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Analysis of the trend in arrivals and prices of tender coconut in Maddur market, Karnataka

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Abstract
The present study analyses the trend in arrivals and prices of tender coconut in the Maddur market by fitting three linear models *viz*. linear (Straight line), quadratic and exponential models, and three nonlinear models *viz*. logistics, Gompertz and Richard's to the annual data on arrivals (In crore nuts) and prices (In rupees per thousand nut) of tender coconuts for the period of 21 year i.e. from 1997-98 to 2017-18. The test statistic to check the goodness of fit of each model was computed using Root Mean Squared Error (RMSE), Mean Absolute Percentage Error (MAPE), and Akaike's Information Criteria (AIC). The main assumptions of independence of errors and normality distribution of error terms of each model were examined by using respectively the 'Run-test' and 'Shapiro-Wilk test. Based on the lowest value of RMSE, MAPE and AIC, Richard's model fitted better than other models for arrivals of the tender coconut, and the Quadratic model was found to be the best-fitted model for the prices of the tender coconut in the Maddur market. Based on the overall goodness of criteria the best-fitted model for arrivals could be ranked as follows: Richard's, logistic, exponential, Gompertz, linear and quadratic models. Trend values obtained by the best-fitted model reveal that both arrivals and prices of tender coconut in the Maddur market have an upward trend.

Keywords: Tender coconut, trend, time-series analysis, linear model, nonlinear model, arrivals and prices, Maddur, Karnataka

1. Introduction

The coconut palm tree (*Cocos nucifera* Linn.) is one of the most natural and valuable gifts to mankind. Considering the versatile nature of the crop and the multifarious uses of its products, the coconut palm is eulogized as Kalpavruksha (The Tree of Heaven). Coconut fruit is considered as Lakshmi Phal, (The Fruit of wealth). Coconut is a source of food, beverage, medicine, natural fibre, fuel, wood and raw materials for units producing a variety of goods. India being the largest coconut producing country in the world occupies 31% of global production. Coconut palm provides food security and livelihood opportunities to more than 12 million people in India. More than 15,000 coir-based industries employ nearly 6 lakh workers of which 80% are women. The crop contributes around Rs. 2, 50, 000 million to the country's GDP and earns export revenue of around Rs.43, 654 million (Anonymous, 2016) [1]. Coconut is grown in more than 93 countries in the world in an area of 12.19 million ha with an annual production of 69836.36 million tonnes of nuts. India ranks first in production (21,665 million nuts) and productivity (10,119 nuts/ha.) of coconut and ranks third in the area (2,141 thousand ha.) under coconut. Indonesia stands first in area (3610 thousand ha.) under coconut, ranks second in production (16354 million nuts) and productivity (4530 nuts/ha.) and the Philippines ranks second in the area (3502 thousand ha.) under coconut, ranks third in production (14696 million nuts) and productivity (4196 nuts/ha.). The largest share of coconut production in 2014 was recorded in India (31.02%) followed by Indonesia (23.42%) and Philippines (21.04%) and other countries 24.52 per cent (Anonymous, 2014) [2].

Traditional areas of coconut cultivation in India are the states of Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Goa, Orissa, West Bengal, Puducherry, Maharashtra and the Island territories of Lakshadweep and Andaman & Nicobar. Coconut cultivation has also spread to non-traditional tracts like Bihar, Chhattisgarh, Gujarat, West Bengal and North Eastern states.

Karnataka stands third in production of coconuts by producing 5128.84 million nuts, which constitutes 23.13 per cent of India's production after Kerala - 7429.39 million nuts (33.51%) and Tamil Nadu 6171.06 million nuts (27.83%) during the year 2015-16. The four southern states *viz*. Kerala, Tamil Nadu, Karnataka and Andhra Pradesh are the major coconut-producing states in India accounting for more than 90 per cent of area and production (Anonymous, 2016) [1].

