Economic Viability of Rice Cultivation in Punjab and Uttar Pradesh: A Cost and Profit Analysis

Abstract

Aims: The main objective of this study is to analyse the profitability of Ricecrop in Punjab and Uttar Pradesh and investigate the factors influencing the cost structure of Rice farming.
Study design: This studyutilized secondary data from the Directorate of Economics & Statistics, the Department of Agriculture & Farmers' Welfare (DA&FW), and the Commission for Agricultural Costs and Prices (CACP)
Place and Duration of Study: The study primarily focused on Punjab and Uttar Pradesh. Starting from 2001-02, every fourth year was selected up to the most recent available data. Finally, the selected points of years were 2001-02, 2005-06, 2009-10, 2013-14, 2017-19, and 2020-21.
Methodology: This study employed various cost concepts to assess the profitability. A Panel Instrumental Variable (IV) regression analysis was conducted to assess the cost structure and the Hausman test was done to select appropriate modelbetween fixed and random effects.
Results: In Punjab, the profitability ratio remained above one for all the selected years, whereas in Uttar Pradesh, it was either close to or slightly below one at Cost C3. Additionally, in Punjab, the profitability ratio consistently exceeded two, while in Uttar Pradesh, it was just above one at Cost A2+FL. This indicates that rice cultivation was significantly more profitable in Punjab compared to Uttar Pradesh. The cost structure was primarily influenced by yield and price fluctuations, both of which were statistically significant.
Conclusion: The results indicate a significant disparity observed in profitability between Punjab and Uttar Pradesh states and highlight that total costs significantly impact technology adoption and price movements, with last year's market conditions influencing current production costs.

Keywords: Rice, profitability, Punjab, Uttar Pradesh.

1. INTRODUCTION

India is the fifth-largest economy in the world, with a population of 1.41 billion people. Around 60 per cent of this vast population relies on the agricultural sector for their livelihoods, either directly or indirectly [1]. The Economic Survey for 2023-24 highlighted that agriculture contributes 18.2 per cent to the nation's GDP, reflecting its critical role in the economy. Rice, a staple food for more than half of the global population holds immense importance in India and across numerous Asian countries. India ranks second in both rice cultivation and consumption, following China. Rice cultivation is particularly labour-intensive, offering millions of individuals vital employment and livelihood opportunities [2]. India accounts for approximately 27.1 per cent of the global rice-growing area [3]Moreover, as the largest rice exporter globally, India commands over 40 per cent of the international market share, playing a pivotal role in ensuring food security around the world. Rice is cultivated during both the Rabi and Kharif seasons, with some regions remarkably managing to grow it up to three times in a single year. The major rice-producing states in India showcase the agricultural diversity of the country, including West Bengal, Uttar Pradesh, Bihar, Punjab, Haryana, Odisha, Chhattisgarh, Andhra Pradesh, Telangana, Tamil Nadu, Kerala, and Assam.

In 2006, Bhatia conducted an insightful study focusing on the sustainability and profitability trends within Indian agriculture. His study findings revealed that during the period from 1996-97 to 2002-03, the farm business income per hectare for Rice production in Andhra Pradesh saw a notable increase, indicating a positive shift in agricultural profitability in that region. In contrast, West Bengal experienced a different trajectory; the farm business income per hectare during the same timeframe exhibited a decline, punctuated by only a few brief spikes of improvement around 1998-99. Narayanamoorthy (2013) carried out an extensive investigation into the profitability of crop cultivation in India, utilizing a comprehensive dataset from the Commission of Agricultural Costs and Prices (CACP) spanning from 1975 to 2006examined key agricultural years to assess the financial viability of major crops, which revealed that many farmers faced either negligible profit margins or substantial financial losses, highlighting the need for more sustainable and viable farming practices.Dhawan (2018) explored the profitability of agriculture in the Indian state of Punjab, drawing insights from the Cost of Cultivation Surveys, highlighted a significant upward trend in profits over the A1 and C2 cost

