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Interaction Effects of Education and Farming Experience on the Technical Efficiency Gains from Palaycheck system Training in Northern Mindanao, Philippines

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Abstract

This study examined the interaction effects of education and farming experience on the technical efficiency gains from PalayCheck System training among rice farmers in Northern Mindanao, Philippines. Anchored on the concept of technical efficiency in agricultural economics, the study utilized Stochastic Frontier Analysis (SFA) to evaluate farmers' ability to maximize output using available inputs and technologies. A mixed-methods sequential explanatory research design was employed using both quantitative and qualitative approaches. The study adopted a with-and-without impact assessment design involving 570 respondents composed of 285 PalayCheck trainees and 285 non-trainees from selected municipalities in Bukidnon, Misamis Oriental, Misamis Occidental, and Lanao del Norte. Quantitative data were gathered through a self-structured survey questionnaire and analyzed using descriptive statistics, Cobb-Douglas Stochastic Frontier Analysis, t-tests, and Propensity Score Matching (PSM) to minimize selection bias. Qualitative data were collected through Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) and analyzed thematically. Findings revealed that PalayCheck participation had a positive but statistically insignificant effect on technical efficiency. Education and farming experience also showed statistically insignificant relationships with technical efficiency, while the interaction effects between training participation and both education and farming experience were likewise insignificant. The results suggest that the effectiveness of the PalayCheck System does not vary according to farmers' educational attainment or farming experience. The study further indicated that structural and institutional factors such as access to production inputs, irrigation, mechanization, credit, and extension services may exert stronger influences on technical efficiency than socio-demographic characteristics alone. The study recommends strengthening the implementation of the PalayCheck System through integrated support services, continuous mentoring, demonstration farms, and farmer-friendly extension approaches to improve rice productivity and farmer welfare. The study supports Sustainable Development Goal (SDG) 2 on Zero Hunger through the promotion of improved rice productivity and sustainable agricultural practices. It also aligns with SDG 4, SDG 8, and SDG 12 by supporting agricultural education, farmer productivity, and efficient resource utilization. The findings contribute to agricultural, socio-economic, and educational sustainability by supporting inclusive extension strategies and integrated crop management practices that may enhance farmer welfare and sustainable rice production.

Keywords: Agricultural Extension, Farming Experience, Palaycheck System, Propensity Score Matching, Rice Farming, Stochastic Frontier Analysis, Technical Efficiency, Training Participation

1. Introduction

Rice remains a primary staple food and a major source of livelihood in the Philippines, making the rice sector essential to food security, rural employment, and agricultural sustainability. However, rice production continues to face challenges such as low productivity, high production costs, inefficient resource utilization, and climate-related risks, which reduce profitability among smallholder farmers. To address these concerns, the Philippine Rice Research Institute developed the PalayCheck System, an integrated crop management approach that promotes science-based and holistic rice farming practices. The system supports improved productivity, profitability, and sustainability through enhanced farmer training and technology adoption. Technical efficiency is widely used to evaluate how effectively farmers maximize output using available resources and technologies. Previous studies have identified education and farming experience as important socio-economic factors influencing technical efficiency, although findings remain inconsistent across different agricultural settings. Despite the extensive promotion of the PalayCheck System, limited studies have explored how education and farming experience influence the effectiveness of PalayCheck training in improving technical efficiency among rice farmers. This study therefore examines the interaction effects of education and farming experience on technical efficiency gains from PalayCheck System training among rice farmers in Northern Mindanao.

1.1 Background of Technical Efficiency and PalayCheck System Training Among Rice Farmers

Rice plays a crucial role in ensuring food security, rural employment, and agricultural sustainability in the Philippines. Millions of Filipino farmers rely on rice farming as their primary source of income, particularly in rural communities. However, the Philippine rice industry continues to encounter persistent problems, including low farm productivity, rising production costs, inefficient use of resources, and vulnerability to climate-related risks. These challenges contribute to yield gaps and reduced farm profitability among smallholder rice farmers. To improve rice productivity and sustainability, the Philippine Rice Research Institute developed the PalayCheck System, a Rice Integrated Crop Management (RICM) approach that integrates science-based recommendations on seed quality, land preparation, crop establishment, nutrient management, water management, pest management, and harvest management. The system emphasizes a holistic approach to rice farming rather than fragmented technology recommendations, enabling farmers to optimize production practices more effectively. The PalayCheck System also functions as a learning-based agricultural extension strategy that promotes farmer participation, discussion, and continuous improvement in farm management practices. Farmer Field School-PalayCheck programs were introduced to strengthen farmers' knowledge, skills, and adoption of improved rice production technologies in support of national rice self-sufficiency initiatives. Studies have shown that participation in PalayCheck training programs enhances farmers' awareness and adoption of recommended practices.