Nowadays, tender coconut is becoming more popular as a health and energy drink by replacing artificial soft drinks. Coconut water is highly recommended by fitness and nutrition experts as a rehydrating agent. It has a caloric value of 17.4 per 100 gm. On a percentage basis, coconut water is 94.5 per cent water, the rest would contain: Protein (0.15 to 0.55%), fat (0.10%), ash (0.46%), and carbohydrates (4.40%). Tender coconut water is not merely a thirst-quenching drink but a mineral drink that cures most human diseases and helps one regain lost health. Tender coconut water has been given intravenously to cholera epidemic victims in Sri Lanka, Indonesia, Bangladesh and India. Tender coconut water being rich in potassium and other minerals plays a major role in increasing urinary output (Ravi Kumar, 2012) [3].

In Karnataka, about 14 per cent of the total production of coconut is harvested in the form of tender nuts, which is confined to Mandya, Bengaluru, Mysore and Hassan districts. The production of coconut is localized while the consumption is spread throughout the country. Though Kerala tops the list at the national level for coconut production, it is largely used for oil extraction while the fruits from Mandya, Ramanagaram and Tumkur are known for their high water content.

Maddur is one of the world's largest tender coconut hubs. Every day, about four million tender coconuts are brought to an exclusive market set up by the Agricultural Produce Marketing Committee on the Bengaluru-Mysore highway. The nuts are brought by farmers and harvesters from Maddur, Mandya, Chamarajnagar, Kollegal, Malavalli, Bannur, Nagamangala, Pandavapura, K. R. Pet and Srirangapatna. Over 60 per cent of these tender coconuts are loaded onto 300 trucks and sent to New Delhi, Mumbai, Pune, Kolkata, Goa, Hyderabad, Ahmedabad and other places. The rest are sold within Karnataka.

Marketing of tender coconut plays a significant role in the movement of commodities from the producer to the consumer and stabilizing prices. The planned increase in agricultural output must be coordinated with changes in the demand and supply for agricultural commodities and marketing. This can be achieved only when the producer's share in the consumer's rupee increases considerably irrespective of the volume of the marketable surplus produced by the farmers. The coconut market in India is always unstable and uncertain due to frequent fluctuations in prices. Usually, fluctuation in price occurs due to changes in market conditions created in response to seasonal and annual variations in production (Mohan Kumar *et al*., 2009) [4]. The seasonal variation in prices of tender coconut is more due to supply factors than due to demand factors. Usually, the magnitude of fluctuation is higher during the lean period compared to the peak period. The pattern of movement of the product from the farm to the ultimate consumer plays a crucial role in determining the returns to the farmers (Savitha and Kunnal, 2016) [5]. Analysis of market arrivals and prices over a period of time is important for formulating a sound agricultural policy. Fluctuations in market arrivals may largely contribute instability of prices. Thus, the study of trend in arrivals and prices of tender coconut will be of greater relevance to the policy makers to assess the demand, supply, and price behaviour, which intern helpful to improve the income of farmers.

To study of trend in arrivals and prices of any crop, generally, the time-series analysis is performed. Keeping these points in view, our objective of the study is to analyze the pattern of arrivals and the prices of tender coconut in the Maddur market.

2. Materials and Methods

The data for the study are confined to arrivals and prices of tender coconut, tender coconut market, Maddur, which is situated on the premises of the Agricultural Produce Market Committee (APMC), Maddur, Mandya district. The secondary data pertaining to annual arrivals (in Crore nuts) and annual prices (in rupees per thousand nuts) of tender coconuts for the period of 1997-98 to 2017-2018 were collected from APMC, Maddur. Annual arrivals are the total arrivals in that year and annual prices are the modal prices in that year.