categories between the years 1981-82 and 2010-11 and found that wheat farming experienced a profit increase of 10.82 per cent over A1 costs and 12.45 per cent over C_2 costs. Similarly, Rice cultivation also showed impressive growth, with profits rising by 9.92 per cent over A1 costs and 11.36 per cent over C2 costs. Monga and Sidana (2021) conducted a study on the changes over time in the cost structure and profitability of wheat and Rice crops in India, found that the percentage margin of the Minimum Support Price (MSP) over Cost A2+FL was highest for wheat in Punjab at 169.6 per cent, while it was lowest in Uttar Pradesh at 67.8 per cent. Additionally, they noted that the margin of MSP over Cost A2 plus factor cost plus 50 per cent would be advantageous for some states but not for all. In the 2015-16 period, this margin exceeded 100 per cent in Punjab, Haryana, and Madhya Pradesh, whereas it was approximately 70 per cent in Bihar and Uttar Pradesh.Mandal (2024) conducted an in-depth analysis of the economic factors surrounding Rice cultivation in Eastern India, focusing on the trends and patterns of costs and profitability in this vital agricultural sector. His research revealed that Jharkhand emerged as the leading state in terms of profitability, boasting the highest average profit-to-cost ratio (A2) among the regions studied. Following Jharkhand, West Bengal, Bihar, and Odisha displayed varying levels of profitability, reflecting the diverse agricultural dynamics and challenges faced by farmers in these areas. His study findings provided valuable insights into the economic landscape of Rice farming, highlighting the factors that influence success in this important industry.

Rice cultivation is a cornerstone of Indian agriculture, providing sustenance to millions of farmers and contributing significantly to the country's food security. However, despite its importance, the profitability of Rice cultivation in India is increasingly under pressure. Farmers face challenges such as rising input costs, volatile market prices, climate-induced risks, and stagnant productivity levels(Ravikumar & Sudheesh, 2013). Average cost inflation reached a record high of 13 per cent, with over half of this attributed to rising labour costs. While the use of physical inputs has only marginally increased, a significant share of the rise in cultivation costs is due to escalating input prices [11]. Between 2013 and 2019, farmers' incomes rose by 30 per cent, but their debt surged by approximately 58 per cent[12]. Furthermore, the rate of farmer suicides increased from 4.3 per cent in 2014 to 6.6 per cent in 2021 [13].There is a need to evaluate the profitability of the farming sector through scientific evidence. In this scenario, this study aims to analyse the profitability of Rice in selected states of India i.e., Punjab and Uttar Pradesh and examine the underlying factors influencing the cost structure.

2. MATERIAL AND METHODS

Rice was selected for the study based on its highest cultivation area in India. Cost of cultivation data was collected from the reports of the Directorate of Economics and Statistics (DES), GoI, for the period from 2001 to 2021. Starting from 2001-02, every fourth year was selected, along with the latest available year. The selected years were 2001-02, 2005-06, 2009-10, 2013-14, 2017-18, and 2020-21.

2.1 Cost concepts: Commission for Agricultural Costs and Price (CACP) has been using nine different cost concepts and publishes the state level and unit level data of cost of cultivation of various crops. The cost concepts are as follows:

Cost A_1 = All actual expenses in cash and kind incurred in production by the owner.
Cost A_2 = Cost A_1 + rent paid for leased-in land.
Cost A_2+ FL = Cost A_2 + imputed value of family labour.
Cost B_1 = Cost A_1 + interest on value of owned capital assets (excluding land).
Cost B_2 = Cost B_1 + rental value of owned land (net of land revenue)
Cost C_1 = Cost B_1 + imputed value of family labour.
Cost C_2 = Cost B_2 + imputed value of family labour.
Cost C_2* = Cost C_2 estimated by taking into account statutory minimum or actual wage whichever is higher.
Cost C_3 = Cost C_2* + 10 per cent of cost C_2* on account of managerial functions performed by farmer.

