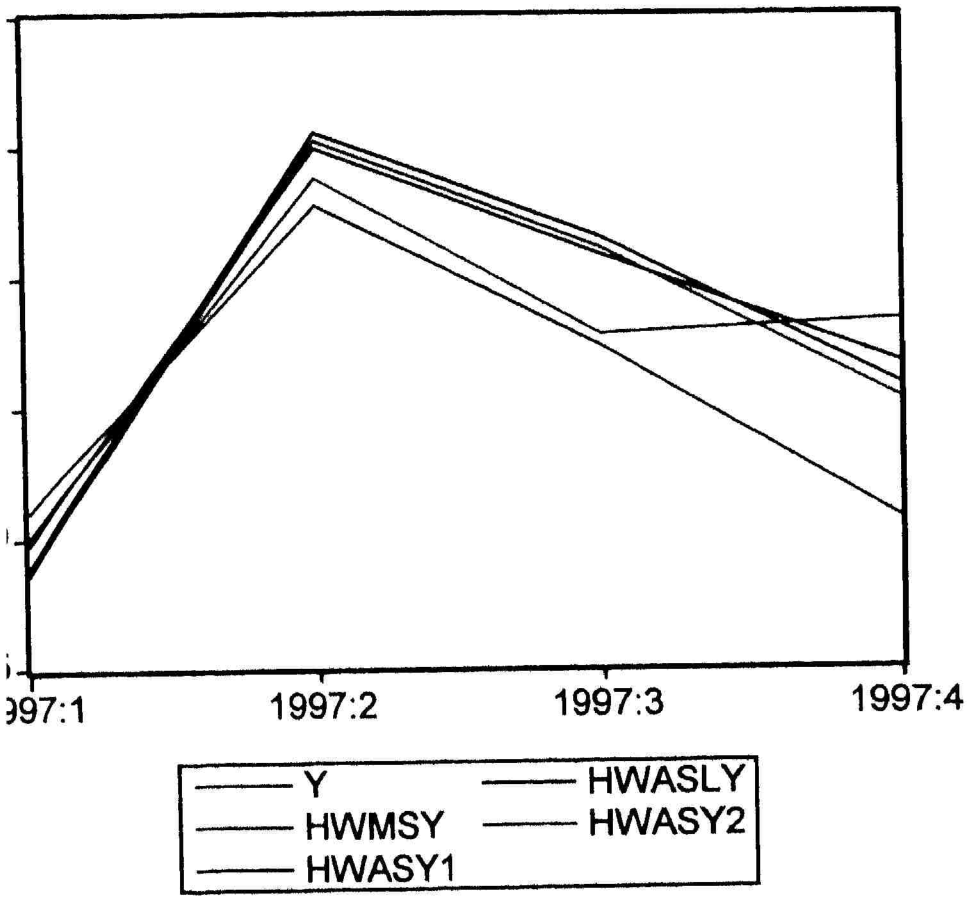
ıble 5.7 shows the comparison of actual yield and the forecast yield l by Exponential Smoothing Method in the post sample forecast 'he forecasts given in Table 5.7 obtained for transformed series (LY_t, $Y2_t$) are converted back to the original scale. Figure 5.9 shows the actual yield and forecasted yield by Holt-Winters' Multiplicative ality (HWMS) method on original series (Y_t) and Holt-Winters' ɜ Seasonality(HWAS) method on power-transformed series, LY_t , $Y1_t$ $_t$ which has constant seasonality.

5.7: Actual Yield And Forecast Yield Generated By Holt-Winters Method In Post Sample Forecast Range

-1997	Q1	Q2	Q3	Q4
l	0.410390	0.527630	0.473456	0.407115
S (Y_t)	0.386691	0.552312	0.511290	0.453109
S (LY_t)	0.389160	0.555639	0.515292	0.458569
S ($Y1_t$)	0.398120	0.549524	0.508633	0.466886
S ($Y2_t$)	0.400725	0.537963	0.478024	0.483526

'or first, third and fourth quarter, the fitted models are under asting, whereas, for second quarter the fitted models are over asting. The fitted models above, except for HWAS on $Y2_t$ follow the ɜ seasonal pattern of the actual yield series. As for HWAS on $Y2_t$, it ; not follow the seasonal pattern because the forecasted yield for ter 4 shows an increase instead of a decline.

F 5.9: Plot Of Actual Yield And Forecast Yield
By Holt-Winters Method Models



Forecast Performance in the Post Sample Forecast Range:
Nodels by Holt-Winters Method

In order to compare the forecasting performance, the transformed ıst yield are be brought back to original scale. Table 5.8 shows the nean sum square error and mean absolute percentage error of the models. These performance measures indicated that forecasted values ·ated from these fitted models do not differ. HWAS on $Y1_t$ give the best rmance. The performance of HWAS on $Y2_t$ is also good but the plot in e 5.9 shows the generated forecasts by this fitted model ot follow the predicted seasonal pattern. For Holt-Winters method, on $Y1_t$ able to forecast the yield very close to the actual values.

5.8: Forecast Performance In Post Sample Forecast Range: Holt-Winters Method

	RMSE	MAPE
; on Y_t	0.0343	7.435
; on LY_t	0.0819	9.655
; on $Y1_t$	0.0607	3.420
; on $Y2_t$	0.1974	5.272

orecasting: Box-Jenkins Methodology

Model Building

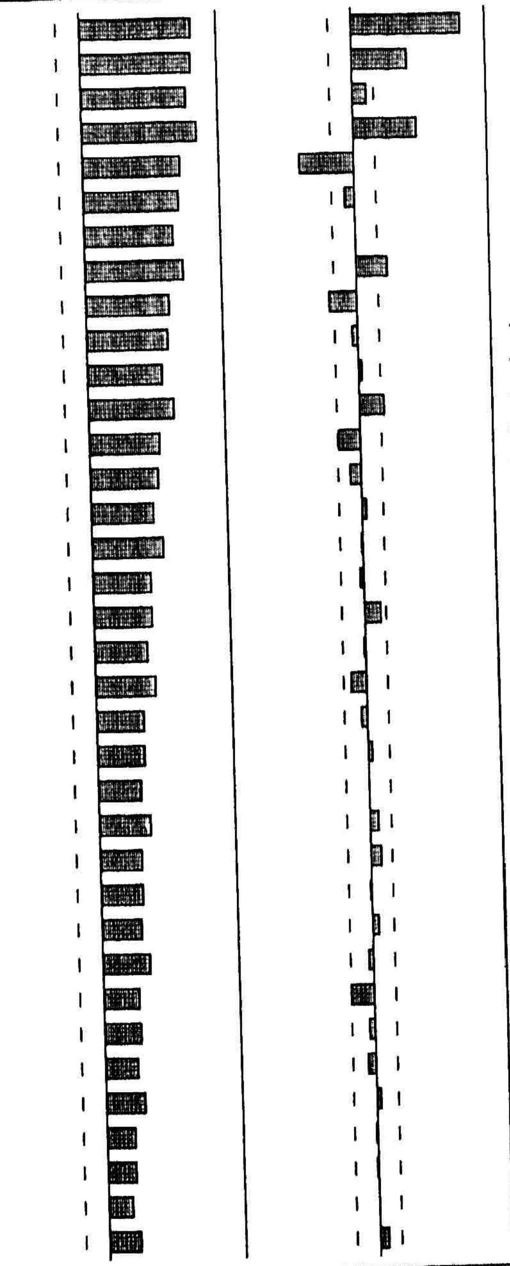
.1 Identification

Autocorrelation plots of LY_t , $Y1_t$ and $Y2_t$ series is shown in Exhibit 5.1 xhibit 5.3 respectively. Exhibit 5.1 to 5.3 suggest that these series are stationary and need to be differenced. The autocorrelation plots for the differenced series for LY_t , $Y1_t$ and $Y2_t$ are shown in Exhibit 5.4 to 5.6 ectively, These plots suggest that seasonal differencing is required. The es differenced once for trend and once for seasonality are shown in ibit 5.7 to 5.9. These plots are not very different and the series appear to stationary and many of the dominant seasonal spikes have disappeared. ıs, the study has identified the model to be an ARIMA (p, 1, q)(P, 1, Q)$_4$ ere values for p, q, P and Q are yet to be determined.