Trend analysis is the general tendency of the data to increase or decrease over a long period of time without bothering about short-term fluctuations. Generally for estimating the long-term trend of arrivals and prices, the *Method of Least Squares* estimate was employed. In this method, a trend in arrivals and prices is measured by establishing a mathematical relation between time and the response variable, which depends on time. The relation may be,

1. Linear (Straight line) $Y_t = \alpha + \beta t + \varepsilon$
2. Quadratic (Parabolic) $Y_t = \alpha + \beta t + kt^2 + \varepsilon$
3. Exponential $Y_t = \alpha\beta^t + \varepsilon$

Where, Y_t=Arrivals or prices in time period t

α= Intercept or average effect

β & k =Slope or regression coefficients (β= Linear effect parameter and

k = Quadratic effect parameter)

ε = error term or disturbance term

Coefficients α, β & k are constant parameters to be estimated.

In the above models, the relationship between the response variable and time is assumed to be linear or curvilinear. However, the assumptions of linearity, curvilinear or exponential functional form may not hold for the real data in nature. Most of the time series relating to business and economic phenomena over a long period of time do not exhibit sudden growth which is at a constant rate and in a particular direction over a long period of time, chronological series are not likely to show either a constant amount of change or a constant ratio of change. The rate of growth is initially slow, then it picks up and becomes faster and gets accelerated, then becomes stable for some time after which it shows retardation. The curves, which can be fitted to such data are called *Growth Curves*. Growth rate analysis is also widely employed to describe the long-term trends in variables over time in various crops (Mohan Kumar, *et al*. 2012a) [6].

Growth models are generally 'mechanistic' and the parameters have meaningful biological interpretation.

The following are some of the important nonlinear growth curves, which are generally used to describe the measurements in a time series.

1. Logistic $Y_t = \frac{\alpha}{1+\beta \exp(-kt)} + \varepsilon;\ \beta = \frac{\alpha}{Y_0} - 1$
2. Gompetz $Y_t = \alpha\, exp(-\beta ex\,\mathrm{p}(-kt)) + \varepsilon;\ \beta = \ln\left(\frac{\alpha}{Y_0}\right)$

3. Richard's $Y_t = \frac{\alpha}{[1+\beta exp(-kt)]^{1/m}} + \varepsilon;\ \beta = \frac{\alpha^m}{{Y_0}^m} - 1$

Where, Y_t represents arrivals or prices in a time period t
$\alpha, \beta, m,$ and k are parameters and
ε denotes the error term.

The parameter 'k' is the 'intrinsic growth rate', while the parameter 'α' represents the 'carrying capacity or yield ceiling'. For the third parameter, although the same symbol 'β' was used, this represented different functions of the initial value Y_0 for different models and 'm' is the added parameter (Prajneshu and Das, 2000) [7].

It may be noted that all the above growth models are 'nonlinear', as each one of these involves at least one parameter in a nonlinear manner. Parameter estimates in nonlinear cases also can be obtained by minimizing the residual sum of squares. However, because of nonlinearity, the resulting normal equations are nonlinear in parameters and so cannot be solved exactly. Accordingly, several iterative procedures have been developed to obtain approximate solutions. Four main methods are available in the literature to obtain estimates of the unknown parameters of nonlinear regression models: (i) Linearization method, (ii) Gradient method, (iii) Does not use derivatives (DUD) method, and (iv) Levenberg-Marquardt (LM) method. Nowadays most of the standard statistical software packages like SPSS, and SAS contain programs for fitting nonlinear models by LM and DUD procedures. However, convergence to biologically meaningful values cannot always be guaranteed by any procedure and the success rate is quite low. The present statistical analysis was carried out by using the LM procedure available in PROC NLIN facility of the SAS software package (Mohan Kumar *et al*. 2012b) [8]. The LM iterative method requires the specification of the initial estimates of each parameter of the models to be estimated. Initial value specification is one of the most difficult problems encountered in estimating parameters of nonlinear models. Inappropriate initial values will result in longer iteration, greater execution time, non-convergence of the iteration and possibly convergence to an unwanted local minimum sum of squares residual. To start the iterative procedure, many sets of initial values were tried to ensure global convergence. The iterative procedure was stopped when the reduction between successive residual sums of squares was found to be negligibly small (Mohan Kumar *et al*, 20120c) [8].