In this study the profitability ratio over Cost A_2 + FL, Cost C_2, and Cost $C_3$was estimated by for the states with the highest area (Uttar Pradesh) and highest yield (Punjab). The formula for profitability ratio is given below. (Narayanamoorthy, 2013)

$$\text{Profitability ratio} = \frac{\text{Cost}}{\text{Value of Output}}$$

2.2 Panel Instrumental Variable (IV) Regression

Panel IV regression analysis was done to determine Rice's cost structure. Cost C_2 is taken as the dependent variable, the previous year's farm price is the independent variable and crop yield is the endogenous variable, which is influenced by seed, fertilizer, human labour, animal labour and manure, time series data has been taken for six years i.e., from 2014-15 to 2019-20 and cross-sectional data has been taken for nine states of Rice *viz*, Punjab, Uttar Pradesh, Andhra Pradesh, Assam, Bihar, Madhya Pradesh, Odisha. Tamil Nadu and West Bengal. The Panel IV regression model is as follows. (Arellano & Bond, 1991; Balaji and Kumar, 2016).

$$C_{it} = \alpha O_{it} + \beta X_{it} + y_{it} + \varepsilon_{it}$$

Where C_{it}- Cost per ha
O_{it}- Yield (endogenous)
X_{it}- Price
ε_{it} – Error term

2.3. Hausman test

The Hausman test is used to determine whether a fixed effects or random effects model is more appropriate in panel data analysis. The test compares the estimates from both models to check for systematic differences.

$$H=(\beta_{RE}-\beta_{FE})'[V_{FE}-V_{RE}]^{-1}(\beta_{RE}-\beta_{FE})$$

where:

β_{FE} - Coefficient estimates from the Fixed Effects model
β_{RE} - Coefficient estimates from the Random Effects model
V_{FE} - Variance-covariance matrix of Fixed Effects estimates
V_{RE} - Variance-covariance matrix of Random Effects estimates
H - Chi-square (χ^2) distribution with degrees of freedom equal to the number of regressors.

If H is significant (p-value < 0.05) then Reject the null hypothesis, meaning Fixed Effects model is preferred (since random effects are correlated with regressors).If H is not significant (p-value > 0.05) thenfail to reject the null hypothesis, meaning Random Effects model is appropriate (since there is no correlation between random effects and regressors). (Hausman, 1978)

The appropriate models selected after the Hausman test was- Generalized Two-Stage Least Squares (G2SLS) Random Effects. This method is used in econometrics for instrumental variable (IV) estimation in panel data models when dealing with endogeneity issues in random effects models.

3. RESULTS AND DISCUSSION

3.1Area, Production and Yield of Field crops in India (2017-18 to 2021-22):

The normal estimates of the area, production, and yield of major field crops for the period from 2017-18 to 2021-22 are presented in Table 1. Among these crops, rice stands out as the most prominent, occupying an impressive area of 44.27 million hectares (M ha). Following rice, wheat claims a substantial 30.44 M ha, making it the second most cultivated crop. Cotton, another crucial agricultural staple, covers 12.55 M ha, while soybean is cultivated over 11.55 M ha. In addition to these leading crops, gram and maize also play significant roles in the agricultural landscape, with areas of 9.85 M ha and 9.50 M ha, respectively. Besides these prominent crops, a variety of other important agricultural products are grown throughout the country. For instance, bajra, mustard, and groundnut are cultivated on considerable tracts of land alongside urad, jowar, sugarcane, and red gram.

Table1Area, production and yield of major field crops in India – Normal estimates(2017-18 to 2021-22)

Crops	Area (M.ha)	Production (M tons)	Yield (kg/ha)
Foodgrains			
Rice	44.73	120.39	2692
Wheat	30.38	105.73	3480
Maize	9.57	30.12	3149
Jowar	4.42	4.40	995
Bajra	7.32	9.77	1335
Nutri/Coarse Cereals			
Tur	4.63	4.01	866
Gram	10.11	11.57	1145
Total Pulses	29.29	24.66	842
Total Food Grains	127.85	298.82	2337
Oil Seeds			
Groundnut	5.23	9.26	1770
Soyabean	11.74	12.21	1039
Sunflower	0.25	0.23	890
Rapeseed & Mustard	6.73	9.80	1456
Other Cash Crops			
Sugarcane	4.89	400.13	81893
Cotton@	12.87	32.66	431
Jute & Mesta	0.69	9.85	14311

