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Article

Keywords: Farm profit efficiency, Entrepreneurial mindset, Farmer behavior, Paddy farming, Entrepreneurial intention

Posted Date: November 10th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11194308/v1

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Additional Declarations: No competing interests reported.

Beyond farm resources: Entrepreneurial and behavioral determinants of profit efficiency in paddy farming

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Abstract

Context: The enhancement of farm profitability is not just a matter of access to productive resources, but also depends on the perception of opportunities, risk management, farm information and access, and decision-making regarding resource allocation. However, the behavioral and entrepreneurial nature of farm profit inefficiency has not been adequately comprehended.

Objective: This study aims to examine the linkages between farmers' entrepreneurial mindset, entrepreneurial intention, and profit efficiency in paddy cultivation.

Methods: The study is based on primary data collected from a sample of 389 paddy farmers in four districts of Tamil Nadu, India, using a stochastic profit frontier model, principal component analysis, and beta regression to derive estimates of profit efficiency and the behavioral and socio-economic determinants of profit efficiency.

Results and conclusion: The outcomes show that profit efficiency was 86.5 percent, and there was significant variation among the farms ranging from 35.8% to 99%. Education, family size, farming experience, training, access to the Uzhavan App, economic motivation, and innovativeness are positively associated with profit efficiency, whereas family involvement in agriculture, farmer-producer organization membership, market information access, cropping land, information-seeking behavior, and proactiveness show negative associations. Entrepreneurial intention, risk-taking, autonomy, need for achievement, risk orientation, achievement motivation, and decision-making behavior are not statistically significant. These findings demonstrate that entrepreneurial characteristics do not uniformly translate into greater profit efficiency; their effects depend on how

entrepreneurial and behavioral orientations interact with farm management and resource-allocation conditions.

Significance: The study contributes to farm-efficiency research by bringing farmer-level entrepreneurial and behavioral heterogeneity into the explanation of profit efficiency and offers implications for designing more capability-oriented extension, market, training, and farm-management interventions.

Keywords: Farm profit efficiency; Entrepreneurial mindset; Farmer behavior; Paddy farming; Entrepreneurial intention

1.Introduction

Agriculture is more of a business than production, and a farmer needs to spot the opportunity, collect information, handle risk, embrace innovation, and make good decisions about limited resources. The transition is particularly important for smallholder farmers who remain important contributors to rural economies and who continue to face limited access to markets, technologies, capital and risk management (Barrett et al. 2017; Sinyolo & Mudhara 2018; Condor 2020). Hence, the role of agricultural entrepreneurship in increasing competitiveness, resilience, and sustainable agricultural development (SAD) of farms is getting focus (Anusree & Swarupa, 2024).

This transformation also has consequences at the farm level as well as for the overall performance of the livestock sector. Farmers' capacity to make their production, resource and market decisions is improved, making them an increasingly crucial component of productive, resilient, and inclusive food systems. Farmers organization review shows that, whereas farmer empowerment through FBMK methodologies brings improvement in farmers' production, livelihoods and food security, evidence is not uniform (Bizikova et al., 2020). Similarly, food system resilience depends on the capacity and agency of food system actors to react to food system disruption and reconfigure activities (Ingram et al., 2023). The emphasis has moved more recently towards global food-system assessments, reflecting the need for decision-making processes that recognize interactions and trade-offs between production and livelihoods and resilience and governance (Schneider et al., 2025). These perspectives suggest that the goal of enhancing the food security of farmers is not solely to provide additional inputs and technologies, but also to strengthen their capacity to use what they have and to make better decisions under conditions of uncertainty.

Technological change has also expanded the entrepreneurial dimension of farming by enabling farmers to access improved inputs, production technology and market information, and alternative

production systems (Mustaffa et al., 2019; Naseer et al., 2023). The availability of these opportunities is not the only constraint, however, as the farmers must also be able to identify opportunities, to access information and to process and interpret, to manage uncertainty, to innovate and to organize effectively. Recent studies on agricultural entrepreneurship have highlighted the importance of opportunity recognition ability, resource acquisition, operating management, and strategic decision-making capabilities in shaping the performance of agricultural entrepreneurs (Tao et al., 2024; Yang et al., 2025; Shi et al., 2025).

Climate change and market volatility further exacerbate this situation, forcing farmers to adapt their farming practices constantly and face uncertainty (Mohapatra et al., 2022; Nguyen & Virdis, 2025). Entrepreneurial practices that can facilitate more efficient farming practices include value addition, enhanced market participation, cost control, and using production factors in smart ways (Saravia-Matus et al., 2021; Abdulaziz et al., 2022; Chozin & Sudjatmiko, 2015; Kamanda et al., 2023; Odunga et al., 2025). Notably, recent research has found that entrepreneurial capabilities can be linked to the technical efficiency of smallholder farmers (Ikuemonisan et al., 2024).

Nevertheless, one question remains unanswered: is entrepreneurship always more efficient in using limited production factors than the conventional farm? Innovativeness, opportunity-seeking, autonomy, and risk-taking do not necessarily guarantee highly efficient production or an economically rational use of inputs by a farmer. The separation is big, particularly for paddy, a basic of food systems in Asia, where better production outcome from land, labor and input resources can generate higher food availability without relying on extra resource acquisition.

So the entrepreneurial farmer is not only a farmer looking for new opportunities or for better returns, but a farmer who can make entrepreneurial thinking work in production and in allocation of resources. This study is, to our best knowledge, the first empirical paper to combine multidimensional entrepreneurial abilities with technical and allocative efficiency, expanding upon the traditional definition of efficiency using only physical and socioeconomic factors. From this point of view, farmer capability is one of the possibly significant, but less explored, tools available for optimizing resource-use performance and consolidating the basis of resilient and food secure agricultural systems.

Although entrepreneurship has attracted significant attention as a key factor influencing farmers' performance, the literature on agricultural efficiency mainly examines the conventional farm and socioeconomic traits that determine efficiency, such as education, age, farm size, experience, and

access to resources (Rahman, 2003; Wongnaa et al., 2019; Tasila Konja et al., 2019; Khan et al., 2019; Purba et al., 2020; Muhardi & Effendy, 2021; Dong, 2023). Thus, the behavioral and entrepreneurial capacities that enable farmers to assess and identify opportunities, acquire knowledge, manage risks, innovate, and coordinate resources are not yet widely leveraged.

Recent research has revealed that entrepreneurial capability can influence technical efficiency (Ikuemonisan et al., 2024), while emerging studies have identified entrepreneurial competencies as factors that influence farmers' resource integration, operational management, and performance (Shi et al., 2025; Yang et al., 2025). The literature is fragmented, however, and there is little research that has examined the combined effect of certain predictive entrepreneurial and behavioral attributes and allocative and technical efficiency among smallholder farmers. This is particularly true due to the fact that technical efficiency is correlated with the capacity of the farmer to produce the largest output from a given set of resources, while allocative efficiency refers to the capacity of the farmer to combine the resources in a way that would provide the greatest economic value to his output.

It is therefore not known whether entrepreneurial capacity is missing socio-economic behavioral factor of farm efficiency or not, which is an important point to address. The entrepreneurial traits (information-seeking, innovativeness, achievement motivation, risk orientation, autonomy, proactiveness, and entrepreneurial intention) are related with entrepreneurial performance of farmers in the framework of production and resource allocation analysis which can be extended.

Under this background this study examined the question of whether farmers' entrepreneurial skills are a silent contributor to technical and allocative efficiency in paddy production. The study first estimates the technical and allocative efficiency levels of farmers based on primary data gathered from paddy farmers in the study area using the stochastic frontier approach. Technical efficiency would measure farmers' ability to maximize output given a specific amount of inputs, while allocative efficiency would measure their ability to use inputs in economically "optimal" proportions. The study then examines how variations in efficiency outcomes can be attributed to the entrepreneurial and behavioral characteristics of farmers. Along with farm and socioeconomic characteristics, special attention is given to economic motivation, information-seeking behavior, risk orientation, achievement motivation, decision-making behavior, innovativeness, need for achievement, risk-taking, autonomy, proactiveness and entrepreneurial intention.

Contrary to the assumption that entrepreneurial orientation is always linked to efficiency, the study empirically explores the direction and impact of personal entrepreneurial competences on technical and allocative performance. This study seeks to further refine the concept of farm efficiency by introducing the elements of entrepreneurship, which will provide a more behaviorally-oriented understanding of why farmers differ in their ability to alter and effectively manage their agricultural resources.

2.Literature review

2.1 A transition from Entrepreneurial Mindset to Farm Efficiency

Agricultural entrepreneurship is now not simply equated with farmers who recognize new markets or commercialize their products; it is now also a way of thinking and acting that requires farmers to recognize opportunities, mobilize resources, and manage uncertainty and make strategic production decisions. This is an approach that goes beyond the limited understanding of agribusiness as simple producers, processors, and distributors of farm commodities (Anitha & Rajyalakshmi, 2014; Abdulaziz et al., 2022; Darekar et al., 2025; Odunga et al., 2025). Entrepreneurial mindset is defined as the approach to identifying opportunities and adjusting to market and production conditions, while entrepreneurial intention is the decision to translate entrepreneurial mindset into action (Jiatong et al., 2021; Ambad, 2022; Khan & Sharif, 2023).