Once the parameters of the models were estimated, a diagnostic check of residuals of the fitted models has to be analyzed to check any violations in the main assumptions of 'independence of residuals' and 'normality of residuals'. The main assumptions of 'independence of residuals' and 'normality of residuals' were examined by using respectively the 'Run-test' and 'Shapiro-Wilk test' (Prajneshu and Das, 2000) [7].

Finally, the goodness of fit of a model is assessed by computing the Root Mean Squared Error (RMSE), Mean Absolute Percentage Error (MAPE), and Akaike's Information Criteria (AIC).

3. Result and Discussion

Time series analysis was attempted to study the trend in the arrivals and prices of tender coconut in the Maddur market. To determine the nature of trend movement in the arrivals and prices of tender coconut in the Maddur market, linear models *viz*. Linear (Straight line), Quadratic and Exponential form of the model, and nonlinear growth model *viz.* Logistic, Gompertz and Richard's model were fitted to annual data on arrivals (In crore nuts) and prices (In rupees per thousand nut) for the period of 21 years i.e. from 1997-98 to 2017-18.

3.1 Arrivals of tender coconut

The parameter estimates of all fitted models and their standard errors (Given in round bracket) for arrivals are presented in Table 1. Statistical significance of the parameters of linear and quadratic models was determined by evaluating student t-test. In the linear model slope is found to be significant, whereas the intercept is not significant, with respect to the quadratic model all the parameters are found to be non-significant. The statistical significance of the parameters of the other remaining models was determined by computing the 95% asymptotic confidence intervals of the estimated parameters. Exponential, logistic and Richard's models are significantly fitted to tender coconut arrivals, except the Gompertz model, which showed negative signs in some of the parameters. The null hypothesis was rejected when the 95% asymptotic confidence interval of the corresponding parameter estimate did not include zero. The main assumptions of 'independence' and 'normality' of error terms of each model were examined by using respectively the 'Run-test' and 'Shapiro-Wilk test', and test statistic along with probability values are presented in Tables 1. Results revealed that the number of runs was found to be non-significant (Z < 1.95 or p-value > 0.05) and the Shapiro-Wilk statistic was also non-significant (P-value > 0.05) at a 5% significance level for all six models. Hence, the assumptions of randomness of residual and normal distribution of residual are satisfied.

The test statistic to check the goodness of fit of each model was computed using RMSE, MAPE, and AIC and they are presented in Table 1. The lowest values of RMSE (2366.88), MAPE (30.57), and AIC (334.31) indicated that Richard's model fitted better than other models to tender coconut arrivals in the Maddur market. On the contrary, the highest value of RMSE (3049.80), MAPE (39.27), and AIC (342.95) revealed that the Quadratic model was less performed than other models. Based on the overall goodness of criteria the best-fitted model for arrivals could be ranked as follows: Richard's, Logistic, Exponential, Gompertz, Linear and Quadratic models.

Table 1: Parameter estimates and goodness of fit by different models for arrivals (in crore nuts) of tender coconuts for the period of 1997-98 to 2017 -18

Parameter	Models					
	Linear	**Quadratic**	**Exponential**	**Logistic**	**Gompertz**	**Richard's**
α	1449.39^{NS} (1450.83)	1320.15^{NS} (2379.18)	3621.07* (950.21)	14769.30* (2872.20)	2191.0* (575.00)	13410.70* (1105.50)
β	619.45* (115.54)	653.17^{NS} (498.14)	1.07* (0.02)	13.07* (10.35)	-1.65^{NS} (-)	3.05E18* (8.88E20)
k	-	-1.53^{NS} (21.99)	-	0.25* (0.11)	-0.0684 * (0.0162)	2.88* (19.81)
m	-	-	-	-	-	19.89* (139.40)
Test for randomness and normality of residuals						
Runs test Z	-2.234^{NS}	-2.234^{NS}	-2.682 ^{NS}	-2.234^{NS}	-2.682 ^{NS}	-2.234^{NS}