Source: Directorate of Economics & Statistics, DA&FW

3.2. Area, Production and Yield of Rice for last two years in India:

Given that Rice utilizes the largest agricultural area in India, we undertook an analysis of the profitability trend associated with rice crops. As illustrated in Table 2, we presented average estimates regarding the area, production, and yield of rice for the top 10 rice-producing states in the country. The cultivation of Rice spans a total area of 46.28 M ha throughout India, yielding an impressive production figure of 129.47 (M tons) during 2021-22. Among the states, Uttar Pradesh stands out with the largest share of Rice area, closely followed by West Bengal. However, when it comes to production, West Bengal surpasses all others, taking the lead over Uttar Pradesh in overall rice output. Punjab demonstrates remarkable efficiency, boasting the highest yield of rice per hectare in the nation. On the other hand, Odisha lags in productivity, having recorded the lowest yield of rice in the country. It is noteworthy that both Punjab and Odisha focus their rice cultivation efforts exclusively during the Kharif season, a vital time for Rice planting. In this study for analyzing profitability, we have taken Uttar Pradesh and Punjab because former has the highest area under cultivation and the latter one is having high productivity.

Table2Area, production and yield of rice in India in major producing states during 2021-22 and 2022-23

S. No.	State/ UT	Area (M.ha)		Production (M. tons)		Yield (kg/ha)	
		2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
1	Uttar Pradesh	5.70	5.90	15.27	16.14	2678	2737
2	Telangana	3.65	4.66	12.41	15.88	3395	3406
3	West Bengal	5.59	5.07	16.73	15.48	2995	3057
4	Punjab	2.97	3.10	12.89	12.99	4340	4193
5	Chhattisgarh	3.76	3.77	8.02	9.81	2134	2602
6	Odisha	3.95	4.06	9.29	8.25	2353	2030
7	Andhra Pradesh	2.29	2.13	7.76	7.94	3392	3730
8	Tamil Nadu	2.22	2.16	7.91	7.56	3566	3500
9	Bihar	3.09	2.86	7.72	7.02	2496	2453
10	Madhya Pradesh	2.11	3.41	4.81	7.02	2283	2057
	All India	**46.28**	**47.83**	**129.47**	**135.76**	**2798**	**2838**

Source: Directorate of Economics & Statistics, DA&FW

3.3. Profitability of Rice in Uttar Pradesh:

Table 3 represents the profitability analysis of rice in Uttar Pradesh. In the 2021-22, the total cost at Cost C3 was Rs. 82,122 per hectare, with a derived yield of 36.15 Q/ha. The profit ratio at Cost C3 was either slightly below or just above one for all selected years. A similar situation was noted at Cost C2, indicating that there was no marginal profit at either Cost C2 or C3. At Cost A_2 + FL, the profit ratio was highest at 1.91 in 2013-14, which was due to a higher yield of 42.41 Q/ha and a higher average market price of Rs. 1,497 per quintal compared to other years. The results are in accordance with Ram et al, 2023,in which the economic analysis of paddy in Chhattisgarh state was analysed. However, during the years 2017-18 and 2021-22, net returns were negative, and the average price received by farmers was below the MSP, as illustrated in Figures 1 and 2.

