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TIMBER PRICE TRENDS IN KERALA

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ABSTRACT

This study examines the long-term trend in prices obtained in timber auctions in the Kerala Forest Department depots, and predict future prices. The timbers considered for the study are teak ***(Tectona grandis)*** in different girth-classes: E (logs with mid-girth underbark 185 cm and above), 1 (150-184cm), 2 (100-149cm), 3 (75-99cm) and 4 (60-74cm). ***anjily (Artocarpus hirsutus), irul (Xylia xylocarpa),*** jack ***(Artocarpus heterophyllus), maruthu (Terminalia paniculata), thembavu (Terminalia crenulata), venga (Pterocarpus marsupium)*** and ***venteak (Lagerstroemia microcarpa).*** The analysis of real prices, obtained by deflating the current prices with the wholesale price indices, for the period from 1956-57 to 1993-94 using moving averages showed that the overall trend was more or less similar for all timbers.

Different trend models were fitted to the real price series for detailed analysis. Among them, linear spline model with three knots was found to be the best for prices of teak logs in all girth-classes except girth-class ***E*** and for all other timbers except ***anjily.*** The analysis showed that during the period from 1956-57 to 1968-69, the real prices declined moderately for teak logs in all girth-classes and other timbers. During the periods from 1969-70 to 1976-77 and from 1977-78 to 1983-84, the prices of all timbers showed similar behaviour. During the period from 1969-70 to 1976-77, the rate of increase was moderate whereas the rate of increase was drastic during the period from 1977-78 to 1983-94 for all timbers. In the period from 1984-85 to 1993-94, while prices of teak logs in all girth-classes continued to increase, prices of other timbers showed a decline in prices except that of ***anjily*** and ***irul.*** Although the prices of ***anjily*** and ***irul*** increased, the rate of increase was very marginal.

For explaining the price trend of each species of timber, the relationships of real price with sale quantity and that with forest timber production were examined. The total quantity of each timber sold in all the depots of the Forest Department constituted the sale quantity. Autoregressive relationship was estimated for each timber, taking real price as regressand and real price lagged by one year and sale quantity as regressors. The analysis showed that the current year's real price of a timber was closely related to its preceding year's price and the sale quantity of a timber had no influence on its real price. That is, the price was found to be inelastic with respect to the quantity of timber sold.

The influence of annual forest timber production on prices was also examined. Step-wise regression analysis through origin was carried out for each species of timber, taking first-order ***differenced*** real price as regressand and first-order ***differenced*** production in the current year and lagged by one and two years as regressors. The analysis was done separately for the whole period under study and for the period during which real prices increased drastically. The analysis showed that the real prices were not related to current year's production. However, the prices of ***teak, venteak*** and ***maruthu*** were related to one and two year lagged production. That is, the reduction in the production in the previous one and two years had influence on the increase in the current year's real price. Significant relationship was seen only for teak and ***venteak*** for the above two periods. For ***maruthu*** , significant relationship was seen only for

the whole period and for ***irul*** only for the second period. During the period from 1976-77 to 1992-93, when the prices increased drastically, 74% of the variation in the ***(differenced)*** real prices of teak was explained by the one and two year lagged ***(differenced)*** production of teak. While 47% of the variation in the ***(differenced)*** prices of ***venteak*** was explained by the one and two year lagged ***(differenced)*** production of ***venteak,*** 30% of the variation in ***(differenced)*** prices of ***lrul*** was explained only by one-year lagged ***(diferenced)*** production. For the timber from the forests to be sold in auction, there exists a time-lag for transporting logs from the forests to the depots and auction procedure. Timber traders take into account the availability ***of*** timber in the depots during auction. This is the reason for the relationship between price and lagged production. The timbers for whichno significant price-production relationship was seen are mutually substitutable. Among them, jack and ***anjily*** are abundantly available in home-gardens of Kerala. Due to this, changes in production of these timbers from forests may not have any influence on the prices of these timbers in the depots.

Future prices of teak logs in girth-classes 1,2, and 3 were predicted for the years up to 2015-16, using autoregressive integrated moving average models based on current prices for a 53-year period from 1941-42 to 1993-94. The price forecasts for teak logs in girth-classes 1, 2, and 3 for the year 2015-16 at current prices are Rs. 90,000 per m^3 with 95% confidence limits from Rs. 45,000 to Rs. 135,000 per m^3, Rs. 71,000 per m^3 with limits from Rs. 39,000 to 103,000 per m^3 and Rs. 67,000 per m^3 with limits from Rs. 37,000 to 98,000 per m^3 respectively.

1. INTRODUCTION

This study of timber price trends in Kerala updates the earlier studies in this area. Data on timber prices for the period from 1956 to 1981 is available in Krishnankutty *et al.* (1985). Timber price trends up to the year 1984-85 were analysed in Krishnankutty (1989). Since these studies, there was considerable change in timber production and composition of output. Stoppage of clearfelling of natural forests in 1984 and selective felling in 1989 resulted in the reduction in the supply of different timbers which were obtained from natural forests. At present, teak is the main timber from the forests of Kerala, although timbers of other species are also available in smaller quantities. Further, import of timber to Kerala has been increasing especially after 1985 (Krishnankutty, 1990). In this situation, it is useful to study the timber price trends in Kerala particularly of teak and predict the future prices. These information are helpful for planning timber sale strategies and formulating price policies in the State.

The present study is more comprehensive compared to the narrow coverage of data in the earlier study (Krishnankutty *et.al.*, 1985). Further, all available Forest Working Plans were referred for obtaining past price data. In this process, a full revision of data has been achieved. This study analyses the price trends of teak in different girth-classes as well as seven other important timbers in Kerala and forecasts future prices of teak.

2. DATA BASE AND METHODOLOGY

2.1 Data Base

Timbers selected for the study are teak *(Tectona grandis)*, *anjily (Artocarpus hirsutus)*, *irul (Xylia xylocarpa)*, jack *(Artocarpus heterophyllus)*, *maruthu (Terminalia paniculata)*, *thembavu (Terminalia crenulata)*, *venga (Pterocarpus marsupium)* and *venteak (Lagerstroemia microcarpa)*. The selected timbers accounted for about 48% of the total volume of timber sold during the period from 1956-57 to 1992-93 from all the depots of the Kerala Forest Department (see Appendix 1 for the list of depots). The quantum of disposal of each timber as well as the importance of the timbers for construction and other common purposes were taken into account in the choice of the above eight timbers. Based on the availability, data were collected from 23 depots out of 28 depots currently functioning. Appendix 1 gives the names of the depots from which data were collected.

The analysis of price trends[1] was based on the average annual prices for Kerala during the period from 1956-57 to 1993-94. Based on the sale value realised and quantity sold during monthly auctions, weighted average prices of teak logs in different girth-classes[2]

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[1] Kerala State was formed in 1956 and the study was, therefore, confined to the period starting from 1956-57.

[2] The girth-classes are based on the mid-girth, under bark, of the logs. The different classes for teak are *E* (logs with mid-girth 185 cm and above), 1 (150-184 cm), 2 (100-149 cm), 3 (75-99 cm) and 4 (60-74

in each year for the State were worked out for the period from 1975-76 to 1993-94. Since the data prior to 1975-76 were not available in most of the depots, the average prices of teak logs in different girth-classes given in various Divisional Forest Working Plans were used to fill up the gap in data[3]. Using the prices and quantity sold of teak logs in different girth-classes, weighted average prices of teak (girth-glasses combined) in each year for the period from 1956-57 to 1993-94 were also worked out. For other timbers, average annual prices of both girth-classes combined for the period from 1956-57 to 1993-94 were worked out (see foot-note 2) . Average annual current prices computed for *teak* in different girth-classes and other timbers were used to analyse the timber price trends in Kerala (see Appendices 2 and.3).

For examining how changes in timber production from Kerala forests and quantity of timber sold through the depots affect prices, data on production of teak and other timbers from Kerala forests and their quantities sold through the Kerala Forest Department depots were compiled from various issues of the Administration Reports of the Kerala Forest Department for the period from 1956-57 to 1992-93 (see Appendices 4 and 5).

Average annual current prices of teak in girth-classes 1, 2 and 3 were also gathered from various Forest Working Plans and compiled for the period from 1941-42 to 1955-56 (see Appendix 6). The appended data on average annual current prices of teak for the period from 1941-42 to 1993-94 were used for estimating the autoregressive integrated moving average (ARIMA) model for forecasting.

2.2 Methodology of Trend Analysis

2.2.1 Conversion of current prices to real prices

Changes in the current prices are due to changes in real prices and inflation. For eliminating the effect of price change due to inflation, the current prices are to be deflated with some price indices (Croxton *et al.*, 1973). In this study, the current prices in respect of various years were deflated with the All India wholesale price indices[4] of all commodities with base year 1981-82 = 100. This gives the real prices and this alone reflects the actual change in price. The real prices (that is, prices at 1981-82 constant prices) of teak in different girth-classes and other timbers were used for analysing the price trend (Appendices 7 and 8).

2.2.2 Trend models and selection criteria

To identify the general trend in prices, moving averages of real prices were found so as to smoothen out the effect of year to year fluctuations. Here, 3, 5, and 7 year moving averages were adopted to explain the general trend. Price trend was studied in detail by

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cm). The girth-classes of other timbers are 1 (logs with mid-girth 125 cm and above) and 2(mid-girth up to 124cm).

[3] Twenty two Divisional Forest Working Plans for different periods have been referred. For a complete list, see References.

[4] The wholesale price indices for the period 1956-57 to 1993-94 were taken from Government of (1994).

fitting different trend equations to the real price series. The different trend equations tried were (1) linear , (2) quadratic, (3) cubic, (4) logarithmic, (5) inverse, (6) compound, (7) power, (8) S-curve, (9) growth, (10) exponential and (11) logistic , where the dependent variable *Pt* stands for the real price at time *t*, the time trend variable, and *t* takes values from 1 to 38 for the years from 1956-57 to 1993-94. The models 1 to 11 are given in Appendix 9.

Apart from the above models, linear and quadratic spline[5] models were also attempted. From the real prices plotted, different periods could be identified during which the prices were observed to follow more or less a linear or a quadratic pattern. In such cases, piece-wise regression models can be fitted (Montgomery and Peck, 1982) so as to compare the price movements between periods. Here, linear and quadratic spline models with two and three knots each were tried. The knots identified graphically were *k1* = 13 (for the year 1968-69), *k2* = 21 (for the year 1976-77) and *k3* = 28 (for the year 1983-84). The linear spline model, continuous at two knots *k1* and *k2* (model 12) and that at three knots *k1, k2* and *k3* (model 13), and the quadratic spline model continuous at two knots (model 14) and that at three knots (model 15) are also given in Appendix 9.

The parameters in the models 1 to 15 given in Appendix 9 were estimated for each timber by the method of least squares. The best fitting model for each timber was selected based on i) statistical non-significance of the Durbin-Watson d-statistic used for testing the autocorrelation of residual terms in the model (Johnston, 1972), ii) highest adjusted R^2 value and iii) the least mean square error value.

2.2.3 Real price in relation to quantity of timber sold

Quantity of a timber sold is the total quantity of that timber sold in all the Forest Department depots. Analysis was done for examining the relationship between real price and quantity of each timber sold. Regression model was estimated for each timber taking real price as regressand and real price lagged by one year and quantity sold as regressors. The lagged real price was included in the model mainly because of the fact that each year's price is likely to be correlated with the preceding year's price. The inclusion of the lagged regressand in the model makes the Durbin-Watson d-test invalid so that the Durbin h-statistic was computed for testing the autocorrelation of errors (Johnston, 1972).

2.2.4 Real price in relation to forest timber production

Volume of each timber produced from Kerala forests during the period from 1956-57 to 1992-93 were used to examine the extent of influence of production on real prices. First-order differencing was employed to all series of real prices and volume of timber produced of each timber for eliminating the problem of autocorrelation (Montgomery and Peck, 1982). The differenced series were used to examine the relationship between real prices and production of each timber. A step-wise regression analysis through origin was

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[5] Splines are piece-wise polynomials of order *k*. The joint points of the pieces are usually called 'knots'.

carried out for each timber, taking the *(differenced)* real price as regressand and the *(differenced)* production in the current year and lagged by one and two years as regressors.

2.3. Methodology of Price Forecasting

2.3.1 Box-Jenkins procedure for ARIMA modelling

Various techniques are available for forecasting. Among them, econometric models of timber market consisting of variables such as demand, supply, price, etc. can be employed. But developing econometric models of timber market needs time series data on the endogenous and exogenous variables. Not only that, employing econometric models to forecast timber prices, forecasts of the exogenous variables are also necessary. In this context, the autoregressive integrated moving average (ARIMA) models developed by Box and Jenkins (1976) are flexible. For forecasting with ARIMA models, the past history of the variable being forecasted is only necessary.

The general form of the ARIMA model of order (p, d, q) for a time series Z_t is written as

$$\phi(B)(1-B)^d Z_t = \theta(B)\, a_t$$

where $\phi(B) = (1-\phi_1 B - \phi_2 B^2 - \ldots - \phi_p B^p)$,

$\theta(B) = (1-\theta_1 B - \theta_2 B^2 - \ldots - \theta_q B^q)$,

$B^j Z_t = Z_{t-j}$, where B is the backward shift operator,

a_t : the random shock which is distributed $N(0,\sigma_a^2)$,

d : the degree of differencing.

$\phi(B)$ and $\theta(B)$ are called autoregressive operator of order p and moving average operator of order q respectively. $\phi_1, \phi_2, \ldots, \phi_p$, known as autoregressive parameters, and $\theta_1, \theta_2, \ldots, \theta_q$, known as moving average parameters, and σ_a are to be estimated from the data. When the degree of differencing, d, is zero, Z_t is replaced by $\bar{Z}_t = Z_t - \mu$, where μ is the mean of the series Z_t.

The method developed by Box and Jenkins (1976) for analysing time series has four stages (i) identification (ii) estimation diagnostic check and (iv) forecasting. The first stage is to identify the time series model based on the characteristics of the autocorrelation and partial autocorrection functions. The various parametes in the identified model are estimated in the second stage. The suitability of the estimated model is then verified after diagnostic check. If the model is found suitable, it is used for forecasting, otherwise return to identification, estimation and diagnostic check till a best model is obtained.

2.3.2 ARIMA modelling in teak prices

The average annual current prices of teak from 1941-42 to 1993-94 were used in this study (see Appendices 2 and 6). There were no missing values in the time series data on current prices of teak logs in girth-classes 1,2, and 3. Range-mean plots showed that no transformation was required for teak.