Exhibit 5.1: Output of the SAC and SPAC for LY_t

Correlogram of LY

: 05/07/00 Time: 11:47
ple: 1960:1 1996:4
ded observations: 148



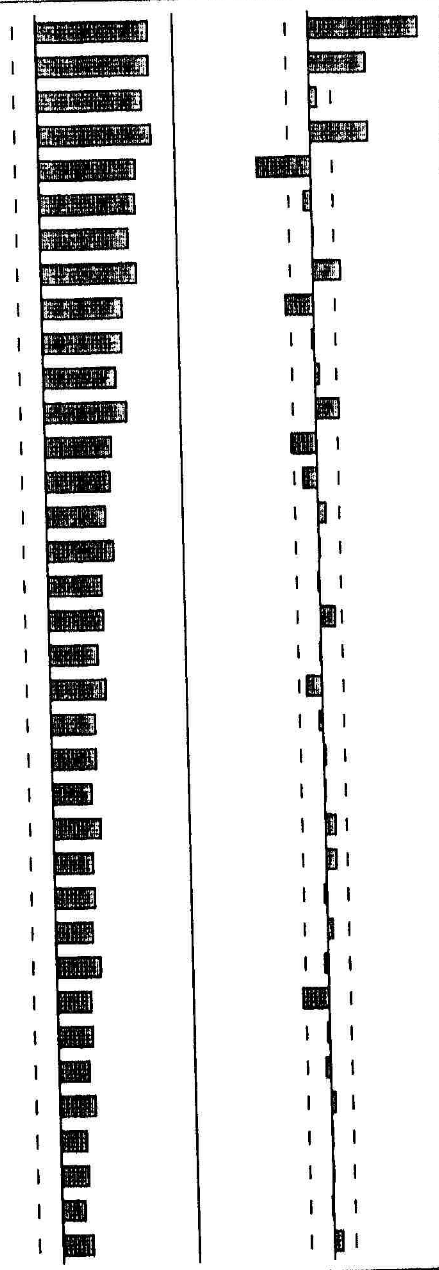
	AC	PAC	Q-Stat	Prob
1	0.849	0.849	108.77	0.000
2	0.840	0.427	216.01	0.000
3	0.797	0.114	313.21	0.000
4	0.869	0.494	429.60	0.000
5	0.742	-0.422	515.16	0.000
6	0.728	-0.069	597.92	0.000
7	0.679	0.005	670.60	0.000
8	0.751	0.245	760.15	0.000
9	0.632	-0.206	824.01	0.000
10	0.619	-0.036	885.56	0.000
11	0.574	0.027	938.86	0.000
12	0.653	0.196	1008.5	0.000
13	0.540	-0.160	1056.4	0.000
14	0.523	-0.080	1101.8	0.000
15	0.480	0.033	1140.3	0.000
16	0.546	-0.006	1190.4	0.000
17	0.444	-0.022	1223.8	0.000
18	0.446	0.129	1257.7	0.000
19	0.406	-0.001	1286.0	0.000
20	0.462	-0.110	1323.1	0.000
21	0.368	-0.033	1346.8	0.000
22	0.368	0.040	1370.6	0.000
23	0.328	0.003	1389.8	0.000
24	0.395	0.068	1417.7	0.000
25	0.321	0.088	1436.2	0.000
26	0.327	-0.002	1455.7	0.000
27	0.305	0.056	1472.7	0.000
28	0.365	-0.025	1497.4	0.000
29	0.278	-0.171	1511.8	0.000
30	0.284	-0.041	1527.0	0.000
31	0.249	-0.051	1538.8	0.000
32	0.300	0.034	1556.0	0.000
33	0.216	-0.007	1565.0	0.000
34	0.218	-0.002	1574.2	0.000
35	0.183	0.005	1580.8	0.000
36	0.241	0.072	1592.3	0.000

Exhibit 5.2: Output of the SAC and SPAC for $Y1_t$

Correlogram of Y1

05/07/00 Time: 11:59
le: 1960:1 1996:4
ded observations: 148

tocorrelation   Partial Correlation



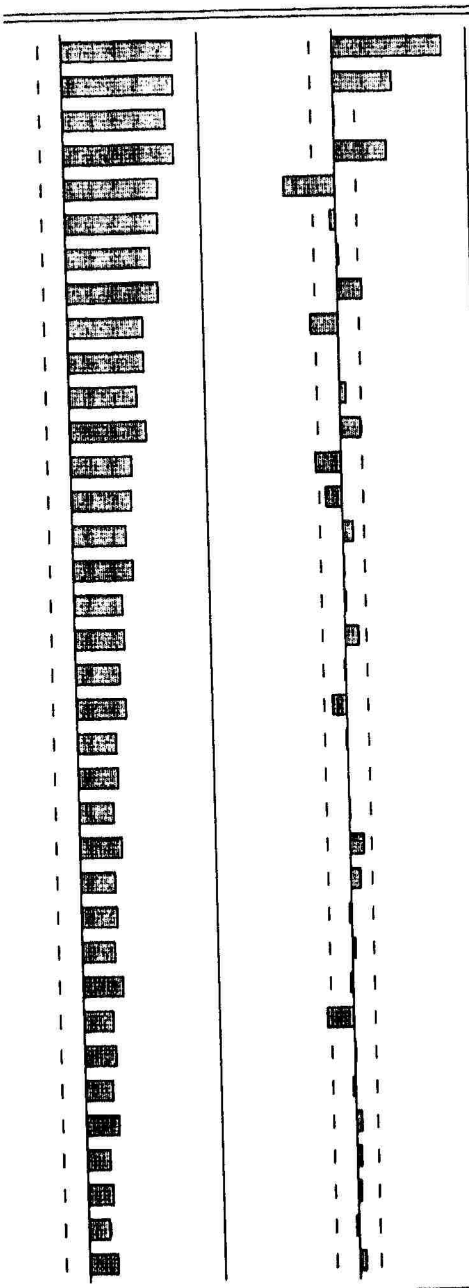
	AC	PAC	Q-Stat	Prob
1	0.850	0.850	109.23	0.000
2	0.847	0.446	218.22	0.000
3	0.793	0.065	314.38	0.000
4	0.857	0.453	427.72	0.000
5	0.733	-0.410	511.06	0.000
6	0.723	-0.053	592.72	0.000
7	0.666	0.013	662.49	0.000
8	0.729	0.221	746.82	0.000
9	0.612	-0.207	806.62	0.000
10	0.605	-0.016	865.53	0.000
11	0.553	0.038	915.16	0.000
12	0.626	0.182	979.05	0.000
13	0.512	-0.183	1022.2	0.000
14	0.499	-0.101	1063.3	0.000
15	0.451	0.060	1097.3	0.000
16	0.509	0.009	1140.9	0.000
17	0.412	-0.002	1169.6	0.000
18	0.419	0.120	1199.6	0.000
19	0.376	-0.003	1223.9	0.000
20	0.427	-0.109	1255.5	0.000
21	0.338	-0.017	1275.5	0.000
22	0.341	0.021	1296.0	0.000
23	0.302	0.010	1312.1	0.000
24	0.365	0.086	1336.0	0.000
25	0.296	0.083	1351.8	0.000
26	0.305	-0.010	1368.7	0.000
27	0.282	0.044	1383.3	0.000
28	0.339	-0.024	1404.6	0.000
29	0.256	-0.189	1416.8	0.000
30	0.267	-0.011	1430.2	0.000
31	0.231	-0.031	1440.3	0.000
32	0.278	0.041	1455.2	0.000
33	0.201	0.012	1463.0	0.000
34	0.209	0.014	1471.5	0.000
35	0.175	-0.003	1477.5	0.000
36	0.233	0.067	1488.3	0.000

Exhibit 5.3: Output of the SAC and SPAC for $Y2_t$

Correlogram of Y2

]5/07/00 Time: 12:04
e: 1960:1 1996:4
ed observations: 148

tocorrelation   Partial Correlation

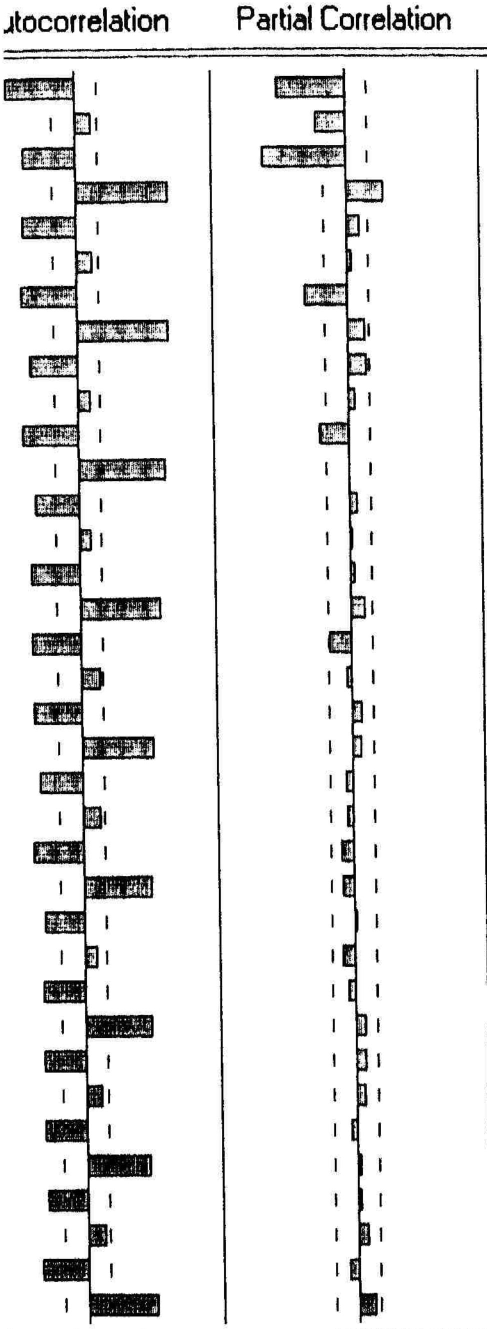


	AC	PAC	Q-Stat	Prob
1	0.848	0.848	108.70	0.000
2	0.849	0.461	218.29	0.000
3	0.783	0.016	312.10	0.000
4	0.842	0.414	421.46	0.000
5	0.716	-0.395	501.04	0.000
6	0.710	-0.036	579.86	0.000
7	0.644	0.024	645.20	0.000
8	0.700	0.189	722.96	0.000
9	0.582	-0.205	777.05	0.000
10	0.582	0.006	831.49	0.000
11	0.524	0.050	876.04	0.000
12	0.590	0.160	932.83	0.000
13	0.475	-0.192	969.91	0.000
14	0.464	-0.119	1005.6	0.000
15	0.413	0.083	1034.0	0.000
16	0.463	0.012	1070.2	0.000
17	0.370	0.020	1093.4	0.000
18	0.382	0.109	1118.3	0.000
19	0.338	-0.008	1138.0	0.000
20	0.383	-0.100	1163.4	0.000
21	0.298	-0.006	1179.0	0.000
22	0.305	0.003	1195.4	0.000
23	0.267	0.010	1208.0	0.000
24	0.326	0.109	1227.1	0.000
25	0.263	0.074	1239.6	0.000
26	0.276	-0.013	1253.4	0.000
27	0.252	0.027	1265.1	0.000
28	0.305	-0.015	1282.3	0.000
29	0.226	-0.204	1291.9	0.000
30	0.242	0.011	1302.9	0.000
31	0.207	-0.010	1311.0	0.000
32	0.250	0.042	1322.9	0.000
33	0.180	0.033	1329.2	0.000
34	0.193	0.026	1336.4	0.000
35	0.161	-0.011	1341.5	0.000
36	0.217	0.056	1350.8	0.000