Shapiro-Wilk	0.971^{NS}	0.970^{NS}	0.967^{NS}	0.966^{NS}	0.967^{NS}	0.968^{NS}
The goodness of fit criteria						
RMSE	3049.71	3049.80	3200.30	2823.88	3200.30	2366.88
MAPE	38.77	39.27	36.31	35.59	36.31	30.57
AIC	340.96	342.95	342.98	339.73	344.98	334.31

* Significant at 5% level of significance, NS: Not Significant; Values in (.) indicate standard error

Based on the performance of model fit and goodness of fit criteria, Richard's model was chosen for predicting the trend values of arrivals of tender coconut. The predicted values of arrivals by Richard's model along with observed arrivals are presented in Table 3. From Table 3, it is very clearly evident that during the reference period, the annual arrivals in terms of the number of nuts transacted in the Maddur market over the years have shown an upward trend that was from 1826 to 13411 crore nuts during the periods of 1997-98 to 2017-18. Observed and predicted arrivals of tender coconuts by Richard's model for the period of 1997-98 to 2017-18 are plotted in Fig.1. In line with our study results, Mohan Kumar *et al*. (2012c) [9] reported that the Richard model was found to be the best-fitted model to describe the pattern of coffee export from India which revealed that the coffee export from India has an increasing trend.

3.2 Prices of tender coconut

The parameter estimates of all fitted models and their standard errors (Given in round bracket) for prices of tender coconuts are presented in Table 2. In the linear model, only the slope is found to be significant. With respect quadratic model all the parameters are found to be significant. Quadratic, Exponential, and Richard's models are significantly fitted to tender coconut prices, except the logistic and Gompertz models, which showed negative signs in some of the parameters. The null hypothesis was rejected when the 95% asymptotic confidence interval of the corresponding parameter estimate did not include zero. The main assumptions of 'independence' and 'normality' of error terms of each model were examined by using respectively the 'Run-test' and 'Shapiro-Wilk test', and test statistics along with probability values are presented in Table 2. Results revealed that the number of runs was found to be non-significant ($Z < 1.95$ or p-value > 0.05) and the Shapiro-Wilk statistic was also non-significant (P-value > 0.05) at 5% significance level for all six models fitted. Hence, the assumptions of randomness of residual and normal distribution of residual are satisfied.

The test statistic to check the goodness of fit of each model was computed using RMSE, MAPE, and AIC and they are presented in Table 2. In comparison with all other models, the Quadratic model produced the lowest value of RMSE (1040.31), MAPE (16.52), and AIC (297.79) indicating that the Quadratic fitted better than other models for prices of tender coconut in the Maddur market. On the contrary, the highest values of RMSE (1546.93), MAPE (32.11), and AIC (312.45) revealed that the linear model was less performed than other models. Based on the overall goodness of criteria the best-fitted model for prices could be ranked as follows: Quadratic, Exponential, Gompertz, Logistic, Richard's, and Linear models.

Based on the performance of model fit and goodness of fit criteria, the Quadratic model was chosen for predicting the trend values of prices of tender coconut. The predicted values of prices by the Quadratic model along with observed prices are presented in Table 3.

Table 3, clearly indicates that the price of tender coconut in the Maddur market has shown an upward trend over the years which increased to Rs. 11352.29 from Rs. 3227.61 per thousand nuts during the periods of 1997-98 to 2017-18. In a similar line to Mohan kumar *et al*., 2012b [8] reported that the area under coffee production in India has shown an upward trend. The graph of the trend value of prices over the years obtained by the quadratic model for the period of 1997-98 to 2017-18 is plotted in Fig.2.