Table3Profitability of rice in Uttar Pradesh state

Year	Derived Yield (Q/ha)	Cost A_2+ FL (Rs/ha)	Cost C_2 (Rs/ha)	Cost C_3 (Rs/ha)	VOP (Rs/ha)	VOP/ (Cost A_2+ FL)	VOP/C_2	VOP/C_3
2001-02	32.99	12120	15844	17429	14549	1.20	0.92	0.83
2005-06	34.37	13866	20557	22613	19386	1.40	0.94	0.86
2009-10	37.58	21337	32328	35561	36978	1.73	1.14	1.04
2013-14	42.41	30983	45357	49893	59154	1.91	1.30	1.19
2017-18	37.06	44083	61382	67520	51364	1.17	0.84	0.76
2021-22	36.15	55810	74657	82122	57564	1.03	0.77	0.70

Source: Authors compution using the data from the Directorate of Economics & Statistics, DA&FW

(VOP: Value of Product)

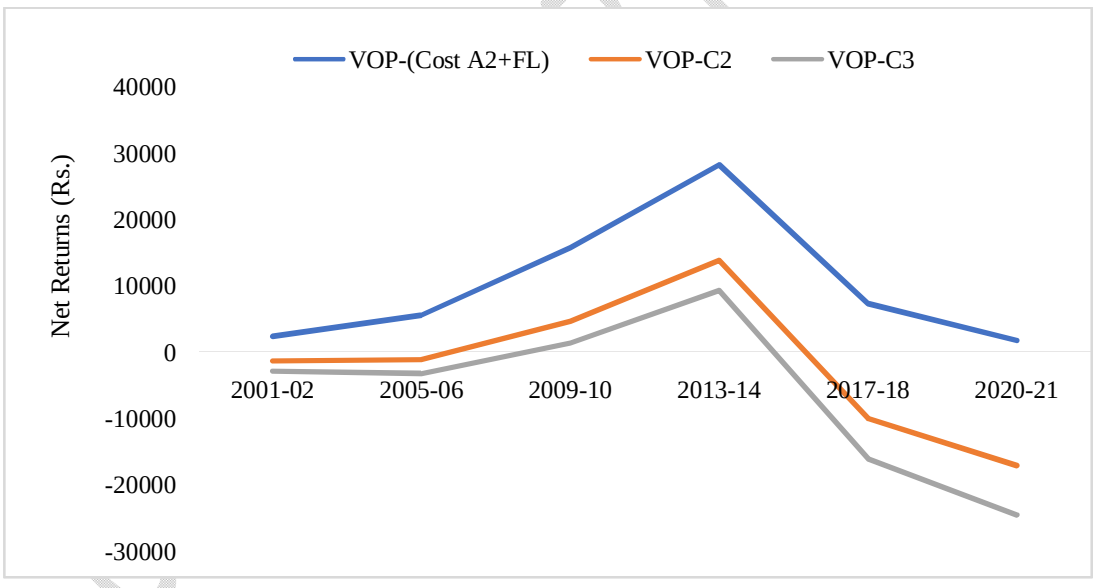

Fig. 1:Trend in net returns of Rice in Uttar Pradesh

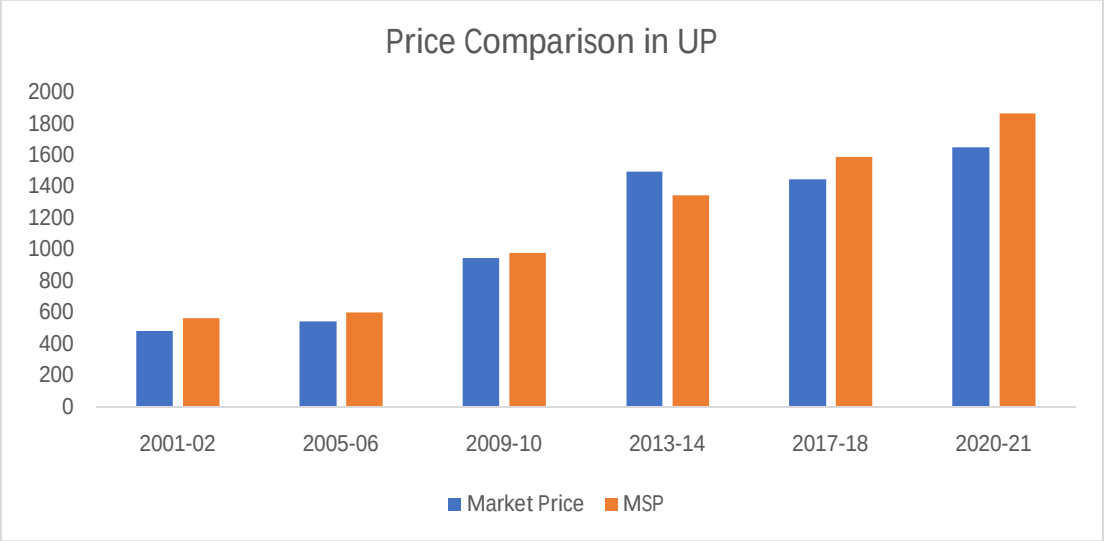

Fig. 2:Comparison of market price and MSP of Rice in Uttar Pradesh (in Rs./q)

3.4 Profitability of Rice in Punjab:

Punjab has achieved remarkable agricultural success in Rice cultivation, boasting the highest average yield in the nation at an impressive 4,179 kg/ha during the 2021-22 farming season. The Cost C_3 is Rs. 111478/ha, and the net returns stand at Rs. 30,641/ha (Table 4). The profit ratio exceeds two for all selected years when using Cost A2+FL, signifying that farmers are earning more than double their input costs—representing a profit margin greater than 100 per cent. Furthermore, at both Cost C2 and C3 assessments, the profit ratios are consistently above one across all monitored years, highlighting sustained profitability in