More recent studies on agricultural entrepreneurship, however, indicate that the key question is not whether farmers are entrepreneurs, but what they can do with their entrepreneurial orientation. The concept of entrepreneurial competence has gradually developed into opportunity-recognition ability, opportunity-development ability, ability of learning and innovation, ability of resource allocation, strategic planning ability, cooperation ability and risk-management ability (Yang et al., 2025). This is important for efficiency in farm operations because agricultural production is basically a problem of converting limited resource in accordance with technological and economic constraints.

This perspective implies that entrepreneurial ability can influence profit efficiency by influencing the choice of information, technology, market type, price fixing, and waste avoidance. In the case of the maize farming practice in Nigeria, it revealed that farmer's entrepreneurial capability had a significant relationship with technical efficiency, meaning that farmer's technical efficiency is not limited to physical input but also entrepreneurial competence (Ikuemonisan et al., 2024). Similarly,

some recent studies indicate that farmers' entrepreneurial skills encompass resource allocation and operational management (Yang et al., 2025).

The implication is also profit efficiency, although this aspect is less investigated. For allocative efficiency, farmers are required to select combinations of inputs in line with input prices and output value. Information searching, decision making, risk evaluation, opportunity recognition, strategic planning are skills which may be entrepreneurial and are likely to affect the level of farmers' output; and are also likely to affect the manner in which farmers combine and allocate resources to bring about that level of output. Thus, entrepreneurial performance is seen in more subtle ways: an entrepreneurial farmer need not use more inputs, adopt more technologies, or pursue more opportunities; it is enough that he or she allocates production factors to conditions of input, output, and risk.

Interestingly, entrepreneurial skills are not assumed and should be taught so as to achieve efficiency. Recent empirical studies over the last few years show that entrepreneurial competence can manifest in multiple combinations of capabilities and resources conditions (Shi et al., 2025; Yang et al., 2025). Likewise, the research on farmer entrepreneurial profile characteristics shows that some of these dimensions such as proactiveness, autonomy, risk-taking, and innovativeness may not affect entrepreneurial intention (Ihou & Mansingh, 2025). This heterogeneity is the theoretical basis to research individual entrepreneurial skills without assuming entrepreneurship is a single positive trait.

Entrepreneurial capabilities are thus viewed as a potential behavioral dimension of farm efficiency, linking the cognitive and behavioral profile of farmers with their ability to engage with the technical frontier and the more efficient allocation of their factors of production. This view is complementary to the traditional one focused mainly on farm structure and socio-economic factors, and it will be used to investigate if entrepreneurial skills contribute to understanding differences in profit efficiency among paddy farmers.

2.2 Theoretical foundation

The economic basis for measuring farm-level profit efficiency is the profit maximization theory. It assumes that producers use available resources and make production decisions so as to maximize the difference between their revenues and costs, given market prices, technology, and resources available. Profit-maximization, therefore, serves as a valid criterion for assessing whether farmers can obtain the maximum profit they can from the resources at their disposal (Haring & Smith,

1959; Wong, 1975; Anderson & Ross, 2005). Profit efficiency refers to the farmer's ability to maximize profit with the prices of inputs and outputs, and the technology available in agriculture. This economic interpretation is not exhaustive, however, in explaining why farmers under apparently similar production and market conditions can be more or less efficient in their profit margins. These disparities can also stem from the fact that farmers have varying abilities to recognize opportunities, interpret information, deal with uncertainty, innovate, and allocate resources.

This heterogeneity could be theoretically accounted for from the perspective of entrepreneurial orientation. Entrepreneurial orientation is defined as behavioral aspects that impact an individual's ability to find opportunities, manage risk, and organize resources, including innovativeness, proactiveness, risk taking, and autonomy (Lumpkin & Dess, 1996). In agricultural production, these factors can affect the uptake of better technologies, experimentation with production practices, market participation, and the utilization of limited farm resources. Empirical research has correlated entrepreneurial inclination with farm performance (Verhees et al., 2011) and evidence from smallholder agriculture has shown that non-cognitive attributes may affect technology adoption and technical efficiency (Ali et al., 2020). However, entrepreneurial traits are not necessarily consistently beneficial. Their contribution is likely to vary based on how they are communicated and the ability of farmers to convert entrepreneurial tendencies into economically sound choices. Entrepreneurial intention also reflects the farmer's readiness to commit to a planned action following the thoughts of entrepreneurship. Based on the Theory of Planned Behavior, intentions are the motivational basis of future behavior, and they are influenced by attitudes, social influences, and perceived behavioral control (Ajzen, 1991).

In addition to entrepreneurial orientation and intention, farmers' psychological and behavioral attributes may affect the quality of their production and resource allocation. Economic motivation and achievement motivation can affect the effort farmers are willing to put in to improve economic outcomes, and information-seeking behavior allows farmers to acquire knowledge that is necessary to make production and marketing decisions. Farmer decision-making has been described as a sequential process consisting of the following steps: problem recognition, information search, evaluation, choice, and implementation (Öhlmér et al., 1998). Risk orientation and risk taking are also crucial, because agricultural decisions are taken under uncertainty and farmers vary in their risk preferences and risk management capabilities. Based on this, this study

defines profit efficiency as an economic phenomenon that might be influenced not only by traditional socioeconomic and farm factors but also by the entrepreneurial attitude, entrepreneurial intention, motivation, information seeking behavior, risk orientation, and decision-making behavior of farmers. This integrated view enables this study to analyze the factors that account for the observed differences in how available resources and market opportunities are translated into profit, rather than assuming efficiency is given by the observable farm characteristics.

3.Methodology

3.1 Study Area

The study was conducted in Tamil Nadu, the largest agricultural state in India, with diverse farming systems and agriculture institutions and farmer participation in market-oriented activities. The state is a major producer of paddy cropping and has undertaken programmes for the modernization of agriculture, entrepreneurship, and value addition, such as the Tamil Nadu Irrigated agriculture modernization project (TNIAMP) (Suthar et al., 2024; Sujatha et al., 2024). These attributes may offer an appropriate setting for examining the link between the entrepreneur's attributes and the efficiency of resource utilization.

In order to study the agricultural significance, geographic proximity, and agricultural intensity of the paddy cultivation, the four districts (Tiruvannamalai, Vellore, Ranipet, and Tirupathur) were selected purposively. The district of Tiruvannamalai was selected because of the volume of paddy land available, and the adjoining districts provide a contiguous study area. In addition, Vellore historically covered the towns of Ranipet and Tirupathur, which were reorganized in 2019, meaning that the agro-climatic and socioeconomic conditions are broadly similar.

For the selected districts, paddy growing blocks were purposively selected based on the size of paddy cultivation and 5 villages were selected from each purposively selected block. Simple random sampling was used to select farmers from these villages so that equal weightage is given to sampling of eligible farmers in the villages who are engaged in paddy cultivation. Paddy was selected because it is one of the main food crops and has significant economic and agricultural importance in the study area (Jayaraj & Periyasamy, 2023; Elenchezhian et al., 2023).

3.2 Sampling Method, Sample Size and Data Collection

A multistage sampling procedure combining purposive and probability sampling was employed. Four districts, Vellore, Ranipet, Tirupathur and Tiruvannamalai, were purposively selected based

on their agricultural importance and concentration of paddy cultivation. From each district, two blocks with relatively larger paddy-cultivated areas were purposively selected, followed by the purposive selection of five paddy-growing villages from each block. This resulted in the deliberate concentration of the study in areas most relevant to the research objectives. Within the selected villages, paddy farmers were identified and selected using simple random sampling to provide each eligible farmer an equal probability of selection.

The total identified paddy-farmer population was 14,243, from which the required sample of 389 farmers was determined using Slovin's formula at a 5% margin of error.

$$n = \frac{N}{(1+Ne^2)} \quad (1)$$

Where:

n = Required sample size

N = Total population size

e = margin of error (5%)

The resulting sample was proportionally distributed across the selected villages using probability proportional to size (PPS) to ensure representation consistent with the size of the farming population:

$$n_v = \frac{\text{Number of farmers in the village} * n}{N} \quad (2)$$

Where : n_v is the village sample; n is the study sample; N is the population selected

The sample size from each village details is in the Table a (See supplemental file).

The instrument was reviewed by the doctoral advisory committee, subjected to expert validation and obtained the ethical approval (See supplemental file). A pilot study involving 100 farmers outside the study population was conducted to identify and refine potential instrument-related issues before the main survey. The questionnaire captured socioeconomic and farm characteristics, input use and cultivation costs, access to credit and market information, digital and extension-related practices, and farmers' economic motivation, achievement motivation, information-seeking behavior, decision-making behavior, risk orientation, entrepreneurial mindset, and entrepreneurial intention.

3.3 Data Analysis

The next step is to estimate the profit efficiency (PE). Based on this analysis, the efficiency scores were predicted for PE, which is the efficiency with which farmers use their resources and take advantage of market opportunities.

Latent variables such as entrepreneurial mindset and entrepreneurial intention were treated as mean score in the Tobit regression analysis with robustness, because PCA extracts weighted components which maximize variance and minimize multicollinearity. For PE regression, the predictor variables are socioeconomic and entrepreneurial factors.

