



Research Article

TREND AND FUNCTIONAL ANALYSIS OF SUGARCANE AND SUGAR IN KARNATAKA STATE

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Abstract- The study was undertaken to analyses the trend and functional analysis of sugarcane production, sugarcane supplies to the factory, sugarcane price and sugar price in the Karnataka state. The data required for the study relating to the area, production and productivity of sugarcane, sugarcane price, sugar price, gur prices, installed capacity, rainfall, levy percent of sugar, SMP were sourced from cooperative sugar publications, DES, Bangalore and indiastats.com from 1985-86 to 2012-13. The data were analysed by using trend equations, multiple regressions, two-stage simultaneous equations and growth rate analysis. The results of the study found that, the sugarcane prices, factory supplies of sugarcane, sugar prices and sugarcane production were increasing trends with highly significant growth rates (8.39 %, 6.29 %, 5.48 % and 2.10 %, respectively) and also showed higher instabilities (66.54 %, 58.83 %, 49.96 % and 31.12 %, respectively) in the study period. These fluctuations were due to cyclical nature of sugarcane production which usually happens once in 2-3 years i.e. two year surplus production followed by deficit production of cane and also due to changing government policies like levy obligations, quarterly or monthly sugar release mechanism, influence of state government advisory price and export and import restrictions etc.

Keywords- Sugar, Sugarcane, Trend and functional analysis

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Introduction

Karnataka state is the fourth largest producer of sugarcane and third largest producer of sugar in the country. During 2012-13, the area under sugarcane in the state was 4.25 lakh hectares with a production of 357 lakh metric tonnes. The average sugarcane productivity in the state is around 85 tonne/ha with an average sugar recovery of 10.36 percent [1] Karnataka is bestowed with favorable agro-climatic conditions duly supplemented with suitable soils for sugarcane cultivation. In the state, there were a number of perennial rivers with dams, reservoirs, borewells and open wells to supply water for sugarcane cultivation. The northern part of the Karnataka state contributes a lion share in the sugarcane production by constituting 70-75 percent of total sugarcane production.

It is also a major provider of livelihood to millions of agricultural families and their dependents particularly in rural areas. About a million people in the state depend upon sugar industry, directly or indirectly. Apart from this, sugar factories are considered to be Welfare Centers in rural areas, as they give scope for establishment of educational institutions, hospitals, communication and transportation facilities etc [4]. In Karnataka, 61 sugar factories (23 in co-operative sector, 36 in private sector and 2 in public sector) are in operation of which 18 sugar factories are having distilleries (4 co-operative factories, 13 private factories and 1 public factory) with 16 distilleries having ethanol manufacturing facilities with a production capacity of 820 KL/day. As many as 36 sugar factories (27 in private sector, 8 in co-operative sector and 1 in public sector) are having co-generation units with installed power generation capacity of 950.20 megawatt [2]. The study has been undertaken to assess the trend and functional analysis of sugarcane (production, supply and price) and also the sugar prices in Karnataka state for the period from 1985-86 to 2012-13.

Methodology

The study has considered only secondary data for fulfilling the above objective and were sourced from Directorate of Economics and Statistics, Bengaluru and 'Cooperative sugar' publications and indiastats.com for gathering the data on area, production and productivity of sugarcane, sugarcane price paid by factories, sugar price, gur prices, installed capacity of the factories, quantity of export and import of sugar, total sugar production, opening stock of sugar, annual rainfall, competing crops (paddy price), levy percent of sugar and statutory minimum price (SMP) of sugarcane for the period from 1985-86 to 2012-13. The details of analytical tools used for the study are described in the following sub headings.

Trend Analysis

Depending upon the nature of data, linear and polynomial forms of trend equations were fitted to sugarcane price, sugar price, sugarcane production and cane supplied to the factories. The trend in these parameters was analyzed using time series data from 1985-86 to 2012-13 [10,3,6].