agricultural practices. Throughout the analysis, it is noteworthy that no negative net returns have been reported, suggesting a robust economic environment for farmers (Figure 3). Additionally, the market prices received by farmers consistently outpace the MSP across all evaluated years, underscoring the financial benefits farmers are reaping in Punjab's agricultural sector (Figure 4).The results are in accordance with Chanakya and Nandi (2024) and Abdulaziz et al (2021) who stated that Rice cultivation is the most lucrative in Punjab and Haryana states respectively, highlighting profit margins through an insightful profitability assessment. This achievement can be attributed to several factors, including the state's extensive and reliable irrigation facilities, the cultivation of high-yielding varieties of both basmati and non-basmati rice and the widespread adoption of mechanisation in farming practices [15].

Table 4Profitability of Rice crop in Punjab state

Year	Derived Yield (Q/ha)	Cost A_2+ FL (Rs/ha)	Cost C_2 (Rs/ha)	Cost C_3 (Rs/ha)	VOP (Rs/ha)	VOP/ (Cost A_2+ FL)	VOP/C_2	VOP/C_3
2001-02	59.48	14380	23577	25935	33516	2.33	1.42	1.29
2005-06	61.15	17247	30007	33008	37154	2.15	1.24	1.13
2009-10	64.70	29032	50650	55715	70622	2.43	1.39	1.27
2013-14	64.90	39687	68383	75221	98255	2.48	1.44	1.31
2017-18	74.90	42465	81378	89516	123161	2.90	1.51	1.38
2021-22	69.80	58782	101344	111478	142119	2.40	1.40	1.27

Source: Authors calculated using the data from the Directorate of Economics & Statistics