1.2 Themes and Insights on Education, Farming Experience, and Technical Efficiency

Technical efficiency is an important indicator in agricultural economics that measures the ability of farmers to maximize output from a given set of inputs and technologies. Improving technical efficiency is essential for increasing agricultural productivity without expanding cultivated land or significantly increasing production costs. Several studies on rice farming in the Philippines have applied Stochastic Frontier Analysis (SFA) to evaluate technical efficiency and determine factors affecting farm performance. Education and farming experience are among the socio-economic variables commonly associated with technical efficiency. Education is believed to improve farmers' decision-making ability, understanding of agricultural technologies, and capacity to adopt improved farming practices. Farming experience may also contribute to accumulated practical knowledge and management skills. However, previous studies have produced inconsistent findings regarding the significance of these variables. Some studies reported positive effects of education and farming experience on technical efficiency, while others found weak or insignificant relationships depending on farming conditions and access to agricultural resources.

1.3 Local, National, and Global Context of PalayCheck System Implementation and Rice Farming Efficiency

At the national level, the Philippine rice sector remains central to agricultural development and food security initiatives. The government continues to promote programs aimed at improving rice productivity and farmer welfare through technology adoption and agricultural extension services. The PalayCheck System was introduced as part of these efforts to strengthen rice self-sufficiency and improve farm management practices among Filipino rice farmers. Locally, rice farmers in Northern Mindanao face challenges related to productivity, profitability, and resource management. These conditions highlight the importance of evaluating whether training interventions such as the PalayCheck System effectively improve technical efficiency across different farmer groups. Understanding how education and farming experience influence training outcomes may contribute to more responsive and inclusive agricultural extension programs. Globally, improving agricultural efficiency and sustainability remains a priority in addressing food security concerns, climate risks, and rural poverty. Integrated crop management systems and farmer training programs are increasingly recognized as important strategies for enhancing sustainable agricultural production and resource efficiency.

1.4 Theoretical and Conceptual Basis of Technical Efficiency, Education, and Farming Experience

The study is anchored on the concept of technical efficiency in agricultural economics, which refers to the ability of farmers to achieve the maximum possible output from available inputs and technologies. Stochastic Frontier Analysis (SFA) is commonly used to measure technical efficiency and evaluate factors influencing farm performance. The study also draws from the concept that socio-economic factors such as education and farming experience influence farmers' ability to understand, adopt, and apply agricultural technologies effectively. Education may enhance farmers' comprehension of improved farming practices and decision-making skills, while farming experience contributes to practical knowledge and farm management capabilities. These factors may influence the effectiveness of PalayCheck System training in improving technical efficiency among rice farmers.

1.5 Research Gaps on the Interaction Effects of Education and Farming Experience in PalayCheck Training

Although the PalayCheck System has been widely promoted in the Philippines, limited studies have examined whether education and farming experience influence the effectiveness of PalayCheck training in improving technical efficiency among rice farmers. Existing studies provide inconsistent findings regarding the role of these socio-economic factors in determining farm efficiency outcomes. There is therefore a need to determine whether PalayCheck training benefits farmers equally regardless of their educational background and farming experience. Identifying factors that enhance or constrain the effectiveness of training programs may contribute to the improvement of agricultural extension strategies and policy interventions aimed at increasing rice productivity and farmer welfare.

1.6 Alignment of the Study on PalayCheck System Training with Relevant Sustainable Development Goals (SDGs)

The study aligns with SDG 2: Zero Hunger by supporting efforts to improve rice productivity, food security, and sustainable agricultural practices through the PalayCheck System. The study also relates to SDG 8: Decent Work and Economic Growth by promoting improved farm productivity and profitability among rice farmers. In addition, the research supports SDG 12: Responsible Consumption and Production through the promotion of efficient resource utilization and integrated crop management practices. The emphasis on farmer training and knowledge development also reflects SDG 4: Quality Education, particularly in strengthening agricultural learning and extension programs.

