Estimating Determinants of Sugarcane Production in Bihar : An Empirical Analysis

Aditi [1]
Raviranjan Kumar [2]
Rathi Kanta Kumbhar [3]

Abstract

Purpose : The present study focused on identifying the factors that influence sugarcane production in Bihar. The increasing significance of cash crops such as sugarcane in the nation led us to examine the factors influencing sugarcane output in Bihar, one of the top-producing states of India, prior to its independence.

Methodology : To analyze the time series data on Bihar's sugarcane output, the area under cultivation, and sugar factories from 1950–1950 to 2020–2021 multiple linear regression model (MLRM) was used. When the number of sugar factories and the area under cultivation served as the explanatory factors, and production was the dependent variable.

Findings : We found that the area under sugarcane and the number of operational sugar factories had an impact on sugarcane production. Both explanatory factors were found to be favorably connected to the dependent variable. Hence, the number of sugar factories and areas under sugarcane were important determinants of sugarcane production.

Originality : In contrast to other studies on the factors influencing sugarcane output, the current work developed a model to investigate the variables influencing sugarcane production in Bihar.

Practical Implications : Industrialists should take note of the study's significant implications, and policymakers should use the study's results to promote laws that encourage sustainable sugarcane farming methods and the expansion of Bihar's industry as a whole. Although our study has limitations, it leaves room for more research because more variables might be taken into account.

Keywords : sugarcane, production, sugar mills

JEL Classification Codes : Q19, E23, L66

Paper Submission Date : August 10, 2023 ; Paper sent back for Revision : January 20, 2024 ; Paper Acceptance Date : February 10, 2024

Sugarcane is a major crop cultivated commercially in over 120 countries globally and ranks as the second-largest producer in the world, and India holds that position (Kulshrestha & Agarwal, 2019; Rajput et al., 2021). Sugarcane and the sugar industry are important in the Indian economy, trade, and life. It impacts the livelihoods of approximately five crore farmers and their dependents who cultivate sugarcane on nearly 50 lakh hectares in India. Sugarcane cultivation is primarily divided into the north zone and the south zone. India initiated sugar production by crushing sugarcane to extract, pressing its juice, and boiling it to obtain crystals (Umarani & Nithya, 2013).

Sugarcane, a major industrial crop in Bihar, held the distinction of being the highest sugar-producing state next

[1] *Ph.D. Scholar,* Central University of South Bihar, Gaya - 824 236, Bihar. (Email : aditi@cusb.ac.in)
[2] *Ph.D. Scholar,* Central University of South Bihar, Gaya - 824 236, Bihar. (Email : r.ranjan95048@gmail.com)
[3] *Professor,* Central University of South Bihar, Gaya - 824 236, Bihar. (Email : rathikanta@cusb.ac.in)

DOI : https://doi.org/10.17010/aijer/2024/v13i1/173415

to the UP during the years 1939–1940. The establishment of the first sugar mill spanned the period from 1904 to 1932. It is worth noting that during the early period of 1914 century, Bihar only contributed up to 40% of the sugar production of the country (Singh et al., 2021). At the time of independence, Bihar had 28 sugar mills. However, the current number of operational sugar factories in the state has diminished to just 11, with an additional two mills closing down after 2020 Sugarcane Industries Department, Bihar. (n.d). In addition, farmers who grow sugarcane encounter a number of difficulties, such as low pricing for the crop, high production costs, late payments, and a shortage of labor (Patil & Mahajanashetti, 2017). Therefore, it is imperative to investigate the contribution of sugar mills to Bihar's sugarcane production.

Only a few numbers of studies have been conducted to investigate the factors that influence sugar production in the state of Bihar. Most studies assert that climatic change and the shortage of skilled workers influenced sugarcane output. Understanding the factors affecting sugar production in Bihar, such as the number of operational sugar mills and the extent of sugarcane crops, was crucial. The purpose of this article was to close the gaps that were found and identify the main predictor of Bihar's sugar output. Therefore, applying a multiple linear regression model (MLRM) is the best way to examine the important variable.

Review of Literature

Green Revolution was marked by a significant increase in agricultural production, particularly of wheat and rice, but did not witness a similar surge in sugarcane production (Khosla, 2012; Ouattara et al., 2022). Despite numerous studies focusing on sugarcane monitoring to boost production and the socio-economic determinants that affect sugarcane production (Som-ard et al., 2021). However, these determinants are often classified into various factors, including socio-economic, bio-physical, institutional or external, and individual categories (Lavanya & Manjunatha, 2019). The vast majority of these approaches are not related to the MLRM.

