Research Article

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Analysis of growth rate and supply response of cocoa in Tamil Nadu, India: Nerlovian adjustment model

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Abstract

The present study focussed on the growth rate of area, production and productivity of cocoa in Tamil Nadu and estimated the impact of cocoa allocation decision, price variation and its supply in selected districts. The study employed the CAGR, Nerlovian model using the secondary data from 2011-12 to 2020-21. A positive significant growth in the area (40.24%) and production (34.60%) was witnessed in the Coimbatore district, while Thanjavur district showed a decline in the growth rate of cocoa. The area response concluded by lagged values of area and price significantly influenced the current year area in Coimbatore. The lagged productions were positively significant for both the districts and inferred that the increase in the price with one per cent level with the respective rise in price variability in Coimbatore district and opposite trend in Thanjavur district. The study suggested improving cocoa productivity and smoothing out variability in domestic prices can help boost farmers' confidence in cocoa cultivation. The government provided the subsidy for transportation of the beans from one place to another, procurement centres in cocoa growing districts in Tamil Nadu and supplying the HYV to increase production, developing crop insurance schemes for cocoa during uncertain conditions and establishing facilities for the distribution of beans through Farmer Producer Companies (FPO), as well as attracting foreign consumers by improving bean quality.

Keywords: Cocoa, growth rate, Nerlovian adjustment model, price, production, supply response

Introduction

Cocoa (*Theobroma cacao* L.) is a native of South America, and it entered India during the 20th century. In India, cocoa has been grown commercially since the early 1970s. It was mostly grown as an intercrop (70% of the total cocoa area) within coconut and areca nut plantations rather than monocrop. India ranks 38th position (0.28%) in the export of cocoa (APEDA, 2020). Cocoa is cultivated in the states of Andhra Pradesh, Kerala, Karnataka, and Tamil Nadu, with a total production of 27,072.15 MT from 1,03,376 ha in the year 2020-21. Tamil Nadu increased cocoa production by three folds; this could be attributed to an increase in area from 21 thousand hectares to 32 thousand hectares during the past decade (DCCDB, 2021). The state also increased its share from 1.1 per cent to 10 per cent of the nation's cocoa production. India provided the scope for improving cocoa cultivation under the Mission for the Integrated Development of Horticulture (MIDH) in the year 2014-15, with the objective of enhancing the farmer's income through integrated innovations in the cultivation of horticultural and perennial crop plantations. As cocoa production has been increasing over the years, it is essential to study the behaviour of supply and responsiveness of farmers, *i.e.,* whether the increase in production is due to extensive or intensive cultivation and other factors responsible for the increase in area and yield, which in turn contributes to the increase in the output supply (Patil *et al*., 2014).

Empirical studies have been conducted on the supply response and growth of areas under cocoa. Jeyalakshmi (2010) inferred that lagged values of price and area factors are responsible for the acreage response of sugarcane, and Patil *et al.* (2012) found that an increase in the price of arecanut leads to an

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increase in production, bringing more area under cultivation. The recent studies of Ganga Devi and Jadav (2020) suggested that increasing the trend in price, yield, and lagged area would help farms for expansion of cultivation. Jaweriah *et al*. (2020) concluded that farmers' response in the allocation of farms is significant to price index over the short and long run.

According to data published by the State Department of Horticultural and Plantation crops, cocoa was cultivated in Coimbatore, Thanjavur, Dharmapuri, Dindigul, Erode, Kanyakumari, Selam, Namakkal, Thiruppur and Theni districts of Tamil Nadu, since 2011 onwards. The present study was conducted to know the growth rate of area, production, and productivity of cocoa in Tamil Nadu and to estimate the impact of allocation decisions and price variation on the supply of cocoa beans in the selected districts.

Materials and methods

The present study was conducted based on secondary data on area, production and productivity in India from 2011-12 to 2020-21. The share of major cocoa-producing states of India was analysed by the triennium average ending 2020-21. Data were collected for major districts growing cocoa, namely Coimbatore, Thanjavur and overall Tamil Nadu State, for the last 10 years. Secondary data were collected from various sources *viz.,* Directorate of Cashewnut and Cocoa Development Board (DCCDB), Kochi and Department of Horticulture and Plantation Crops, Tamil Nadu. The rainfall data for 2021 was collected from Indian Meteorological Department. This variable was considered an appropriate surrogate for the weather (Gajanana, 1985). The farm harvest price 2021 was obtained from the Directorate of Economics and Statistics (www.dacnet.nic.in). The collected data were analysed using R software and the following tools.