Models were identified based on the Box and Jenkins methodology and parameters were estimated by the method of maximum likelihood using the statistical computer package of SPSS Inc. (1987). After having estimated the model, the diagnostic check was performed. If there exists autocorrelation in the residual terms in the estimated model, the model is not suitable, otherwise the model can be accepted. The autocorrelation of residuals was tested with Box-Ljung statistic. After checking the model for Box-Ljung statistic, the best one among the different models identified was selected based on (i) the least values of Akaike Information Criterion (AIC) and Schwartz Bayesian Criterion (SBC), (ii) low mean absolute prediction error, (iii) relatively small residual standard error and (iv) comparatively small number of parameters. In this study, the best model was selected considering all the above criteria. Method of estimating magnitude of forecast error by model validation using a pre-separated data set, is available. However, this was not pursued in this study.

3. RESULTS OF TREND ANALYSIS

3.1 General Trend in Real Prices

Figure 1 shows the current prices of teak logs in different girth-classes in Kerala from 1956-57 to 1993-94 . For getting a clear understanding of the real change in prices, the real prices of teak logs in different girth classes were plotted (Figure 2). For smoothing out the year-to-year fluctuations, 3, 5 and 7-year moving averages of real prices were computed which are depicted in Figure 3. From the figures, it can be seen that the trends in prices of teak logs in all girth-classes are more or less the same.

Current prices of teak (girth-classes combined) and other timbers are depicted in Figure 4 , the real prices in Figure 5 and the 3,5 and 7-year moving averages in Figure 6. From the Figures, it can be seen that the general trends in prices of teak and other timbers were. more or less similar, although teak commanded higher prices than that of others.

3.2 Selection of Trend Models

Among the different trend models estimated for teak in different girth-classes, linear spline model with three knots *k1* (for the year 1968-69), *k2* (for the year 1976-77) and *k3* (for the year 1983-84) was found to be the best in most cases except for prices of teak

Fig.1 Current prices of teak logs in different girth-classes in Kerala

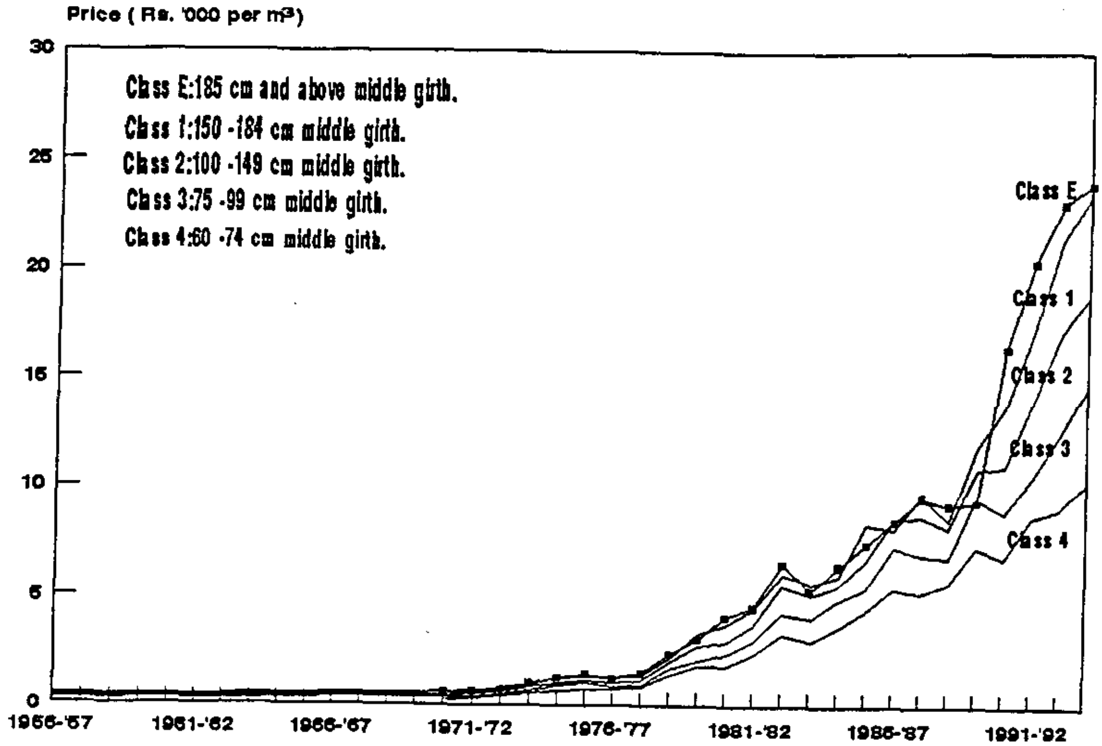


Fig.2 Real prices of teak logs in different girth-classes in Kerala

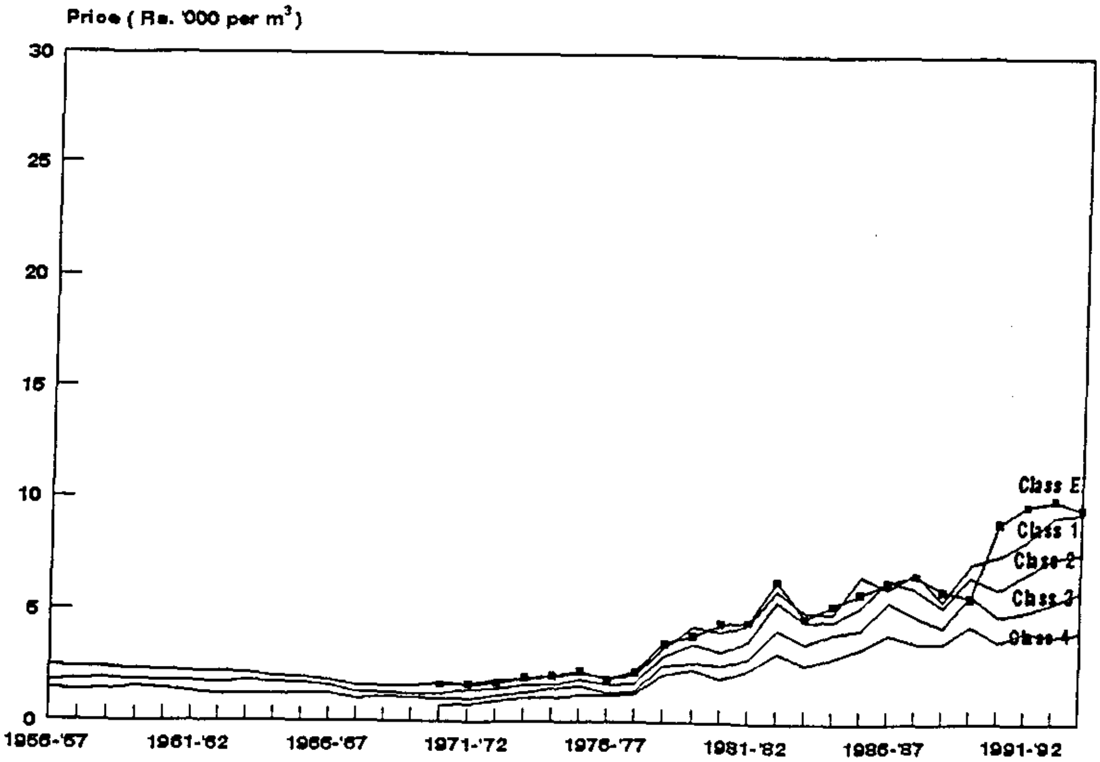
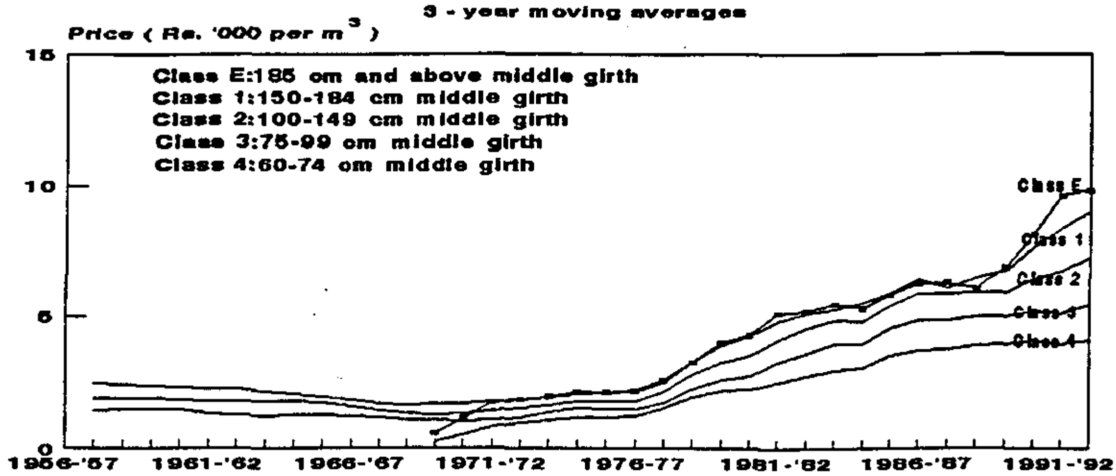
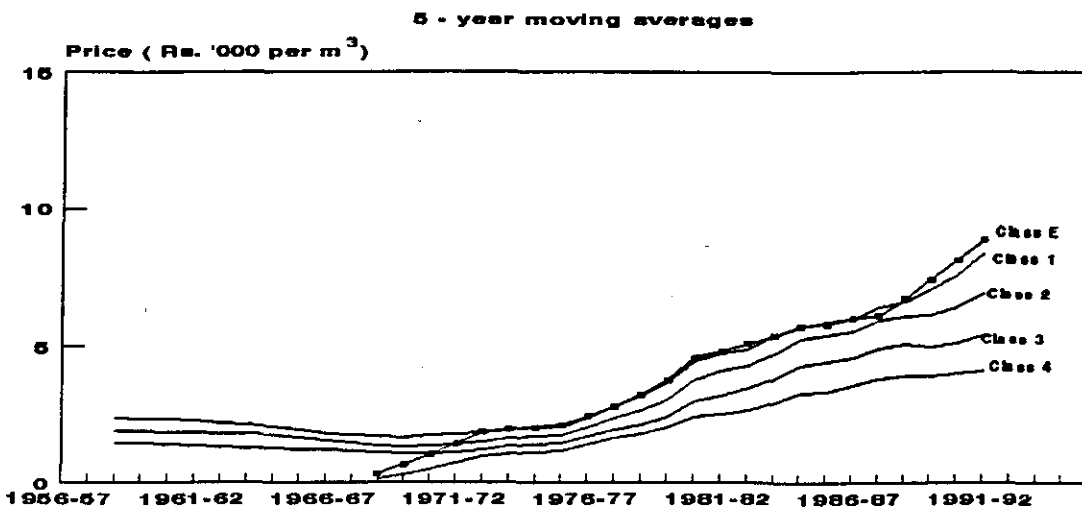


Fig.3 Moving average of real prices of teak logs in different girth-classes in Kerala