Table 2: Parameter estimates and goodness of fit criteria by different models for prices (in Rs per thousand nuts) of tender coconuts for the period of 1997-98 to 2017-2018

Parameter	Models					
	Linear	**Quadratic**	**Exponential**	**Logistic**	**Gompertz**	**Richard's**
α	602.86^{NS} (735.91)	3556.99* (811.68)	1516.3* (278.50)	6.83E8* (1.25E8)	1053.9* (193.6)	88447.60* (2.49E8
β	406.23* (58.61)	-364.41* (169.94)	1.0989* (0.012)	450838 (-)	-1.4388 (-)	151255* (1.08E9)
k	-	35.029* (7.50)	-	0.094* (0.011)	-0.0943 (0.0107)	0.2767* (357.6)
m	-	-	-	-	-	2.9328* (3792.2)
Test for randomness and normality of residuals						
Runs test Z:	-3.580^{NS}	-2.682^{NS}	-3.131 ^{NS}	-3.133 ^{NS}	-3.130 ^{NS}	-3.132 ^{NS}
Shapiro-Wilk	0.939^{NS}	0.924^{NS}	0.962^{NS}	0.961^{NS}	0.961^{NS}	0.962^{NS}
Goodness of fit criteria						
RMSE	1546.93	1040.31	1173.49	1173.50	1173.49	1173.54
MAPE	32.11	16.52	21.90	21.91	21.90	21.91
AIC	312.45	297.79	300.85	302.85	302.80	304.85

* Significant at 5% level of significance, NS: Not Significant; Values in (.) indicate standard error

Table 3: Trend values of arrivals (Crore nuts) and prices (Rs per thousand nuts) of tender coconut by best-fitted models

Years	By Richard's model		By Quadratic model	
	Actual Arrivals	**Arrivals Trend values**	**Actual Prices**	**Prices Trend values**
1997-98	2888	1826	2400	2627.61
1998-99	4894	2111	2500	2968.29
1999-2000	4881	2439	3000	2779.03
2000-01	4982	2819	3500	2659.82
2001-02	4319	3258	3000	2610.67

2002-03	3797	3765	3400	2631.58
2003-04	2486	4351	3200	2722.56
2004-05	2903	5028	3100	2883.58
2005-06	4300	5811	3100	3114.67
2006-07	5452	6715	3500	3415.82
2007-08	6082	7760	3500	3787.02
2008-09	7993	8968	3200	4228.28
2009-10	10677	10361	4000	4739.61
2010-11	12916	11917	4000	5320.99
2011-12	16709	13126	4600	5972.43
2012-13	17062	13391	6000	6693.92
2013-14	11215	13410	10500	7485.48
2014-15	13603	13411	10000	8347.09
2015-16	17506	13411	10000	9278.77
2016-17	10018	13411	10000	10280.5
2017-18	8848	13411	10000	11352.29