The variability in sugarcane area, production, and yield carried significant consequences for the supply of cane to sugar mills, affecting the duration of sugar production and ultimately affecting the income and livelihood security of farmers. These fluctuations depend on a range of factors, encompassing the provision of farm inputs, comparative cost benefit, the relative profitability of crops, government pricing strategies, infrastructural facilities, prevailing weather, and climatic conditions (Gangwar et al., 2014). In Thailand, Suchato et al. (2021) used a probit model to examine the factors influencing farmers' decisions to switch from rice to sugarcane farming. The result showed that farm size, crop conversion experience, sugarcane price, household assets, and sugarcane price guarantee significantly influence the farmers' land use decisions. Major constraints were the burden of loans and unclear support policies, which critically decreased the probability of switching to sugarcane production. Nidheesh (2010) and Singhal et al. (2023) used the autoregressive distributed lag model and found that natural calamities like drought, flood, and cyclones have a severe impact on agriculture production in India. This impact led to a decline in farm income and forced the farmers to shift from rural agriculture to urban labor. In Keyna, Murunga (2021) identified key determinants influencing sugarcane production, including the extent of sugarcane cultivation, total fertilizer, pesticides and insecticides use, human labor, tractor labor, and the quantity of seed cane employed. The chi-square test confirmed a significant correlation between farm size and the profitability of sugarcane farming, attributed to increased sales resulting from higher production. Lavanya and Manjunatha (2019) identified the micro-level decisions made by sugarcane farmers in India. By using descriptive statistics and heuristic decision-making theory to understand the decision-making process of sugarcane farmers key factors were identified influencing these decision interest rates on credit, land availability, credit availability, price, expected profit, market, and water availability. In Keyna, a study conducted by Owino (2018) investigates the socio-economic factors influencing sugar production in the Nyando sugar belt by applying a multiple regression model. The finding indicated that variables such as gender and input costs (covering land preparation, fertilizer application, weeding and weed control, as well as seed cane and planting expenses) exhibited substantial and positive effects on sugar output. Dwivedi et al. (2023) analyzed the factors influencing sugarcane production and the policy implications in India's primary sugarcane-producing state. The study found that there was a significant relationship between the area and sugarcane output. Additionally, they observed that rainfall and fair and remunerative prices (FRP) had a weakly positive association with production.

Objective

The purpose of the study is to estimate the coefficients of determinants of sugarcane production using a data set over time from 1950–1951 to 2020–2021.

Methodology

The study gathered information from secondary sources using a quantitative research methodology. From 1950–1951 to 2020–2021, the Indian Council of Agricultural Research–Sugarcane Breeding Institute, Coimbatore, Bihar, provided secondary time series data on sugarcane land, production, and the number of sugar mills. The secondary data is used to fulfill the objective of the study. The data were analyzed using an econometrics model.

Economic models usually consist of a single dependent variable and two or more independent variables, and these models are commonly known as multiple regression models (Gujarati & Porter, 2007). Several independent or predictor variables and a dependent or criterion variable are the subjects of the primary goal of multiple regression, a term first used by Pearson in 1980.

About Data, the Data Source, and Its Reliability

The research employed 71 years of time series data, spanning from 1950–1951 to 2020–2021, regarding sugarcane production in thousand tons (Production), the area planted with sugarcane in thousand hectares, and the count of companies that are currently in operation or engaged in the manufacturing of sugar. According to the objective of the study, production is the dependent variable, and area and factories are explanatory variables. This study uses the MLRM to analyze the data set with the help of E-views 10 software packages. The ordinary least square (OLS) method is used to regress the model. The OLS method gives the best and most unbiased estimated coefficients. One method for data analysis is regression, which is used to describe and examine the causal and functional relationships between variables. A model or equation was used to express the relationship between the variables. The calculated coefficients show how changing the explanatory variable by one unit affects the dependent variable Greene (2003). The following is how we have defined our MLRM model in order to meet the study's goal:

$$Production_t = \alpha + \beta_1 Area_t + \beta_2 Factories_t + u_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Here, *Production* is the dependent variable, t is the year, and area and factories are the explanatory variables. α is the intercept, and β is the coefficient of explanatory variables. u_t is a disturbance term.