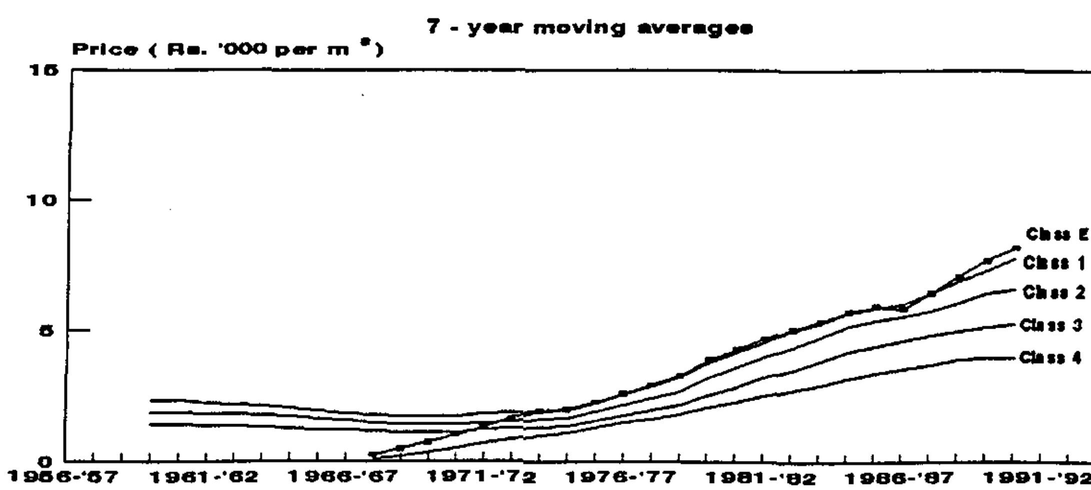


Fig.4 Current prices of teak and selected timbers in Kerala

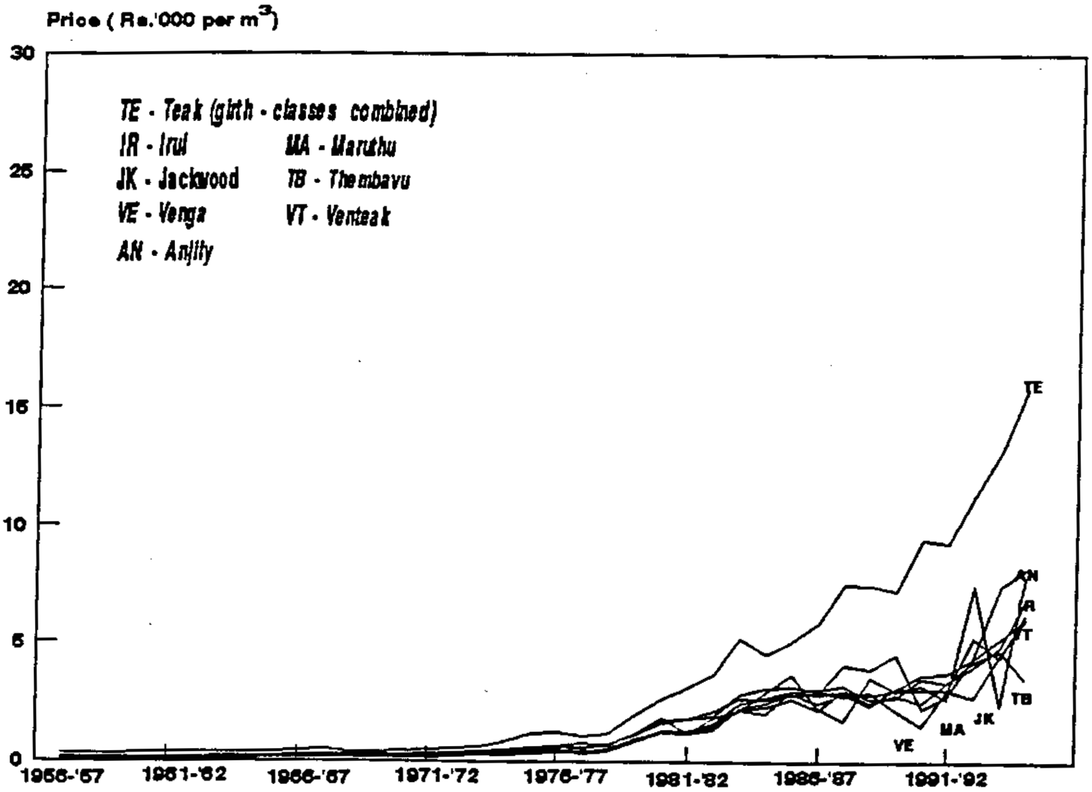


Fig.5 Real prices of teak and selected timbers in Kerala

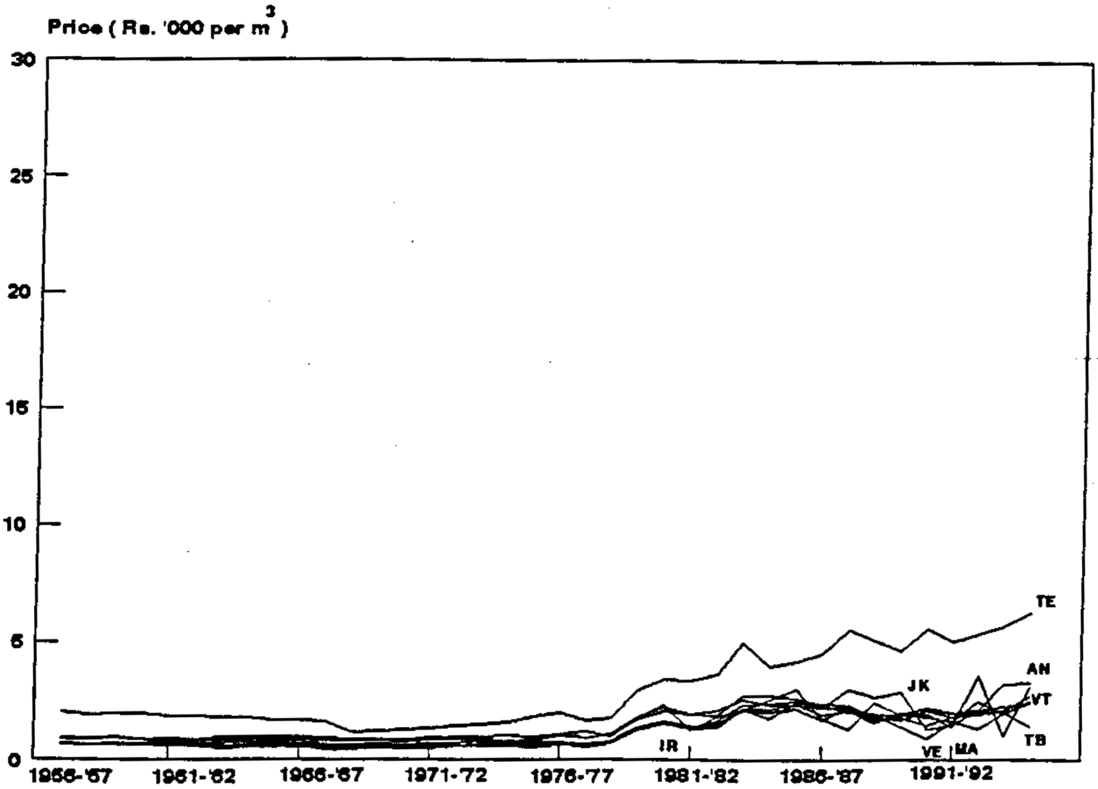
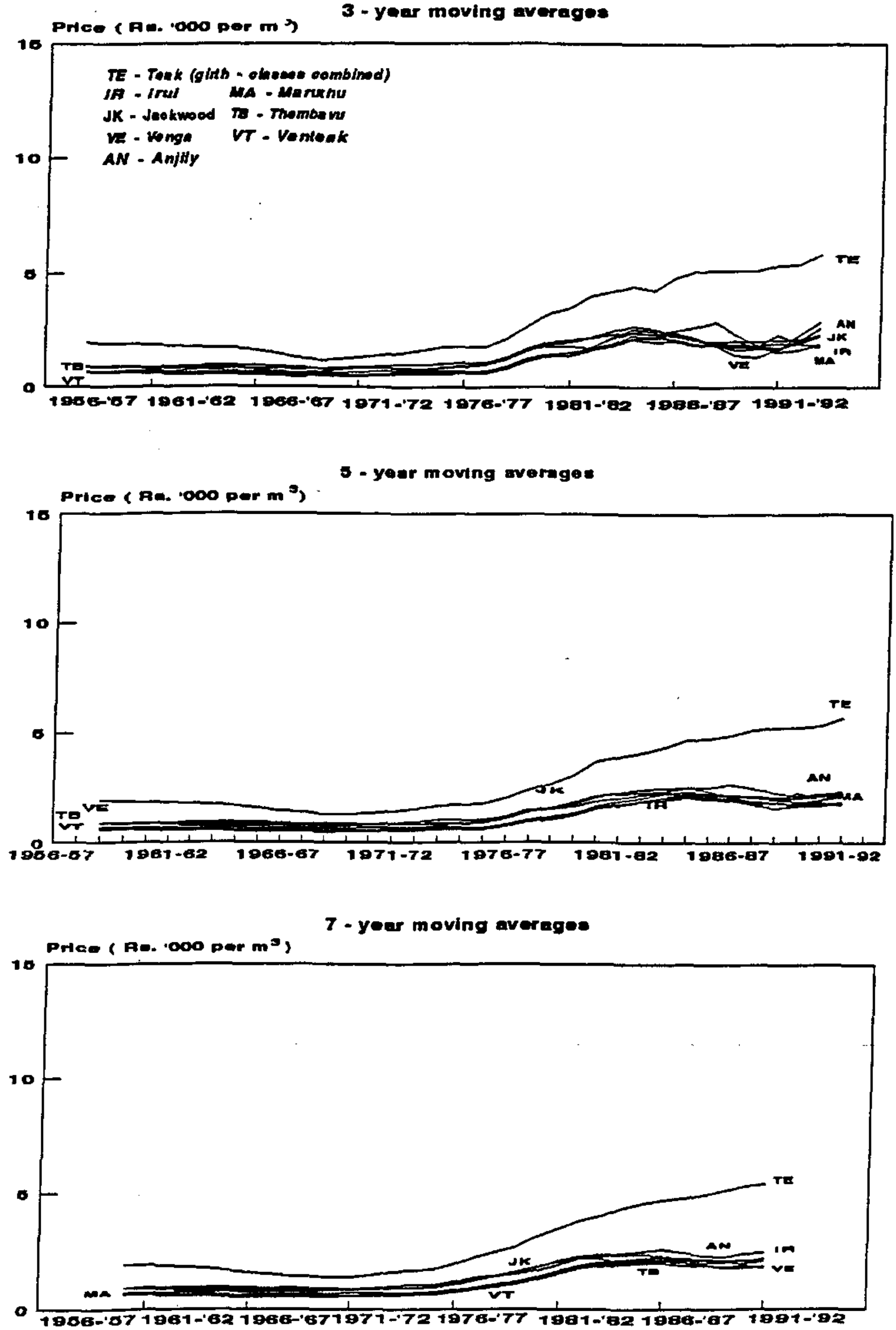


Fig.6 Moving averages of real prices of teak and selected timbers in Kerala



logs in girth-class E(see Appendices 10 to 14). For the prices of teak in girth-class *E*, quadratic spline model having 3 knots with adjusted R^2 value 0.92 was the best (Appendix 10). since Durbin-Watson d-statistic is non-significant at 5% level. For the linear spline model with 3 knots with adjusted R^2 value 0.91, the *d*-test was inconclusive. For the price of teak in girth-class 1, both the linear spline models having 2 and 3 knots and quadratic spline model with 3 knots were found to be better (see Appendix 11). The preference of linear spline model with 2 knots over the model with 3 knots is only in the increase of 0.01 in the adjusted R^2 value. For the prices of teak in girth-class 4, the linear spline model with 3 knots was found to be better than the cubic and quadratic spline models considering the lower value of *d* which was non-significant at 5% level (Appendix 14).

Linear spline model with three -knots (model 13) was found to be the best among different trend models estimated for *teak* (girth-classes combined) and for most of the other timbers except for *anjily* and *venteak* (see Appendices 15 to 22). Durbin-Watson *d*-statistic was significant at 1% level for most of the models of prices of *anjily* except for linear spline model with 3 knots and quadratic spline models with 2 and 3 knots for which it was significant at 5% level (Appendix 16). The highest adjusted R^2 value and least mean square error were for the linear spline model having 3 knots. For the prices of *venteak,* the Durbin-Watson *d*-statistic in none of the models was non-significant. However, the linear spline model with 3 knots had highest adjusted R^2 value and the Durbin-Watson d-test was inconclusive (Appendix 22). Since the selection of the trend model was only for comparing the real change in prices during different periods, the linear spline model with 3 knots was selected for all girth-classes of teak and for other timbers.

3.3 Price Behaviour in Different Periods

The estimated linear spline model having three knots k1, *k2* and k3 (model 13) is given by

$$\hat{P}_t = \hat{\beta}_{00} + \hat{\beta}_{01}t + \hat{\beta}_1(t-k_1)_+ + \hat{\beta}_2(t-k_2)_+ + \hat{\beta}_3(t-k_3)_+ ,$$

where $\hat{\beta}_{00}, \hat{\beta}_{01}, \hat{\beta}_1, \hat{\beta}_2$ and $\hat{\beta}_3$ are the least square estimates of the regression coefficients $\hat{\beta}_{00}, \hat{\beta}_{01}, \hat{\beta}_1, \hat{\beta}_2$ and $\hat{\beta}_3$ respectively. The resulting models for different periods with respect to the above estimated model are:

$$\hat{P}_t = \hat{\beta}_{00} + \hat{\beta}_{01}\, t \qquad ,\text{if } t \le k_1$$

$$\hat{P}_t = (\hat{\beta}_{00} - k_1\,\hat{\beta}_1) + (\hat{\beta}_{01} + \hat{\beta}_1)\, t \qquad ,\text{if } k_1 < t \le k_2$$

$$\hat{P}_t = (\hat{\beta}_{00} - k_1\,\hat{\beta}_1 - k_2\,\hat{\beta}_2) + (\hat{\beta}_{01} + \hat{\beta}_1 + \hat{\beta}_2)\, t \qquad ,\text{if } k_2 < t \le k_3$$

$$\hat{P}_t = (\hat{\beta}_{00} - k_1\,\hat{\beta}_1 - k_2\,\hat{\beta}_2 - k_3\,\hat{\beta}_3) + (\hat{\beta}_{01} + \hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3)t \qquad ,\text{if } t > k_3$$

From the above models, the rates of change of real prices with respect to the year *t* during the period $t \le k_1$, $k_1 < t$ k_2, $k_2 < t \le k_3$ and $t > k_3$ are $\hat{\beta}_{01}$, $(\hat{\beta}_{01} + \hat{\beta}_1)$,

$(\hat{\beta}_{01} + \hat{\beta}_1 + \hat{\beta}_2)$ and $(\hat{\beta}_{01} + \hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3)$ respectively.

The regression coefficients, along with adjusted R^2 and the Durbing-Watson d-statistics, of the estimated models of real price of teak logs in different girth-classes are presented in Table 1. The adjusted R^2 values ranged from 0.91 to 0.97 and all R^2 were statistically significant at 1% probability level. All the Durbin-Watson d-statistics were non-significant at 5% probability level except for girth-class E for which the d-test was inconclusive at 5% level, but non-significant at 1% level. All the regression coefficients were statistically significant either at 1% or 5% probability level, except the coefficients of *r-k3* in the trend models for girth-class *E* and 1 and the intercept of the equation for girth-class 4.

Table 1. Regression coefficients of linear spline model of real prices of teak logs in different girth-classes along with adjusted R^2 and Durbin-Watson d-statistic.

Girth Class $	$\hat{\beta}_{00}$	$\hat{\beta}_{01}$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	Adj. R^2	Durbin-Watson *d*-statistic
E	-396.31 (2423.0)'	134.37 (129.7)	-	254.38* (198.6)	64.68 142.6)	0.91**	1.41^ic
1	2680.37** (255.2)	-79.82** (29.2)	157.09** (62.5)	350.71** (79.5)	-52.47 (76.6)	0.96**	1.75^ns
2	2101.16** (203.2)	-53.97* (23.3)	102.52* (49.8)	397.28** (63.3)	-196.06** (60.9)	0.97**	2.19^ns
3	1583.36** (174.7)	-38.09* (20.0)	81.86* (42.8)	331.41** (54.4)	-202.71** (52.4)	0.97**	2.46^ns
4	-532.79 (858.5)	87.45* (45.96)	-	175.50* (70.3)	-140.83** (50.5)	0.95**	2.27^ns

$ For girth-classes, *E* and 4, price data were obtained only from the year 1970-71 onwards
# The figures in parentheses are the standard errors of the coefficients.
* Statistically significant at 5% probability level and ** at 1% level.
ns Statistically non-significant.
ic Durbin-Watson d-test inconclusive at 5% level, but non-significant at 1% level.

The regression coefficients of the trend models of teak (girth-classes combined) and selected timbers are presented in Table 2. All R^2 were statistically significant at 1% probability level and the adjusted R^2 values ranged from 0.66 to 0.96. Most of the regression coefficients were significant. Among the coefficients which were significant, except three, all were significant at 1% level. Except for prices of *anjily* and *venteak,* Durbin-Watson d-statistics were non-significant either at 5% or 1% level. For *anjily,* the Durbin-Watson d-statistic was significant at 5% level showing the presence of autocorrelation of errors. In this case, the regression coefficients will be less reliable. For *venteak,* the Durbin-Watson test for autocorrelation was inconclusive.

However, since the purpose of this study was to examine the price behaviour during different periods, the models for which the test for autocorrelation significant and inconclusive were also considered.

Table 2. Regression coefficients of linear spline model of real prices of teak (girth-classes combined) and selected timbers along with adjusted R^2 and Durbin-Watson d-statistic.