Profit efficiency

PE in agriculture refers to how well farms can maximize profit based on input/output prices and available technology. Under the theory of profit maximization, farmers will maximize profit by equating the marginal revenue with the marginal cost, which implies that farmers will use their resources efficiently, including their inputs including labor, seed, and fertilizers (Chambers, 1994). This is a balance between TE (maximizing output from inputs) and AE (optimal input combinations based on prices). Several factors, including soil quality and availability of irrigation and market conditions affect PE (Farrell, 1957).

Poor practices, such as over-dependence on high-cost inputs or mismatching crops to growers' needs, lower profits. The PE is often estimated using SFA, which can show deviations from the optimal profit frontier as a result of inefficiencies or external influences such as weather (Kumbhakar et al., 1991). Better PE improves farm income and sustainable farming (Battese and Coelli, 1995). Policy measures, such as improved access to markets, may increase efficiency even more.

Empirical foundation of Profit efficiency

The stochastic profit frontier method is widely referred to as the primary method of estimation of efficiency, particularly PE in the agricultural value chains (Tzouvelekas et al., 2001). It has been widely applied to estimate PE of various types of crops produce manufacturers including sesame, maize, rice, coffee and vegetable products (Trong and Napasintuwong, 2015; Wongnaa et al., 2019; Jonah et al., 2020). A new type of techno-socio-economic analysis is applied to measure the technological, social and economical factors influencing the performances of innovative firms in different sectors. The population of smallholder rice producers engaged in semi-subsistence operations and low-input production systems are targeted in this research (Kuivanen et al., 2016).

Techno-socio-economic approach studies the benefits generated by the innovative behavior of companies (Shahbeig and Nosrati, 2020). Profit tends to move in this direction with innovation and technological development. However, the innovation is low in smallholder production systems (Kilelu et al., 2013; Lema et al., 2021). Therefore, in the current study, the stochastic frontier methodology was chosen because the econometric procedures are used to estimate the parameters from a specified functional form of the output-input relationship. The good thing about SFA is hypothesis testing and two components of errors.

The reward to a producer who is operating on the frontier is PE, and the highest possible profit is the profit frontier (Trong and Napasintuwong, 2015). The stochastic profit approach, which considers both technical and AE, also provides an explanation for the loss of profit or revenue associated with mistakes in production decisions. In this instance, profit inefficiency is defined as the foregone profits that result from the inability to operate in the frontier (Tzouvelekas et al., 2001) and can be written in linear form using the explanatory variables that are characteristics of the farms (Battese and Coelli, 1995). This method was employed as it can estimate the farm-level efficiency of the growers, and sources of inefficiency in one step are being carried out by Maximum Likelihood Estimation (MLE) technique.

$$\pi_i = f(P_{ij}, Z_{kj}) Exp.\, e_i \qquad (3)$$

Where :

- π_i is the profit of jth farm calculated
- P_{ij} is the price of jth variable input encountered by ith farm
- Z_{kj} is the level of the kth fixed factor in the ith farm
- $e_i = (v_i - u_i)$ is the error
- i ….. n are the number of farms in the sample

The profit frontier approach employing the Cobb-Douglas type functional form was applied for estimation. The model is expressed as follows:

$$\pi_i = \emptyset_0 + \emptyset_1 P_{i1} + \emptyset_2 P_{i2} + \cdots + \emptyset_n P_{ij}\, \emptyset_n Z_{kj} + e_i \qquad (4)$$

Verification of the inefficiencies existing and predicting factors influencing the Profit efficiency

The equation procedure is adopted by Coelli (1996). It consists of maximizing the natural logarithm of the likelihood function and calculating the likelihood ratio (LR). For this author, the

natural logarithm of the likelihood function can be mathematically expressed as follows: $\Upsilon=\sigma_v^2/\sigma_u^2$.

To test the existence of profit inefficiency, Coelli (1996) suggested using the one-sided generalized likelihood ratio test. This approach consists of testing the null hypothesis H_0: Y = 0 against the alternative hypothesis H_1: Y> 0. The procedure leads to the calculation of the likelihood ratio by the formula. When the ratio is less than zero, then it concludes that there is no inefficiency.

The profit efficiency function is:

$$PE = \delta_0 + \delta_1 Z_{i1} + \delta_2 Z_{i2} + \cdots + \delta_n Z_{ni} + e \quad (5)$$

With :

- PE is the efficiency
- Z_{i1} to Z_{in} are the independent variables (include the entrepreneurial factors)
- δ is a vector of parameters to estimate

The estimate is made when the verification ratio rejects the hypothesis of the absence of inefficiency. For this estimation, the model will depend on the nature of the efficiency score value; so, if the score takes a value strictly between 0 and 1, without the value 0 and 1, then the Beta-regression is more adequate, if not, the value is truncated, then the Tobit model is more adequate for the estimation.

The main objective of the study is based on this analysis, where the entrepreneurial mindset, intention and behavioral factors will serve as independent variables, and their influence will be assessed.

Principal component analysis:

Principal component analysis (PCA) was employed to construct composite measures of the multi-item entrepreneurial and behavioral constructs used in the efficiency-determinant models. Specifically, PCA was applied to the items measuring entrepreneurial intention, entrepreneurial mindset, economic motivation, achievement motivation, information-seeking behavior, risk orientation, decision-making behavior, innovativeness, need for achievement, risk-taking, autonomy, and proactiveness. The purpose was to reduce the dimensionality of correlated questionnaire items while retaining the maximum possible proportion of their variation and to generate a single component score for each construct for subsequent regression analysis. PCA produces new, mutually uncorrelated linear combinations of the original variables, with the first principal component accounting for the maximum possible variance (Jolliffe & Cadima, 2016).

For each construct, let Zi1,Zi2,...,Zip denotes the vector of standardized responses of farmer (i) to (p) questionnaire items. Standardization was used so that items measured on the same construct contributed to the PCA according to their correlation structure rather than their original measurement scale. The correlation matrix of the standardized items was then decomposed into its Eigenvalues and eigenvectors:

$$Rw_k = \lambda_k w_k \qquad (6)$$

where $\boldsymbol{R}$is the $(p \times p)$correlation matrix, $\lambda_k$is the eigenvalue associated with the k^{th}principal component, and $\boldsymbol{w}_k$is the corresponding eigenvector containing the component weights (loadings). The eigenvalues were ordered such that $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_p$. The first principal component was retained to construct the composite indicator where it provided the dominant representation of the underlying item set, as reported in the supplemental PCA results. The PCA score for farmer (i) was calculated as the weighted linear combination of the standardized item responses:

$$PC_{1i} = Z_i' w_1 = \sum_{j=1}^{p} w_j Z_{ij} \qquad (7)$$

where PC_{1i}represents the composite score of farmer i, Z_{ij}represents the standardized response to item j, and $w_j$represents the corresponding PCA loading. Thus, items with relatively larger absolute loadings contributed more strongly to the resulting composite measure. The first component was subsequently used as the empirical measure of the corresponding entrepreneurial or behavioral construct in the technical- and allocative-efficiency regression models. The proportion of total variance explained by the retained component was calculated as:

$$V_1 = \frac{\lambda_1}{\sum_{k=1}^{p} \lambda_k} \times 100 \qquad (8)$$

where V_1denotes the percentage of total standardized variance explained by the first principal component. Eigenvalues, component loadings, and the percentage of variance explained for the individual constructs are reported in Table d of the supplementary material.

PCA was preferred to an unweighted arithmetic mean because the component scores assign data-driven weights to the individual items according to their covariance/correlation structure rather than assuming that all items contribute equally. PCA therefore provides a systematic procedure for reducing correlated multi-item measures into composite scores while retaining the largest possible proportion of the observed variance (Jolliffe, 2002; Jolliffe & Cadima, 2016; Shlens, 2014). These

resulting component scores were then entered into the technical- and allocative-efficiency models as continuous explanatory variables. The study performed all the analysis in STATA 17.

4.Results

4.1 Profit frontier analysis

As per the profit function linearized by logs, the factors affecting the production profit margin of Tamil Nadu paddy are analyzed using the SFA method, and production cost and revenue is shown in Table 1. The significant inefficiency parameters (insig2v, -24.140, 0.059; insig2u, -3.071, p-value< 0.001) indicate that technical inefficiencies are high, and farmers are not realizing maximum profit levels. The model has a high chi-square statistic (428.629) and a low p-value (0.000), indicating that the model is robust and fits the data well, supporting its ability to explain the profit outcome. The model fits relatively well, as indicated by the Akaike information criterion (AIC = 550.819), when compared to other models. The overall picture is marred by inefficiencies, both in the utilization of inputs and in cost management, contributing to a suboptimal profit margin. Regarding the coefficient estimates, the coefficient of paddy yield marketed (LPaddyQtmarketed) is positive and significant (p-value < 0.001), which means that selling paddy in the market reduces profit margins slightly, possibly because the price has been fixed by the government. Furthermore, the positive influence of rice marketed (LRiceOtmarketed) with coefficient 0.020 (p-value < 0.001) indicates that the sale of rice leads to lower profitability, which corresponds to more price competitiveness with the production of the large industry. The positive coefficients (0.050, p-value < 0.001 for Straw marketed; 0.068, p-value < 0.001 for rice waste marketed) demonstrate that other by-products such as Straw marketed and rice waste marketed also help to improve profit margins, albeit to a lesser degree than rice.