The linear and polynomial trend equations fitted to the data were of the following forms.

$$\text{Linear} \quad Y = a + bt + e \quad \text{-----}[1]$$

$$\text{Polynomial 4th order} : Y = a + bt + ct^2 + dt^3 + ft^4 + e \quad \text{-----}[2]$$

Where,

Y = Quantity of sugarcane production/ cane supplied to the factories/ sugarcane price/sugar price

t = Time period (years)

a = Intercept

b, c, d, f = Slope of variables

e = Error term

Multiple Linear Regression Analysis

Multiple regression analysis was carried out to estimate the sugarcane production and cane supplied functions using time series data for the period 1985-86 to 2012-13, [11].

The equation was used for estimating sugarcane production function:

$$S_p = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + u \quad \text{-----[1]}$$

Where,

S_p = Quantity of sugarcane production in the state (lakh tonnes)

X_1 = Sugarcane price lagged by one year (Rs.)

X_2 = Paddy (competing crop) price lagged by one year (Rs.)

X_3 = Total rainfall during production period (mm)

X_4 = Installed capacity of sugar factories in the state (lakh tonne crushed per day)

X_5 = Sugarcane area (lakh hectares)

u = Random error term

b_0, b_1, b_2, b_3, b_4 and b_5 = Parameters to be estimated

The equation for estimation of sugarcane supplies to the factories:

$$S_s = a_0 + a_1 Y_1 + a_2 Y_2 + a_3 Y_3 + a_4 Y_4 + u \quad \text{-----[2]}$$

Where,

S_s = Quantity of Sugarcane supplied to the factories in the state (lakh tonnes)

Y_1 = Sugarcane production in the state (lakh tonne)

Y_2 = Gurprice (Rs./qtl.)

Y_3 = Installed capacity of sugar factories in the state (Lakh tonnes per day)

Y_4 = Factory paid price (Rs./tonne)

u = Random error term

a_0, a_1, a_2, a_3 and a_4 = Parameters to be estimated

Two-Stage Least Squares (2SLS) Regression Analysis

Two-Stage least squares (2SLS) regression analysis is a statistical technique that is used in the analysis of structural equations. This technique is an extension of the OLS method. It is used when the dependent variable's error terms are correlated with the independent variables. Additionally, it is useful when there are feedback loops in the model. In structural equations modeling, we use the maximum likelihood method to estimate the path coefficient.

Two-Stage least squares (2SLS) regression analysis was employed to estimate the sugarcane and sugar price functions. Since, these two functions are interdependent with one another while estimating each equation. Thus, 2SLS technique was used to arrive at better result than multiple regressions [8].

Linear Equation for Sugarcane Price is,

$$SC_p = \alpha_0 + \alpha_1 S_p + \alpha_2 G_p + \alpha_3 TSS + \alpha_4 SMP + e_1 \quad \text{-----[Eq-1]}$$

Where, S_p is an endogenous variable

[Eq-1] Regress S_p on SC_p, G_p, TSS and SMP to obtain $\hat{X}_1$

$$\hat{X}_1 = \beta_0 + \beta_1 SC_p + \beta_2 G_p + \beta_3 TSS + \beta_4 SMP + e \quad \text{-----[Eq-2]}$$

Where SC_p is an instrumental variable

[Eq-2] plug in the fitted value of $\hat{X}_1$ from the [Eq-1] into the original regression equation:

$$SC_p = \alpha_0 + \alpha_1 \hat{X}_1 + \alpha_2 G_p + \alpha_3 TSS + \alpha_4 SMP + e_1 \quad \text{-----[Eq-3]}$$

Where, e_1 is composite error term that is uncorrelated with $\hat{X}_1, G_p, TSS$ and SMP

Linear Equation for Sugar Price,

$$S_p = a_0 + a_1 SC_p + a_2 TSS + a_3 L + a_4 NE + e_1 \quad \text{-----[Eq-4]}$$

Where, SC_p is an endogenous variable

[Eq-4] Regress SC_p on S_p, TSS, L and NE to obtain $\hat{Y}_1$

$$\hat{Y}_1 = b_0 + b_1 S_p + b_2 TSS + b_3 L + b_4 NE + e_1 \quad \text{-----[Eq-5]}$$

Where S_p is an instrumental variable

[Eq-5] Plug in the fitted value of $\hat{Y}_1$ from the [Eq-4] into the original regression equation:

$$S_p = a_0 + a_1 \hat{Y}_1 + a_2 TSS + a_3 L + a_4 NE + e_1 \quad \text{-----[Eq-6]}$$

Where, e_1 is composite error term that is uncorrelated with $\hat{Y}_1, TSS, L$ and NE

Where,

SC_p = Sugarcane price paid by the factory (Rs.)