Timber	Regression coeffients					Adj R^2	Durbin Watson d-statistic
	β_{00}	β_{01}	β_1	β_2	β_3		
Teak	2171.71** (180.8)'	-67.81** (20.7)	144.22** (44.3)	299.19** (56.3)	-232.11* (54.2)	0.96**	2.17^{ns}
Anjily	934.09** (220.3)	-6.50 (25.2)	31.17 (54.0)	182.85** 68.7)	-201.65' (66.1)	0.77**	1.16*
Irul	735.90** (122.4)	-14.88 (14.03)	42.41 (30.0)	165.47** (38.1)	-188.61* (36.7)	0.91**	1.62^{ic}
Maru- thu	716.40** (119.9)	-18.51 (13.7)	40.44 (29.4)	187.18** (37.4)	-239.60 (36.0)	0.90**	1.63^{ic}
Jack-	657.47* (278.1)	5.43 (31.8)	55.37 (68.2)	83.08 (86.6)	-145.31 (83.5)	0.63**	2.70^{ns}
Them- bavu	953.39** (93.6)	-24.82* (10.7)	40.68 (22.9)	176.27** (29.1)	-235.47' (28.1)	0.91**	
Venga	735.90** (122.4)	-14.88 (14.0)	42.41 (30.0)	165.47** (38.1)	- 188.61' (36.7)	0.91**	1.62^{ic}
Venteak	665.40** (83.30)	-14.97 (9.6)	42.25* (20.4)	202.53** (25.9)	-245.08' (25.0)	0.96**	1.52^{ic}

#The figure in parenthesis is the standard error of the coefficient.

* Statistically significant at 5% probability level and ** at 1% level.

ns Statistically non-significant.

ic Durbin-Watson d-test inconclusive, but non-significant at 1% level

Table 3 gives the annual rate of change of real prices of teak in different girth-classes and Table 4 presents that of teak (girth-classes combined) and other timbers during different periods.

Table 3. Rates of changes of real prices of teak logs in different girth-classes during

Girth class	$t \leq k_1$	$k_1 < t \leq k_2$	$k_2 < t \leq k_3$	$t > k_3$
	$(\hat{\beta}_{01})$	$(\hat{\beta}_{01} + \hat{\beta}_1)$	$(\hat{\beta}_{01} + \hat{\beta}_1 + \hat{\beta}_2)$	$(\hat{\beta}_{01} + \hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3)$
E	-	134.37	388.75	452.83
1	-79.82	77.27	427.98	375.51
2	-53.97	48.55	445.83	249.77
3	-38.09	43.77	375.18	172.47
4	-	87.45	262.95	122.12

$ *k1*, *k2* and *k3* stand for the years 1968-69, 1976-77 and 1983-84 respectively.

Table 4. Rates of changes of real prices of teak (girth-classes combined) and selected timbers during different periods$.

Timber	$t \leq k_1$	$k_1 < t \leq k_2$	$k_2 < t \leq k_3$	$t > k_3$
	$(\hat{\beta}_{01})$	$(\hat{\beta}_{01} + \hat{\beta}_1)$	$(\hat{\beta}_{01} + \hat{\beta}_1 + \hat{\beta}_2)$	$(\hat{\beta}_{01} + \hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3)$
Teak	-67.81	76.41	375.60	143.49
Anjily	-6.50	24.67	207.52	
Irul	-14.88	27.53	193.00	
Jack	5.43	60.8	143.88	-1.43
Maruthu	-18.51	21.93	209.11	-30.49
Thembavu	-24.82	15.86	192.13	-43.34
Venga	-14.88	27.53	193.00	-4.39
Venteak	-14.97	27.28	229.81	-15.27

$ *kl*, *k2* and *k3* stand for the year 1968-69, 1976-77 and 1983-84 respectively

3.3.1 Period $t \leq k1$ (1956-57 to 1968-69)

The real prices of teak logs in girth-classes 1,2 and 3 registered a decline during this period. The rate varied from Rs. 38 for girth-class 3 to Rs.80 for girth-class 1 per annum. The real prices of selected timbers registered a decline at a marginal rate in comparison with teak except for jack for which the real prices increased at a marginal rate (Rs. 5 per annum). When teak (girth-classes combined) prices came down at a rate of about Rs. 68 per year, the rate of decline for the remaining timbers varied from Rs. 7 for *anjily* to Rs. 25 for *thembavu*.

3.3.2 Period $k1 < t \leq k2$ (1969-70 to 1976-77)

During this period, the real prices of teak in all girth-classes increased at a moderate rate. The rate varied from Rs. 44 for girth-class 3 to Rs. 134 for girth-class *E* whereas the prices of logs in girth-class 4 increased more than that registered for girth-classes 1, 2 and 3. The rate was Rs. 87 per annum. The rate of increase of real price of teak (girth-classes combined) was Rs. 76 and that of jackwood was Rs. 61 per annum. The rate of increase in prices for other timbers was more or less the same except for thembavu for which it was only Rs. 16 per annum. The rate of other timbers varied from Rs. 22 for maruthu to Rs. 28 for irul and venga.

3.3.3 Period $k, < t \leq k3$ (1977-78 to 1983-84)

This period was characterised by a rapid increase in prices for teak in all girth-classes. The rate of increase for girth-class *E* was Rs. 389 per annum which was lower than that for girth-classes 1 and 2. The rate of increase ranged from Rs. 263 for girth-class 4 to Rs. 428 for girth-class 1 per annum. For other timbers also, this period was marked by a drastic increase in prices. The rate varied form Rs. 144 for jack to Rs. 230 for venteak and the rate of teak (girth-classes combined) was Rs. 376 per year.

3.3.4 Period $t > k3$ (1984-85 to 1993-94)

Although the increasing trend continued for prices of teak logs in all girth-classes during this period, the rate of increase was lower than that existed during the preceding period except for girth-class *E* for which the rate was higher than that of the preceding period. Prices of teak (girth-classes combined) showed an increasing trend but the rate had considerably gone down. The rate of increase of real prices of *anjily* and irul were very marginal. The real prices of other timbers declined at a moderate rate except for anjily and venteak for which the prices increased marginally.

3.4 Price - Quantity Relationship

The results of the regression analysis, taking current year's real price as regressand and real price lagged by one-year and quantity sold as regressors, are presented here. The regression coefficients of the estimated model of each timber along with adjusted R^2 value and Durbin h-statistic are given in Table 5.

For the estimated autoregressive models of all timbers, the R^2 values were significant at 1% level and the Durbin h-statistics were non-significant at 5% level. All the coefficients of the real prices lagged by one-year were significant at 1% level confirming that each price was related with preceding price for each timber. That is, each year's price was very close to the previous year's price. This conforms to what is expected. In the monthly auction of a timber of a particular species, quality and size in the depot, the auction initially commences at the upset price which is the average of prices of the same species, quality and size obtained in the preceding three auctions in the depot. If the upset price is not agreed upon by the participants in the auction to start with, it is further reduced and auction begins at the reduced rate. However, the auction will be confirmed in the spot only if the final bid amount exceeds 90% of the upset price. Usually, the participants will try to increase the final bid price above 90% of the

Table 5. Regression coefficients of the autoregressive models of real prices of different timbers

Timber	Regression coefficients			Adj. R^2	Durbin h-statistic
	Intercept	Real price agged by 1 year	Quantity sold		
Teak	598.9181 (524.10)	0.9466** (0.07)	-0.0105 (0.01)	0.91**	-1.20^{ns}
Anjily	352.0811 (237.78)	0.861I** (0.11)	-0.0252 (0.03)	0.71**	1.25^{ns}
Irul	172.2805 (179.40)	0.9176** (0.09)	-0.0039 (0.01)	0.85**	-1.19^{ns}
Maruthu	307.8490 (179.35)	0.8426** (0.10)	-0.0047 (0.003)	0.83**	-0.33^{ns}
Venga	316.3871 (220.14)	0.8337** (0.10)	-0.0123 (0.02)	0.76**	1.67^{ns}
Thembavu	248.9949 (183.24)	0.8696** (0.10)	-0.0066 (0.01)	0.83**	-1.39^{ns}
Venteak	 (149.86)	0.9629** (0.07)	00.0022 (0.01)	0.92**	0.94^{ns}

* Statistically significant at 5% level and ** at 1% level
ns Statistically non-significant at 5% level
The figures in parenthesis are standard errors of the coefficients.

upset price. That is, auction price in a particular month is dependent on the preceding month's price. The relationship between current year's real price and preceding year's price is a reflection of the successive dependence of monthly prices.

As can be seen in Table 5, the coefficient of the sale quantity variable of each timber was not statistically significant. Except for venteak, the sign of the coefficient is negative which is as expected. This shows that sale quantity of a particular timber had no influence on its price. That is, the price in the depots was found to be inelastic with respect to the quantity of timber sold in all the depots in Kerala.

3.5 Price-Production Relationship

The results of the step-wise regression analysis, taking the *(differenced)* price as regressand and *(differenced)* production in the current year, lagged by one and two years as regressors, are discussed here.

The analysis was done separately for two periods, i) the whole period under study and ii) from 1976-77 to 1992-93, the period during which the real prices increased drastically. Price-production relationship was significant only for teak and *venteak* for the above two periods. For *maruthu*, significant relationship was seen only for the whole period under study and for *irul* only for the period from 1976-77 to 1992-93. The estimated regression equations along with adjusted R^2 value and Durbin-Watson d-statistic, for teakwood in the above two periods are given below.

$$(DPR\ TEAK)_t = -0.0461^{**}\ (DPD\ TEAK)_{t-1} - 0.0302^{**}\ (DPD\ TEAK)_{t-2}, \quad \ldots\ldots(3.1)$$

$$\qquad\qquad (0.01) \qquad\qquad\qquad\qquad (0.01)$$

$$\text{Adj. } R^2 = 0.37^{**}, \qquad d = 2.54^{ns}$$

$$(DPR\ TEAK)_t = -0.0827^{**}\ (DPD\ TEAK)_{t-1} - 0.0329^{**}\ (DPD\ TEAK)_{t-2}, \quad \ldots\ldots(3.2)$$

$$\qquad\qquad (0.01) \qquad\qquad\qquad\qquad (0.01)$$

$$\text{Adj. } R^2 = 0.74^{**}, \qquad d = 2.31^{ns}$$

where $(DPR\ TEAK)_t$ denotes the (differenced) real price of teak during the year *t*, $(DPD\ TEAK)_{t-1}$ and $(DPD\ TEAK)_{t-2}$ represent the *(differenced)* production of teak in Kerala during the year *t-1* and *t-2* respectively.

In the above analysis, current year's production of teak was dropped by the step-wise regression procedure from the model. The teak prices were related only with one and two-year lagged production. As expected, the signs of all the regression coefficients are negative and the coefficients were significant at 1% probability level. The R^2 values of the models for the two periods were statistically significant at 1% probability level and Durbin-Watson d-statistics were all non-significant at 5% level. During the whole period under study, 37% of the variation in (differenced) prices of teak was explained by the one and two-year lagged *(differenced)* production of teak (Equation 3.1). During the period from 1976-77 to 1992-93, when the prices increased drastically, 74% of the variation in *(differenced)* prices of teak was explained by the one and two-year lagged *(differenced)* productions of teak (Equation 3.2). An important observation is that the coefficients of the two-year lagged *(differenced)* production in the equations for the two periods are almost the same, This shows that teak production two-year back has steady influence on current year's real price.

For *venteak*, the estimated regression equations, along with adjusted R^2 value and Durbin-Watson d-statistic, for the two periods are given below.

$$(DPR\ VENT)_t = -0.0148^{*}\ (DPD\ VENT)_{t-1} - 0.0169^{**}\ (DPD\ VENT)_{t-2}, \qquad \ldots\ldots\ldots\ldots(3.3)$$
$$\qquad\qquad (0.006) \qquad\qquad\qquad (0.006)$$
$$\text{Adj. } R^2 = 0.21^{**}, \qquad d = 1.67^{ns}$$

$$(DPR\ VENT)_t = -0.0397^{**}\ (DPD\ VENT)_{t-1} - 0.0273^{*}\ (DPD\ VENT)_{t-2}, \qquad \ldots\ldots\ldots(3.4)$$
$$\qquad\qquad (0.01) \qquad\qquad\qquad (0.01)$$
$$\text{Adj. } R^2 = 0.47^{**}, \qquad d = 1.82^{ns}$$

where $(DPR\ VENT)_t$ denotes the *(differenced)* real price of *venteak* during the year t, $(DPD\ VENT)_t$ and $(DPD\ VENT)_{t-2}$ represent the *(differenced)* production of *venteak* during the year *t-1* and *t-2* respectively. All the R^2 values were statistically significant at 1% level. Durbin-Watson d-statistics were non-significant at 5% level for Equations 3.3 and 3.4. Only 21% of the variation in *(differenced)* prices of *venteak* was explained by its lagged *(differenced)* production for the whole period under study (Equation 3.3). During the period from 1976-77 to 1992-93, 47% of the variation in *(differenced)* price of *venteak* was explained by its one and two year lagged *(differenced)* production. *Venteak* is available mainly from Kerala forests. It is moisture sensitive and so not preferred in Kerala. It is mainly exported to drier areas of Tamil Nadu, where it has a good market.

The relationship for *maruthu* for the period from 1956-57 to 1992-93 is given by Equation 3.5 and that of irul for the period from 1976-77 to 1992-93 is given by Equation 3.6.

$$(DPR\,MARU)_t = -0.0104^{**}(DPD\ MARU)_{t-1} - 0.0087^{*}\ (DPD\,MARU)_{t-2}, \qquad \ldots\ldots(3.5)$$
$$\qquad\qquad (0.004) \qquad\qquad\qquad (0.004)$$
$$\text{Adj. } R^2 = 0.21^{**}, \qquad d = 2.45^{ns}$$

$$(DPR\,IRUL)_t = -0.0680^{*}\ (DPD\,IRUL)_{t-1}, \qquad \ldots\ldots\ldots(3.6)$$
$$(0.02)$$
$$\text{Adj. } R^2 = 0.30^{*}, \quad d = 2.34^{ns}$$

where $(DPR\,MARU)_t$ and $(DPR\,IRUL)_t$ denote respectively the *(differenced)* real prices of *maruthu* and *irul* during the year *t;* $(DPD\ MARU)_{t-1}$ and $(DPD\ MARU)_{t-2}$ represent respectively the *(differenced)* production of *maruthu* during the year *t-1* and *t-2* and $(DPD\ IRUL)_{t-1}$ denotes the *(differenced)* production of *irul* during the year r-1.In equations 3.5 and 3.6 the adjusted R^2 values were significant and d-statistics were non-significant at 5% level. Only 21% of the variation in *(differenced)* prices of *maruthu* was explained by its lagged *(differenced)* production for the period from 1956-57 to 1992-93 (Equation 3.5). In the case of *irul*, significant relation existed only after 1976-77 during which 30% of the variation in *(differenced)* price is explained by one-year lagged *(differenced)* production (Equation 3.6) and two-year lagged *(differenced)* production had no influence on current year's price.

It is expected that the price of a timber is dependent on the production in the previous years. For the timber from forests to be sold in auction, there exists a time lag for transporting logs to the Forest Department depots and auction procedure. Timber traders take into account the availability of timber during auction. This is the reason for the relationship between price and lagged productions.