Concerning the market price variables, paddy price (LPaddyPrice) and rice price (LRicePrice) also show significant positive influence on the market margin (1.330, p-value < 0.001 and 2.230, p-value < 0.001), pointing out that higher market prices for both paddy and rice significantly increase the profit margins. It also observed that the price of the rice in the market has more influence on the profit margin than the paddy harvested price. On the wage cost side, the cost of hiring a tractor per hour (LTPC) shows a significant positive effect (0.239, p-value = 0.003), suggesting that investments in mechanization contribute positively to profit margins by potentially improving

productivity. However, fertilizer costs, such as the cost of urea (LUreaRateRs) and cost of DAP (LDAPRateRs) per kg, show negative coefficients of -0.040 (p-value = 0.002) and -0.120 (p-value = 0.270), respectively, pointing to the fact that while fertilizers are essential for crop growth, their high costs can negatively affect profit margins. The urea price shows a significant effect, due to the frontier reached by that price; any increase in the kg of urea will decrease significantly the profit margin of paddy production compared to the DAP fertilizer kg price but shows no significance.

Other input-related costs, such as the cost of seed per kg (LSeedRateRs) and cost of farmyard manure per kg (LFYMRateRs) respectively with coefficient 0.085 (p-value < 0.001) and 0.076 (p-value = 0.045) present positive and significant effect on the profit margin, which mean that those factors price per kg have not yet reached the frontier price actually good for the farmers. Moreover, the cost of MoP fertilizer (MoPRateRs) per kg, with a positive coefficient of 0.174 (p-value < 0.001), suggests that these costs have not yet reached the profit frontier, since any increase in that fertilizer price per kg will increase the profit margin. Similarly, the cost of pesticides (LPesticideRateRs) at 0.050 (p-value <0.001) significantly increases the profit margin, although this effect is small. In the model, it has been found that achieving maximum profit margin is a fine balance between minimizing production costs, increasing product prices and maximizing the sale of paddy and by-products. This production inefficiency is still a significant obstacle to achieving greater profitability, making it imperative for improvements in management, control of production cost, and use of more efficient technologies.

In PE, the mean score was 0.865, indicating that farmers operate at 86.5% of their potential profit margin based on their technical and AE. The PE standard deviation is 0.118, indicating moderate variation between PE values of 0.358 and 0.990. This means that although most farmers operate near the profit frontier, some farmers are significantly less profitable and may be hampered by high input costs or low market prices. The higher PE relative to technical and allocative efficiencies suggests that, overall, farmers are more effective at producing profits than they are at using their resources and allocating costs efficiently.

4.2 The factors influencing the profit efficiency of paddy farmers

Factors influencing paddy farmers PE (PE) derived from beta regression analysis reveal a wide range of influences, with some having strong positive or negative associations (Table 2). Education

(0.151, p-value < 0.001) is a key positive factor, meaning that better educated farmers are more likely to use their resources effectively and are more profitable. This finding is consistent with the idea that education increases a farmer's capacity to make informed choices and use modern farming methods.

Family Size (0.122, p-value = 0.002) has a significant positive effect on PE. Larger family sizes is likely to provide additional labor and support to farming activities, directly contributing to better PE. Farming experience (0.011, p-value = 0.009) also shows a positive and significant relationship with PE, indicating that more experienced farmers are better at managing resources, mitigating risks, and enhancing farm profitability. Table 2 shows that attending a training program on paddy cultivation presents a positive and significant effect on the PE (0.523, p-value = 0.008), which means that more farmers attend training better they will improve their profit margin. Similarly, the use of the Uzhavan App (1.018, p-value < 0.001) has a significant positive coefficient, which proves that its intended purpose is to aid farmers and aligns well with farmers' needs. Its perceived ease of use is increased due to its availability in the local language, which has a greater effect on PE.

Concerning the entrepreneurial and psychological traits, economic motivation (0.287, p-value < 0.001) demonstrates a positive and significant relationship with PE. This suggests that farmers with strong economic motivation are more likely to make decisions that enhance their profitability. From the entrepreneurial mindset dimension, innovativeness (0.121, p-value = 0.009) shows a positive and significant effect, indicating that more farmers take innovative action more this will increase their PE.

On the negative side, several key variables have significant negative relationships with PE. Starting with number of family members involved in the paddy farming (-0.341, p-value < 0.001), presenting a negative and significant effect on the PE. This can be due to the lack of professional action of the family members, or the willingness to leave the farm activities.

Similarly, FPO membership (-0.679, p-value < 0.001) shows a high negative and significant effect, suggesting that membership in FPOs may not always translate into improved PE. This could be due to the inefficiencies associated with organizational structures or challenges within the FPOs model that prevent farmers from fully realizing profit potential. Moreover, market information access (-0.569, p-value = 0.001) negatively and significantly impacts PE, indicating that limited access to timely and accurate market information constrains farmers' ability to make profitable

decisions. This result highlights the need for better information systems and market linkages to improve profitability. Finally, cropping land also shows a negative and significant effect on the PE of paddy production (-0.081, p-value = 0.001). The negative effect of cropping land implies that a larger land area does not necessarily guarantee higher PE, possibly due to inefficiencies in land management or underutilization of available land.

Information-seeking behavior factor shows a negative and significant effect on the PE (-0.108, p-value = 0.033), indicating that inefficiencies may arise when farmers rely on inaccurate or poorly sourced information during decision-making. From the entrepreneurial mindset dimension, proactiveness (-0.173, p-value = 0.003) shows a negative and significant effect, indicating that overly proactive behavior might lead to suboptimal decisions, such as over-investment or taking unnecessary risks, thus reducing PE.

Several other factors, such as decision-making behavior, risk orientation, achievement motivation, need for achievement, risk-taking, autonomy, and entrepreneurial intention, did not exhibit significant relationships with PE. These findings imply that although some psychological and entrepreneurial characteristics directly affect PE, not all aspects of an entrepreneurial mindset result in enhanced PE. In conclusion, the analysis highlights the complex dynamics of factors influencing PE among paddy farmers. Understanding these relationships can help design targeted interventions to improve PE in paddy farming.

5.Discussions

5.1 Profitability Drivers and Resource-Use Patterns in Paddy Production

Profit frontier output showed that paddy, rice, and their byproducts boost profitability. Due to the government's regulated pricing structure, selling paddy is slightly more profitable than processed rice, which is less profitable due to significant competition and price pressure from large-scale companies. Selling by-products like straw and rice waste boosts profit margins, although less than paddy and rice. Rice milling connects producers and consumers, and the effectiveness of milling and marketing each product sustains farm incomes, according to Goeb *et al.* (2022). Tan *et al.* (2023) noted that rice bran is a valuable functional food ingredient, while Gupte *et al.* (2022) showed that rice waste streams may be turned into biofuels, proving that byproducts have economic and environmental value.

By-products, strategic market engagement, and value-added innovation boost profitability. Illankoon *et al.* (2023) found that circular business models like rice residue biochar production increase profits and address environmental issues. New processing methods that boost profitability and sustainability were also stressed by Kumar *et al.* (2022) and Spaggiari *et al.* (2021). Studies show that farmers can increase income through efficient production, processing integration, by-product optimization, and strategic positioning in value-added markets. Additionally, mechanization, particularly tractor costs, positively impacts profitability. Tractor services boost productivity and business margins despite their high cost. Peng *et al.* (2022) showed that even small mechanization increases yield and revenue, whereas Gebiso *et al.* (2024) showed that mechanization boosts agricultural efficiency and profitability. Meanwhile, Sun *et al.* (2024) found that mechanization regularly increases profit margins, making it a key driver of economic efficiency.

Fertilizer costs affect profitability differently. The cost of urea rises negatively impact company margins, while DAP fertilizer does not. While fertilizers are necessary for agricultural growth, rising prices, especially for urea, can reduce profitability. The cost of seed and farmyard manure per kilogram also positively and significantly affects profit margins, demonstrating that these input costs still favor farmers. MoP fertilizer and pesticide prices also positively and significantly affect profitability, indicating that their current prices still allow for lucrative returns. Both paddy and rice prices positively affect profit margins, but rice prices more so. Improving paddy and rice prices boosts farmer income and profitability. When linked with value-added strategies, processing costs boost profitability. According to Sgroi (2023) In mechanization in agricultural processing, technological integration makes harvesting cheaper and boosts profit margins when matched with value-enhanced output, which applies to rice systems.

Despite these favorable linkages, resource and managerial inefficiencies exist. Mugera and Langemeier (2016) observed that profitability growth depends on technology adoption, while Zhang *et al.* (2024) noted that successful mechanization decreases over-reliance on costly inputs and improves sustainability. These findings show that paddy farming profitability requires balance. To increase profit margins and ensure long-term economic resilience, product pricing must be optimized, automation promoted for productivity improvements, fertilizer dependency minimized, and value addition combined with effective management methods.