Exhibit 5.4: Output of the SAC and SPAC for LY_t by using the Transformation $ZLY_t = LY_t - LY_{t-1}$

Correlogram of ZLY

05/07/00 Time: 12:13
ıle: 1960:1 1996:4
ded observations: 147

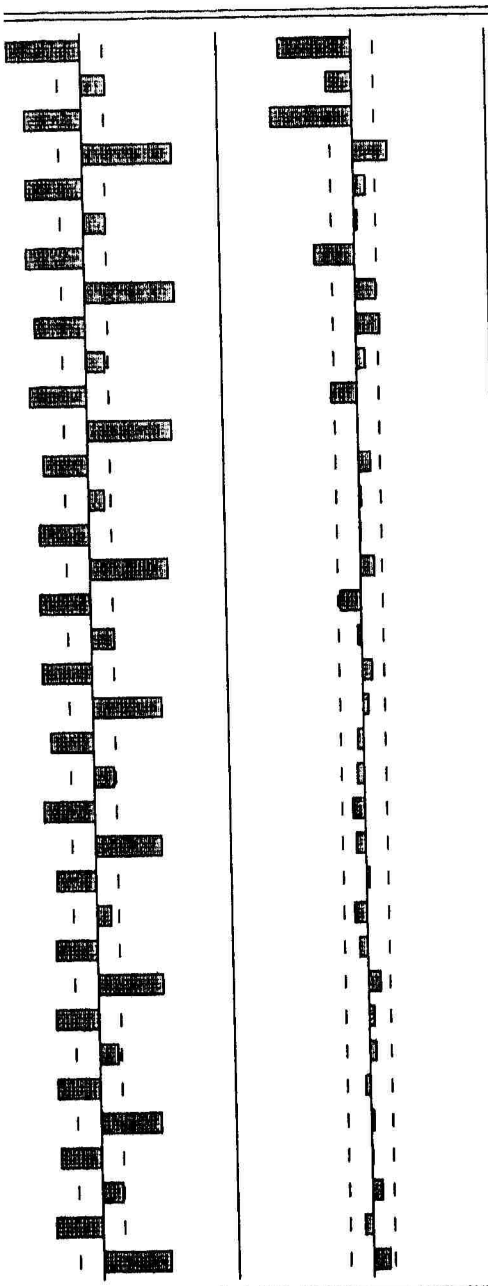


	AC	PAC	Q-Stat	Prob
1	-0.527	-0.527	41.662	0.000
2	0.115	-0.225	43.655	0.000
3	-0.398	-0.645	67.725	0.000
4	0.698	0.292	142.36	0.000
5	-0.403	0.104	167.46	0.000
6	0.115	0.041	169.51	0.000
7	-0.418	-0.323	196.89	0.000
8	0.689	0.137	271.78	0.000
9	-0.357	0.145	291.97	0.000
10	0.091	0.053	293.29	0.000
11	-0.423	-0.214	322.15	0.000
12	0.659	0.002	392.56	0.000
13	-0.323	0.060	409.58	0.000
14	0.082	0.020	410.69	0.000
15	-0.368	0.037	433.12	0.000
16	0.608	0.107	494.99	0.000
17	-0.364	-0.157	517.37	0.000
18	0.141	-0.031	520.74	0.000
19	-0.360	0.078	542.89	0.000
20	0.549	0.066	594.79	0.000
21	-0.319	-0.047	612.49	0.000
22	0.135	-0.040	615.66	0.000
23	-0.372	-0.082	640.16	0.000
24	0.519	-0.075	688.09	0.000
25	-0.288	0.018	703.01	0.000
26	0.097	-0.084	704.69	0.000
27	-0.305	-0.044	721.64	0.000
28	0.516	0.080	770.58	0.000
29	-0.308	0.079	788.15	0.000
30	0.119	0.066	790.80	0.000
31	-0.308	-0.037	808.74	0.000
32	0.486	0.031	853.77	0.000
33	-0.293	0.026	870.28	0.000
34	0.137	0.079	873.91	0.000
35	-0.338	-0.060	896.20	0.000
36	0.527	0.130	951.06	0.000

Exhibit 5.5: Output of the SAC and SPAC for $Y1_t$ by using the Transformation $ZY1_t = Y1_t - Y1_{t-1}$

Correlogram of ZY1

: 05/07/00 Time: 12:19
ple: 1960:1 1996:4
ded observations: 147

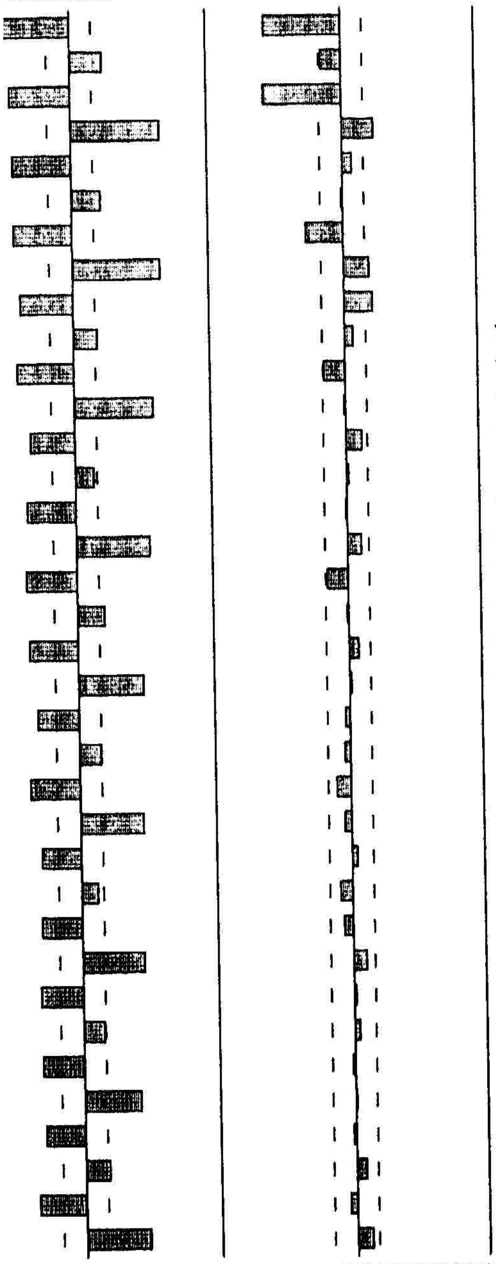


	AC	PAC	Q-Stat	Prob
1	-0.560	-0.560	47.055	0.000
2	0.181	-0.193	52.014	0.000
3	-0.428	-0.628	79.850	0.000
4	0.686	0.270	152.00	0.000
5	-0.427	0.091	180.08	0.000
6	0.171	0.025	184.64	0.000
7	-0.435	-0.308	214.23	0.000
8	0.681	0.162	287.36	0.000
9	-0.377	0.181	309.97	0.000
10	0.139	0.066	313.08	0.000
11	-0.433	-0.192	343.29	0.000
12	0.640	0.003	409.67	0.000
13	-0.332	0.097	427.73	0.000
14	0.115	0.017	429.92	0.000
15	-0.373	0.015	452.97	0.000
16	0.593	0.109	511.84	0.000
17	-0.380	-0.155	536.12	0.000
18	0.179	-0.019	541.54	0.000
19	-0.369	0.080	564.83	0.000
20	0.531	0.045	613.47	0.000
21	-0.319	-0.038	631.18	0.000
22	0.155	-0.041	635.41	0.000
23	-0.378	-0.088	660.61	0.000
24	0.511	-0.059	707.11	0.000
25	-0.292	0.032	722.41	0.000
26	0.114	-0.089	724.78	0.000
27	-0.307	-0.051	742.03	0.000
28	0.504	0.091	788.76	0.000
29	-0.317	0.048	807.42	0.000
30	0.140	0.054	811.11	0.000
31	-0.313	-0.032	829.60	0.000
32	0.469	0.025	871.55	0.000
33	-0.296	0.009	888.40	0.000
34	0.161	0.081	893.45	0.000
35	-0.349	-0.055	917.22	0.000
36	0.521	0.131	970.78	0.000

:xhibit 5.6: Output of the SAC and SPAC for $Y2_t$ by using the Transformation $ZY2_t = Y2_t - Y2_{t-1}$