The timbers, for which no significant relationship was seen, are *anjily, thembavu,* jack and *venga*. Production of *anjily* and jack is dominated by home-gardens. Although *maruthu, thembavu* and *venga* come to the market mostly from forests through depots, the price of these timbers in the'government depots need not be influenced by change in timber production from forests alone, as most of these timbers are mutually substitutable with jack and *anjily,* which are abundantly available in home gardens. Due to this, change in production of these timbers from forests may not influence the prices of these timbers. This may be the reason why no significant relationship between real price and production was seen.

4 PRICE FORECASTS FOR TEAKWOOD

The results of forecasting future prices of teak in Kerala using autoregressive integrated moving average (ARIMA) models are presented in this section.

4.1 Estimated ARIMA Models for Teak Prices

The models identified for teak in girth-classes 1,2, and 3 are estimated and are presented in Appendices 23, 24 and 25 respectively. From the different models estimated for each girth-class, the best fitting model was selected. The models ARIMA(1, 2, l), ARIMA(0, 2, 2) and ARIMA(0, 2, 2). given by 4.1, 4.2 and 4.3 are the estimated best models for current prices of teak logs in girth-classes 1,2 and 3 respectively.

$$\underset{(0.17)}{(1+0.5320^{**}B)}(l-B)^2 Z_t = \underset{(0.19)}{(1-0.3299^{*}B)}a_t \quad \text{.........(4.1)}$$

$$(l-B)^2 Z_t = (1-\underset{(0.14)}{0.9358^{**}B} + \underset{(0.21)}{0.2947 B^2})at \quad \text{......... (4.2)}$$

$$(l-B)^2 Z_t = (1-\underset{(0.14)}{1.3140^{**}B} + \underset{(0.11)}{0.8022^{**}B^2})a_t \quad \text{.........(4.3)}$$

where Z_t denotes the annual current price in the year t, B the backward shift operator defined as $B^k Z_t = Z_{t-k}$ and at, the random shock. The figures in parentheses are standard errors of the parameters. Statistical significance at 5% and 1% probability level is indicated by * and ** respectively.

4.2. Price Forecasts for Teak

ARIMA models are generally used for short-term predictions and not preferred for long-term predictions. However, due to the need for projected prices for planning purposes, medium-term predictions of teak prices have been presented here with 95% confidence limits.

Projecting forward the selected ARIMA models given by 4.1,4.2, and 4.3, the forecasts for future prices for the years up to 2014-15 were obtained. The price forecasts with 95% confidence limits for teak logs in girth classes 1, 2, and 3 are given in Table 6.7 and 8 respectively, and depicted in Figures 7, 8, and 9 respectively. The price forecasts for teak logs in girth-classes 1,2 and 3 for the year 2015-16 at current price are. Rs. 90,000 per m^3 with 95% confidence limits from Rs. 45,000 to Rs.135,000 per m^3, Rs. 71,000 per m^3 and with limits from Rs.39,000 to Rs.103,000 per m^3 and Rs. 67,000 per m^3 with limits from Rs. 37,000 to Rs. 98,000 per m^3 respectively.

Table 6. Price forecasts for teak in girth-class 1 in Kerala

(At current price in Rs. per m^3)

Year	Price forecast	95% confidence limit	
		Lower limit	Upper limit
1994-95	27040	25478	28601
1995-96	29788	27423	32154
1996-97	32950	29353	36546
1997-98	35891	31038	40745
1998-99	38950	32652	45248
1999-00	41946	34113	49780
2000-01	44975	35483	54468
2001-02	47987	36739	59235
2002-03	51008	37905	64112
2003-04	54025	38975	69075
2004-05	57043	39958	74129
2005-06	60061	40857	79265
2006-07	63079	41674	84484
2007-08	66097	42414	89780
2008-09	69115	43078	95152
2009-10	72133	43669	100597
2010-11	75151	44188	I06113
2011-12	78169	44639	111698
2012-13	81187	45022	117351
2013-14	84204	45340	123069
2014-15	81222	45593	12885
2015-16	90240	45784	134696

Table 7. Price forecasts for teak in girth-class 2 in Kerala

(At current price in Rs. per m^3)

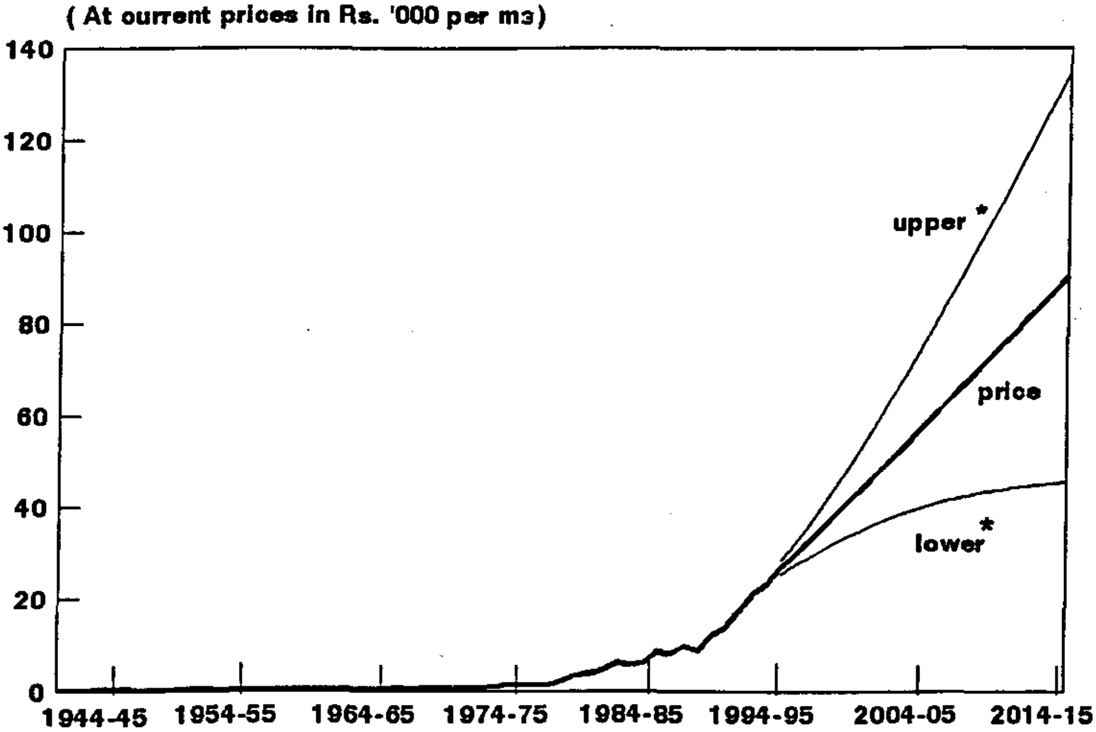
Year	Price forecast	95 % confidence limit	
		Lower limit	Upper limit
1994-95	21349	20018	22680
1995-96	23725	21781	25669
1996-97	26101	23387	28815
1997-98	28477	24873	32082
1998-99	30853	26259	35448
1999-00	33230	27557	38903
2000-01	35606	28775	42437
2001-02	37982	29919	46044
2002-03	40358	30995	49721
2003-04	42734	32006	53463
2004-05	45110	32954	57267
2005-06	47487	33843	61130
2006-07	49863	34676	65050
2007-08	52239	35454	69024
2008-09	54615	36178	73052
2009-10	56991	36852	77131
2010-11	59367	37476	81259
2011-12	61744	3805	85436
2012-13	64120	38580	89660
2013-14	66496	39062	93929
2014-15	68872	39500	98244
2015-16	71248	39895	102602

Table 8. Price forecasts for teak in girth-class 3 in Kerala

(At current price in Rs. per m^3)

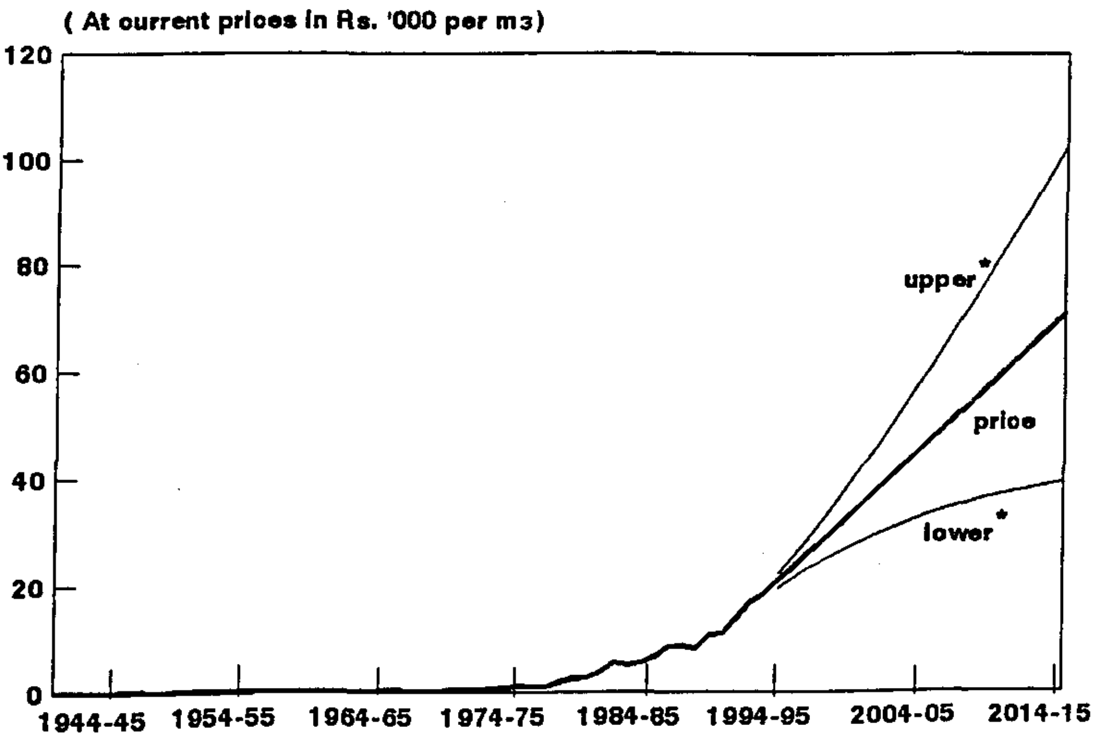
Year	Price forecast	95% confidence limit	
		Lower limit	Upper limit
1994-95	16002	14956	17049
1995-96	18452	17183	19721
1996-97	20901	19134	22668
1997-98	23350	20871	25830
1998-99	25799	22450	29148
1999-00	28249	23908	32589
2000-01	30698	25261	36134
2001-02	33147	26524	39771
2002-03	35596	27702	43490
2003-04	38045	28804	47287
2004-05	40495	29833	51157
2005-06	42944	30793	55095
2006-07	45393	31688	59098
2007-08	47842	32521	53163
2008-09	50292	33294	57289
2009-10	52741	34009	11472
2010-11	55190	34668	15712
2011-12	57639	35273	30005
2012-13	60089	35826	14351
1013-14	62538	36327	18748
2014-15	64987	36779	93195
2015-16	57436	37182	97691

Fig.7 Price forecasts for teak logs in girth-class 1 in Kerala



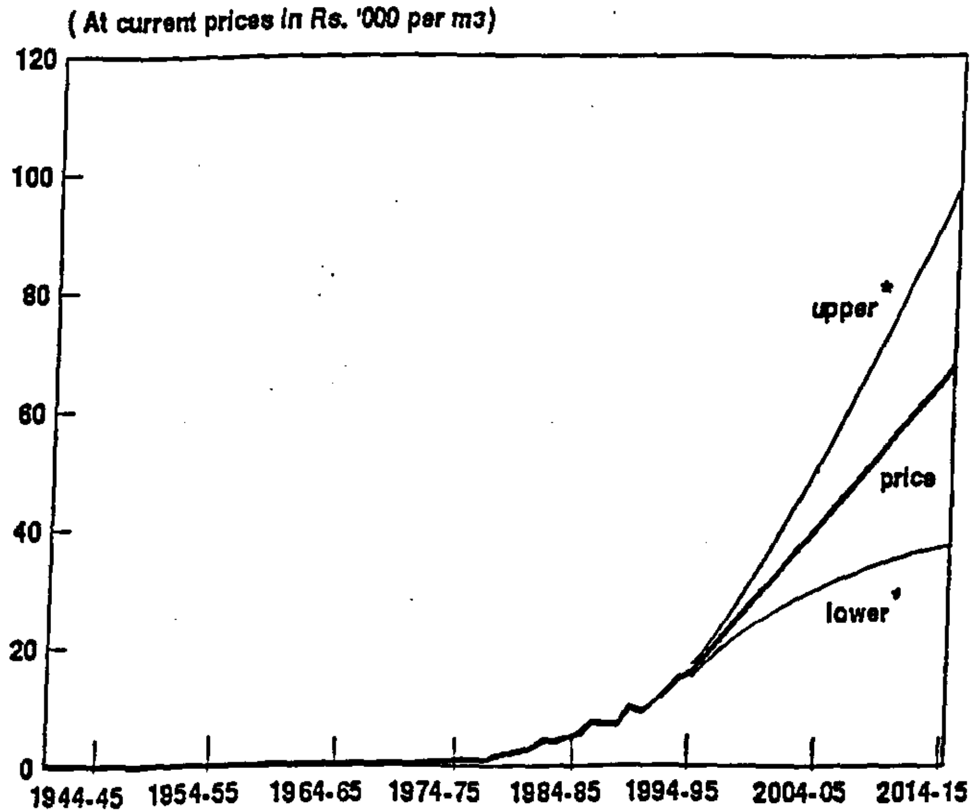
* The upper and lower limits of the price forecasts are at 95% confidence level.

Fig.8 Price forecasts for teak logs in girth-class 2 in Kerala



* The upper and lower limits of the price forecasts are at 95% confidence level.

Fig. 9 Price forcasts for teak logs in girth-class 3 in Kerala



* The upper and lower limits of the price forecasts are at 95% confidence level.

5. CONCLUSIONS

The price trends of important timbers in Kerala, using prices for the period from 1956-57 to 1993-94, were analysed in real terms. The general trends of teak in different girth-classes and seven other important timbers, using 3.5 and 7 year moving averages, are found to be more or less similar.

Among different trend models tried, the best fitting model identified for real prices were the linear spline model with three knots. Using the estimated model, the price behaviour of teak in each of the four periods from 1956-57 to 1968-69, 1969-70 to 1976-77,1977-78 to 1983-84 and 1984-85 to 1993-94 was analysed. In the first period, the real prices declined for all girth-classes. In the other three periods, the prices increased. The period from 1977-78 to 1983-84 saw the highest rate of increase.

The price trends of teak (girth-classes combined) and those of seven other timbers showed similar behaviour from 1956-57 to 1983-84. In the last period, while the price of teak continued to increase, most of the other timbers showed a decline in price. The rate of increase in teak prices was Iower than that in the previous periods.