We have a time series data set, so the time series variables need to be stationary or satisfy the three conditions that are:

$$E(Y_t) = \mu = \text{constant for all } t, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$\text{Var}(Y_t) = \sigma^2 = \text{constant for all } t, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$\text{Cov}(Y_t, Y_{t-s}) = \Upsilon_s = \text{constant for all } t \neq s. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

The time series variable must meet all three of these criteria to be considered stationary. Otherwise, the estimated t-value produced by the OLS technique will not be accurate, even though there may not be any correlations between the variables. This issue is known as spurious regression. Therefore, before using the OLS approach, we must first determine whether or not the variables are stationary. If not, we must use a different cointegration method and error correction mechanism (Engle & Granger, 1987). To examine the factors that affect the production of sugar. In order to accomplish the goal, we first validated all of the equation's essential tools, including the estimated regression model of the data's R-squared goodness of fit metrics. It should be in the range of 0 and 1. When the value is close to 0, the explanatory variables have not contributed significantly to the understanding of the variation in the dependent variable; however, when the value is close to 1 or higher, the estimated equation has a good fit and contributes significantly to the understanding of the dependent variable. When an estimated coefficient is statistically significant, the null hypothesis is rejected; conversely, when it is statistically insignificant, the null hypothesis is accepted. The estimated model's regression's overall significance is examined using the F-test. Statistical significance for the F-test is considered up to a 5% level. The estimated F is statistically significant when p-value > 0.05 (Bhaumik, 2015).

Analysis and Results

From 1950–1950 to 2020–2021, we have time series data on the output of sugarcane, the area that is planted with the crop, and the factories in Bihar. To apply the OLS regression approach, we must first confirm that the series is stationary before doing any regression analysis. We can examine for unit roots or non-stationarity in each of these three series separately by using the Augmented Dickey–Fuller (ADF) test.

ADF Test for Production

The estimated t-value (–3.558279) is bigger than the crucial t-value and statistically insignificant (p-value –0.8230), indicating that the level of the production series is non-stationary. Since production has a unit root, we accept the null hypothesis and draw this conclusion. We repeat the test to confirm the stationarity in the initial difference. The calculated t-value for the first difference (–9.859097) is less than the crucial threshold at the 1% level (–3.528515). We then rule out the null hypotheses and conclude that the production series is stationary in the first difference form at the 1% level (p-value = 0.000).

ADF Test for Area

The area series has a non-stationary level and a computed t-value (–1.823985) that is higher than the crucial t-value and a p-value that is not statistically significant. As a result, we accept the null hypotheses and conclude that the area has a unit root. We then repeat the test to ensure stationarity in the first difference. The computed t-value (–9.754236) in the first difference is less than the crucial value at the 1% level of significance with a p-value of 0.000. As a result, the null hypotheses are rejected, and we infer that the area series is stationary in the first difference form at the 1% level.

ADF Test for Factories

The factory series' unit root test in level form reveals that it is non-stationary. Because the computed t-value (–0.389419) is greater than the critical t-value at 1%. The ADF test is now repeated to ensure stationarity in the first difference. At a 5% significance level (p-value 0.0093), the estimated t-value (–3.558279) is smaller than the critical t-value. We conclude that the factory series is stationary in the first difference form and reject the unit root null hypotheses as a consequence.

Results of Cointegration and Error Correction Mechanism

Because all three series are stationary in the first difference form, we used the cointegration and error correction mechanism (ECM). To validate the cointegration between variables, we conduct a simple OLS regression of production on area and factories and produce a series of residuals. The R-square (0.903905) and adjusted R-square (0.901079) values of the basic OLS regression are extremely high and very close to 1. These variables have a very strong correlation, which suggests that either our model is overestimated. Now, we use the ADF test to determine if the residuals are stationary. The residual series (resid01) is stationary in level form because the computed t-value (–3.370276) is lower than the critical t-value (–2.903566) at a 5% level of significance. Hence, we reject the null hypotheses of unit root and conclude that the resid01 series is stationary in level form. This implies that cointegration among dependent and explanatory variables is valid.

Now, we proceed to ECM because cointegration among variables has become valid. Our ECM model is specified as follows:

$$\Delta production = \alpha + \beta \Delta area + \gamma \Delta factories + \lambda (\text{resid01})_{t-1} + \varepsilon_t \quad \ldots\ldots\ldots(5)$$

Here, $\Delta production = production_{t-1}$; similarly, other variables are also used in the form of the first difference (t–1), and the resid01 series is included in the model as an explanatory variable in the one-period lag form. If ECM is appropriate, the estimated coefficient of resid01$_{t-1}$ is negative because if there is any short-term disturbance from a long-run stable relationship that is corrected over time and long-run stable relationship will be restored. The results are shown in Table 1.