Correlogram of ZY2

05/07/00 Time: 12:20
le: 1960:1 1996:4
led observations: 147



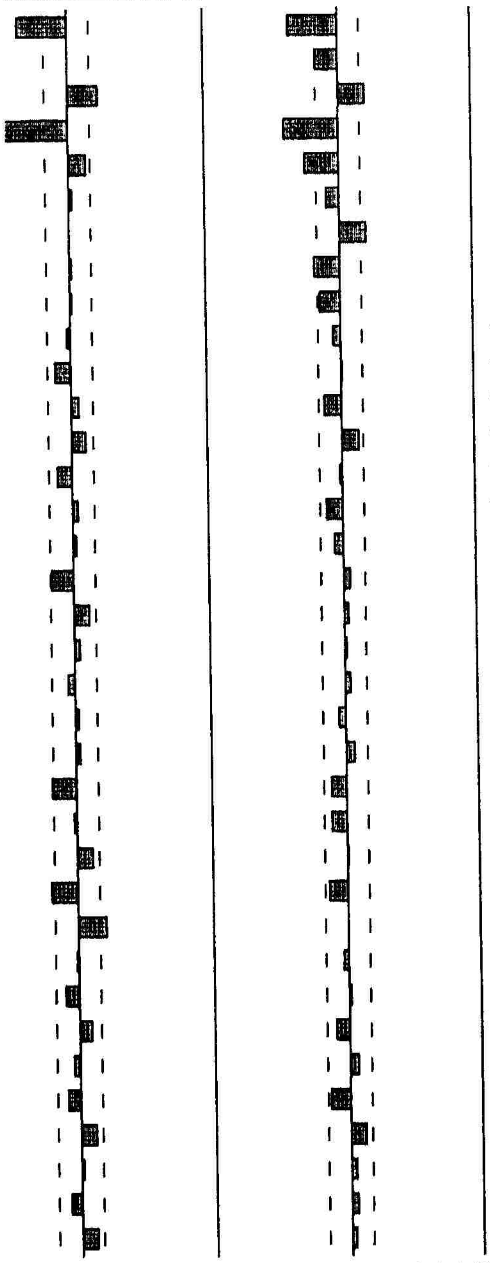
	AC	PAC	Q-Stat	Prob
1	-0.591	-0.591	52.483	0.000
2	0.249	-0.155	61.864	0.000
3	-0.460	-0.601	94.067	0.000
4	0.674	0.252	163.60	0.000
5	-0.448	0.074	194.59	0.000
6	0.224	-0.005	202.41	0.000
7	-0.444	-0.280	233.19	0.000
8	0.670	0.201	303.83	0.000
9	-0.396	0.222	328.66	0.000
10	0.182	0.073	333.94	0.000
11	-0.432	-0.158	363.98	0.000
12	0.606	-0.003	423.53	0.000
13	-0.331	0.131	441.48	0.000
14	0.142	0.020	444.78	0.000
15	-0.364	-0.003	466.74	0.000
16	0.563	0.109	519.75	0.000
17	-0.383	-0.155	544.45	0.000
18	0.206	-0.008	551.63	0.000
19	-0.365	0.076	574.41	0.000
20	0.501	0.022	617.67	0.000
21	-0.311	-0.030	634.44	0.000
22	0.168	-0.039	639.38	0.000
23	-0.369	-0.104	663.46	0.000
24	0.488	-0.046	705.86	0.000
25	-0.288	0.046	720.80	0.000
26	0.129	-0.088	723.82	0.000
27	-0.301	-0.060	740.32	0.000
28	0.478	0.104	782.42	0.000
29	-0.317	0.017	801.08	0.000
30	0.156	0.045	805.62	0.000
31	-0.307	-0.016	823.38	0.000
32	0.438	0.015	859.98	0.000
33	-0.291	-0.013	876.29	0.000
34	0.181	0.077	882.62	0.000
35	-0.346	-0.048	906.06	0.000
36	0.496	0.119	954.57	0.000

Exhibit 5.7: Output of the SAC and SPAC for LY_t by using the Transformation $ZZLY_t = LY_t - LY_{t-1} - LY_{t-4} + LY_{t-5}$

Correlogram of ZZLY

05/07/00 Time: 12:32
e: 1960:1 1996:4
ed observations: 143

tocorrelation Partial Correlation



	AC	PAC	Q-Stat	Prob
1	-0.383	-0.383	21.368	0.000
2	0.006	-0.164	21.374	0.000
3	0.234	0.209	29.455	0.000
4	-0.511	-0.421	68.393	0.000
5	0.136	-0.255	71.177	0.000
6	0.029	-0.092	71.303	0.000
7	0.005	0.212	71.307	0.000
8	0.021	-0.191	71.377	0.000
9	0.020	-0.153	71.437	0.000
10	-0.017	-0.051	71.481	0.000
11	-0.108	0.009	73.318	0.000
12	0.065	-0.130	73.991	0.000
13	0.108	0.136	75.835	0.000
14	-0.102	-0.009	77.518	0.000
15	0.048	-0.118	77.885	0.000
16	0.030	-0.065	78.035	0.000
17	-0.164	0.051	82.448	0.000
18	0.115	0.036	84.659	0.000
19	0.048	0.022	85.041	0.000
20	-0.042	0.041	85.340	0.000
21	0.028	-0.048	85.475	0.000
22	0.040	0.069	85.749	0.000
23	-0.176	-0.109	91.112	0.000
24	-0.010	-0.107	91.130	0.000
25	0.122	0.011	93.764	0.000
26	-0.195	-0.135	100.52	0.000
27	0.218	0.000	108.98	0.000
28	-0.008	-0.030	108.99	0.000
29	-0.092	0.018	110.52	0.000
30	0.094	-0.095	112.14	0.000
31	-0.036	0.072	112.39	0.000
32	-0.085	-0.146	113.74	0.000
33	0.119	0.117	116.39	0.000
34	0.019	0.043	116.46	0.000
35	-0.072	0.056	117.46	0.000
36	0.123	0.034	120.38	0.000

xhibit 5.8: Output of the SAC and SPAC for $Y1_t$ by using the Transformation $ZZY1_t = Y1_t - Y1_{t-1} - Y1_{t-4} + Y1_{t-5}$

Correlogram of ZZY1

)5/07/00 Time: 12:31
e: 1960:1 1996:4
ed observations: 143

ocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.395	-0.395	22.732	0.000
		2	0.016	-0.165	22.769	0.000
		3	0.216	0.192	29.659	0.000
		4	-0.509	-0.430	68.355	0.000
		5	0.146	-0.272	71.575	0.000
		6	0.017	-0.108	71.619	0.000
		7	0.014	0.191	71.650	0.000
		8	0.029	-0.187	71.778	0.000
		9	0.017	-0.156	71.825	0.000
		10	-0.007	-0.040	71.832	0.000
		11	-0.094	0.028	73.232	0.000
		12	0.043	-0.141	73.527	0.000
		13	0.122	0.145	75.896	0.000
		14	-0.128	-0.019	78.539	0.000
		15	0.049	-0.111	78.926	0.000
		16	0.049	-0.047	79.313	0.000
		17	-0.193	0.032	85.416	0.000
		18	0.153	0.028	89.317	0.000
		19	0.034	0.039	89.516	0.000
		20	-0.067	0.026	90.264	0.000
		21	0.051	-0.067	90.707	0.000
		22	0.018	0.067	90.764	0.000
		23	-0.161	-0.082	95.261	0.000
		24	-0.001	-0.138	95.261	0.000
		25	0.126	0.011	98.047	0.000
		26	-0.184	-0.115	104.05	0.000
		27	0.197	-0.011	111.01	0.000
		28	0.014	-0.025	111.05	0.000
		29	-0.106	0.018	113.10	0.000
		30	0.078	-0.094	114.21	0.000
		31	-0.009	0.063	114.23	0.000
		32	-0.122	-0.159	117.01	0.000
		33	0.123	0.105	119.88	0.000
		34	0.019	0.023	119.94	0.000
		35	-0.074	0.047	121.00	0.000
		36	0.130	0.029	124.28	0.000

hibit 5.9: Output of the SAC and SPAC for $Y2_t$ by using the Transformation $ZZY2_t = Y2_t - Y2_{t-1} - Y2_{t-4} + Y2_{t-5}$