The red price of a timber in an year was found to be closely related to its preceding year's price. The price was not related to the quantity of that timber sold. This shows that the price is inelastic with respect to the quantity of timber sold. The real prices were not related *to* the current year's production of timber from forests. However, the prices of teak, *venteak* and *maruthu* were related to one and two-year lagged production, whiIe *irul* prices were related to only one-year lagged production. That is, a reduction in forest timber production during one and two years back would increase the current year's real price. Although, significant relationship between price and lagged production was seen for the above four timbers, strong relationship was seen only for teak. High quality teak is available only from forests and a reduction in the previous years forest production affects the red price. The production of *venteak maruthu* and *irul* comes almost entirely from forests. The traders, participating in timber auction in the depots, take into account the availability of timber in the depots during auctions. The time lag, for transporting logs from forests to the depots and auction procedures, explains the relationship between the current year's price and lagged production .

The timbers for which no significant relationship between price and lagged production was seen are *anjiliy,* jack, *thembavu* and *venga.* Most of these timbers are mutually substitutable and jack and *anjily* are abundantly available in home-gardens of Kerala Due to this, change in timber production from forests may not influence the price of these timbers in the depots.

Future prices of teak were predicted for the years upto 2015-16 with 95% confidence limits using autoregressive integrated moving average model based on current prices from 1941-42 to 1993-94. The teak price forecast for the year 2015-16 at current price for girth-classes 1.2 and 3 are Rs. 90,000, Rs. 71,000 and Rs. 67,000 per m^3 respectively.

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Appendix 1

List of Kerala Forest Department timber depots

Southern Forest Circle	Central Forest Circle**	Northern Forest Circle
1. Achencoil *	1. Chalakudy *	1. Aruvacode*
2.. Angamoozhi	2. Kothamangalam*	2. Bavali*
3. Areekkakavu*	3. Kumily*	3. Chaliyam*
4. Arienkavu*	4. Mudickal*	4. Kannoth
5. Kadakkamon*	5. Parampuzha*	5. Kuppadi*
6. Konni*	6. Thalakode*	6. Mysore
7. Kulathuputha*	7. Veetoor*	7. Nanjangode*
8. Pathanapuram*	8. Vettikkad*	8.
9. Thenmala*		
10. Veeyapuram*		

* Timber depots from which price data were collected for the study

** Includes depots belonging to High Range Circle

Appendix 2

Average current prices of teak logs in different girth-classes in Kerala during the period from 1956-57 to 1993-94

(At current price in Rs. per m^3)

Year	Girth-classe					Weighted average
	Export	1	2	3	4	
1956-57	**NA**	406	306	244	**NA**	328
1957-58	**NA**	416	325	242	**NA**	327
1958-59	**NA**	'425	344	258	**NA**	342
1959-60	**NA**	439	352	292	**NA**	356
1960-61	**NA**	452	360	283	**NA**	360
1961-62	**NA**	440	361	269	**NA**	357
1962-63	**NA**	459	361	254	**NA**	362
1963-64	**NA**	477	393	268	**NA**	379
1964-65	**NA**	483	425	298	**NA**	402
1965-66	**NA**	515	454	339	**NA**	435
1966-67	**NA**	547	483	379	**NA**	466
1967-68	**NA**	531	446	345	**NA**	382
1968-69	**NA**	531	442	374	**NA**	386
1969-70	**NA**	581	449	370	**NA**	44I
1970-71	607	631	455	366	270	474
1971-72	650	646	542	385	291	550
1972-73	739	799	630	508	419	626
1973-74	1011	952	837	682	563	809
1974-75	1303	1271	1044	935	706	1152
1975-76	1435	1367	1197	1030	768	1221
1976-77	1206	1275	1076	833	751	1052
1977-78	1506	1406	1163	921	855	1166
1978-79	2378	2237	2009	1700	1431	1980
1979-80	3057	3340	2757	2105	1873	2667
1980-81	4100	3750	2946	2374	1826	3092
1981-82	4575	4490	3770	2992	2404	3670
1982-83	6561	6096	5596	4312	3284	5180
1983-84	5361	5641	5176	4072	3000	4527
1984-85	6461	6026	5595	4905	3646	5107
1985-86	7468	8417	6751	5480	4386	5873
1986-87	8515	8141	8624	7327	5450	7508
1987-88	9647	9754	8757	7002	5271	7476
1988-89	9276	8609	8225	6847	5702	7251
1989-90	9442	11954	I0921	9630	7357	9432
1990-91	16556	13865	11115	8956	6886	9299
1991-92	20475	17295	14110	10633	8786	11352
1992-93	23131	21450	17178	12572	9162	13326
1993-94	24034	23516	18986	14784	10375	15859

Source: Computed from the monthly auction foles of the government timber depots and various Working Plans of different Forest Divisions.

Appendix 3

Average current prices of selected timbers in Kerala during the period from 1956-67 to 1993-94

(At current price in Rs. per m^3)

Year	Anjily	Irul	Maruthu	Jack	Them. bavu	Venga	Venteak
1956-57	146	111	108	109	144	153	107
1957-58	149	109	111	109	152	147	108
1958-59	163	118	119	113	158	I75	113
1959-60	158	121	128	121	159	158	115
1960-61	177	159	130	125	173	150	117
1961-62	171	136	119	135	169	163	113
1962-63	194	121	121	144	165	176	97
1963-64	207	134	114	186	157	193	114
1964-65	235	163	139	197	167	211	131
1965-66	248	165	140	208	177	221	165
1966-67	269	166	143	189	186	230	126
1967-68	277	163	146	199	203	257	164
1968-69	277	186	155	218	203	259	166
1969-70	275	185	163	258	221	282	178
1970-71	349	197	172	298	235	300	186
1971-72	340	206	211	374	254	332	221
1972-73	313	264	249	412	330	353	242
1973-74	381	322	319	515	362	403	291
1974-75	487	477	397	618	462	543	340
1975-76	627	477	422	681	461	683	403
1976-77	577	393	319	758	363	590	431
1977-78	710	531	541	656	510	738	521
1978-79	1197	917	830	1192	907	1140	924
1979-80	1742	1269	1217	1844	1226	1617	1241
1980-81	1780	1312	1194	1169	1278	1807	1222
1981-82	2125	1454	1360	1830	1578	1905	1642
1982-83	2632	2218	2247	2157	2207	2834	2419
1983-84	2621	2021	2476	2931	.2316	3108	2713
1984-85	2840	2999	2886	3679	2626	3169	3009
1985-86	2875	3041	2468	2260	2181	3006	2817
1986-87	4046	3191	2859	1753	2986	2768	2961
1987-88	3922	2621	2336	3579	2497	2931	2800
1988-89	4513	2689	3102	3000	2826	2186	3046
1989-90	2229	3486	3016	3218	2466	1511	3670
1990-91	2173	3309	3053	2624	3318	2987	3720
1991-92	4422	4015	2726	7481	4260	5232	4374
1992-93	7474	4853	4537	2376	4688	4428	5201
1993-94	8224	6862	6051	7835	3492	6202	6061

Source: Computed from the monthly auction files of the government timber depots and various Working Plans of different Forest Divisions

Appendix 4

Production of teak and other timbers from Kerala Forest during the period from 1956-57 to 1992-93.

(Volume in m³)

Year	Teak	*Anjily*	*Irul*	*Maruthu*	*Jack*	*Thembavu*	*Venga*	*Venteak*
1956-57	30768	1924	2046	8254	NA	3820	1461	3882
1957-58	18853	1440	3101	5783	NA	3185	1099	3517
1958-59	33610	2218	9543	15406	NA	10789	3648	7175
1959-60	25423	2247	6961	16540	NA	11064	4405	11709
1960-61	33612	1758	7597	17753	NA	10592	4567	15045
1961-62	37651	3017	7570	25079	NA	13074	4172	17353
1962-63	26475	2910	7535	19329	NA	12731	4659	20134
1963-64	33986	3081	6677	23344	NA	13228	7589	19695
1964-65	30346	3398	9820	23857	38	7615	6113	22150
1965-66	38563	3037	13182	29956	41	10633	8264	20666
1966-67	34549	4097	13395	40180	44	23093	9017	23637
1967-68	46672	5011	21414	40567	1378	19847	10478	27510
1968-69	43644	4934	16912	41654	147	17513	9326	37379
1969-70	42574	10502	19064	55935	158	25070	11478	34319
1970-71	41357	4333	13278	36168	33		7878	19848
1971-72	39845	4853	17544	38978	147	11213	6369	25640
1972-73	45094	8255	15010	30420	90	16331	10511	21192
1973-74	42519	3775	13480	27771	498	11841	9716	22558
1974-75	51909	18584	9871	48253	96	17315	8205	22795
1975-76	55074	5154	25284	65174	967	34370	10800	31713
1976-77	36529	4181	14866	31340	262	9107	6961	20077
1977-78	39642	2817	10567	23277	387	13645	5622	17651
1978-79	33689	2818	19752	25452	246	16872	5719	21246
1979-80	39082	4276	16809	43659	269	14494	7733	23539
1980-81	27518	3177	13976	30339	710	8857	5732	13974
1981-82	17899	2691	3095	10444	218	3710	1999	6811
1982-83	27672	1549	3061	6354	150	1278	1633	6881
1983-84	25369	1785	1534	4773	667	905	875	1856
1984-85	21820	495	417	3322	135	394	956	1931
1985-86	14051	1090	1107	2293	181	987	765	2000
1986-87	16252	1642	1544	6509	1040	908	406	3424
1987-88	19189	925	320	3195	256	169	91	823
1988-89	8062	296	597	611	61	291	92	500
1989-90	24719	271	1413	865	20	260	266	560
1990-91	15514	314	449	932	66	107	342	413
1991-92	19750	525	462	2383	96	427	575	672
1992-93	32374	449	1333	2342	65	466	471	532

Source: Compiled from the Adminisrative reports (various isuues) of the Kerala Forest Department

Appendix 5

Quantity of teak and selected timbers sold through all the government timber depots during the period from 1956-57 to 1992-93

(Quantity in m^3)

Year	Teak	*Anjily*	*Venteak*	*Venga*	*Maruthu*	*Them bavu*	Jack	*Irul*
1956-57	28647	1439	3339	1710	10447	3034	NA	1575
1957-58	30764	1800	5209	1921	9095	5471	NA	3335
1958-59	30710	1958	5318	2650	10328	7128	NA	5235
1959-60	26744	1704	9151	3476	13649	9227	NA	8697
1960-61	23441	2988	13371	3473	16695	8353	NA	8144
1961-62	37847	2760	13932	4708	21922	10423	NA	7763
1962-63	34732	1662	18060	3927	19053	10762	NA	6902
1963-64	31452	2607	23834	6344	26573	12168	NA	7739
1964-65	32082	4208	21621	4771	25248	8187	NA	10673
1965-66	32172	2393	20959	9688	29780	20907	74	12281
1966-67	31260	4042	22397	9561	37408	20585	30	12660
1967-68	47065	5236	25608	9699	37948	19179	1127	11785
1968-69	38064	3796	30981	8970	41911	13651	312	22422
1969-70	37438	8128	30096	7410	40472	14365	136	16149
1970-71	45028	5725	24019	9188	43942	14280	139	11224
1971-72	31190	1839	18107	5219	15488	2558	84	12868
1972-73	42712	5189	14742	7953	19959	12658	116	8123
1973-74	52362	6030	31686	4955	33607	11980	112	20678
1974-75	46843	6624	24917	9394	45373	12939	447	9251
1975-76	53984	9503	3332	12216	67801	34194	330	21122
1976-77	57861	14960	34757	15733	50259	29869	794	24249
1977-78	37438	3347	9253	6034	24351	13769	293	11413
1978-79	36298	2941	20498	5771	26949	17868	272	18913
1979-80	37983	3513	21590	7422	40241	13408	608	16663
1980-81	30562	4121	15793	5090	27868	8509	293	9547
1981-82	19252	2722	9121	3162	15319	4293	159	7561
1982-83	23781	1577	6475	1563	7999	3286	602	4015
1983-84	31697	1760	3385	1129	306	1020	191	1601
1984-85	18927	531	1563	727	2442	554	138	380
1985-86	24308	1295	2481	488	5697	1359	116	2825
1986-87	19197	1722	3518	914	6262	1515	1013	1747
1987-88	21896	885	1025	511	3720	211	234	434
1988-89	10987	293	1027	175	899	19	38	346
1989-90	21131	272	523	155	1144	152	105	734
1990-91	17280	100	370	388	835	171	22	635
1991-92	24517	487	793	525	2322	380	95	703
1992-93	22794	420	568	215	830	585	13	807

Source: Complied from the Administration Reports (various issues) of the Kerala Forest Department

Appendix 6

Average current prices of teak logs in different girth-classesin Kerala during the period from 1941-42 to 1955-56

(At current price Rs. per m^3)

Year	Girth-class		
	1	2	3
1941-42	78	58	49
1942-43	177	123	104
1943-44	196	159	96
1944-45	298	177	123
1945-46	265	196	124
1946-47	339	266	173
1947-48	233	209	141
1948-49	206	195	110
1949-50	175	182	118
1950-51	268	250	186
1951-52	348	284	197
1952-53	255	235	168
1953-54	232	213	139
1954-55	255	202	141
1955-56	301	251	160

Source: Computed from various Divisional Forest Working Plans in Travancore and Cochin States and District (of Madras Presidency) which conform to the present Kerala State.

Appendix 7

Average real prices of teak logs in different girth-classes in Kerala during the period from 1956-57 to 1993-94

(At real price in Rs. per m^3)

Year	Export	Girth-classes 1	2	3	4	Weighted average
1956-57	NA	2461	1855	1479	NA	1988
1957-58	NA	2447	1911	1424	NA	1924
1958-59	NA	2401	1944	1458	NA	1932
1959-60	NA	2386	1913	1586	NA	1935
1960-61	NA	2306	1837	1444	NA	
1961-62	NA	2245	1841	1372	NA	1819
1962-63	NA	2250	1770	1245	NA	1775
1963-64	NA	2208	1819	1241	NA	1756
1964-65	NA	2012	1771	1242	NA	1675
1965-66	NA	1996	1760	1314	NA	1686
1966-67	NA	1861	1643	1289	NA	1585
1967-68	NA	1619	1360	1052	NA	1166
1968-69	NA	1634	1360	1150	NA	1188
1969-70	NA	1636	1265	1097	NA	1275
1970-71	1710	1777	1282	1031	761	1335
1971-72	1733	1723	1445	1027	776	1466
1972-73	1789	1935	1525	1230	1015	1516
1973-74	2034	1915	1684	1372	1132	1627
1974-75	2095	2043	1678	1503	1135	1852
1975-76	2334	2223	1946	1674	1249	1985
1976-77	1920	2031	1714	1327	1196	1675
1977-78	2282	2130	1762	1396	1295	1766
1978-79	3603	3390	3044	2576	2168	3000
1979-80	3950	4315	3562	2719	2420	3446
1980-81	4481	4098	3220	2595	1996	3379
1981-82	4575	4490	3770	2992	2404	3670
1982-83	6395	5942	5454	4203	3201	5049
1983-84	4774	5023	4609	.3626	2671	4031
1984-85	5371	5009	4651	4077	3031	4245
1985-86	5871	6617	5307	4308	3448	4617
1986-87	6359	6080	6441	5472	4070	5607
1987-88	6695	6769	6077	4859	3658	5188
1988-89	5996	5565	5317	4426	3686	4687
1989-90	5698	7214	6591	5812	4440	5692
1990-91	9062	7589	6084	4902	3769	5090
1991-92	9853	8323	6790	5117	4228	5463
1992-93	10114	9379	7511	5497	4006	5827
1993-94	9699	9490	7662	5966	4187	6400

the average cum prices timber

Appendix 8
Average real prices of selected timbers in Kerala during the period from 1956-57 to 1993-94.