5.2 Profit Efficiency and Unexploited Profit Potential among Paddy Farmers

The profit efficiency (PE) was also relatively high (86.5) and this means that farmers are more efficient in transforming production into income than they are in terms of resource utilization or distribution of cost. Research has shown that strategic market interaction and value capture enhances profits. Saravanakumar and Kiruthika (2015) found that effective marketing channels can help in boosting net income. Besides, the study by Kumar *et al.* (2023) also found that increased gross and net returns under SRI and demonstrated that integrated farming systems improve economic resilience. Simultaneously, a study estimated the unrealized potential-optimizing input and the best practices adoption might increase output and profit by a significant margin (Kumari *et al.*, 2018). The knowledge gaps and technical capacity were also limiting the broader adoption of profit-enhancing options (Habanyati *et al.*, 2024), hence policy should enhance market linkages and post-harvest infrastructure and encourage the use of targeted training and incentives to optimize inputs and add value and efficient marketing to enable farmers to maintain and broaden profit margins as they work to overcome underlying TE and AE drawbacks.

5.3 Entrepreneurial, Behavioral and Socioeconomic Drivers of Profit Efficiency

Education, family size, farming experience, use of Uzhavan App and training clearly stand out as socioeconomic factors influencing profit efficiency (PE) of paddy farming. Education and training equip farmers with the skills to make informed decisions, adopt sustainable practices, and strategically manage resources. These results are consistent with data from China and Vietnam, where formal education and training have been demonstrated to greatly increase productivity and efficiency (Nguyen *et al.,* 2019). Similarly, a larger family size strengthens labor availability and collective support in farming activities, enhancing productivity, especially in diversified systems (Maini *et al.*, 2021). Experience further reinforces these gains, with experienced farmers better equipped to reduce risks and allocate resources appropriately in line with what Jamil et al. (2023) demonstrated in their findings that farming experience and education are important factors that can help in the effectiveness of extensions. There are also positive impacts that come from the adoption of technology. However, locally adapted and user-friendly tools like the Uzhavan App. had a positive and significant effect on PE, with appropriate use of digital technologies that can meaningfully support farmer decision-making (Xayavong et al., 2016). These factors collectively

illustrate the power of knowledge, labor, and learning-by-doing in achieving sustainable efficiency and profitability.

The results also show that there are institutional or technological factors that do not have a positive effect at the same time. While the findings align with those of Sapbamrer and Thammachai (2021), it is also noted that the level of effectiveness of FPOs does not necessarily result in better outcomes because of organizational inefficiencies or cooperation problems. Likewise, larger cropping areas do not necessarily mean high efficiency; careless use of the land and poor management systems often reduce the potential efficiency gains from scale (Mujuru et al., 2022).

Structural and informational barriers add to limited PE. Poorly designed market information systems (MIS) restrict farmers' capacity to make profitable choices (Choudhary et al., 2022), arguing the significance of functioning input, information and market access channels in Nepal's rice production system. Lack of price signals and timely information prevents farmers from maximizing sales and input utilization, which adversely affects profitability even if production is efficient. Similarly, in the same context, seeking information from unreliable and incomplete sources can affect negatively on PE rather than positively. This highlights the need to involve farmers in more robust market linkages and ensure innovations in information systems are locally appropriate and adaptive. Addressing these gaps could revolutionize PE, and move knowledge, resources, and institutional support toward market-relevant results.

Entrepreneurial and psychological characteristics prove to be significant factors in the process of PE, where economic motives in particular demonstrate a strong influence. As shown by Yang et al. (2022), motivation is what influences learning and ultimately performance, and farmers with economic interests are more likely to follow strategies that improve profitability. Similarly, Fazal et al. (2022) highlighted those motivational factors such as self-confidence and openness to change support entrepreneurial competencies, which sustain enterprise success. Similarly, the entrepreneurial mindset dimension innovativeness is also found to have a positive and significant impact on PE, as indicated by the results. Innovators who act ahead are more likely to embrace new practices and technologies and turn concepts and inputs into positive results. The results support the idea that the economic motivation and innovativeness help farmers turn their choices into better financial results. There is, however, no consistent positive association between entrepreneurial traits and efficiency. Too much proactivity can negatively impact efficiency as it

can lead to risky or premature decisions, as noted by Yanore et al. (2024), who point out that while proactivity can be a motivator, it is important to manage the risks involved. Research on farm risk taking behavior also shows that in situations like credit crises or technological bottlenecks, farmers might make decisions with high stakes that could undermine, not boost profitability. Imran et al. (2019) have stated that not all entrepreneurial traits directly affect financial outcomes as orientation or contextual factors intervene in some cases. This illustrates the fine line between entrepreneurship and efficiency: entrepreneurial spirit is not necessarily an efficient one, depending on how these traits are manifested. In addition to individual traits, psychological and entrepreneurial traits combine with external conditions like institutional settings and networks. Findings indicate that social capital strengthens the effects of entrepreneurial attributes, as observed by Etriya et al. (2019), who find that entrepreneurial traits are linked to better financial outcomes among farmers with wider entrepreneurial networks. In parallel, Ali et al. (2019) demonstrate that noncognitive attributes such as optimism affect adoption behavior and TE; sometimes more than traditional education. When taken together, these insights confirm that entrepreneurial and psychological characteristics are important but that they also depend on external enablers, networks, markets and policy stability that influence the viability of intentions to entrepreneurial profit.

5.4 Policy Implications for More Efficient Paddy Farming Systems

The findings suggest that improving paddy farmers' profit efficiency requires a shift from production-centered support toward profit-oriented farm management, market coordination and capability development. First, policies should strengthen farmers' capacity to capture value beyond the sale of raw paddy by linking FPOs with decentralized milling, grading, storage and by-product enterprises. Evidence that rice/bran valorization and value addition can improve returns (Goeb et al., 2022; Tan et al., 2023) supports moving from simple aggregation toward farmer-controlled value capture. This is particularly relevant because information and transaction costs can push farmers toward less remunerative local markets (Mishra et al., 2018), while recent evidence confirms that market-channel choice among Indian paddy farmers is associated with MSP awareness, technical advice, farm size and education (Naik and Mohan, 2026).

Second, mechanization policy should prioritize access rather than ownership. The positive profitability associated with mechanization in the present study supports strengthening Custom

Hiring Centres (CHCs), particularly where machinery can reduce labour costs and improve the timeliness of operations. Existing evidence supports CHCs as a means of reducing capital burdens and improving machinery utilization (Dahlin & Rusinamhodzi, 2019; Ganavi et al., 2024), while ICAR currently emphasizes cluster-based CHCs for small and marginal farmers. For Tamil Nadu, CHCs could be integrated with FPOs to provide machinery together with advisory services, rather than treating mechanization as an isolated subsidy intervention.

Third, the significant effects of economic motivation, innovativeness and proactiveness indicate that farmer-development programmes should explicitly strengthen entrepreneurial and decision-making capabilities. Extension should therefore move beyond technology dissemination toward training in partial budgeting, input-cost comparison, market-price interpretation, risk assessment and evaluation of expected returns before investment. This is especially important because the negative coefficient for proactiveness suggests that entrepreneurial behaviour does not automatically translate into efficiency. Finally, market-information systems should be integrated with credit and insurance services so that farmers can evaluate profitability before undertaking potentially costly innovations (Invernizzi et al., 2016; Shrestha et al., 2022). Recent ICAR initiatives combining CHCs, scientific advisory kiosks and market intelligence illustrate the feasibility of such integrated farmer-support models. Value-addition clusters should similarly prioritize locally feasible rice-processing and by-product enterprises, building on the documented potential of rice residues and bran (Gupte et al., 2022; Illankoon et al., 2023), rather than promoting processing infrastructure without assured markets.

6.Conclusion

This study examined the determinants of profit efficiency among paddy farmers in Tamil Nadu by moving beyond the conventional emphasis on farm and socioeconomic characteristics and incorporating entrepreneurial and behavioral dimensions into the efficiency framework. Using a stochastic profit frontier, the study estimated farmers' profit efficiency and subsequently examined whether entrepreneurial mindset, entrepreneurial intention, motivation, information-seeking, risk orientation and decision-making characteristics explain differences in efficiency. The findings show that profit efficiency was relatively high with a mean of 86.5%, but with significant difference between farmers ranging from a minimum of 35.8% to a maximum of 99.0%, suggesting high unrealized profitability potential. Profit efficiency was positively associated with

education, farming experience, training, family size, Uzhavan App use and economic motivation, and conversely, negatively associated with family involvement in agriculture, membership in FPOs, access to market information and cropping land. Not all entrepreneurial and psychological factors were necessarily positive. Profit efficiency was significantly and positively correlated with innovativeness and economic motivation, and information-seeking behavior and proactiveness were significantly and negatively correlated with profit efficiency. There are no statistically significant differences in the areas of risk orientation, achievement motivation, need for achievement, risk-taking, autonomy, and decision-making behavior and entrepreneurial intention. The results show that entrepreneurial traits are relevant but not directly so in terms of farm profitability unless they are translated to economically appropriate decisions for the allocation of resources and the production of the farm.