1.7 Importance of the Study on Rice Farming Technical Efficiency to Multidisciplinary Sustainability

The study contributes to socio-economic sustainability by identifying factors that may improve rice productivity, farmer income, and agricultural efficiency. Improved technical efficiency can help farmers maximize available resources without necessarily increasing production costs or expanding cultivated land. The study also contributes to educational sustainability through its focus on farmer training, knowledge transfer, and agricultural extension effectiveness. By examining how education and farming experience influence training outcomes, the research may support the development of more inclusive and responsive extension strategies. Furthermore, the study supports agricultural and environmental sustainability by promoting integrated crop management practices that encourage efficient resource utilization and improved farm management. The findings may assist policymakers and agricultural institutions in strengthening programs that enhance both farmer welfare and sustainable rice production.

2. Material and methods

2.1 Research Design

The study employed a mixed-methods sequential explanatory research design using both quantitative and qualitative approaches. A with-and-without impact assessment approach was adopted to compare PalayCheck trainees and non-trainees. The quantitative component utilized a descriptive research design to describe the economic, social, and environmental characteristics of the respondents. Mean scores, frequencies, and averages were generated and analyzed using Stata software. To determine the technical efficiency of rice farmers, the study applied Stochastic Frontier Analysis (SFA) using the Cobb-Douglas production function. T-tests were conducted to identify statistical differences between trainees and non-trainees. Propensity Score Matching (PSM) was also utilized to minimize selection bias between treatment and control groups, particularly regarding technical efficiency outcomes. The qualitative component was conducted after the quantitative analysis to provide deeper explanations of the findings. It described the PalayCheck training program, training inputs, and changes in knowledge, attitudes, skills, aspirations, and behaviors (KASA), including the significant experiences of trainees. Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) were conducted, while thematic analysis was used to interpret qualitative responses.

2.2 Locale of the Study

The study was conducted in selected municipalities in Northern Mindanao, specifically within the provinces of Bukidnon, Misamis Oriental, Misamis Occidental, and Lanao del Norte. The municipalities included Tangub City, Malaybalay City, Malitbog, Maramag, Jimenez, Naawan, Balingasag, Oroquieta, Lala, Kapatagan, and Tubod. These areas were selected as locations where PalayCheck trainees and non-trainees could be identified and compared.

2.3 Respondents of the Study

The respondents consisted of PalayCheck trainees and non-trainees involved in rice farming in Northern Mindanao. The study included a total of 570 respondents, composed of 285 PalayCheck trainees and 285 non-trainees from the selected municipalities. Additional qualitative participants included training providers who participated in Key Informant Interviews.

2.4 Sample and Sampling Procedure

A probabilistic sampling design was employed for selecting the PalayCheck trainees using the Cochran formula to ensure statistical representativeness based on a predetermined confidence level, margin of error, and estimated population proportion. The study utilized a self-structured survey questionnaire as the primary research instrument. The respondents were proportionally distributed across municipalities in Bukidnon, Misamis Oriental, Misamis Occidental, and Lanao del Norte. Both trainees and non-trainees were equally represented in the sample to facilitate comparison between the treatment and control groups.

2.5 Research Instrument

The study utilized a self-structured survey questionnaire as the primary instrument for quantitative data collection. The questionnaire gathered information regarding the respondents' socio-economic, environmental, and farm characteristics relevant to the assessment of technical efficiency and PalayCheck training outcomes. For the qualitative component, Focus

Group Discussions (FGDs) and Key Informant Interviews (KIIs) were conducted to obtain deeper insights into the PalayCheck training program, changes in knowledge, attitudes, skills, aspirations, and behaviors (KASA), and the experiences of trainees and training providers.

2.6 Data Gathering Procedure

Prior to data collection, ethical approval was secured from the Central Mindanao University Institutional Ethics Review Committee (IERC). Letters of permission were sent to the Municipal Mayors and Municipal Agriculture Offices of the identified municipalities in Bukidnon, Misamis Oriental, Misamis Occidental, and Lanao del Norte. Preparatory activities, including courtesy visits and coordination with local offices, were conducted from the last week of December 2025 to the first week of January 2026. Respondents were informed about the objectives of the study and were requested to sign informed consent forms before participation. Face-to-face interviews with trainees and non-trainees were conducted in homes, farms, and workplaces, while Key Informant Interviews with training providers were conducted at farm sites and schools. Each interview lasted approximately one hour. Data gathering was conducted from the last week of December 2025 until April 2026.