Correlogram of ZZY2

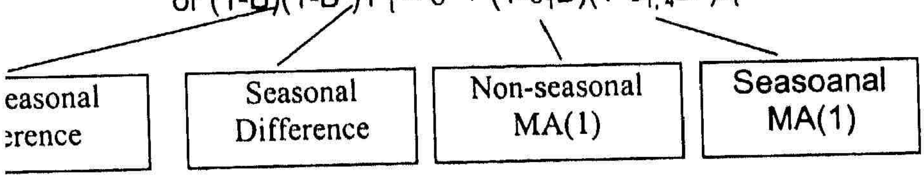
5/07/00 Time: 12:31
1960:1 1996:4
d observations: 143

correlation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.396	-0.396	22.914	0.000
		2	0.032	-0.149	23.060	0.000
		3	0.180	0.165	27.883	0.000
		4	-0.507	-0.451	66.280	0.000
		5	0.156	-0.287	69.942	0.000
		6	0.002	-0.113	69.943	0.000
		7	0.034	0.168	70.123	0.000
		8	0.043	-0.181	70.410	0.000
		9	0.007	-0.159	70.419	0.000
		10	-0.002	-0.035	70.419	0.000
		11	-0.082	0.045	71.466	0.000
		12	0.015	-0.144	71.501	0.000
		13	0.137	0.149	74.507	0.000
		14	-0.142	-0.026	77.745	0.000
		15	0.049	-0.102	78.140	0.000
		16	0.062	-0.024	78.772	0.000
		17	-0.212	0.016	86.147	0.000
		18	0.179	0.019	91.439	0.000
		19	0.022	0.058	91.517	0.000
		20	-0.080	0.010	92.605	0.000
		21	0.068	-0.084	93.390	0.000
		22	-0.006	0.060	93.395	0.000
		23	-0.143	-0.058	96.915	0.000
		24	0.004	-0.166	96.918	0.000
		25	0.124	0.011	99.606	0.000
		26	-0.164	-0.103	104.36	0.000
		27	0.175	-0.028	109.85	0.000
		28	0.032	-0.015	110.04	0.000
		29	-0.114	0.022	112.40	0.000
		30	0.061	-0.088	113.08	0.000
		31	0.009	0.060	113.09	0.000
		32	-0.145	-0.152	117.00	0.000
		33	0.123	0.088	119.86	0.000
		34	0.012	-0.001	119.88	0.000
		35	-0.068	0.025	120.76	0.000
		36	0.129	0.025	123.98	0.000

erved Exhibit 5.7 to 5.9 show that a single peak in the first few lags \CF with a decay in the PACF suggest an MA(1) for the non- ıl part. Similarly, the single peak in the seasonal part of the ACF with ponding decay in the PACF suggest an MA(1) for the seasonal part. the study comes up with the tentative identification for all the three s shown below:

$$\text{ARIMA}(0, 1, 1)(0, 1, 1)_4$$

$$\text{or } (1-B)(1-B^4)Y^*_t = \delta + (1-\theta_1 B)(1-\theta_{1,4} B^4)\varepsilon_t$$



$Y^*_t = LY_t$ or $Y1_t$ or $Y2_t$ and δ = constant term

? Estimation of Parameters and Diagnostic Checking

Table 5.9, 5.10 and 5.11 shows the summary of criterion measures oosing the best ARIMA model for LY_t, $Y1_t$ and $Y2_t$ respectively. Each s supported by Diagnostic Checking measures based on Ljung-Box Q- tic value. The table also includes columns for p-value and decision on ıer the residuals follow a white noise model at 5% level of significance.

9: ARIMA Models For Ly_t Series And Criterion Measures For Choosing The Best Model

MODEL	m	Log(L)	AIC	Ljung-Box Q-Statistic (36 obs.)	p-value	White Noise Model* (Y/N)
$(0,1,1)_4$	2	152.1536	-4.9239	34.4	0.461	Y
$(0,1,1)_4$	3	152.1561	-4.9099	34.1	0.410	Y
$)(0,1,2)_4$	3	152.1781	-4.9103	34.1	0.380	Y
$)(0,1,1)_4$	3	151.0589	-4.9091	34.8	0.380	Y
$)(1,1,1)_4$	3	147.2669	-4.8993	38.3	0.242	Y
$)(1,1,1)_4$	4	146.2363	-4.8848	38.7	0.194	Y
$)(1,1,0)_4$	2	133.7862	-4.7333	78.6	0.000	N

ier of parameters in the estimation) = p+q+P+Q
id at 5% Level of Significance
N: No

sults in Table 5.9 suggest that the parsimonious ARIMA model for LY_t

MA$(0,1,1)(0,1,1)_4$

10: ARIMA Models For $Y1_t$ Series And Criterion Measures For Choosing The Best Model

MODEL	m	Log(L)	AIC	Ljung-Box Q-Statistic (36 obs.)	p-value	White Noise Model* (Y/N)
$(0,1,1)_4$	2	175.4775	-5.2502	36.2	0.367	Y
$)(0,1,1)_4$	3	175.4883	-5.2363	36.3	0.322	Y
$)(0,1,2)_4$	3	175.6212	-5.2382	35.1	0.369	Y
$)(0,1,1)_4$	3	174.8040	-5.2435	35.9	0.330	Y
$)(1,1,1)_4$	3	158.8513	-5.0821	67.1	0.000	N
$)(1,1,1)_4$	4	169.3165	-5.2193	39.6	0.168	Y
$)(1,1,0)_4$	2	157.1039	-5.0713	83.1	0.000	N

er of parameters in the estimation) = p+q+P+Q
d at 5% Level of Significance
: No

sults in Table 5.10 suggest that the parsimonious ARIMA model for

RIMA$(0,1,1)(0,1,1)_4$

11: ARIMA Models For $Y2_t$ Series And Criterion Measures For Choosing The Best Model

MODEL	m	Log(L)	AIC	Ljung-Box Q-Statistic (36 obs.)	p-value	White Noise Model* (Y/N)
$(0,1,1)_4$	2	-6.0473	-2.7113	36.3	0.362	Y
$(0,1,1)_4$	3	-6.0227	-2.6977	36.2	0.323	Y
$(0,1,2)_4$	3	-5.5005	-2.7030	37.4	0.275	Y
$)(0,1,1)_4$	3	-4.91846	-2.7123	38.7	0.226	Y
$)(1,1,1)_4$	3	-13.4706	-2.4998	62.6	0.001	N
$)(1,1,1)_4$	4	-4.7626	-2.69963	37.0	0.248	Y
$)(1,1,0)_4$	2	-15.4524	-2.5043	83.1	0.000	N

er of parameters in the estimation) = p+q+P+Q
d at 5% Level of Significance
N: No

The criterion measures of choosing the best model in Table 5.11 that, ARIMA$(0,1,1)(0,1,1)_4$ Y2 model has the highest likelihood value nallest AIC. However an increase in two additional parameters in this does justify the change in AIC as compared AIC of the ARIMA(0, 1, l, $1)_4$ model. The change is very small and therefore, ARIMA(0, 1, , $1)_4$ is also taken to be the best model for $Y2_t$.

ing and Forecasting

he parsimonious estimated model for all the three series is), 1, 1)(0, 1, 1)$_4$. Eviews output of these estimated models, together correlogram of the residuals is given in Table B9 to B11 and Exhibit 37 (Appendix B). The results of these estimated models is ised and shown in Table 5.12. The constant term in the estimated f all three series is insignificant at 5 % level of significance.

.12: Estimated Parameters For The Parsimonious Models Of Ly_t, $Y1_t$ And $Y2_t$ Series

LY_t Series : ARIMA(0, 1, 1)(0, 1, 1)$_4$ Model

ieter	Coefficient	Std. Error	T-Statistic	Prob.
	-0.000793	0.000955	-0.830621	0.4076
	-0.461671	0.071385	-6.467342	0.0000
	-0.774250	0.052652	-14.70517	0.0000

$Y1_t$ Series : ARIMA(0, 1, 1)(0, 1, 1)$_4$ Model

neter	Coefficient	Std. Error	T-Statistic	Prob.
	0.000729	0.000771	0.944626	0.3465
	-0.473520	0.069396	-6.823477	0.0000
	-0.784360	0.050182	-15.63035	0.0000

$Y2_t$ Series : ARIMA(0, 1, 1)(0, 1, 1)$_4$ Model

meter	Coefficient	Std. Error	T-Statistic	Prob.
	0.002904	0.002794	1.039399	0.3004
	-0.487696	0.068007	-7.171214	0.0000
	-0.772290	0.049680	-15.54537	0.0000

ıdel for the three transformed series that will be fitted and used to

e forecast values are:

ı Series: Logarithmic Transformation $LY_t = Log(Y_t)$

$(1 - B)(1 - B^4) LY_t = (1 + 0.461671B)(1 + 0.774250B^4)\varepsilon_t$

ı Forecast Range (SFR): Model is Fitted

'able B12 (Appendix) shows the forecast values in sample forecast Figure 5.10 shows the plot of actual yield series (LY_t) and forecast eries (FLY_t). The root mean sum square error and mean absolute tage error from this fitted model is: $RMSE_{psfr}$ = 0.083, $MAPE_{psfr}$ = 7.2.

ſample Forecast Range (PSFR): Forecasting

Table 5.13 shows the actual (LY_t) and forecast values(FLY_t) in post e forecast range. Figure 5.11 shows the plot of LY_t and FLY_t from ɔ1 to 1997:Q4. The root mean sum square error and mean absolute ıtage error from this fitted model is: $RMSE_{sfr}$ = 0.067, $MAPE_{sfr}$ = 4.2.

1_t Series: Power Transformation $Y1_t = Y_t^{(-0.5)}$

l: $(1 - B)(1 - B^4) Y1_t = (1 + 0.473520B)(1 + 0.784360 B^4)\varepsilon_t$

ıle Forecast Range (SFR) : Model is Fitted

Table B13 (Appendix) shows the forecast values in sample forecast). Figure 5.12 shows the plot of actual yield series ($Y1_t$) and forecast series ($FY1_t$). The root mean sum squared error and mean absolute ɜntage error from this fitted model is: $RMSE_{psfr}$ = 0.071, $MAPE_{psfr}$ = 3.3

nple Forecast Range (PSFR): Forecasting

able 5.14 shows the actual ($Y1_t$) and forecast values ($FY1_t$) in post forecast range. Figure 5.13 shows the plot of $Y1_t$ and $FY1_t$ from to 1997:Q4.The root mean sum squared error and mean absolute ıge error from this fitted model is: $RMSE_{sfr}$ = 0.048, $MAPE_{sfr}$ = 2.7.

ieries: Power Transformation $Y2_t = Y_t^{(-1)}$

$- B^4) Y2_t = (1 + 0.487696 B)(1 + 0.772290 B^4)\varepsilon_t$

ıe constant is insignificant to be included in the model.