S_p = Sugar price (Rs.)

G_p = Gur price (Rs.)

TSS = Total Supply of Sugar

(current year sugar production & opening stock in qty.)

SMP = Statutory Minimum Price (Rs.)

L = Levy proportion of sugar (%)

NE = Net sugar export

Results and Discussion

Trend in Sugarcane Production

The trend analysis revealed that high fluctuation was observed in sugarcane production in the state during the study period [Fig-1]. The wide variation was due to cyclical nature of sugarcane production which happens once in 2-3 years i.e. two year surplus production followed by deficit production of cane in the succeeding two/ three years [9]. Thus, during the period of 1992-93, 1997-98, 2003-04, 2008-09 and 2009-10 area under sugarcane showed declining trend due to the frequent occurrence of droughts and floods resulting in irregular supply of cane. On the contrary, during the years (1998-99 to 2002-03, 2005-06, 2006-07 and 2010-11), there was a considerable increase in sugarcane production owing to favorable monsoon.

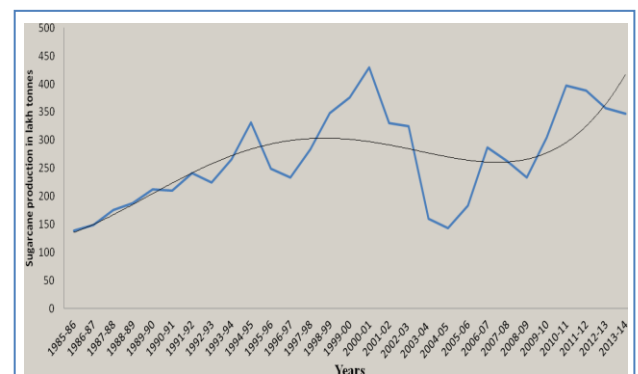


Fig-1 Trend analysis of sugarcane production in Karnataka

Trend in Sugarcane Supplied to Factories

The trend in sugarcane supplied to the factories in Karnataka state over the study period was found to be highly fluctuating. However, the linear trend equation showed high R^2 of 0.75 [Table-1]. The sugarcane supplied to the factories was influenced by sugarcane production in the state and the price paid by the factories over and above FRP to the sugarcane growers. However, during the study period, lower cane supplied to the factories was observed during the periods of 1991-93, 1995-97, 2001-04 and 2008-09 [Fig-2], which was attributed to decline in the production of cane. On the contrary, during the periods of 1993-95, 1997-01, 2006-07 and 2010-11, there was an increasing trend in sugarcane supplied to the factories due to higher production.

Trend in Sugarcane Price

Persistent increasing trend was observed in sugarcane price paid by the sugar

factories to the farmers with little fluctuation observed during initial period of the study [Fig-3]. The linear trend equation was found to be good fit with R^2 value of 0.81 [Table-1] and it was significant at one percent level of probability. The increasing trend in sugarcane price paid to the farmers by the factories was influenced by increasing trend in FRP announced by the Government of India over years. Further, additional revenue earned by the factories from the byproducts such as bagasse, molasses etc might have also prompted the factories to pay higher prices. Nevertheless, in the year 2009-10 there was a sudden increase in sugarcane price due to lower production of sugarcane at state and national level because of failing rains and diversion of cane for production of ethanol on account of Government policy (National Policy on Bio-fuel, 2009) for mandatory blending of 5 percent of ethanol with petrol [7].