The results have significant policy and extension implications in India. To enhance profit efficiency of the farmers, interventions should link production, market access, financial management and behavior rather than just input provision or technology application. Extension programmes should incorporate practical training on enterprise budgeting, input-cost management, market-price interpretation, investment appraisal and risk assessment so that entrepreneurial motivation and innovativeness are converted into economically sound decisions. Custom Hiring Centres and FPOs can be strengthened as integrated service platforms providing machinery, technical advice, market information and value-addition opportunities, particularly for small and medium paddy producers. Greater attention should also be given to decentralized rice processing, storage and by-product utilization so that farmers can capture a larger share of value beyond the farm-gate sale of paddy. The negative association of proactiveness and information-seeking behavior further suggests that simply encouraging farmers to be more proactive or to seek more information may be insufficient; the quality, reliability and economic relevance of information are critical. Future interventions should therefore promote validated, locally relevant market and technical information linked with credit and risk-management instruments. Such an approach can help farmers pursue innovation while limiting poorly informed investments and improving the conversion of entrepreneurial capabilities into measurable profit gains.

Future research should extend this framework beyond a single cross-sectional assessment and examine how entrepreneurial and behavioral characteristics influence profit efficiency over time.

Panel datasets may provide insight into whether shifts in entrepreneurial mindset, motivation, or information behaviors lead to shifts in efficiency and profitability. Comparative analysis across crops, regions and farming systems might also help identify if the observed relationship is unique to the paddy production in Tamil Nadu or a general trend in agricultural entrepreneurship. The research should focus on how entrepreneurial characteristics impact on efficiency, such as technology uptake, input allocation, market channel selection, financing access and value addition. Qualitative methods, longitudinal data, and causal methods could increase the evidence of these pathways. Another avenue for research is to examine how the link between entrepreneurial capabilities and profit efficiency is moderated by institutional support, digital advisory services and participation in FPOs, respectively. This evidence will support the design of more specific and effective strategies for supporting farmers that link entrepreneurial capacity to more concrete economic results.

Declarations

Ethical approval

All research was conducted in accordance with relevant guidelines and regulations applicable to studies involving human participants. Ethical approval was obtained from the Institutional Ethical Committee for Human Studies, Vellore Institute of Technology, Vellore, India, under approval number VIT/IECH/2025/16 IECH/8 February 2025/30, granted on March 3, 2025, for one year. The committee members included Dr. S. Sivakumar, Dr. Pragasam Viswanathan, Dr. Rajesh N. G., Dr. C. P. Girish Kumar, Dr. Kalaiselvi, Dr. S. Sreeja, Dr. N. Aravind Yuvaraj, Dr. Prasanna Samuel, Dr. Nagaraju Gundemeda, Dr. Venkatesan Kuppusamy, and Mr. M. R. Ravishankar. The study was independently reviewed by the ethics committee and deemed to have scientific and social value while minimizing risks to participants. The scope of approval includes collecting quantitative and qualitative data from consent-informed respondents, conducting statistical and thematic analysis based on the self-collected data, and sharing results with the public without releasing respondents' personal information.

Informed consent

Informed consent was obtained through signed consent forms from all respondents after providing detailed information about the study's objectives, risks, and benefits in Tamil language. The respondents included are the members of Farmers' Producer Companies, Farmers' Producer

Organizations, and key informant farmers. Dr. Atsu Ihou conducted focus group discussions and key informant interviews in March 2025. The consent covered respondents' willingness, data use, and publication. Since this study did not involve interventions and relied on surveys and questionnaires, respondents were assured of their anonymity, the research purpose, and potential risks. No vulnerable individuals, such as minors, patients, or refugees, were involved.

Data Availability: The data is available upon request to ihou.atsu@vit.ac.in.

Conflict of Interest

The authors declare that the research was conducted without any commercial or financial relationships that could potentially create a conflict of interest.

Author Contributions

Dr. Atsu: Conceptualization; Identification of the Topic; Methodology; Investigation in data collection; Theoretical framework; Data analysis; Manuscript draft.

Dr. Paul: Supervision; Validation of the topic; Theoretical framework; Supervision; Final Manuscript validation

Dr. Saravanan: Methodology; Supervision; validation; review of manuscript

Dr. Venkattakumar: Methodology; Supervision; validation; review of manuscript

Dr. Kossi Ayenagbo: Methodology; Supervision; validation; review of manuscript

Funding

No funding is involved in this study. University support in the data collection investigation

Acknowledgments

Not Applicable

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Table 1 Stochastic frontier analysis of Paddy profit of production

LMARGIN	Coef.	St.Err.	t-value	p-value	95% Conf Interval		Sig
LMC	0.086	0.062	1.38	0.168	-0.036	0.209	
LWC	0.095	0.049	1.92	0.055	-0.002	0.192	*
LCPC	-0.058	0.044	-1.31	0.191	-0.146	0.029	
LTPC	0.239	0.080	2.98	0.003	0.081	0.396	**
LSeedRateRs	0.085	0.015	5.67	0.000	0.056	0.115	***
LFYMRateRs	0.076	0.038	2.01	0.045	0.001	0.150	**
LUreaRateRs	-0.040	0.013	-3.03	0.002	-0.066	-0.014	**
LDAPRateRs	-0.120	0.109	-1.10	0.270	-0.334	0.093	
LMoPRateRs	0.174	0.043	3.98	0.000	0.088	0.260	***
LHerbicideRateRs	-0.147	0.119	-1.24	0.216	-0.381	0.086	
LPesticideRateRs	0.050	0.009	5.10	0.000	0.030	0.069	***
LPaddyQtmarketed	0.133	0.003	41.22	0.000	0.127	0.140	***
LRiceQtmarketed	0.020	0.003	5.84	0.000	0.013	0.027	***
LStrawQtmarketed	0.050	0.004	10.33	0.000	0.040	0.059	***
LRICEWASTQtmar	0.068	0.004	14.55	0.000	0.058	0.077	***
LPaddyPriceRs	1.330	0.047	28.23	0.000	1.238	1.423	***
LRicePriceRs	2.230	0.059	37.60	0.000	2.113	2.346	***
LStrawPriceRs	-0.059	0.025	-2.39	0.017	-0.108	-0.010	**
LPaddyQt	1.408	0.036	38.37	0.000	1.336	1.480	***
LTOTALCOST	-0.547	0.031	-17.62	0.000	-0.608	-0.486	
Constant	-10.07						
/lnsig2v	-24.140	12.788	-1.89	0.059	-49.205	0.923	*
/lnsig2u	-3.00	0.071	-41.93	0.000	-3.147	-2.866	***
Mean dependent var	11.182		SD dependent var		0.676		
Number of obs	389		Chi-square		428.629		
Prob > χ^2	0.000		Akaike crit. (AIC)		550.819		
*** p<.001, ** p<.05, * p<.1							

Source: Survey data (2024 - 2025)

Table 2 Beta regression analysis of factors influencing the profit efficiency of paddy farmers

PE	Coef.	Std. Err.	z	P>z	95% conf.interval		Sig
Education	0.151	0.041	3.660	0.000	0.070	0.231	***
Familysize	0.122	0.040	3.060	0.002	0.044	0.199	**
Familyinagriculture	-0.341	0.064	-5.330	0.000	-0.466	-0.215	***
FarmingExperience	0.011	0.004	2.610	0.009	0.003	0.020	**
FPO	-0.679	0.160	-4.240	0.000	-0.993	-0.365	***
Training	0.523	0.199	2.630	0.008	0.134	0.912	**
MarketinfAccess	-0.569	0.164	-3.460	0.001	-0.891	-0.247	**
UzhavanApp	1.018	0.239	4.260	0.000	0.549	1.487	***
CroppingLand	-0.081	0.025	-3.220	0.001	-0.130	-0.032	**
MeanDM	-0.249	0.265	-0.940	0.347	-0.769	0.270	
EMpca1	0.287	0.053	5.460	0.000	0.184	0.390	***
ISBpca1	-0.108	0.051	-2.130	0.033	-0.208	-0.009	**
ROpca1	0.048	0.047	1.030	0.305	-0.044	0.140	
AMpca1	0.018	0.050	0.370	0.711	-0.079	0.116	
EMInpca1	0.121	0.047	2.610	0.009	0.030	0.213	**
EMNApca1	0.055	0.059	0.930	0.352	-0.061	0.172	
EMRTpca1	0.056	0.066	0.840	0.398	-0.073	0.184	
EMApca1	-0.016	0.055	-0.290	0.771	-0.123	0.091	
EMPapca1	-0.173	0.059	-2.950	0.003	-0.288	-0.058	**
EIpca1	0.035	0.035	0.990	0.324	-0.034	0.104	
cons	2.130	0.395	5.390	0.000	1.356	2.905	
cons	1.986	0.077	25.700	0.000	1.834	2.137	

Number of obs = 389 LR χ^2 (20) = 201.05 Prob > χ^2 = 0.0000
*** p<.001, ** p<.05, * p<.1
Source: Survey data (2024 - 2025)