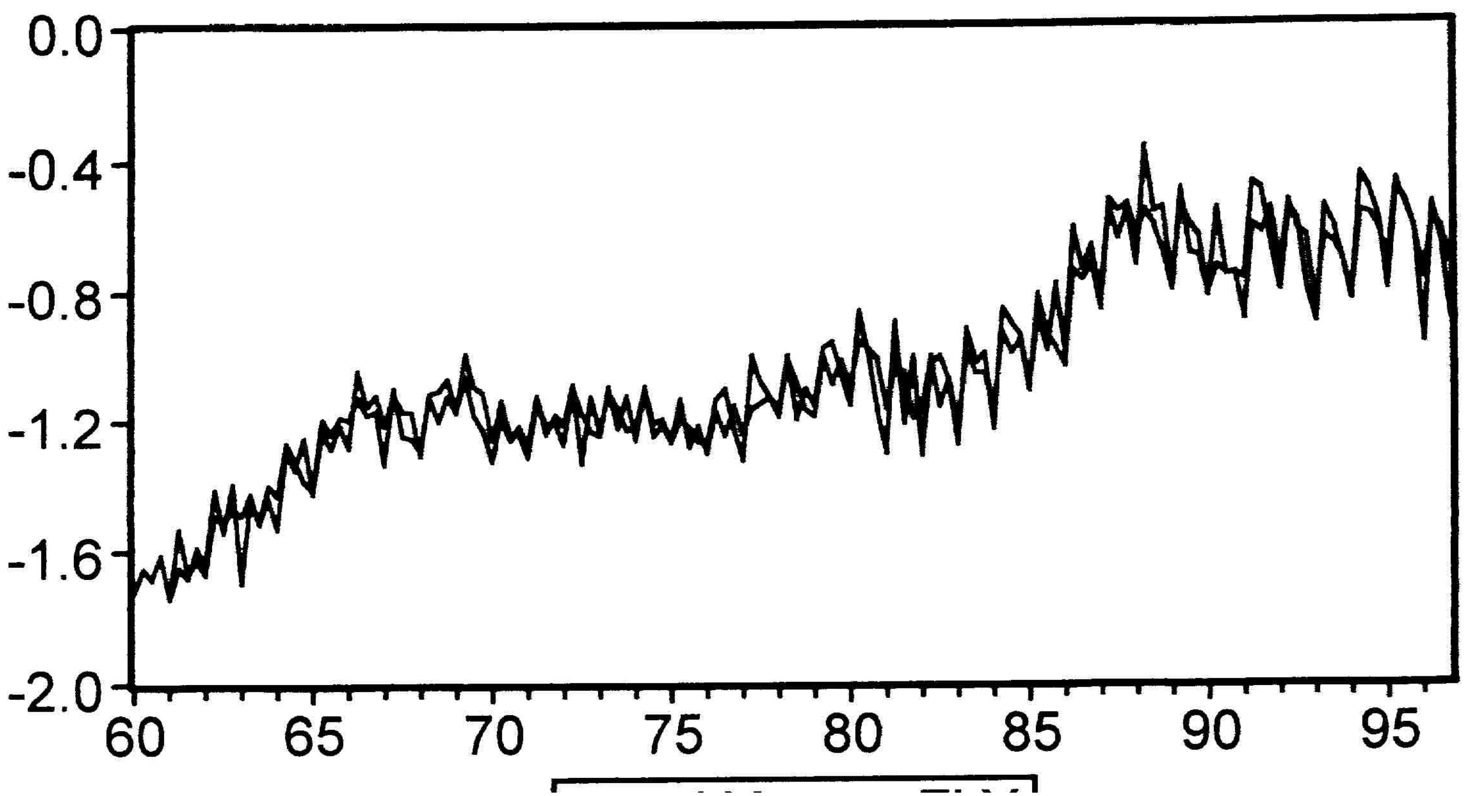
Forecast Range (SFR): Model is Fitted

ɔle B14 shows the forecast values in sample forecast range. Figure ıows the plot of actual yield series ($Y2_t$) and forecast yield series The root mean sum squared error and mean absolute percentage ɔm this fitted model is: $RMSE_{psfr}$ = 0.254, $MAPE_{psfr}$ = 6.9

iample Forecast Range (PSFR): Forecasting

ɔle 5.15 shows the actual ($Y2_t$) and forecast values ($FY2_t$) in post ı forecast range. Figure 5.15 shows the plot of $Y2_t$ and $FY2_t$ from Ɋ1 to 1997:Q4. The root mean sum squared error and mean absolute ıtage error from this fitted model is: $RMSE_{sfr}$ = 0.144, $MAPE_{sfr}$ = 4.9.

Figure 5.10: Plot of Yield Series (LY_t) and Forecast Series (FLY_t) by $(1 - B)(1 - B^4)\ LY_t = (1 + 0.461671B)(1 + 0.774250B^4)\varepsilon_t$



: Actual (LY_t) And Forecast (FLY_t) From 1997:Q1 To 1997:Q4 By ARIMA $(0,1,1)(0,1,1)_4$

	Q1	Q2	Q3	Q4
97	-0.890647	-0.639349	-0.747696	-0.898660
97	-1.002820	-0.615724	-0.702357	-0.847943

.11: Plot Of LY_t And FLY_t From 1997:Q1 To 1997:Q4 By ARIMA $(0,1,1)(0,1,1)_4$ LY_t

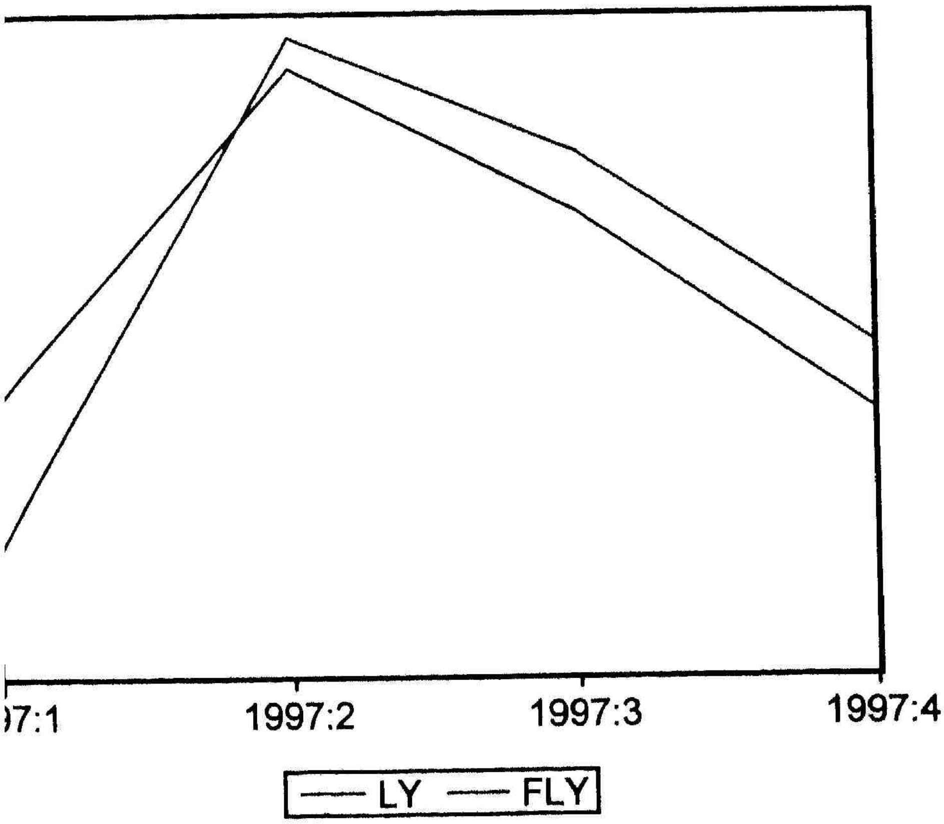
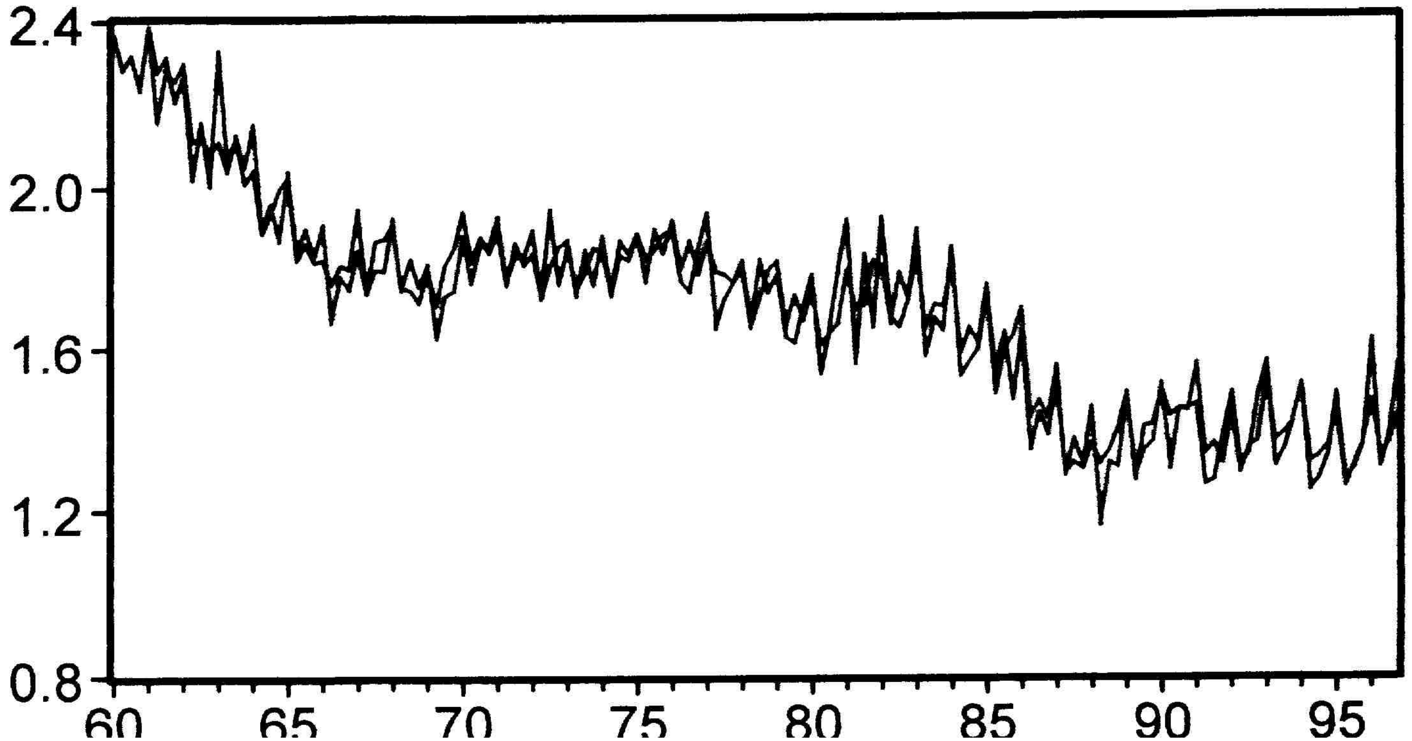