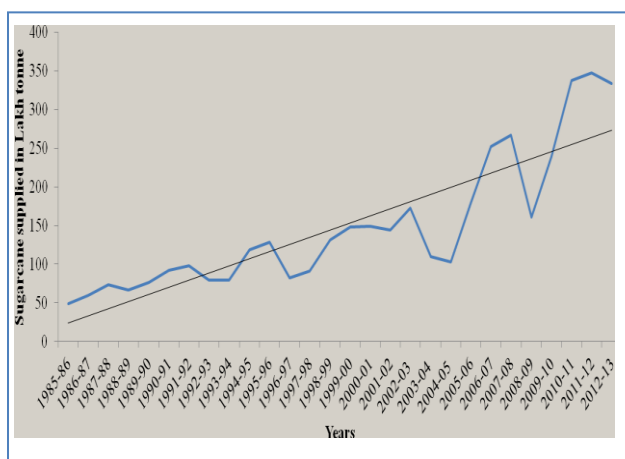


Fig-2 Trend Analysis of Sugarcane Supplied to Factories in Karnataka

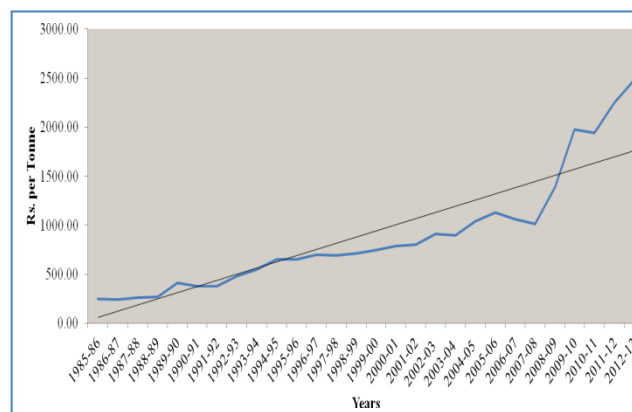


Fig-3 Trend Analysis of Sugarcane Price in Karnataka

Trend Analysis of Sugar Price

The sugar prices in the Karnataka state had shown increasing trend over the study period. The results showed a good fit of linear trend as shown in the [Fig-4]. Government was indirectly controlling the sugar prices through its dual pricing mechanism. In spite of government control, still a few ups and downs were observed in sugar prices due to surplus and deficit production of sugarcane. For example, during the year 2009-10, due to lower production, the price of sugar was high. This higher increase in prices in terms of index measures was to the extent of 52.14 percent and 17.17 percent in 2009-10 and 2010-11, respectively [1]. Further, Waughray, 2011 [5] stated that, Sugar's price broke record level in August, 2009 due to a combination of failing rains in India and Brazil, conversion of cane crops to ethanol fuels, projections of economic recovery, and a greater sweet tooth in Asia. Amplify all this with commodity investors, and price of sugar doubled in just six months.

Table-1 Estimated Trend Equations for Sugarcane Production, Cane Supplied to Factories, Sugarcane Price and Sugar Price

Sl. No.	Particulars	Parameter estimates					R^2	F value
		Intercept	T	T ²	T ³	T ⁴		
1.	Sugarcane production	124.94 (1.70)	8.11 (0.24)	2.59 (0.59)	-0.23 (-1.07)	0.004 (1.39)	0.50	6.11**
2.	Cane supplied to the factories	15.17 (0.87)	9.22** (8.83)	-	-	-	0.75	78.01**
3.	Sugarcane price	-71.53 (-0.68)	66.60** (10.66)	-	-	-	0.81	113.67**
4.	Sugar price	293.2* (2.05)	82.80** (9.98)	-	-	-	0.78	99.67**

Note: 1. ** and * - significant at one and five per cent.

1. Parenthesis indicates t- value

Table-2 Growth and Fluctuation in Sugarcane Production, Factory Supplies of Cane, Prices of Sugarcane and Sugar in Karnataka (1985-86 to 2012-13)

Parameters	Sugarcane production (lakh tonnes)	Sugarcane supplied to factory (lakh tonnes)	Sugarcane price (Rs./ tonnes)	Sugar price (Rs. /qtl.)
Growth rate	2.10**	6.29**	8.39**	5.48**
t- value	3.39	8.83	66.48	78.39
Mean	267.91	149.01	910.65	1474.11
Standard deviation	83.38	87.67	605.96	736.43
Coefficient of Variation (%)	31.12	58.83	66.54	49.96