Compound annual growth rate (CAGR)

The compound growth rates for the area, production and productivity of cocoa in Coimbatore, Thanjavur and overall Tamil Nadu state for the period of last 10 years (2011-12 to 2020-21) were estimated using the exponential growth function of the form given by George and Raju (2021).

$$\mathbf{Y = ab^t u_t}$$

Where,

Y= area, production and productivity of cocoa

a = Intercept

b = Regression coefficient

t = Time variable for the last decade (2011-12 to 2020-21)

u_t = Error term

The equation was estimated after transforming the above equation into a logarithmic form:

$$\ln Y = \ln a + t \ln b + \ln u_t$$

Then, the per cent CGR (g) was calculated using the relationship;

g = {antilog of (ln b)-1} *100

Supply response model

The supply responses of cocoa in selected districts, *viz.,* Coimbatore and Thanjavur, were estimated by the Nerlovian model (Braulke, 1982). To examine the responsiveness of supply and cocoa growers' decision on area allocation under cocoa, Nerlovian Lagged Adjustment Model was used in the following three econometric equation models. The supply behaviour of cocoa farmers depends on price and non-price factors, including prices of competing crops, rainfall, *etc*. A thorough knowledge of the supply responses of cocoa and the implications of policies will be useful for planning cocoa area allocation and production in the selected districts.

$$\text{Log } A_t = \log a_0 + a_1 \log p_{t-1} + a_2 \log P_{t5ma} + a\text{-}_1 \log R_t + a_4 \log A_{t-1} + e_t \quad \ldots\ldots (1)$$

$$\text{Log } Q_t = \log a_0 + a_1 \log p_{t-1} + a_2 \log R_t + a_3 \log Q_{t-1} + e_t \quad \ldots\ldots (2)$$

$$\text{Log } Y_t = \log a_0 + a_1 \log p_{t-1} + a_2 \log R_t + a_3 \log Y_{t-1} + e_t \quad \ldots\ldots (3)$$

Where,

A_t = Area under cocoa in the current year (ha)

Q_t = Production of cocoa in the current year (qtl)

Y_t = Yield of cocoa in the current year (qtl ha^{-1})

P_{t-1} = Farm harvest price of cocoa lagged by one year (₹ qtl^{-1})

P_{t5ma} = 5-year moving average price of cocoa (₹ qtl^{-1})

R_t = Total rainfall in the current year (mm)

A_{t-1} = Area under cocoa lagged by one year (ha)

Q_{t-1} = Production of cocoa lagged by one year (ton)

Y_{t-1} = Yield of cocoa lagged by one year (ton ha^{-1})

The method of least squares was used to estimate the regression coefficients, and the student 't-test' was used as empirical criteria to test the significance of regression coefficients.

Short-run and long-run elasticity

In the case of the log-linear form of Nerlove's model, regression coefficients of the price of variables represent their short-run elasticities. The long-run elasticities were computed by dividing short-run elasticities with their corresponding coefficients of adjustments. The adjustment mechanism was examined by applying the formula $(1\text{-}B)^N = 0.05$, where 'B' is the coefficient of adjustment derived from the regression coefficient of lagged dependent variable and 'N' is the number of years required to realise the gains of 95 per cent price effect. Durbin- Watson's test was applied to test the incidence of autocorrelation.

Descriptive analysis

Descriptive analysis was carried out to analyse the percentage share of cocoa production in India with a triennium average ending 2020-21 in terms of metric tonnes.

Results and discussion

The results were discussed in three sections, *viz*., major states of cocoa cultivation, growth rate analysis and supply response model.