Table 1 shows the result of ECM, we regress the production on area and factories. Both the explanatory variables are expected to be positively related to the dependent variable. The factory is statistically insignificant but its estimated coefficient (40.47148) is positive, which means a number of sugar factories are positively related to sugarcane production. The coefficient of the area series (53.39875) is statistically significant at a 1% level of significance with a p-value of 0.0000. The value of R-squared is 0.733156; the model explains 73% variability of the dependent variable. The overall model is significant at a 1% level (F-statistic –60.44509, with p-value –0.00000). The result is satisfactory, especially because resid01 estimated coefficient (λ= –0.243606) is negative and statistically significant at a 5% level; this implies that if there were any short-term disturbance over or estimate the long-term stable relationship (coefficients), such disturbance would be corrected and the long-term stable relationship would be stored.

Table 1. *Results of Estimated ECM*

Variables	Coefficients	*t*-value	Prob. (*p*-value)
C	109.7751	1.255933	0.2136
D(AREA)	53.39875	13.06037	0.0000
D(FACTORIES)	40.47148	0.675889	0.5015
RESID01(–1)	–0.243606	–2.392866	0.0196
Dependent variable		*D(PRODUCTION)*	
R-squared	0.733156	*F*-statistic	60.44509
Adjusted *R*-squared	0.721026	Prob(*F*-statistic)	0.000000

Note. Included observations : 70 after adjustments.

Conclusion and Implications

The number of sugar mills and variations in the area used for sugarcane cultivation were the two main areas of attention for this study, which looked at the factors affecting the yield of sugarcane in Bihar. The inference made is that the amount of sugarcane cultivated and the sugar mills' influence on sugarcane production are crucial factors. By filling in a knowledge vacuum about the factors influencing sugar output in Bihar, the study adds significant value to the body of current literature.

The managerial implications of this study are significant, guiding sugar industry professionals in optimizing operations. This includes adjusting production schedules, efficiently allocating resources, and streamlining processes to enhance output while minimizing costs. Understanding the key determinants of sugarcane production in Bihar enables marketers to tailor strategies emphasizing product attributes and effectively target specific customer segments.

The study's findings can improve demand forecasting, inventory control, and the development of strong bonds with sugarcane suppliers for those in charge of obtaining raw materials like sugarcane, ensuring a dependable supply chain. The results of the study can be used by those involved in the sugar business, such as associations and legislators, to promote sustainable sugarcane farming methods and the expansion of the sector as a whole in Bihar. Practitioners can impact policy decisions intended at increasing the long-term sustainability and competitiveness of the sugar sector by drawing attention to the importance of factors such as the number of sugar factories and areas under cultivation in determining production.

Limitations of the Study and Scope for Further Research

The main limitation of the study is that it only looked at a relatively limited number of factors that affect sugarcane output, most of which were connected to Bihar. The scope of future research could encompass various aspects that could be included in subsequent studies.

Authors' Contribution

Aditi conceptualized and designed the qualitative and quantitative aspects of the empirical study, identifying and extracting relevant research papers of high repute. She meticulously filtered these papers based on keywords, generating key concepts and codes integral to the study design. Raviranjan Kumar validated the analytical method using EViews, ensuring the robustness of the chosen approach. Dr. Rathi Kanta Kumbhar provided comprehensive supervision throughout the entire study. Ms. Aditi collaborated with both authors in crafting the manuscript, showcasing a collective effort in the research process.

Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

Finding Acknowledgment

The authors received no financial support for the research, authorship, and/or the publication of this article.

References

Bhaumik, S. K. (2015). *Principles of econometrics: A modern approach using EViews*. Oxford University Press.

Dwivedi, N., Vani, G. K., & Shrivastava, A. (2023). Economic analysis of factors affecting sugarcane production in major sugarcane producing states in India. *Economic Affairs, 68*(3), 1395–1401. https://doi.org/10.46852/0424-2513.3.2023.6

Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica, 55*(2), 251–276. https://doi.org/10.2307/1913236

Gangwar, L. S., Solomon, S., Singh, P., Hasan, S. S., & Sah, A. K. (2014). *Socio-economic impact of sugarcane production and diversification in India. A policy paper* (ICAR-IISR/ 2014/ Policy Paper / 01). Indian Institute of Sugarcane Research, Lucknow. https://iisr.icar.gov.in/iisr/download/publications/book/book_gangwar.pdf

Greene, W. H. (2003). *Econometric analysis*. Pearson Education India.

Gujarati, D. N., & Porter, D. C. (2007). *Basic econometrics*. Tata McGraw-Hill Education.