2.7 Data Analysis Techniques

Quantitative data were processed and analyzed using Stata software. Descriptive statistics, including frequencies, percentages, means, and averages, were used to summarize the respondents' socio-economic, environmental, and farm characteristics. Stochastic Frontier Analysis (SFA) using the Cobb-Douglas production function was employed to estimate the technical efficiency of rice farmers. T-tests were performed to determine significant differences between PalayCheck trainees and non-trainees. To minimize selection bias resulting from non-random participation in the PalayCheck training program, Propensity Score Matching (PSM) was applied to construct comparable treatment and control groups based on observable characteristics.

2.8 Ethical Considerations

The study strictly adhered to ethical research standards. Ethical clearance was obtained from the Central Mindanao University Institutional Ethics Review Committee (IERC) before data collection. Participation in the study was voluntary, and informed consent was obtained from all respondents. Respondents were assured that their responses would remain confidential and anonymous, and all collected information was used solely for academic and research purposes.

3. Results and Discussion

3.1 Effects of Education and Farming Experience on Technical Efficiency with Program Participation Interaction Terms

3.1.1 Effect of PalayCheck Participation on Technical Efficiency

The regression results showed that the overall model had very weak explanatory power, with an R-squared value of 0.0038, indicating that only 0.38% of the variation in technical efficiency was explained by PalayCheck participation, education, farming experience, and their interaction terms. The overall model was also statistically insignificant (Prob > F = 0.8256). PalayCheck participation showed a positive coefficient ($\beta = 0.0138$), suggesting that trainees were approximately 1.38 percentage points more technically efficient than non-trainees. However, the effect was statistically insignificant ($p = 0.620$). The insignificant effect suggests that participation in the PalayCheck training program alone may not be sufficient to significantly improve technical efficiency. Although the program promotes science-based rice farming practices, efficiency gains may still depend on farmers' access to inputs, irrigation facilities, machinery, capital, and institutional support. This finding supports the observations of Briones (2017), who emphasized that structural factors such as farm size, capital availability, and input utilization often exert stronger influences on technical efficiency than participation in training programs alone. Similarly, Issahaku and Abdul-Rahaman (2019) reported that socio-economic constraints, particularly limited access to agricultural resources and technology, tend to overshadow the effects of training and education among smallholder farmers.

3.1.2 Effect of Education on Technical Efficiency

Education showed a small negative coefficient ($\beta = -0.0049$), indicating that a 1% increase in years of education corresponded to a 0.0049% decrease in technical efficiency. However, the relationship was statistically insignificant ($p = 0.652$), suggesting that formal education did not significantly contribute to higher technical efficiency among rice farmers in the study area. The insignificant relationship implies that formal education alone may not necessarily improve farm management practices or the utilization of agricultural technologies. Rice farming decisions are often influenced more by practical experience, indigenous knowledge, and access to extension services than by formal schooling. This finding is consistent with Ogundari (2016), who found that education frequently demonstrates weak and inconsistent effects on technical efficiency across agricultural settings. Likewise, Castillo (2022) observed that socio-economic variables such as education may not significantly affect technical efficiency when farmers operate under similar production conditions and resource limitations.

3.1.3 Effect of Farming Experience on Technical Efficiency

Farming experience showed a positive but negligible coefficient (β = 0.0018), indicating that a 1% increase in farming experience was associated with a 0.0018% increase in technical efficiency. However, the effect remained statistically insignificant (p = 0.630), suggesting that farming experience alone did not significantly improve technical efficiency among the respondents. The findings suggest that long farming experience may not always result in innovation or adoption of improved technologies. Some experienced farmers may continue relying on traditional practices instead of integrating modern rice production technologies promoted through the PalayCheck System. Moreover, rice farming efficiency may depend more heavily on access to production inputs, mechanization, extension services, and environmental conditions rather than experience alone. This result supports the findings of Cañete and Temanel (2017), who reported that farming experience may not significantly influence rice productivity when structural constraints remain present.

3.1.4 Interaction Effects Between Program Participation, Education, and Farming Experience

The interaction terms between PalayCheck participation and education (pc × lnedu) and between participation and farming experience (pc × lnexp) were both statistically insignificant, with p-values of 0.882 and 0.748, respectively. These findings indicate that the effectiveness of PalayCheck training did not vary according to the educational attainment or farming experience of the farmers. The results suggest that the training program benefited farmers similarly regardless of differences in education and farming experience. The insignificant interaction effects imply that the PalayCheck System may be accessible and understandable to farmers regardless of their socio-economic background. This suggests that the training modules and extension approaches are practical and adaptable for a wide range of rice farmers. However, the findings may also indicate that training alone is insufficient to generate substantial efficiency gains without complementary support systems such as access to credit, irrigation, mechanization, and production inputs. This finding supports Vedra (2023), who argued that sustainable improvements in rice productivity require integrated support systems beyond farmer training alone. While extension programs such as PalayCheck may improve awareness and knowledge, actual efficiency gains often depend on farmers' capacity to implement recommended practices under real farming conditions.