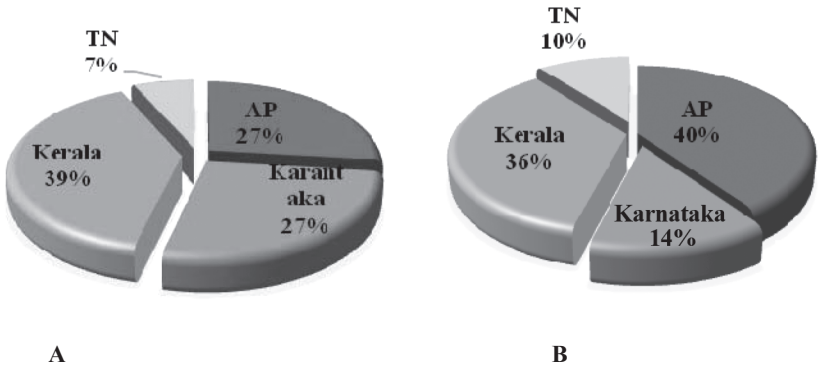
Major states of cocoa cultivation in India

The climatic condition in India is suitable and adaptable for cocoa cultivation as an intercrop with coconut and arecanut crops as well as monocrop in India. The percentage share of major states growing cocoa in India was calculated by the triennium average ending 2020-21 to identify the ranking of states in terms of metric tonnes by percentage analysis, which is represented in Table 1. The state-wise percentage share of cocoa production during the last decade (2011-12 to 2020-21) is given in Figure 1.

Table 1. Share of major states of growing cocoa in India 2020-21

Sl. No.	States	Cocoa production (MT)	Per cent share (%)	Rank
1.	Andhra Pradesh	10300.73	40.22	1
2.	Kerala	9114.03	35.59	2
3.	Karnataka	3534.03	13.80	3
4.	Tamil Nadu	2663.15	10.40	4
	Total	25612.05	100	

Source: Department of Horticulture and Plantation crops, Tamil Nadu



A B

Fig. 1. Percentage share of cocoa production in India during 2011-12 (A) and 2020-21 (B)

The total cocoa production in the triennium average ending 2020-21 was 25612 MT. Table 1 showed that Andhra Pradesh accounted for the highest percentage share (40.22%) of cocoa production in the triennium ending 2020-21 and ranked first place, followed by Kerala (35.59%), Karnataka (13.80%) and Tamil Nadu (10.40%).

Figure 1 depicts the percentage share of cocoa production in four major states of India. In the case of Tamil Nadu, the percentage share was increased from 7 per cent with 1000 MT of production in 2011-12 to 10 per cent with the production of 2802.45 MT in 2020-21. It showed around 1.8 fold increase from the last decade and revealed a wide scope for the increasing area under cocoa and to increase its production in the state.

Growth rate analysis

The two major cocoa-growing districts, Coimbatore and Thanjavur in Tamil Nadu, were considered for the study for 10 years from 2011-12 to 2020-21. The compound annual growth rate was analysed for two major districts and overall Tamil Nadu, and the results are presented in Table 2.

Table 2 shows that the average cocoa production in Tamil Nadu was 1773 MT with a growth rate of 13.03 per cent per annum, and the average area under cocoa was 27383 ha with a growth rate of 4.43 per cent per annum. Both production and area indicated a positive growth rate and statistical significance. It showed that the production of cocoa over the period of time was increasing. The mean cocoa production in the Coimbatore district was 632.07 MT with an extent of 360.5 ha, and productivity was 1.95 MT ha^{-1}. The growth of area and production registered a positive growth rate of 40.24 per cent and 34.60 per cent per annum and was statistically significant at a 5 per cent level. In comparison, a negative growth rate of -3.99 per cent per annum was seen in productivity. In the case of Thanjavur district, the average cocoa area was 392 ha with a production of 710.56 MT, and the productivity was 1.57 MT ha^{-1}. The area, production and productivity witnessed a decline growth rate of -23.84 per cent, -30.02 per cent and -8.73 per cent, respectively. This might be because of the natural disaster in the Thanjavur district.

Supply response of cocoa

Supply response of cocoa was estimated using the secondary data based on the area in hectares, production in metric tonnes and productivity in MT ha^{-1} for selected districts in Tamil Nadu state for 2011-12 to 2020-21.