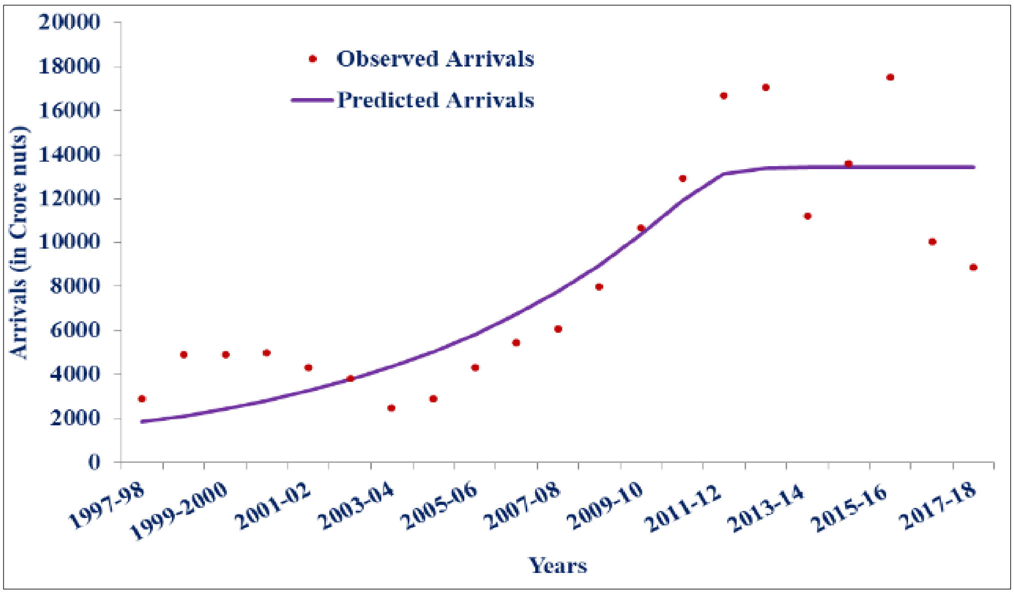

Fig 1: Observed and predicted arrivals of tender coconuts by Richard's model for the period of 1997-98 to 2017-18

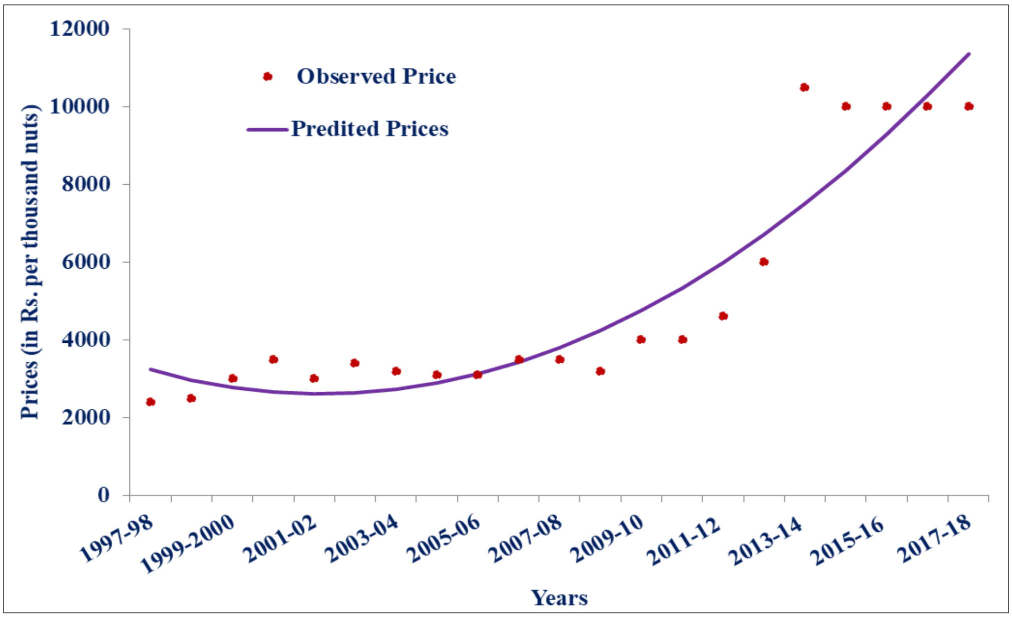

Fig 2: Observed and predicted prices of tender coconuts by Quadratic model for the period of 1997-98 to 2017-18

4. Conclusions

To analyze the trend in arrivals and prices of tender coconut in the Maddur market, three linear models *viz*. Linear (Straight line), Quadratic and Exponential models, and three nonlinear models *viz*. Logistics, Gompertz and Richard's were fitted to annual data on arrivals (In crore nuts) and prices (In rupees per thousand nut) for the period of 21 years i.e. from 1997-98 to 2017-18. The test statistic to check the goodness of fit of each model was computed using Root Mean Squared Error (RMSE), and Mean Absolute Percentage Error

(MAPE). Based on the lowest values of RMSE, MAPE and AIC values, Richard's model fitted better than other models for the arrivals, whereas the quadratic model was found to be best-fitted compared to other models for the prices of tender coconut in the Maddur market. Trend values obtained by the best-fitted model reveal that both arrivals and prices of tender coconut in the Maddur market have an upward trend.

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