Figure 5.12: Plot of Yield Series ($Y1_t$) and Forecast Series ($FY1_t$) by $(1 - B)(1 - B^4)\ Y1_t = (1 + 0.473520B)(1 + 0.784360\ B^4)\varepsilon_t$



: Actual ($Y1_t$) And Forecast ($FY1_t$) From 1997:Q1 To 1997:Q4 By ARIMA $(0,1,1)(0,1,1)_4$

	Q1	Q2	Q3	Q4
7	1.560995	1.376679	1.453316	1.567261
7	1.640770	1.367804	1.423720	1.522993

gure 5.13: Plot Of $Y1_t$ And $FY1_t$ From 1997:Q1 To 1997:Q4 By ARIMA $(0,1,1)(0,1,1)_4$ $Y1_t$

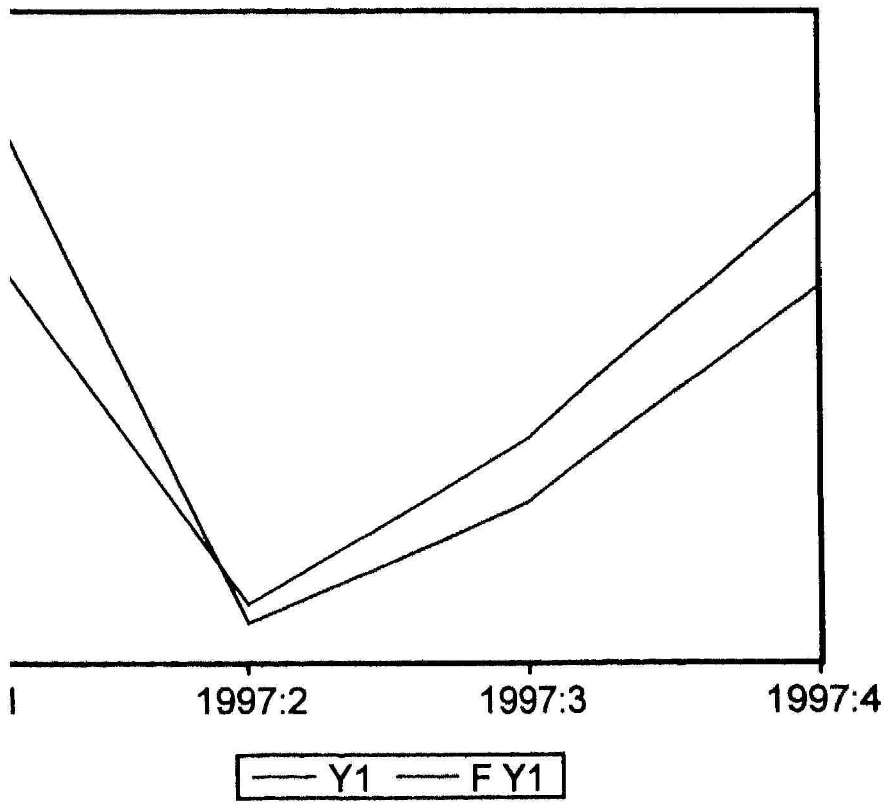
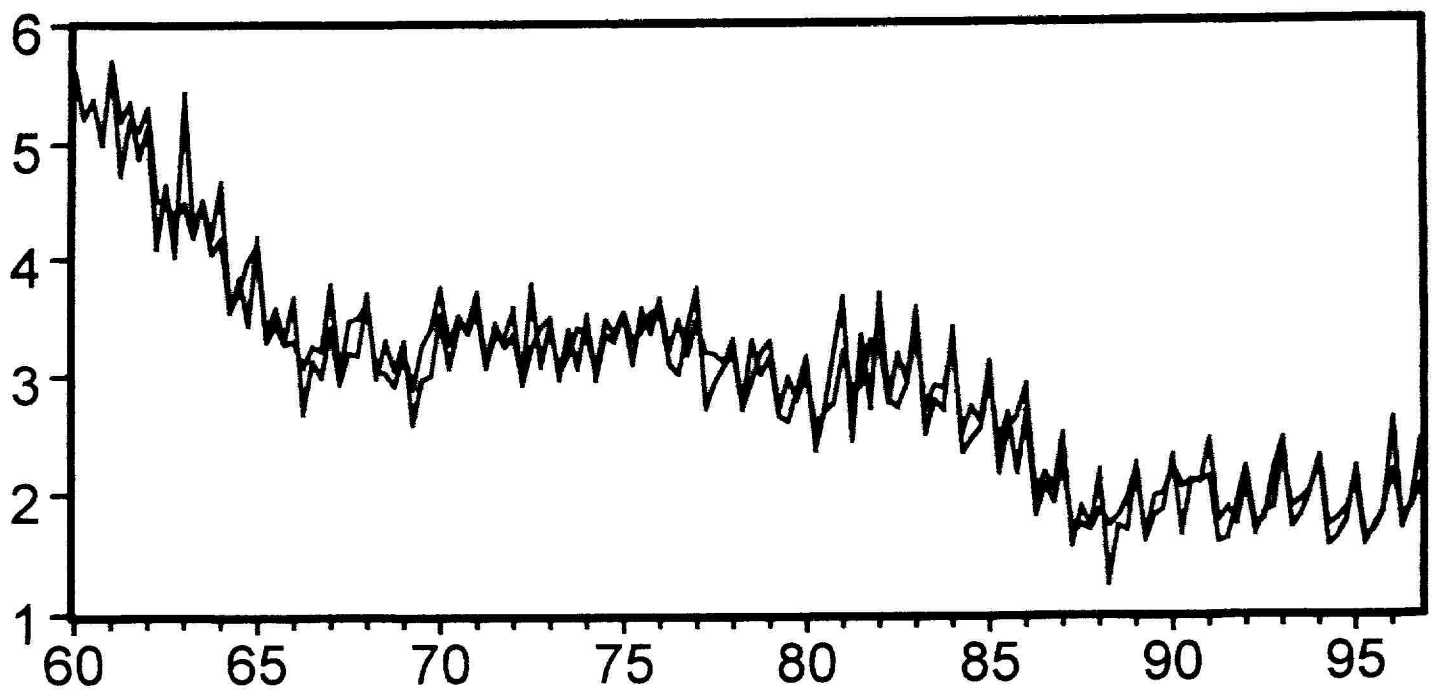