The area, production and yield response of cocoa were analysed using the Nerlovian lagged adjustment model, and the results are presented in Table 3. The result examined the impact of variation in selected explanatory variables on dependent variables. The result of the Durbin-Watson test showed that the computed 'd' statistics were greater than d_u at a 1 per cent level, indicating no positive first-order serial correlation.

Area response

The result of the area response function revealed that R^2 values were 0.93 for Coimbatore

Table 2 Growth rate of area, production and yield of cocoa (per cent per year)

Sl. No.	Particulars	Coimbatore		Thanjavur		Tamil Nadu	
		CAGR	CV	CAGR	CV	CAGR	CV
1.	Area (ha)	40.24**	13.7	-23.84***	7.52	4.43***	1.30
		(360.5)		(392)		(27383)	
2.	Production (MT)	34.60**	14.6	-30.02***	9.40	13.03***	3.61
		(632.07)		(710.56)		(1773)	
3.	Productivity (MT ha^{-1})	-3.99**	1.51	-8.73*	4.01	8.23***	2.65

Figures in parentheses indicate mean value; ****, ** indicate significance at 1 and 5 per cent levels*

CAGR: Compound annual growth rate; CV: Coefficient of variance

Table 3. Area, production and yield response of cocoa in major districts

Sl. No.	Factors	Coimbatore response			Thanjavur response		
		Area	Production	Yield	Area	Production	Yield
1.	Intercept	72.72 ***	14.156	3.964	-7.553	17.391	14.97 ***
		(16.33)	(26.15)	(4.07)	(16.67)	(14.42)	(3.39)
2.	A_{t-1}	0.239 *			0.390		
		(0.14)	-	-	(0.66)	-	-
3.	Q_{t-1}		0.618 *			0.889 ***	
			(0.27)	-	-	(0.23)	-
4.	Y_{t-1}			0.050			0.610 ***
		-	-	(0.41)		-	(0.11)
5.	P_{t-1}	-7.360 ***	-1.446	-0.082	1.794	-2.492	-2.451 ***
		(1.54)	(2.40)	(0.37)	(2.11)	(1.45)	(0.36)
6.	P_{t5ma}	0.275 ***			-0.115		
		(0.053)	-	-	(0.108)	-	-
7.	R_t	0.108	0.712	-0.032	-0.848	1.320	1.649 ***
		(0.42)	(0.96)	(0.15)	(1.27)	(1.28)	(0.32)
8.	R^2	0.935	0.526	0.014	0.709	0.779	0.931
9.	'd' statistics	17.90	2.22	0.029	3.045	7.043	27.01

Figures in parentheses indicate standard error

***, * indicate significance at 1 and 10 per cent levels

and 0.71 for Thanjavur, indicating determinants in the area response function have given a good fit model, which could explain 93 and 71 per cent variation in the dependent variable. The lagged value of the previous year's price had a positive influence. It showed insignificance in Thanjavur district, revealing that lagged year price and rainfall were insignificant on the current year area of the crop (Parvathidevi and Ravichandran, 2014) and had negative and significant in Coimbatore district influences on the current acreage of crop. It implied that the cocoa growers in Thanjavur district were responsive to a decision on area allocation, which suggests that the cocoa area should be expanded with support and remunerative price policy under suitable climatic conditions. The average of the previous five years' crop prices influenced the current year's area in the Coimbatore district. The moving average price movements influenced the price fluctuations of cocoa, which in turn influenced the allocation of the area under a particular crop in both districts. The coefficients of rainfall were positive and insignificant for both districts. The multiple regression results showed that the area under the crop in lagged year area is positive and found significant even at a 1 per cent level.

Production response

The explanatory variables of the production response function explained the 52 per cent and 78 per cent variation in production on the dependent variable. The lagged production coefficients were found to be positive and significant for both districts on the current year's production, and the result implied that the farmer approach was traditional in making production decisions; they responded to price variations in terms of resource allocation. However, a remunerative policy and favourable prices would increase cocoa production. There were no significant and positive values for rainfall coefficients in both districts. The price of cocoa during the previous year showed negative influence and insignificance on the current year on production and negatively influenced production due to price fluctuations.