(In real price in Rs. per m^3)

Year	Anjily	Irul	Maruthu	Jack	Thembavu	Venga	Venteak
1956-57	885	673	655	654	873	927	648
1957-58	876	641	653	641	894	865	635
1958-59	921	667	672	638	893	989	638
1959-60	859	658	696	658	864	859	625
1960-61	903	811	663	638	883	765	597
1961-62	872	694	607	689	862	832	577
1962-63	951	593	593	706	809	863	475
1963-64	958	620	528	861	727	894	528
1964-65	979	679	579	820	696	879	546
1965-66	961	639	543	806	686	856	640
1966-67	916	565	486	643	633	782	429
1967-68	845	491	445	607	619	784	418
1968-69	852	572	477	671	625	797	51
1969-70	816	549	484	765	656	837	528
1970-71	983	555	485	839	662	845	524
1971-72	907	549	563	997	677	885	589
1972-73	758	639	603	998	799	855	586
1973-74	767	648	642	1036	728	811	586
1974-75	783	761	638	994	743	872	547
1975-76	1020	775	686	1107	149	1111	656
1976-77	918	626	508	1207	578	940	687
1977-78	1075	805	684	994	773	1118	789
1978-79	1813	1389	1258	1806	1374	1727	1400
1979-80	2251	1639	1572	2383	1584	2089	1603
1980-81	1945	1434	1305	1278	1397	1975	1336
1981-82	2125	1454	1360	1830	1578	1905	1642
1982-83	2565	2162	2190	2102	2151	2762	2358
1983-84	2334	1800	2205	,2610	2062	2768	2416
1984-85	2361	2493	2399	3058	2183	2634	2501
1985-86	2260	2391	1940	1777	1715	2363	2215
1986-87	3022	2383	2135	1309	2230	2067	2211
1987-88	2722	1819	1621	2484	1133	2038	1943
1988-89	2917	1738	2005	1939	1827	1413	1969
1989-90	1345	2104	1820	1942	1488	912	2215
1990-91	1518	1811	1671	1436	1816	1635	2036
1991-92	2128	1932	1312	3600	2050	2518	2105
1992-93	3268	2122	1984	1039	2050	1936	2274
1993-94	3319	2769	2442	3162	1409	2503	2446

Computed from the average current prices of timber.

Appendix 9

Different models fitted to the real prices of each timber for trend analysis

$$E(P_t) = \beta_0 + \beta_1 t \quad \text{......(1)}$$

$$E(P_t) = \beta_0 + \beta_1 t + \beta_2 t^2 \quad \text{......(2)}$$

$$E(P_t) = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 \quad \text{......(3)}$$

$$E(P_t) = \beta_0 + \beta_1 \ln t \quad \text{......(4)}$$

$$E(P_t) = \beta_0 + \beta_1 / t \quad \text{......(5)}$$

$$E(\ln P_t) = \ln \beta_0 + \ln(\beta_1)\, t \quad \text{......(6)}$$

$$E(\ln P_t) = \ln \beta_0 + \beta_1 \ln t \quad \text{......(7)}$$

$$E(\ln P_t) = \beta_0 + \beta_1 / t \quad \text{.....(8)}$$

$$E(\ln P_t) = \beta_0 + \beta_1 t \quad \text{......(9)}$$

$$E(\ln P_t) = \ln \beta_0 + \beta_1 t \quad \text{......(10)}$$

$$E(\ln(1/P_t - 1/u)) = \ln \beta_0 + \ln(\beta_1)\, t \quad \text{......(11)}$$

$$E(P_t) = \beta_{00} + \beta_{01} t + \beta_1 (t - k_1)_+ + \beta_2 (t - k_2)_+ \quad \text{.....(12)}$$

$$E(P_t) = \beta_{00} + \beta_{01} t + \beta_1 (t - k_1)_+ + \beta_2 (t - k_2)_+ + \beta_3 (t - k_3)_+ \quad \text{.... (13)}$$

$$E(P_t) = \beta_{00} + \beta_{01} t + \beta_{02} t^2 + \beta_1 (t - k_1)_+^2 + \beta_2 (t - k_2)_+^2 \quad \text{......(14)}$$

$$E(P_t) = \beta_{00} + \beta_{01} t + \beta_{02} t^2 + \beta_1 (t - k_1)_+^2 + \beta_2 (t - k_2)_+^2 + \beta_3 (t - k_3)_+^2 \quad \text{..(15)}$$

where $t = 1, 2, \ldots, 38$.

$$(t - k_i)_+^j = (t - k_i)^j \quad \text{if } t > k_i$$

$$= 0 \quad \text{if } t \le k_i$$

$$i = 1, 2, 3 \text{ and } j = 1, 2.$$

Appendix 10

Summary statistics of different trend models fitted to the real prices of teak logs in girth-class *E*

$1. NO.	Trend model	Adj. R^2	Mean square error	Durbin-Watson d-statistic
1	Linear	0.90**	1.77 x 10^5	1.13**
2	Quadratic	0.93**	6.24 x 10^5	1.46[ic]
3	Cubic	0.93**	6.51 x 10^5	1.48[ic]
4	Logarithmic	0.68**	25.00 x 10^5	0.46**
5	Inverse	0.31**	54.50 x 10^5	0.31**
6	Compound	0.93**	6.64 x 10^5	1.34[ic]
7	Power	0.82**	15.32 x 10^5	0.60**
8	S. curve	0.43**	51.39 x 10^5	0.21**
9	Growth	0.93**	6.64 x 10^5	1.34[ic]
10	Exponential	0.93**	6.64 x 10^5	1.34[ic]
11	Logistic	0.88**	8.04 x 10^5	1.09**
12	Linear spline with 2 knots	0.91**	6.42 x 10^5	1.39[ic]
13	Linear spline with 3 knots	0.91**	6.67 x 10^5	1.41[ic]
14	Quadratic spline with 2 knots	0.91**	6.48 x 10^5	1.47[ic]
15	Quadratic spline with 3 knots	0.92**	5.74 x 10^5	1.76[ns]

* Statistically significant at 5% probability level and ** at 1% level.

ns Statistically non-significant.

ic Durbin-Watson d-test inconclusive at 5% level.

Appendix 11

Summary statistics of different trend models fitted to the real prices of teak logs in girth-class I

Sl. No.	Trend model	Adj. R^2	Mean square error	Durbin-Watson d-statistic
1	Linear	0.72**	16.70 x 10'	0.23**
2	Quadratic	0.96**	2.55 x 10^5	1.37*
3	Cubic	0.96**	2.61 x 10^5	1.38*
4	Logarithmic	0.37**	36.90 x 10^5	0.13**
5	Inverse	o.08ns	53.90 x 10^5	0.10**
6	Compound	0.70**	11.55 x 10^5	0.31**
7	Power	0.35**	36.25 x 10^5	0.11**
8	S. curve	0.07ns	57.41 x 10^5	0.07**
9	Growth	0.70**	11.57 x 10^5	0.31**
10	Exponential	0.70**	11.57 x 10^5	0.31**
11	Logistic	0.67**	12.85 x 10^5	0.29**
12	Linear spline with 2 knots	0.97**	2.02 x 10^5	1.73ns
13	Linear spline with 3 knots	0.96**	2.05 x 10^5	1.75ns
14	Quadratic spline with 2 knots	0.96**	2.07 x 10^5	1.76ns
15	Quadratic spline with 3 knots	0.96**	1.97 x 10^5	1

* Statistically significant at 5% probability level and ** at 1% level.

ns Statistically non-significant.

Appendix 12

Summary statistics of different trend models fitted to the real prices of teak logs in girth-class 2

SI. No.	Trend model	Adj. R^2	Mean square error	Durbin-Watson d-statistic
1	Linear	0.74**	11.40 x 10^5	0.26**
2	Quadratic	0.94**	2.60 x 10^5	1.08**
3	Cubic	0.95**	2.47 x 10'	1.17**
4	Logarithmic	0.41**	26.40 x 10^5	0.14**
5	Inverse	0.10*	39.90 x 10^5	0.10**
6	Compound	0.72**	7.77 x 10^5	0.36**
7	Power	0.37**	25.72 x 10^5	0.12**
8	S. curve	0.09ns	42.68 x 10'	0.07**
9	Growth	0.72**	7.77 x 10^5	0.36**
10	Exponential	0.72**	7.77 x 10^5	0.36**
11	Logistic	0.73**	7.86 x 10'	0.36**
12	Linear spline with 2 knots	0.96**	1.65 x 10'	1.68ns
13	Linear spline with 3 knots	0.97**	1.30 x 10'	2.19ns
14	Quadratic spline with 2 knots	0.96**	1.50 x 10^5	1.92ns
15	Quadratic spline with 3 knots	0.96**	1.54 x 10^5	

* Statistically significant at 5% probability level and ** at 1% level,
ns Statistically non-significant.

Appendix 13

Summary statistics of different trend models fitted to the real prices of teak logs in girth-class 3

Sl. No.	Trend model	Adj. R^2	Mean square error	Durbin-Watson d-statistic
1	Linear	0.76**	7.04×10^5	0.33**
2	Quadratic	0.93**	2.05×10^5	1.13**
3	Cubic	0.95**	1.78×10^5	1.34**
4	Logarithmic	0.42**	16.70×10^5	0.17**
5	Inverse	0.11*	25.80×10^5	0.12**
6	Compound	0.75**	4.73×10^5	0.48**
7	Power	0.41**	16.10×10^5	0.15**
8	S. curve	0.09ns	27.68×10^5	0.10**
9	Growth	0.75**	4.73×10^5	0.48**
10	Exponential	0.75**	4.73×10^5	0.48**
11	Logistic	0.75**	6.65×10^5	0.49**
12	Linear spline with 2 knots	0.95**	1.35×10^5	1.70ns
13	Linear spline with 3 knots	0.97**	0.96×10^5	2.46ns
14	Quadratic spline with 2 knots	0.95**	1.18×10^5	
15	Quadratic spline with 3 knots	0.96**	1.07×10^5	2.33ns

* Statistically significant at 5% probability level and ** at 1% level.
ns Statistically non-significant.

Appendix 14

Summary statistics of different trend models fitted to the real prices of teak logs in girth-class 4

Sl. No.	Trend model	Adj. R^2	Mean square error	Durbin-Watson d-statistic
I	Linear	0.94**	1.07×10^5	1.63ns
2	Quadratic	0.94**	1.07 x 10'	1.70ns
3	Cubic	0.96**	0.14×10^5	2.53ns
4	Logarithmic	0.80**	3.43×10^5	0.66**
5	Inverse	0.41**	10.10×10^5	0.36**
6	Compound	0.91**	3.13×10^5	0.63**
7	Power	0.89**	1.54×10^5	1.15**
8	S. curve	0.54**	8.59×10^5	0.24**
9	Growth	0.91**	3.13 x 10'	0.62**
10	Exponential	0.91**	3.13×10^5	0.62**
11	Logistic	0.93**	1.87×10^5	
12	Linear spline with 2 knots	0.93**	1.10×10^5	1.65ns
13	Linear spline with 3 knots	0.95**	0.83×10^5	2.27ns
14	Quadratic spline with 2 knots	0.95**	1.83 x 10'	2.26ns
15	Quadratic spline with 3 knots	0.95**	0.11×10^5	2.54ns

* Statistically significant at 5% probability level and ** at 1% level.

ns Statistically non-significant.

Appendix 15

Summary statistics of different trend models fitted to the real prices of teakwood (girth-classes combined)

Sl. No.	Trend model	Adj. R^2	Mean square error	Durbin-Watson d-statistic
1	Linear	0.74**	7.37 x 10^5	0.31**
2	Quadratic	0.92**	2.48 x 10^5	0.89**
3	Cubic	0.94**	1.94 x 10^5	1.17**
4	Logarithmic	0.40**	16.90 x 10^5	0.16**
5	Inverse	0.09ns	25.60 x 10^5	0.12**
6	Compound	0.70**	5.29 x 10^5	0.41**
7	Power	0.36**	16.25 x 10^5	1.15**
8	S. curve	0.07ns	27.19 x 10'	0.10**
9	Growth	0.70**	5.29 x 10^5	0.41**
10	Exponential	0.70**	5.29 x 10'	0.41**
11	Logistic	0.72**	5.35 x 10^5	0.41**
12	Linear spline with 2 knots	0.95**	1.51 x 10^5	1.46ic
13	Linear spline with 3 knots	0.96**	1.03 x 10^5	2.17ns
14	Quadratic spline with 2 knots	0.95**	1.19 x 10^5	1.92ns
15	Quadratic spline with 3 knots	0.95**	1.23 x 10^5	1

* Statistically significant at 5% probability level and ** at 1% level.

ns Statistically non-significant.

ic Durbin-Watson d-test inconclusive

Appendix 16

Summary statistics of different trend models fitted to the real prices of *anjily*

Sl. No.	Trend model	Adj. R^2	Mean square error	Durbin-Watson d-statistic
1	Linear	0.65**	2.44×10^5	0.68**
2	Quadratic	0.71**	2.04×10^5	0.82**
3	Cubic	0.74**	1.93×10^5	0.92**
4	Logarithmic	0.41**	4.14×10^5	0.43**
5	Inverse	0.12*	6.13×10^5	0.31**
6	Compound	0.68**	2.25×10^5	0.72**
7	Power	0.43**	3.94×10^5	0.43**
8	S. curve	0:13**	6.35×10^5	0.27**
9	Growth	0.67**	2.25×10^5	0.73**
10	Exponential	0.67**	2.25×10^5	0.73**
11	Logistic	0.65**	2.20×10^5	0.75**
12	Linear spline with 2 knots	0.71**	1.89×10^5	0.91**
13	Linear spline with 3 knots	0.77*	1.52×10^5	1.16*
14	Quadratic spline with 2 knots	0.75**	1.61×10^5	1.11*
15	Quadratic spline with 3 knots	0.77**	1.57×10^5	1.15*

*Statistically significant at 5% probability level and ** at % level.
ns Statistically non-significant.