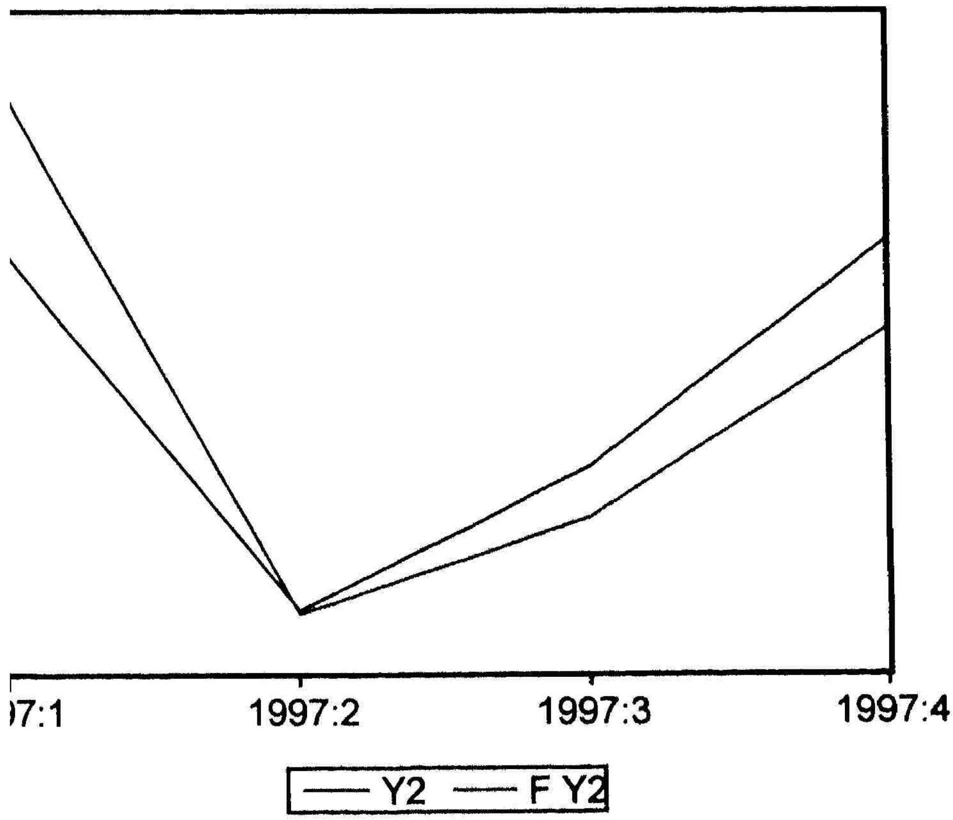
Figure 5.14: Plot of Yield Series ($Y2_t$) and Forecast Series ($FY2_t$) by $(1 - B)(1 - B^4)\, Y2_t = (1 + 0.487696\, B)(1 + 0.772290\, B^4)\varepsilon_t$



: Actual ($Y2_t$) And Forecast ($FY2_t$) From 1997:Q1 To 1997:Q4 By ARIMA $(0,1,1)(0,1,1)_4$

	Q1	Q2	Q3	Q4
7	2.436707	1.895246	2.112129	2.456308
ı7	2.679005	1.889669	2.034875	2.321050

igure 5.15: Plot Of $Y2_t$ And $FY2_t$ From 1997:Q1 To 1997:Q4 By ARIMA $(0,1,1)(0,1,1)_4$ $Y2_t$



5.2.3 Forecast Yield by ARIMA Models

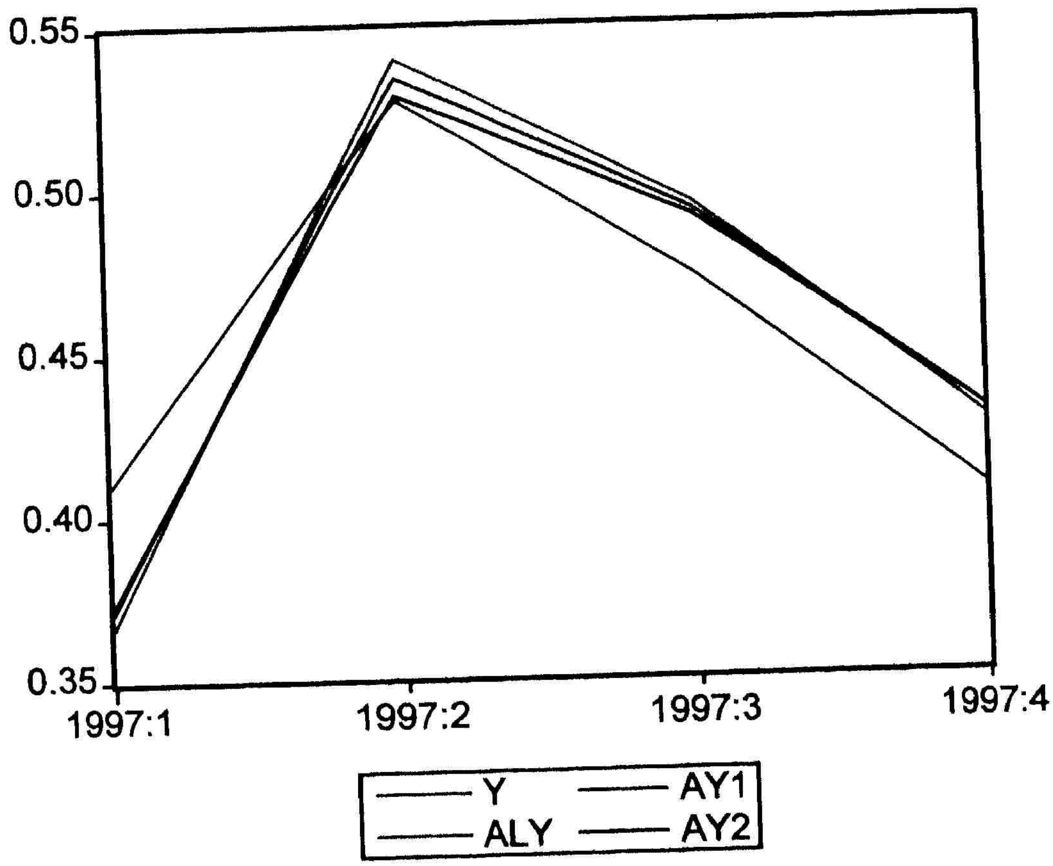
Table 5.16 shows the comparison of actual yield and the forecast yield obtained by Box-Jenkins methodology in the post sample forecast range. The forecasts obtained for transformed series (LY_t, $Y1_t$ and $Y2_t$) are converted back to the original. Figure 5.16 shows the plot of actual yield and forecast yield by ARIMA(0, 1, 1)(0, 1, 1)$_4$ on the power-transformed series, LY_t , $Y1_t$ and $Y2_t$.

Table 5.16: Actual Yield And Forecasts Generated By ARIMA Models In The Post Sample Forecast Range

ARIMA Model	Q1	Q2	Q3	Q4
Actual	0.410390	0.527636	0.473456	0.407115
(0, 1, 1)(0, 1, 1)$_4$ LY_t	0.366843	0.540249	0.495416	0.428295
(0, 1, 1)(0, 1, 1)$_4$ $Y1_t$	0.371454	0.534506	0.493345	0.431126
(0, 1, 1)(0, 1, 1)$_4$ $Y2_t$	0.373273	0.529193	0.491431	0.430839

The forecasted yield obtained from all models for first, third and fourth quarter is under forecasting, whereas, for second quarter, the models are over forecasting. The forecast yield exhibit the same seasonal pattern as the actual yield.

Figure 5.16: Plot Of Actual Yield And Forecast Yield Generated By ARIMA Models



ALY: ARIMA(0, 1, 1)(0, 1, 1)$_4$LY$_t$ Forecast yield
AY1: ARIMA(0, 1, 1)(0, 1, 1)$_4$ Y1$_t$ Forecast yield
AY2: ARIMA(0, 1, 1)(0, 1, 1)$_4$ Y2$_t$ Forecast yield

5.2.4 Forecast Performance in the Post Sample Forecast Range : ARIMA Models

In order to compare the forecasting performance, the transformed forecast yield are brought back to original scale. Table 5.17 shows the root mean sum square error and mean absolute percentage error of the fitted models. These performance measures indicate that forecast values generated from these fitted models do not differ greatly. ARIMA (0, 1, 1)(0, 1, 1)$_4$ $Y2_t$ give the best performance.

Table 5.17: Forecast Performance In Post Sample Forecast Range: ARIMA Models

ARIMA Model	RMSE	MAPE
(0, 1, 1)(0, 1, 1)$_4$ LY_t	**0.0273**	**5.7**
(0, 1, 1)(0, 1, 1)$_4$ $Y1_t$	**0.0252**	**5.2**
(0, 1, 1)(0, 1, 1)$_4$ $Y2_t$	**0.0238**	**4.7**

5.3 Summary

The models developed to generate forecasts for the yield series are:

Exponential Smoothing Method

Holt-Winters' Multiplicative Seasonality(HWMS) on Y_t
using $\alpha = 0.46$;$\gamma = 0$; $\delta = 0.39$

Holt-Winters' Additive Seasonality(HWAS) on LY_t
using $\alpha = 0.45$;$\gamma = 0$; $\delta = 0.37$

Holt-Winters' Additive Seasonality(HWAS) on $Y1_t$
using $\alpha = 0.44$;$\gamma = 0$; $\delta = 0.23$

Holt-Winters' Additive Seasonality(HWAS) on $Y2_t$
using $\alpha = 0.47$;$\gamma = 0$; $\delta = 0$

Box-Jenkins Methodology

LY_t Series : Logarithmic Transformation $LY_t = Log(Y_t)$

$$(1 - B)(1 - B^4)\, LY_t = (1 + 0.461671B)(1 + 0.774250B^4)\varepsilon_t$$

$Y1_t$ Series : Power Transformation $Y1_t = Y_t^{(-0.5)}$

$$(1 - B)(1 - B^4)\, Y1_t = (1 + 0.473520B)(1 + 0.784360\, B^4)\varepsilon_t$$

$Y2_t$ Series : Power Transformation $Y2_t = Y_t^{(-1)}$

$(1 - B)(1 - B^4)\, Y2_t = (1 + 0.487696\, B)(1 + 0.772290\, B^4)\varepsilon_t$

where the constant is insignificant to be included in the model.

Based on the plot fit and forecast performance, Holt-Winters Additive Seasonality method fitted to $Y1_t$, ARIMA(0,1,1)(0,1,1)$_4Y1_t$ and ARIMA(0,1,1)(0,1,1)$_4Y2_t$ are the appropriate models to forecast quarterly yield of tea in Peninsular Malaysia. Holt-Winters Multiplicative Seasonality method fitted to Y_t (original series) would be also appropriate if data transformed is not considered.