ICAR-Sugarcane Breeding Institute, Coimbatore. (n.d*). Sugarcane statistics.* https://sugarcane.icar.gov.in

Khosla, R. (2012). Production efficiency of the selected agro industries in Punjab. *Prabandhan : Indian Journal of Management, 5*(2)*,* 21–26. https://doi.org/10.17010/pijom/2012/v5i2/60129

Kulshrestha, D., & Agarwal, K. K. (2019). An econometric analysis of agriculture production and economic growth in India. *Indian Journal of Marketing, 49*(11), 56–65. https://doi.org/10.17010/ijom/2019/v49/i11/148276

Lavanya, B. T., & Manjunatha, A. V. (2019). *Determinants of micro-level decisions of sugarcane farmers* (Working Paper No. 462). Institute for Social and Economic Change.

Murunga, N. M. (2021). *Factor affecting sugarcane farmers profitability in Kenya: A case of Malava Sub Country in Kakamega Country* [Doctoral dissertation, United States International University-Africa]. https://erepo.usiu.ac.ke/11732/6954

Nidheesh, K. B. (2010). Agriculture insurance in India. *Indian Journal of Finance, 4*(3), 25–35. https://www.indianjournaloffinance.co.in/index.php/IJF/article/view/72627

Ouattara, N., Xiong, X., Guo, C., Traoré, L., & Ballo, Z. (2022). Econometric analysis of the determinant of rice farming systems choice in Côte d'Ivoire. *Sage Open, 12*(2). https://doi.org/10.1177/21582440221094605

Owino, O. E. (2018). Socio-economic determinants of sugarcane production among small scale farmers in Nyando sugarbelt of Kenya. *EPRA International Journal of Economic and Business Review, 6*(9), 37–46.

Patil, G. I., & Mahajanashetti, S. B. (2017). Problem of sugarcane growers and sugar factories. *Indian Farming, 67*(8), 32–35. https://epubs.icar.org.in/index.php/IndFarm/article/view/84536

Rajput, M. A., Rajput, N. A., Syed, R. N., Lodhi, A. M., & Que, Y. (2021). Sugarcane smut: Current knowledge and the way forward for management. *Journal of Fungi, 7*(12), 1095. https://doi.org/10.3390/jof121095

Singh, S. P., Minnatullah, M., Singh, K. M., Kumar, N., & Meena, S. K., (2021). Sugarcane economy in Bihar. In R. K. Rao (Ed.), *Recent approaches in sustainable agriculture development & food security, crop management, forestry, food technology & environmentally balanced production enhancement* (2ed., pp. 76–83). Mahima Research Foundation and Social Welfare.

Singhal, R., Gupta, P., & Singh, A. (2023). Identifying performance indicators for the agriculture sector in developing countries through the ADRL model: Special reference of India. *Indian Journal of Finance*, *17*(2), 68–81. https://doi.org/10.17010/ijf/2023/v17i2/170145

Som-ard, J., Atzberger, C., Izquierdo-Verdiguier, E., Vuolo, F., & Immitzer, M. (2021). Remote sensing applications in sugarcane cultivation: A review. *Remote Sensing*, *13*(20), 4040. https://doi.org/10.3390/rs13204040

Suchato, R., Patoomnakul, A., & Photchanaprasert, N. (2021). Alternative cropping adoption in Thailand: A case study of rice and sugarcane production. *Heliyon, 7*(12), E08629. https://doi.org/10.1016/j.heliyon.2021.e08629

Sugarcane Industries Department, Bihar. (n.d). *Sugar industry at a glance.* https://state.bihar.gov.in

Umarani, R., & Nithya, G. (2013). Profitability analysis of selected companies in the sugar industry in India based on their margin on sales. *Indian Journal of Finance*, *7*(10), 14–24. https://www.indianjournaloffinance.co.in/index.php/IJF/article/view/72076

About the Authors

Aditi is a Ph.D. candidate at Central University of South Bihar, Gaya, in the Economics department. The University of Lucknow is where she finished her post-graduation studies. She has participated in numerous ICSSR-sponsored national and international conferences and published multiple peer-reviewed papers in reputable journals.

Raviranjan Kumar is a Ph.D. Scholar in the Department of Economic Studies and Policy, Central University of South Bihar. He has published many collaborative research papers in good journals. His areas of expertise are migration concerns, development economics, environmental economics, and applied econometrics.

Dr. Rathi Kanta Kumbhar is currently serving as a Professor at the Central University of South Bihar, Gaya. He holds a Ph.D. from JNU and has taught for 10 years. He has also published multiple papers in reputable national and international journals. Development economics is his area of interest in research.