** Significant at 1 per cent

Growth Rate and Fluctuation Analysis

Sugarcane production, cane supplied to the sugar factories, sugarcane price and sugar price have shown a very high positive significant growth rate during the study period [Table-2]. This was due to a number of factors such as increase in area under sugarcane, increase in the number of sugar factories, increase in the crushing capacity of sugar factories, encouragement of sugar factories towards modernization of mills etc. In the meantime, sugarcane prices paid by the factories and sugar wholesale prices in the state were on higher side and thus resulted in

higher growth rate observed for the above mentioned parameters. With respect to the fluctuation analysis, the CV was found to be highest in the case of sugarcane price (66.54%) followed by sugarcane supplied to the factories (58.83%), sugar price (49.96%) and sugarcane production (31.12%). The higher fluctuations in these parameters were mainly due to fluctuation in sugarcane production owing to non-payment of sugarcane price to the farmers and other natural factors.

Estimated Equations of Sugarcane Production

The estimated equation for sugarcane production in Karnataka state was found to have a good fit with R^2 value of 0.90 [Table-3] indicating that 90 percent of the variation in the total quantity of sugarcane production in the state was explained by the variables like sugarcane price paid by the sugar factories, area under sugarcane crop, installed capacity of the sugar factories, variation in the annual rainfall and price of the competing crop (paddy). It indicated that a unit increase in sugarcane area, installed capacity, total rainfall during production period and sugarcane price paid by factories would result in increase of 0.89 unit, 0.26 unit, 0.36 unit and 0.07 unit increase in sugarcane production, respectively. On the other hand, paddy was the competing crop, which had negative influence on the sugarcane production.

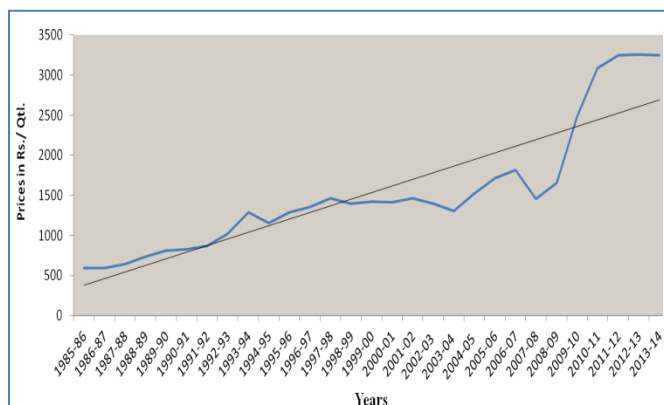


Fig-4 Trend Analysis of Sugar Price in Karnataka

Table-3 Estimated Equation of Sugarcane Production in Karnataka (1985-86 to 2012-13)

Particulars	Parameters Estimates
Intercept	3.7500** (3.9982)
Lagged sugarcane price	0.0738* (2.3567)
Paddy price	-0.2730 (1.6701)
Rainfall	0.3567 (1.4710)
Installed capacity	0.2581 (1.1507)
Sugarcane area	0.8962 ** (7.0391)
R^2 Value	0.90**
F-Value	15.97

Note: 1.** and* indicate the significance at 1 per cent and 5 per cent respectively
2. Figures in parenthesis indicate t-values

Table-4 Estimated Equation for Sugarcane Supply to the Factories (1985-86 to 2012-13)

Particulars	Parameters Estimates
Intercept	-0.7765 (-1.0518)
sugarcane production	0.5329** (3.6873)
Gur price	-0.0041 (-0.0003)
Installed capacity	0.7314** (4.0421)
Factory paid price	0.1328 (0.7921)
R^2 Value	0.90**
F-Value	55.82

Note: 1. ** Significance at 1 per cent
1. Figures in parenthesis indicate t-values

Estimated Equation of Sugarcane Supplied to Factory

The estimated equation for the sugarcane supplied to the sugar factories in the state during the study period [Table-4] showed good fit with R^2 value of 0.90 indicating that the variation in sugarcane supplied was explained by the variables like sugarcane production, installed capacity, price paid by the sugar factories and gur price to the extent of 90 percent. The variables such as current period

sugarcane production, installed capacity of the sugar factories and sugarcane price paid by the sugar factories showed positive influence. However, when the prices of gur increased, the farmers diverted cane to the jaggery manufacturing units resulting in decreased supply of cane to the sugar factories.