Yield response

As the result of area and production response, the R^2 of yield response function inferred that the selected determinants of current productivity of both districts were capable enough to explain the variance adequately. The coefficients of lagged yield on the previous year and rainfall were a positive influence and statistically significant on the current year on yield of Thanjavur district. The cocoa price of lagged values negatively influenced current year yield for both districts. The lagged price of cocoa was statistically significant at a 10 per cent level. The lagged yield positively influenced the current year yield, rainfall negatively influenced the current year yield, and both were insignificant in the Coimbatore district.

Price elasticities and coefficient of adjustment

The price elasticities and coefficient of adjustment obtained are presented in Table 4 for acreage under cocoa and yield of two major districts. The price coefficient of the Coimbatore area and Thanjavur yield was statistically significant, while others were not significant.

The price elasticities were found to be the positive value of price variability of the area in Thanjavur district, denoting that for every one per cent increase in price, the additional area brought under cocoa would be increased by 1.79 per cent in the short run and by 2.94 per cent in the long run. Except for area, in Thanjavur district, others were found to be a negative sign of price variability, indicating that for every one per cent increase in price, additional area brought under cocoa would decrease by 7.36 per cent in the short run and by 9.68 per cent in the long run. The marginal productivity of cocoa would be decreased by 0.08 per cent in the short and long run in Coimbatore district, while in the Thanjavur district, it would be decreased by 2.45 per cent in the short run and by 6.28 per cent in the long run. The results were antipodal with each other, and the negative significant coefficients of the price variable were commensurate with Patil *et al*. (2012). The number of years 'N' required to adjust the area to the expected level was 2.094 and 3.184 years for Coimbatore and Thanjavur, respectively, which indicated that farmers took too many years to back to the cultivation of cocoa (Preethi and Ravichandran, 2022).

Conclusion

The study noted the declined growth rate of area, production and productivity due to the natural disaster ('Gaja cyclone') in Thanjavur district. In contrast, in the Coimbatore district, the same had registered a positive and significant growth rate of area and production with the quality of cocoa beans. The acreage response was positively influenced by the current year's area of cocoa in Thanjavur district and had a negative on the current area in the Coimbatore district, which implies that cocoa growers in Thanjavur district were responsive to the decision on area allocation, which suggests that the cocoa area be expanded with the presence of support and remunerative price policy under suitable climatic conditions. The lagged production was positive for both districts on current year production, and the cocoa price influenced farmers' responsiveness which negatively influenced production. The study concluded that price and non-price factors are antipodal with each other, and the area to the expected level was found to be 2.094 and 3.184 years for Coimbatore and Thanjavur, respectively, which indicated that farmers took too many years to back to the cultivation of cocoa.

Table 4. Coefficient of adjustment and estimated price elasticities

Sl. No.	Price elasticity/B	Cocoa area		Cocoa yield	
		Coimbatore	Thanjavur	Coimbatore	Thanjavur
1.	Short run	-7.360	1.794	-0.082	-2.451
2.	Long run	-9.675	2.943	-0.087	-6.283
3.	B	0.761	0.610	0.950	0.390
4.	N	2.094	3.184	1.001	6.060

'B' refers to the coefficient of adjustment

'N' refers to the number of years required to gain 95% of the price effect

Policy Implications

Indonesia and Malaysia currently dominate the Asian cocoa market. In this background, the present study suggests that enhancing cocoa productivity is important to increase cocoa production in India. In addition, the study also agreed with the fact that smoothing out variability in domestic cocoa prices could help boost farmers' confidence in the cultivation of the crop (George and Raju, 2021). The Directorate of Cashewnut and Cocoa Development (DCCD) Board must motivate the farmers to increase the area under cocoa cultivation based on the suitability of agro-climatic factors as intercrop either in coconut or arecanut gardens.

The findings of this study suggest that the government must facilitate, through the Commodity Boards, smoothening the supply chain, especially for marketing the produce from cocoa farmers. In this regard, establishing facilities for the distribution of cocoa beans through Farmer's Producers Companies (FPO) and attracting foreign consumers by improving bean quality would also help the Commodity Boards in their planting process. At the same time, the State Department of Horticulture and Commodity Boards need to implement specific schemes for expanding high-yielding varieties of cocoa to increase production and encourage crop insurance schemes for cocoa to reduce impacts due to risks and uncertainties.

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