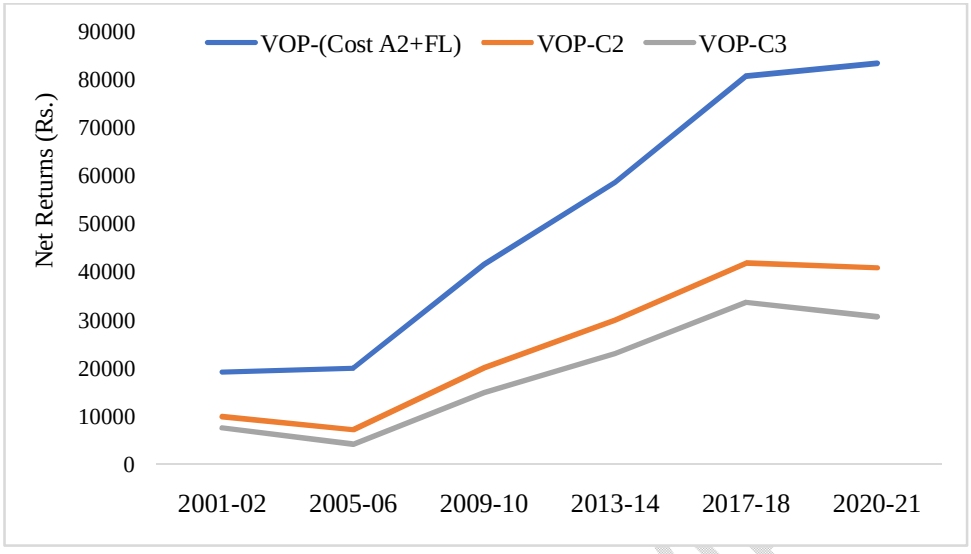

Fig. 3: Trend in net returns of Ricecrop in Punjab, from 2001-02 to 2020-21

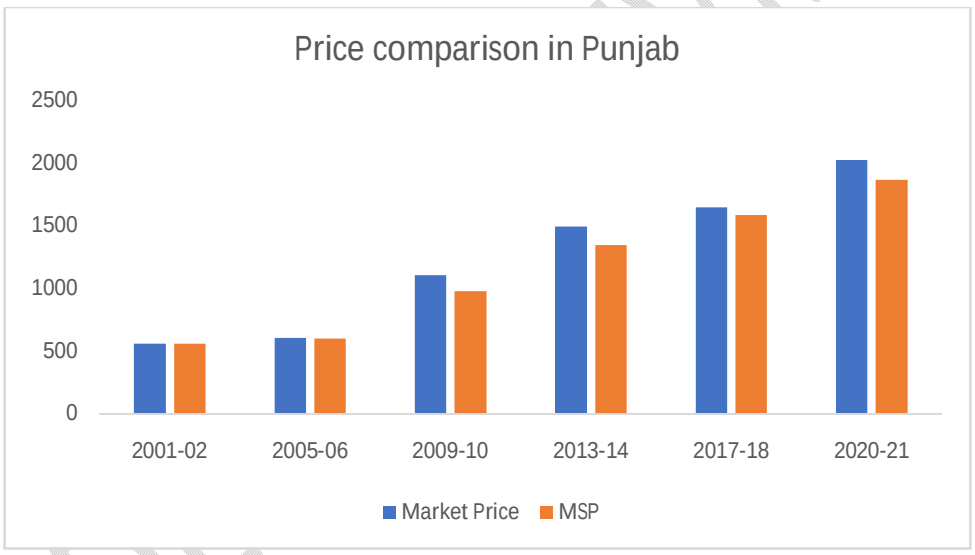

Fig. 4:Comparison of Market Price and MSP of Rice in Punjab(in Rs./q)

3.5 Number of times profit reaped or loss faced by the farmers

The Table 5 presents a detailed analysis of profit distribution across different cost structures. At Cost A2 + FL, it is noteworthy that profits exceeded 30 per centinsix out of six instances in Punjab, indicating a strong performance with no observed losses during the evaluation period. In contrast, at Cost C2, the results showed a more varied outcome: profits fell below the 30 per cent threshold in a single time, while in fiveinstances profits exceeded 30 per cent and no losses occurred. The situation at Cost C3 was less favourable, withprofits less than 30 per cent recorded four times out of 6 evaluations.In the case of Uttar Pradesh at A2 + FL, it is noteworthy that profits exceeded 30 per cent in three out of six instances, indicating a moderate performance with no observed losses during the evaluation period. In contrast, at Cost C2, the results showed a more varied outcome: profits fell below the 30 per cent threshold at onetime, while instances of profits exceeding 30 per cent in one time and at four instances losses occurred. The situation at Cost C3 was less favourable, with losses recorded four times out of six evaluations.