Estimated Equation of Sugarcane Price

Estimated equations of sugarcane price and sugar price were obtained using simultaneous equations method. The estimated equation for sugarcane price is presented in [Table-5]. The R^2 value was 0.82. Sugar price FRP had positive and significant impact on sugarcane price. However, the total stock of sugar available with the factories depressed the sugar price in the market as indicated by the negative coefficient for this variable. The coefficient of gur price was associated with negative sign contrary to expectation. However, the coefficient was statistically insignificant.

Table-5 Estimated Equation for Sugarcane Price in Karnataka (1985-86 to 2012-13)

Particulars	Parameters Estimates
Intercept	-746.937 (-0.7846)
Sugar price	2.5164* (2.4176)
Gur price	-1.6843 (-0.7167)
Total sugar supply (sugar production + opening stock of sugar)	-12.5544* (2.494)
FRP	6.4407* (2.549)
R^2 Value	0.82**
F-Value	27.83

Note: 1. ** and* indicate the significance at 1 per cent and 5 per cent respectively
2. Figures in parenthesis indicate t-values

Estimated Equation of Sugar Price

The estimated R^2 value of the equation for sugar price was 0.96, which was significant at one percent level of probability [Table-6]. Among the explanatory variables, sugarcane price paid by factory, the levy percent and net export were having positive influence on the dependent variable. While increases in sugarcane price naturally lead to increase in sugar price, increase in the levy percentage reduced sugar availability in the open market, which tended to push up sugar prices. The coefficient of net export indicated that increase in net exports would push up the domestic sugar prices. This coefficient however was not significant. The total supply of sugar had negative influence on the sugar price. Increase in the supply of sugar led to decline in the sugar price which is in conformity with law of demand and supply.

Table-6 Estimated Equation for Sugar Price in Karnataka (1985-86 to 2012-13)

Particulars	Parameters Estimates
Intercept	162.3610 (0.8901)
Sugarcane price	1.2160** (9.8003)
Total sugar supply	-2.7830 (0.3312)
Levy %	4.6387* (2.5723)
Net Sugar Export (Export - Import)	0.0038 (1.1942)
R^2 Value	0.96**
F-Value	139.83

Note: 1.** and * indicate the significance at 1 per cent and 5 per cent respectively
2. Figures in parenthesis indicate t-values

Conclusions

The results of the study indicated that, wide temporal fluctuations were observed in sugarcane prices, factory supplies of sugarcane, sugar prices and sugarcane production in Karnataka state as their analysis showed increasing trends, higher significant growth rates (8.39 %, 6.29 %, 5.48 % and 2.10 %, respectively) and higher instabilities (66.54 %, 58.83 %, 49.96 % and 31.12 %, respectively) in the study period. These fluctuations were due to cyclical nature of sugarcane production which happens once in 2-3 years i.e. two year surplus production followed by deficit production of cane in the succeeding two/ three years and also due to government policies like levy obligations, quarterly or monthly sugar

release mechanism, announcement of Fair and Remunerative price (FRP) /State Advisory Price (SAP) and export and import restrictions etc. Hence, these fluctuations were need to be tackled by assuring farmers a best price and quick payment and strengthening irrigation supportive schemes etc. the factories are also need to be strengthened with greater crushing capacity and proper working condition to avoiding delay in cane crushing and also to make quick payment to the cane growers and encourage for following staggered planting and harvesting of cane.

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Author Contributions

1. Dr. Ganeshgouda I. Patil, Ph. D scholar – undertaken research work, data collection, analysis and paper writing
2. Dr. S. B. Mahajanashetti, Chairmen, assisted in analysis and paper writing
3. Mr. Somanagouda I. Patil, Assisted in data collection and analysis of the Data

Abbreviations

SMP- Statutory Minimum Price

FRP- Fair and Remunerative price

SAP - State Advisory Price

CV - Co-efficient of variation

DES – Directorate of Economics and Statistics

KL/day– Kilo litter per day

2SLS - Two-Stage Least Squares

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of Interest: None declared

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