Annexures

The sample selected from each village is depicted in Tables a

Table a Sample size of each village selected for paddy

District	Blocks Selected	Villages Selected	Number of paddy farmers	Sample Size
Tiruvannamalai	Polur	Alliyabath	450	12
		Athimoor	992	27
		Athuvambadi	446	12
		Thurnjikuppam	432	12
		Kasthampadi	415	11
	Kalasapakkam	Kadaladi	1565	43
		Kettavarampalayam	1204	33
		Veeralur	995	27
		Gengavaram	1082	30
		Arunagirimangalam	612	17
Thirupattur	Thirupathur	Pungampattunadu	35	1
		Nellivasalnadu	322	9
		Pudurnadu	285	8
		Andiappanur	144	4
		Kurisilapattu	95	3
	Kandili	Kurumberi	142	4
		Simmanaudhur	95	3
		Adhiyur	46	1
		Lakkinaikenpatti	55	2
		Elavampatti	80	2
Ranipet	Nemili	Ganapathipuram	120	3
		Sayanapuram	100	3
		Pallur	116	3
		Melapulam	80	2
		Thirumalpur	85	2
	Thimiri	Chennasamudram	605	17
		Mambakkam	400	11
		Melapalanthai	375	10
		Irungur	345	9
		Soraiyur	305	8
Vellore	Katpadi 3	Ammundi	220	6
		Kembarajapuram	135	4
		Elayanallore	190	5
		Melpadi	180	5
		Veppalai	165	5
	Kaniyambadi 1	Kammasamudiram	400	11
		Kathalampattu	200	5
		Thuthikadu	130	4
		Sholavaram	420	11

District	Blocks Selected	Villages Selected	Number of paddy farmers	Sample Size
		Mothakkal	180	5
			14243	**389**

Source: Researcher's compilation

The paddy profit production function variables are summarized in Table a below.

Table b: Profits of the production

S.No.	Label	Variable name (ln)	Measurement
1	LMARGIN	Margin from the production and the cost	The reminder from the sales revenue and the cost of production (Rs)
2	LMC	Wage rent of Men	Cost of hiring one man in a farm (Rs)
3	LWC	Wage Rent of Women	Cost of hiring one woman in a farm (Rs)
4	LCPC	Wage Rent of a Cattle pair	Cost of hiring a cattle pair per hour (Rs)
5	LTPC	Wage Rent of a tractor power	Cost of hiring a tractor per hour (Rs)
6	LMPC	Price processing unit	Price of a kg of paddy processed (Rs)
7	LSeedRateRs	Seed price	Price per kg (Rs)
8	LFYMRateRs	FYM price	Price per kg (Rs)
9	LUreaRateRs	Urea price	Price per kg (Rs)
10	LDAPRateRs	DAP price	Price per kg (Rs)
11	LMoPRateRs	MoP price	Price per kg (Rs)
12	LHerbicideRateRs	Herbicide price	Price per kg (Rs)
13	LPesticideRateRs	Pesticide price	Price per kg (Rs)
14	LPaddyQtmarketed	Paddy quantity marketed	In kg
15	LRiceQtmarketed	Rice quantity marketed	In kg
16	LStrawQtmarketed	Straw quantity marketed	In kg
17	LRICEWASTQtmarketed	Rice waste quantity marketed	In kg
18	Lprice of paddy	Price of paddy in the market	In Rs
19	LPaddyPrice	Price of paddy in the market	In Rs
20	LRicePrice	Price of Rice in the market	In Rs
21	LStrawPrice	Price of Straw in the market	In Rs
22	LRicewastePrice	Price of rice waste in the market	In Rs

Source: Researcher's compilation

The principal components of the latent variables are listed in Table b below.

Table c: The principal component of the latent variable

S.No.	Label	Variable name (ln)
1	EM_pca1	Economic motivation principal component
2	ISB_pca1	Information-seeking behavior principal component
3	RO_pca1	Risk orientation principal component
4	AM_pca1	Achievement orientation principal component
5	DMB_pca1	Decision-making behavior principal component
6	EM_In_pca1	Innovativeness principal component
7	EM_NA_pca1	Need for achievement principal component
8	EM_RT_pca1	Risk-taking principal component
9	EM_A_pca1	Autonomy principal component
10	EM_Pa_pca1	Proactiveness principal component
11	EI_pca1	Entrepreneurial intention principal component

Source: Researcher's compilation

VELLORE INSTITUTE OF TECHNOLOGY, VELLORE
VIT School of Agricultural Innovations and Advanced Learning (VAIAL)
Department of Agricultural Extension and Economics
Ph.D. in Agribusiness Management
Interview Schedule for Paddy Farmers

Title: The Influence of Farmers' Entrepreneurial Mindset and Intention on the Profit and Economic Efficiency: The Case of Paddy Farmers in Tamil Nadu

Student Name: Ihou Atsu Frank Yayra **Guide Name:** Dr. Paul Mansingh J

Basic Details

Date: **Respondent No.:**
Name of the farmer: **Village:**
Block: **District:** **Mobile Number:**

PART A: Demographic and Socio-economic Profile

1. Age: --------Years
2. Education: Illiterate / Up to primary (5th)/ 6th to 10th / 11th -12th / Diploma or certificate holders/ Graduate/Postgraduate and above
3. Gender: Male/ Female/Transgender
4. Marital status: Single / Married / Widow
5. Family type: Nuclear/Joint
6. Family Size: ---------Nos.
7. Number of family members involved in agriculture: --------- Nos.
8. Agriculture Occupation: Primary/Secondary
9. Farming experience: --------- years
10. Distance to market: ---------Km.
11. **Socio-political participation**

Give the appropriate response.

Sl.No.	**Category**	**Type of Involvement**		
		Official	Paid Membership	Free Membership
1	Gram panchayat			
2	Co-operative Society			
3	FPO			
4	Others, if any			

12. **Sources of Income**

Give the appropriate response.

Sl.No.	**Sources of income**	**Annual income (Rs.)**
1	Farm income	
2	Off-farm income	

13. **Land ownership**

Give the appropriate response.

Type of Land	**Area in acres**			**Value/acre(Rs.)**	**Land revenue**	**Remark**
	Owned (acre)	**Lased-in (acre)**	**Total (acre)**			
Dry Land						
Wet land						
Garden land						

Any Other Specify						

14. Livestock status

Give the appropriate response.

Sl.No.	Name	Tick mark (✓)	Number
1	Cattle (cow/buffalo/ox)		
2	Sheep		
3	Goat		
4	Pigs		
5	Chicken		

15. Farm inventory status

Give the appropriate response.

Sl.No.	Category	Year of construction	Value (Rs.)	Useful year of life	Depreciation
1	Cattle shed				
2	Tractor				
3	Drip irrigation set				
4	Sprinkler irrigation set				
5	Sprayer				
6	Disc plough				
7	Cage wheels				
8	Leveller				
9	Rotavator				
10	Rice Mill				
11	Others, if any				

16. Economic Motivation

Kindly give your agreement (or) disagreement about each of the following statements.

Sl.No.	Statements	SD	D	N	A	SA
1	A farmer should work hard to achieve economic profit					
2	The most successful farmer is the one who makes the most profit					
3	A farmer should explore any new ideas or occupations that may help to earn more money					
4	While a farmer must earn a living, the most important things in life cannot be defined in economic terms					
5	It is difficult for one's children to make a good start unless one provides them with economic assistance					

SD =Strongly Disagree, D = Disagree, N = Neutral, A = Agree and SA = Strongly Agree

17. Information-seeking behaviour

Kindly give your agreement (or) disagreement about each of the following statements.

Sl.No.	Statements	SD	D	N	A	SA
1	One can learn many things from happenings and experiences of his/her village only					
2	One can satisfy all his/her requirements out of the local resources available to him					
3	One can be happy and contented within his local boundaries					
4	A person who has to seek something worth in his village, need not worry about taking any additional information from sources outside his village					
5	Many things a person ought to know are happenings outside of his village and such happening may be of great advantage to a person					
6	At present where transport and other communication facilities are available, a villager should know more about things happening outside the village					

SD =Strongly Disagree, D = Disagree, N = Neutral, A = Agree and SA = Strongly Agree

18. Risk Orientation:

Kindly give your agreement (or) disagreement about each of the following statements.

Sl.No.	Statements	SD	D	N	A	SA
1	A farmer should grow a large number of varieties to avoid the greater risk involved in growing one (or) two crops					
2	A farmer should take more of a chance in making a big profit than be content with a smaller but less risky profit					
3	A farmer who is willing to take greater risk than the average farmer usually does better financially					
4	It is good for a farmer to take risks when he knows his chance of success is fairly high					
5	A farmer shouldn't try a new farming method unless most others in the locality have used it with success					
6	Trying entirely a new method in farming by an entrepreneur involves risk but it is worth					

SD =Strongly Disagree, D = Disagree, N = Neutral, A = Agree and SA = Strongly Agree

19. Achievement Motivation:

Kindly give your agreement (or) disagreement about each of the following statements.

Sl.No.	Statement	SD	D	N	A	SA
1	Success brings relief for further willpower and not pleasure.					
2	my efforts are directed toward a goal					
3	I try to do extremely well					
4	I hesitate to do a thing which has a chance of failure					
5	I avoid the thing where my performance is evaluated by others					

SD =Strongly Disagree, D = Disagree, N = Neutral, A = Agree and SA = Strongly Agree

20. Extension Agency Contacts:

Give the appropriate response.