3.2 Propensity Score Matching and Treatment Group Comparability

Propensity Score Matching (PSM) was employed to address potential selection bias resulting from non-random participation in the PalayCheck training program. Since participation was voluntary, direct comparisons between trainees and non-trainees could produce biased estimates due to differences in observable characteristics such as education, farm size, and access to resources. The propensity score distribution before matching showed considerable differences between trainees and non-trainees, indicating imbalance in baseline characteristics. After matching, the distributions showed greater overlap, suggesting improved covariate balance between the treatment and control groups. The improved balance after matching increased the reliability of the estimated treatment effects by approximating experimental conditions within observational data. This supports the argument of Austin (2018) that Propensity Score Matching strengthens causal inference by reducing observable selection bias between treatment and comparison groups. Likewise, Lelisho and Lelisho (2024) emphasized that PSM improves the credibility of impact evaluation studies involving non-randomized agricultural interventions.

3.3 Overall Implications on Rice Farming Technical Efficiency

The quantitative findings generally showed that PalayCheck participation had a positive but statistically insignificant effect on technical efficiency. Education and farming experience also failed to significantly influence efficiency gains from training participation. Overall, the results suggest that socio-demographic characteristics alone may not sufficiently explain variations in technical efficiency among rice farmers. The findings imply that structural, institutional, and resource-related factors may exert stronger influences on rice farming efficiency than education, farming experience, or participation in training programs alone. Sustainable improvements in rice productivity may therefore require integrated interventions that combine farmer training with enhanced access to agricultural resources, infrastructure, financial support, and extension services.

4. Conclusion & Recommendations

The study examined the interaction effects of education and farming experience on the technical efficiency gains from PalayCheck System training among rice farmers in Northern Mindanao. Findings revealed that PalayCheck participation had a positive but statistically insignificant effect on technical efficiency. Likewise, education and farming experience did not significantly influence technical efficiency, and the interaction terms between training participation and both education and farming experience were also insignificant. These results suggest that the effectiveness of the PalayCheck System does not vary according to the farmers' level of education or years of farming experience. The findings imply that technical efficiency among rice farmers may be more strongly influenced by structural and farm-specific factors such as access to production inputs, credit, irrigation, mechanization, and institutional support rather than socio-demographic characteristics alone. Nevertheless, the use of Propensity Score Matching improved the comparability between trainees and non-trainees,

strengthening the validity of the impact assessment.

Based on the findings, it is recommended that agricultural agencies and extension institutions strengthen the implementation of the PalayCheck System by integrating complementary support services such as access to quality inputs, financial assistance, mechanization programs, and market support to maximize efficiency gains among rice farmers. Training programs should also be enhanced through continuous follow-up activities, demonstration farms, and farmer mentoring to encourage actual adoption of recommended practices. Since education and farming experience did not significantly affect efficiency gains, extension strategies should continue to focus on practical, farmer-friendly, and participatory approaches that are accessible to all farmers regardless of educational background or farming experience. Future studies may also explore other determinants of technical efficiency, including farm size, access to technology, institutional support, and climate-related factors.

This study was limited by its reliance on observable variables included in the quantitative model and Propensity Score Matching procedure. Although PSM reduced selection bias, unobserved factors such as farmers' managerial ability, motivation, and risk preferences may still have influenced the results. The study was also geographically limited to selected municipalities in Northern Mindanao; therefore, the findings may not fully represent all rice farmers in the Philippines. In addition, the study focused primarily on technical efficiency and did not extensively examine long-term economic, social, and environmental impacts of the PalayCheck System. Future research may employ longitudinal approaches and broader geographic coverage to provide a more comprehensive evaluation of the program's effectiveness.

Compliance with ethical standards

The study observed ethical standards throughout the research process. Participation of the respondents was voluntary, and the participants were informed about the purpose of the study prior to data collection. Confidentiality of the identities and responses of the participants was maintained, and all information gathered was used solely for academic purposes.

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