Table 5Analysis of profit distribution by rice farmers at various cost concepts

Cost Concepts	Punjab	Uttar Pradesh
Cost A2 + FL		
Profit <30 %	0	3
Profit > 30 %	6	3
Loss	0	0
Cost C2		
Profit <30 %	1	1
Profit > 30 %	5	1
Loss	0	4
Cost C3		
Profit <30 %	4	2
Profit > 30 %	2	0
Loss	0	4
Total Time Points	6	6

3.6Determination of cost structure:

The first objective of the study highlighted that the total cost is the most significant factor affecting the profitability of crop cultivation. Several critical elements are integrated into the model to understand better how they impact total costs. Among these, price movements and the technology adopted by farmers emerge as key contributors. Price movements are reflected by the prices that farmers received during the previous year, providing a historical context for current economic conditions. Meanwhile, the technology utilized by farmers is evaluated through the yields they achieve, which serve as an indicator of agricultural efficiency and innovation. Yield itself is classified as an endogenous variable because it is influenced by multiple external factors, including the quality of seeds, the availability and effectiveness of human and animal labour, as well as the types and amounts of fertilizers and manures used.

Given its complex nature, yield is treated as an endogenous variable in the analysis and is instrumented accordingly, with the previously mentioned influencing factors serving as instruments. To validate the model's findings, a Hausman test was conducted, yielding a p-value greater than 0.05. This result suggests that theG2SLS random effects model is suitable for analyzing the data, as per the Table 6.

Table 6Results of the Hausman test

	Coefficients		b-B	Sqrt (Diag(V_b-V_B))
	Fixed Effects (b)	Random Effects (B)	Difference	S.E.
Yield	796.62	641.10	155.52	653.59
Price	40.73	34.28	6.45	2.97

b= consistent under H_0 and H_a; obtained from xtivreg; B = inconsistent under H_a, efficient under H_0; obtained from xtivreg; Chi^2(2) = (b-B)`[(V_b-V_B)^ (-1)] (b-B) = 5.11; Prob>chi^2= 0.077

The Panel Instrumental Variable (IV) regression analysis was performed to explore the factors affecting the total cost of Rice (Cost C2). The analysis revealed that Cost C2 is significantly influenced by two key variables: the yield of the crop and the price from the previous year's harvest. Specifically, for every quintal increase in yield, Cost C_2 rises by Rs. 641 per quintal. This underlines the direct relationship between higher yields and increased costs associated with production. Furthermore, the analysis showed that if the price of Rice from the previous year increases by Rs. 100, there is a corresponding increase of Rs. 34 in Cost C_2 for each quintal. This finding suggests that the previous year's market conditions play a crucial role in determining current production costs. The model's effectiveness is also reflected in its R^2 value of 0.51, indicating that 51 per cent of the variation in Cost C_2 can be explained by the explanatory variables included in the analysis. This demonstrates a moderate level of predictability of Cost C_2 based on the factors considered in the regression model.

Table 7.Results of Panel IV regression analysis (Random effect model G2SLS)

Cost C2	Coefficients	Standard Error	P-value	95% Confidence Interval	
Yield	641.10**	308.41	0.038	36.62	1245.58
Price	34.28***	10.07	0.001	14.55	54.02
Constant	-11071.24	14044.85	0.431	-38598.64	16456.15
R^2	0.51				
Wald Chi^2	32.90**				

*** p<0.01, ** p<0.05, * p<0.1

Conclusion

Uttar Pradesh has the largest area under rice cultivation, while Punjab stands out for its high efficiency and highest yield per hectare. The profitability ratio for rice cultivation in Uttar Pradesh hovers around one at Cost C3, indicating minimal returns, whereas Punjab farmers benefit from market prices often exceeding the MSP, ensuring positive net returns. A significant disparity in profitability between the two states is evident, with Panel IV regression highlighting the critical role of total costs in influencing technology adoption and price movements. Higher yields are associated with increased production costs, reflecting the impact of past market conditions on current expenditures. To improve farmers' profitability, particularly in Uttar Pradesh, strengthening the MSP mechanism, investing in advanced agricultural technologies, enhancing research and development for high-yield rice varieties, and implementing region-specific policies are essential. These measures can create a more equitable agricultural landscape, boosting farmer incomes, ensuring food security, and fostering sustainable rice cultivation across India.

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Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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