Sl.No.	Name of the Extension Agent	Frequency of contact			Purpose of contact	
		Regular	Sometimes	Never	Agri	Non-Agri
1	AAO/AHO					
2	AO/HO					
3	ADA/ADH					
4	DDA/DDH					
5	JDA					
6	Scientists from SAUs/ KVKs					
7	Bank officials					
8	Input dealers					
9	Farmer-to-farmer extension					
10	Social media a) WhatsApp					

	b) Facebook c) Twitter d) YouTube e) Instagram f) Uzhavan app g) Other (specify)					
11	Others (specify)					

21. Decision Making Behaviour:

Sl.No.	Area of Decision-making	(Joint Decision)	(Independent Decision)
1	To try new varieties		
2	To try new practices		
3	To change cropping pattern		
4	Buying / selling of land		
5	Credit procurement and marketing		
6	To buy requirements		
7	Land improvement		
8	Hiring of labour		
9	Time of harvest		
10	Time of sowing		
11	Mode of transport		
12	Place of marketing		
13	Choosing the market channel		
14	Determining the price of produce		
15	Value addition		
16	Profit reinvestment		

22. Do you have access to credit/loan/subsidy? Yes/No:
23. Did you attend training on Paddy? Yes/No:
24. Do you add value to the Paddy? Yes/No:

If Yes, Product
Process
Marketing
Revenue

25. Do you have access to market information Yes/No:

If Yes, how do you access the market information?

26. Do you use the Uzhavan App? Yes/No:

If yes, how is the Uzhavan app useful to you?

27. Do you use e-commerce? Yes/No:

If Yes, how does the e-commerce serve you?

28. Do you use social media? Yes/No:
If yes, give the details.

29. Cropping pattern

1. Previous year production (2022 – 2023)

Season	Crop	Area (acre)	Irrigated/rainfed	Duration (days)	Production (kg)
Kharif	Paddy				
Rabi	Paddy				
Summer	Paddy				

2. Current year production (2023 – 2024)

Season	Crop	Area (acre)	Irrigated/rainfed	Duration (days)	Production (kg)
Kharif	Paddy				
Rabi	Paddy				
Summer	Paddy				

PART B: Cost of Cultivation

1. Farming input: Pre-Production Production and Post Production

Crop: Variety: Area:
Season: Duration: Land Revenue:
Soil Type:

Labor input cost

Wage rate: Rs./day Male: Rs./day Female: Rs./day
Cattle pair: Rs./Hr
Tractor/ machine power/Rice Mill Processing: Rs./Hr/Kg

Sl.No.	Operations	Owned labour					Hired labour					Total
		TP/MP	CP	M	W	C	TP/MP	CP	M	W	C	
1.	**Nursery Preparation**											
a.	FYM application and soaking of field											
b.	First puddling											
c.	Second puddling and soaking of seeds with water											
d.	Basal application of DAP											
e.	Sowing											
f.	Any others											
2.	**Main field preparation – wetland paddy cultivation**											
a.	FYM application and soaking of the main field with water											
b.	First puddling											
c.	Second pudding											
d.	Basal application of fertilizer											
e.	Transplanting											
f.	Hand weeding and top dressing of fertilizer											
g.	Harvesting											
h.	Collection of straws											

i.	Threshing and winnowing											
j.	Cleaning and drying											
k.	Rice Mill processing (kg)											
l.	Bagging											
m.	Any additional activities											

2. Use of material inputs:

Sl.No.	Inputs	Quantity (Kg/l)	Rate (Rs.)	Value (Rs.)	Remarks
1.	Seeds				
2.	FYM				
3.	Fertilizers				
a.	Urea (N)				
b.	DAP (P)				
c.	MoP(K)				
d.	Any Others				
e.					
4.	Plant Protection Materials				
a.	Pesticide				
b.					
c.					
d.	Fungicide				
e.					
f.					
g.					
5.	Others if any				

3. Returns :

Yield	Quantity (kg)	Quantity marketed (kg)	Price (Rs.)	Total value (Rs.)	Remarks
Paddy					
Rice					
Straw					

PART C

1. Entrepreneurial Mindset

Kindly give your agreement (or) disagreement about each of the following statements.

Factors		SD	D	N	A	SA
Innovativeness						
1	I like to take on a new challenge					
2	I try to work in a novel way					
3	I like to accept new ideas					
4	I like imaginative ideas					
5	I try to look for new opportunities earlier than others					
6	I persistently try to come up with outstanding ideas					

Need for Achievement						
7	I act aggressively to achieve a goal					
8	I am more passionate than others					
9	I have a strong will to achieve something					
10	I persist in pushing forward necessary things against all odds					
Risk-taking						
11	I tend to push forward something with high expected value even with high risk					
12	I tend to take risks for new opportunities					
13	I tend to take challenges even when there is a risk of failure					
Autonomy						
14	I am reluctant to receive outside aid					
15	I prefer solving problems independently					
16	I prefer acting based on my own decisions					
Pro-activeness						
17	I proactively plan new things					
18	I plan and act in advance rather than waiting for something to be given					
19	I tend to actively overcome hardships rather than attributing to the environment					

SD =Strongly Disagree, D = Disagree, N = Neutral, A = Agree and SA = Strongly Agree

2. Entrepreneurial Intention

Kindly give your agreement (or) disagreement about each of the following statements.

Factors		**SD**	**D**	**N**	**A**	**SA**
1	I prefer to manage and grow my own farming and processing activities rather than work for someone else					
2	I have serious plans to expand my farming or start new income-generating activities (like processing or selling my produce)					
3	My main objective is to become an independent and successful farm business owner.					
4	I am determined to develop my own farming or processing enterprise in the future.					
5	I am ready to put in all the effort needed to grow my own farm-based or processing business					

SD =Strongly Disagree, D = Disagree, N = Neutral, A = Agree and SA = Strongly Agree

PART 1 - CONTENT FOR CONSENT FORM INFORMATION FOR PARTICIPANTS OF THE STUDY

Title of the project: The Influence of Farmers' Entrepreneurial Mindset and Intention on the Profit and Economic Efficiency: The Case of Paddy and Groundnut Farmers in Tamil Nadu

Name of the investigator/guide: Ihou Atsu Frank Yayra / Dr. Paul Mansingh J

Purpose of this study: The purpose of this survey is to assess the influence of farmers' entrepreneurial mindset and intention on the profit and economic efficiency

Procedure/methods of the study:

Survey Method, the Assistant Agricultural Officer, and research staff will conduct the interviews together with the participant; when the participant accepts, he only decides where to conduct, and the default is to conduct in the place we meet him. When the participant accepts, we will just ask him to respond to our question as he can.

The data will be used for research work only to analyze the influence of their entrepreneurial mindset and intention on economic and profit efficiency.

Expected duration of the subject participation: For each farmer 10 to 15 minutes

Voluntary Participation: Your participation in this survey is completely voluntary. You may choose to stop participating at any time without any obligations.

Confidentiality: All responses will be kept confidential. The collected data will be used solely for this research and stored securely. Your identity will not be associated with your responses.

Anonymity: Your responses and any personally identifiable information will be anonymous and kept confidential.

Risks and Benefits: There are no known risks associated with this survey. Your participation will help us gain valuable insights into how entrepreneurial mindset and intention impact farmers' profitability and economic efficiency, which can contribute to developing better agricultural policies and practices.

Contact Information:

If you have any questions or concerns about this survey, please contact:

Ihou Atsu Frank Yayra (22PHD0457), Contact No: +918148534764/ VIT campus, Men Hostel Block Q 204 Room, 632014.

Prof. Paul Mansingh J, Mr. Ihou Research Guide, Vellore Institute of Technology (VIT), Vellore - 632014, Tamil Nadu, India. Paul.mansingh@vit.ac.in, Contact No: +91 75500 55589

Contact person for addressing ethical concerns related to the study:

Prof. Pragasam Viswanathan, Member Secretary, Institutional Ethics Committee on Human Studies (IECH), Vellore Institute of Technology (VIT), Vellore - 632014, Tamil Nadu, India. Alternate mail id: pragasam.v@vit.ac.in , Contact No : +91-9487320969'

PART 2 - CONTENT FOR PARTICIPANT CONSENT FORM

Participant's name:
Address:

Title of the project: The Influence of Farmers' Entrepreneurial Mindset and Intention on the Profit and Economic Efficiency: The Case of Paddy and Groundnut Farmers in Tamil Nadu

The details of the study have been provided to me in writing and explained to me in my own language. I confirm that I have understood the above study and had the opportunity to ask questions. I understand that my participation in the study is voluntary and that I am free to withdraw at any time, without giving any reason. I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s). I have been given an information sheet giving details of the study. I fully consent to participate in the above study.

Signature of the Participant: Date:

Signature of the Witness: Date:

Signature of the Investigator: Date:

Note: Consent form part 2, should be appropriately worded for adults and children (less than 18 years)
e.g. If the participant is less than 18 years of age, instead of 'my participation', 'my child's/ward's participation' needs to be replaced.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementaryfiles.zip