Appendix 17

Summary statistics of different trend models fitted to the real prices of *Irul*

Sl. No.	Trend model	Adj. R^2	Mean square error	Durbin-Watson 'd' statistic
1	Linear	0.73**	1.42×10^5	0.51**
2	Quadratic	0.81**	1.01×10^5	0.70**
3	Cubic	0.85**	0.8×10^5	0.94**
4	Logarithmic	0.43**	2.92×10^5	0.27**
5	Inverse	0.12*	4.56×10^5	0.20*
6	Compound	0.74**	1.20×10^5	0.52**
7	Power	0.44**	2.72×10^5	0.27**
8	S. curve	0.12*	4.80 x 10'	0.16**
9	Growth	0.74**	1.20×10^5	0.59**
10	Exponential	0.74**	1.20 x 10'	0.59**
11	Logistic	0.73**	1.16×10^5	0.62**
12	Linear spline with 2 knots	0.83**	0.82×10^5	1.31ic
13	Linear spline with 3 knots	0.91**	0.47×10^5	1.62ic
14	Quadratic spline with *2* knots	0.88**	0.60×10^5	1.31ic
15	Quadratic spline with 3 knots	0.87**	0.61×10^5	1.31ic

*Statistically significant at 5% probability level and ** at level.

ns Statistically non-significant.

ic Durbin-Watson d-test inconclusive at 5% level.

Appendix 18

Summary statistics of different trend models fitted to the real prices of *maruthu*

Sl. No.	Trend model	Adj. R^2	Mean square error	Durbin-Watson 'd' statistic
1	Linear	0.67**	1.54 x 10'	0.50**
2	Quadratic	0.74**	1.26 x 10'	0.61**
3	Cubic	0.81**	0.93 x 10'	0.88**
4	Logarithmic	0.40**	2.79 x 10^5	0.30**
5	Inverse	0.10*	4.16 x 10'	0.22**
6	Compound	0.68**	1.42 x 10'	0.52**
7	Power	0.39**	2.70 x 10'	0.28**
8	S. curve	0.09ns	4.42 x 10'	0.18**
9	Growth	0.68**	1.42 x 10'	0.52**
10	Exponential	0.68**	1.42 x 10^5	0.52**
11	Logistic	0.67**	1.32 x 10^5	0.57**
12	Linear spline with 2 knots	0.77**	1.03 x 10'	0.76**
13	Linear spline with 3 knots	0.90**	0.45 x 10'	1.63ic
14	Quadratic spline with 2 knots	0.84**	0.70 x 10^5	1.18*
15	Quadratic spline with 3 knots	0.84**	0.72 x 10'	1.18*

* Statistically significant at 5% probability level and ** at 1% level.

ns Statistically non-significant.

ic Durbin-Watson d-test inconclusive at 5% level, but non-significant at

Appendix 19

Summary statistics of different trend models fitted to the real prices of jack

Sl. No.	Trend model	Adj. R^2	Mean square error	Durbin-Watson 'd' statistic
1	Linear	0.60**	2.68×10^5	
2	Quadratic	0.61**	2.66×10^5	2.41ns
3	Cubic	0.64**	2.58×10^5	2.58ns
4	Logarithmic	0.42**	3.87×10^5	1.64ns
5	Inverse	0.14*	5.74×10^5	1.14**
6	Compound	0.72**	2.71×10^5	2.30ns
7	Power	0.50**	3.61×10^5	1.74ns
8	S. curve	0.21**	5.79×10^5	1.08**
9	Growth	0.72**	2.71×10^5	2.30ns
10	Exponential	0.72**	2.71×10^5	2.30ns
11	Logistic	0.63**	2.56×10^5	2.44ns
12	Linear spline with 2 knots	0.60**	2.58×10^5	2.56ns
13	Linear spline with 3 knots	0.63**	2.43×10^5	2.70ns
14	Quadratic spline with 2 knots	0.61**	2.55×10^5	2.68ns
15	Quadratic spline with 3 knots	0.61**	2.55×10^5	

*Statistically significant at 5% probability level and ** at 1% level.
ns Statistically non-significant.

Appendix 20

Summary statistics of different trend models fitted to the real prices of *thembavu*

SI. No.	Trend model	Adj. R^2	Mean square error	Durbin-Watson 'd' statistic
1	Linear	0.60**	1.27×10^5	0.51**
2	Quadratic	0.67**	1.07×10^5	0.64**
3	Cubic	0.80**	0.67×10^5	0.99**
4	Logarithmic	0.34**	2.12×10^5	0.32**
5	Inverse	0.08ns	2.97×10^5	0.24**
6	Compound	0.58**	1.20×10^5	0.55**
7	Power	0.30**	2.07×10^5	0.32**
8	S. curve	0.06ns	3.10×10^5	0.22**
9	Growth	0.58**	1.20×10^5	0.55**
10	Exponential	0.58**	1.20×10^5	0.55**
11	Logistic	0.59**	1.16×10^5	0.56**
12	Linear spline with 2 knots	0.73**	0.84×10^5	0.82**
13	Linear spline with 3 knots	0.91**	0.27×10^5	2.19ns
14	Quadratic spline with 2 knots	0.86**	0.43×10^5	I.48ic
15	Quadratic spline with 3 knots	0.86**	0.44×10^5	1.48ic

* Statistically significant at 5% probability level and ** at 1% level.
ns Statistically non-significant.
ic Durbin-Watson d-test inconclusive at 5% level.

Appendix 21

Summary statistics of different trend models fitted to the real prices of ***venga***

Sl. No.	Trend model	Adj. R^2	Mean square error	Durbin-Watson 'd' statistic
1	Linear	0.57**	2.12×10^5	0.54**
2	Quadratic	0.57**	2.12×10^5	0.55**
3	Cubic	0.66**	1.71×10^5	0.73**
4	Logarithmic	0.36**	3.04×10^5	0.40**
5	Inverse	0.10*	4.31×10^5	0.31**
6	Compound	0.60**	2.17×10^5	0.52**
7	Power	0.39**	2.93×10^5	0.39**
8	S. curve	0.11*	4.43×10^5	0.21**
9	Growth	0.60**	2.11×10^5	0.53**
10	Exponential	0.60**	2.17×10^5	0.53**
11	Logistic	0.55**	2.04×10^5	0.56**
12	Linear spline with 2 knots	0.60**	1.87×10^5	0.65**
13	Linear spline with 3 knots	0.91**	0.47×10^5	1.62ic
14	Quadratic spline with 2 knots	0.69**	1.44×10^5	0.88**
15	Quadratic spline with 3 knots	0.12**	1.28×10^5	

*Statistically significant at 5% probability level and ** at 1% level.

ns Statistically non-significant.

ic Durbin-Watson d-test inconclusive at 5% level, but non-significant at 1% level

Appendix 22

Summary statistics of different trend models fitted to the real prices of *venteak*

Sl. No.	Trend model	Adj. R^2	Mean square error	Durbin-Watson 'd' statistic
1	Linear	0.75**	1.51×10^5	0.26**
2	Quadratic	0.82**	1.09×10^5	0.36**
3	Cubic	0.88**	0.72×10^5	0.57**
4	Logarithmic	0.45**	3.33×10^5	0.15**
5	Inverse	0.12*	5.36×10^5	0.11**
6	Compound	0.75**	1.30×10^5	0.30**
7	Power	0.44**	3.13×10^5	0.13**
8	S. curve	0.11*	5.76×10^5	0.07**
9	Growth	0.75**	1.30×10^5	0.30**
10	Exponential	0.75**	1.30×10^5	0.30**
11	Logistic	0.75**	1.16×10^5	0.33**
12	Linear spline with 2 knots	0.86**	0.83×10^5	0.48**
13	Linear spline with 3 knots	0.96**	0.21×10^5	1.52ic
14	Quadratic spline with 2 knots	0.92**	0.44×10^5	0.89**
15	Quadratic spline with 3 knots	0.92**	0.46×10^5	0.89**

*Statistically significant at 5% probability level and ** at 1% level.
[ns] Statistically non-significant.
[ic] Durbin-Watson d test inconclusive at 5% level, but non-significant at 1% level.

Appendix 23

Summary of different models fitted to current prices of teak in girth-class 1

Estimated model	AIC	SBC	Residual standard error	Mean absolute prediction error
$(1+0.5320^{**}B)(1-B)^2 Z_t = (1-0.3299^{**}B)a_t$ (0.17)' (0.19)	826.31	830.18	776.85	409.97
$(1+0.5123^{**}B)(1-B)^2 Z_t = 60.1010 + (1-0.3941B)a_t$ (0.18) (44.11) (0.19)	826.58	832.38	770.89	460.98
$(1-B)^2 Z_t = (1-0.6839^{**}B)a_t$ (0.11)	830.79	832.72	820.69	416.22
$(1-B)^2 Z_t = 51.5455 + (1-0.7348^{**}B)a_t$ (31.82) (0.11)	830.48	834.34	809.21	475.45
$(1-0.9602^{**}B)(1-B)Z_t = (1-0.7749^{**}B + 321\ B^2)a_t$ (0.18) (0.26) (0.18)	847.36	853.21	797.48	411.21
$(1-0.9331^{**}B)(1-B)Z_t = 870.02 + (1-0.7738^{**}B + 0.3283B^2)a_t$ (0.16) (743.65) (0.23) (0.18)	848.23	856.04	800.14	455.68
$(1-B)^2 Z_t = 63.3541 + (1-0.8763^{**}B + 0.3141B^2)a_t$ (48.65) (0.15) (0.19)	828.38	834.17	784.92	465.48
$(1-B)^2 Z_t = (1-0.8427^{**}B + 0.3284B^2)a_t$ (0.15) (0.18)	827.94	831.81	789.58	416.80
$(1-0.9650^{**}B)(1-B)Z_t = 876.03 + (1-0.6648^{**}B)a_t$ (0.08) (784.96) (0.17)	851.10	856.95	832.79	452.36
$(1-B)Z_t = (1+0.2998^{*}B) - 0.4681^{**}B^2)a_t$ (0.13) (0.14)	858.24	862.14	906.10	427.41

* Statistically significant at 5% probability level and ** at 1% level
# The figure in parenthesis is the standard error of the parameter

Appendix 24

Summary of different models fitted to current prices of teak in girth-class 2

Estimated model	AIC	SBC	Residual standard error	Mean absolute prediction error
$(1-B)^2 Z_t = 44.5638 + (1-0.9686^{**}B + 0.2603B^2)a_t$ (27.51)# (0.14) (0.20)	809.83	815.63	653.00	388.27
$(1-B)^2 Z_t = (1-0.9358^{**}B + 0.2947B^2)a_t$ (0.14) (0.21)	810.17	814.04	662.22	333.56
$(1+0.1799B)(1-B)^2 Z_t = 40.2355 + (1-0.7194^{**}B)a_t$ (0.21) (23.20) (0.18)	810.66	816.46	658.52	396.56
$(1+0.1950B)(1-B)^2 Z_t = (1-0.6502^{**}B)a_t$ (0.22) (0.20)	811.31	815.17	670.19	336.59
$(1-B)^2 Z_t = (1-0.7754^{**}B)a_t$ (0.11)	810.46	812.39	671.01	335.92
$(1-B)^2 Z_t = 37.6936 + (1-0.7877^{**}B)a_t$ (2123) (0.12)	809.68	813.54	658.70	397.54
$(1-B)Z_t = (1+0.3655^{**}B + 0.1966B^2)a_t$ (0.14) (0.14)	844.63	848.53	797.63	380.61
$(1-0.9806^{**}B)(1-B)Z_t = (1-0.7170^{*}B)a_t$ (0.16) (0.32)	829.17	833.07	678.58	332.00
$(1-0.9826^{**}B)(1-B)Z_t = (1-0.8360^{**}B + 0.1740B^2)a_t$ (0.15) (0.26) (0.20)	829.54	835.39	671.78	331.00
$(1-0.9694^{**}B)(1-B)Z_t = 672.3125 + (1-0.7193^{**}B)a_t$ (0.06) (595.92) (0.15)	830.18	836.04	681.46	371.00
$(1-0.9691^{**}B)(1-B)Z_t = 809.99 + (1-0.9058^{**}B) + 0.2673B^2)$ **a,** (0.16) (0.19)	830.36	838.17	672.91	365.61

* Statistically significant at 5% probability level and ** at 1% level
# The figure in parenthesis is the standard error of the parameter

Appendix 25

Summary of different models fitted to current prices of teak in girth-class 3

Estimated model	AIC	SBC	Residual standard error	Mean absolute prediction error
$(1-B)^2 Z_t = (1-1.3140^{**}B + 0.8022^{**}B)a_t$ (0.10) (0.10)	787.54	791.40	520.67	304.45
$(1+0.1322B)(1-B)^2 Z_t = 50.6649 + (1-1.4117^{**}B + 0.8975^{**}B^2)a_t$ (0.19) (39.62) (0.10) (0.10)	786.16	796.89	514.86	328.51
$((1-B)' Z_t = 45.5123 + (1-0.3401^{**}B + 0.7910B^2)a_t$ (32.30) (0.12)	787.71	793.51	516.94	327.26
$(1-.0.1665B)(1-B)^2 Z_t = (1-1.4145^{**}B + 0.9006^{**}B^2)a_t$ (0.19) (0.10) (0.11)	788.85	794.65	518.15	307.54
$(1-0.9721^{**}B)(1-B)Z_t = (1-1.1591B + 0.3995B^2)a_t$ (0.10) (0.20) (0.18)	807.41	813.26	538.50	284.78
$(1+0.4851^{**}B + 0.5533^{**}B^2)(1-B)^2 Z_t = 1-0.6207B + 0.6167B^2)a_t$ (0.19) (0.16) (0.19) (0.17)	787.83	795.56	515.11	277.25
$(1+0.4734^{*}B + 0.4894^{**}B^2)(1-B)^2 Z_t = 40.6038 + (0.7208^{**}B + 0.5224^{*}B^2)a_t$ (0.24) (0.18) (29.61) (024) (0.23)	788.52	798.18	514.53	310.86
$(1-0.9650^{**}B)(1-B)Z_t = 755.76 + (1-1..2795^{**}B) + 0.7584^{**}B^2)a_t$ (0.07) (699.2) (0.12) (0.12)	807.61	815.41	530.90	321.44

* Statistically significant at 5% probability level and ** at 1% level

\# The figure in parenthesis is the standard error of the parameter