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The Influence of Demographic Factors, Farmer Knowledge, and Motivational Factors on the Adoption of Agricultural Technology Innovation: A Case Study on Dairy Farmers in South Bangka

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ABSTRACT

This study looks into the complex factors that affect dairy producers in South Bangka's use of agricultural technology. Structural Equation Modeling-Partial Least Squares (SEM-PLS) was used to examine the correlations between farmers' knowledge, motivational factors, technology adoption, and demographic characteristics using a sample of 112 farmers. The results highlight the importance of education and adaptability to change by showing a strong positive correlation between demographic characteristics (age, education) and technological adoption. Farmers' knowledge was found to be a crucial element; a substantial positive association suggests that adoption is positively influenced by a deeper understanding of agricultural technologies. Economic incentives and perceived benefits were found to have significant positive connections with technology adoption, indicating the role that perceived benefits play in encouraging the acceptance of new ideas. The model's significant explanatory and predictive ability was validated by the SEM-PLS study, offering a thorough framework for comprehending and improving South Bangka's adoption of technology. The findings highlight the need of a comprehensive strategy that takes into account farmers' goals, experiences, and degree of knowledge in order to promote the adoption of sustainable technologies.

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INTRODUCTION

Agricultural development is crucial for ensuring food security and economic growth, particularly in regions with a strong agricultural background. The adoption of innovative agricultural technologies plays a significant role in increasing productivity, reducing environmental impact, and ensuring the long-term sustainability of agricultural practices [1]. The use of updated technologies and sustainable exploitation of natural resources are important aspects of agricultural advancements [2]. Sustainable development, which aims to meet human needs while protecting the natural system, is a key philosophy in agriculture [3]. Additionally, research highlights the importance of education expenditures and foreign direct investment in reducing the impact of agricultural industries on vulnerability to climate change [4]. Overall, agricultural development and economic growth are essential for improving food security and rural livelihoods [5].

Technological innovation in dairy farming offers opportunities to increase milk production, optimize resource use, and improve overall efficiency. These innovations can be used to improve farm profitability, assist in decision-making, and enhance animal welfare [6]. The automation and robotization of milk production can further increase economic efficiency and improve production in dairy farming [7]. Implementing low-cost and user-friendly innovations can enhance animal productivity and improve farmers' socio-economic welfare, especially in small-scale dairy farms in developing nations [8]. Adoption of machine learning techniques can improve dairy management and milk production by analyzing data collected from smart devices worn by cows [9]. Advanced technologies in milk processing can extend shelf life, enhance nutritional quality, and improve safety of dairy products, contributing to the overall efficiency of the dairy industry [10].

The adoption of agricultural technology is influenced by various factors such as socio-economic background, culture, and education of breeders. Understanding the dynamics of technology adoption is crucial for facilitating sustainable agricultural development. Studies have identified several determinants of technology adoption, including household characteristics such as gender of the household head, education level, farm size, and access to markets and roads [11]. Factors like age, landholding size, family size, income, participation in social organizations, media exposure, and socioeconomic status have also been found to be significant in technology adoption [12]. Additionally, access to agricultural extension services and group membership have been shown to have a positive effect on the adoption of modern agricultural technologies [13]. To promote mass adoption of technology, it is suggested to document the experiences of innovators and early adopters as a guide in building the technology adoption journey map [14]. Policymakers, researchers, and practitioners should consider these factors and insights to develop strategies that facilitate technology adoption and promote sustainable agricultural development.

This research focuses on South Bangka, an area known for its significant contribution to the dairy farming sector. Investigating the factors that influence the adoption of agricultural technology innovations among dairy farmers in South Bangka will provide valuable insights for designing and implementing targeted interventions.

LITERATURE REVIEW

Adoption of Agricultural Technology

The adoption of agricultural technology is influenced by a variety of factors, including economic, social, and institutional considerations. Economic factors, such as increased profitability and cost reduction, are often key drivers of technology adoption by farmers. [15] Additionally, the social context and individual characteristics of farmers play important roles in shaping adoption patterns. [16] The diffusion of innovations theory, developed by Everett Rogers, provides a framework for understanding the process of technology adoption, highlighting the role of communication channels, social systems, and innovation characteristics. [17] Rogers categorizes adopters into different groups, such as innovators, early adopters, and laggards, each with distinct characteristics that influence their willingness to adopt new technologies. [18] Institutional support is also crucial in facilitating technology adoption in agriculture. [19] Overall, a combination of economic, social, and institutional factors contributes to the adoption of agricultural technology.

Demographic Factors and Technology Adoption

Demographic factors such as age, education, and farm size have consistently emerged as critical determinants of technology adoption in agriculture. Younger farmers are often more willing to adopt new technologies, driven by a greater openness to change and exposure to formal education [20]. Education levels correlate positively with technology adoption, as more educated farmers tend to have better access to information, higher analytical abilities, and a greater propensity for risk-taking [11]. Farm size also influences technology adoption, with larger farms typically exhibiting higher rates of adoption due to increased financial capacity and economies of scale [21]. However, the interplay of these demographic factors can vary across regions, necessitating context-specific investigations [22].

Farmers' Knowledge and Technology Adoption

Farmers' knowledge and awareness of agricultural technologies are crucial in the adoption process. Well-informed farmers are more likely to adopt innovations and incorporate them into existing practices to enhance efficiency and productivity. Access to extension services, training programs, and information networks within the farming community significantly contributes to knowledge acquisition and adoption. Studies have shown that potential adopters must have a clear understanding of the benefits and functioning of an innovation to facilitate its adoption [13], [22], [23].

Motivational Factors in Technology Adoption

Motivational factors, encompassing economic incentives, perceived benefits, and social influences, are crucial determinants of technology adoption [13], [22]. Economic considerations, such as increased profitability and cost reduction, consistently emerge as primary motivators for farmers [24]. The perceived benefits of innovation, including improvements in yield, resource optimization, and environmental sustainability, also influence adoption decisions [17]. Social influences within the farming community, such as peer pressure, community norms, and the role of opinion leaders, can either facilitate or hinder technology adoption [25]. Farmers often rely on the experiences and observations of their peers when making adoption decisions, highlighting the importance of social networks in the diffusion of innovations.

Technology Adoption in Dairy Farming

Technology adoption in dairy farming has been instrumental in transforming traditional practices and has the potential to enhance milk production efficiency and overall herd management. Innovations such as automated milking systems, precision feeding, and health monitoring technologies offer opportunities for increased farm efficiency, improved animal welfare, and better decision-making. Dairy practitioners play a crucial role in assisting dairy producers in adopting these emerging technologies and leveraging the data generated by these innovations to improve animal health and performance. The adoption of dairy feed technology bundles has been found to have positive effects on milk production, with gradual positive effects observed between non-adoption and the adoption of different bundles of technologies [6]. Decision-support tools like the Ruminant Farm Systems (RuFaS) model can provide detailed and flexible estimates of environmental impacts, allowing for the comparison of management practices and guiding farm management decisions [26]. The automation and robotization of milk production, including the use of technologies to assess the fatness of a dairy herd, have been shown to increase milk production efficiency and improve economic outcomes [27]. The application of nanotechnology in packaging and delivery systems has the potential to improve the quality and safety of dairy products, offering new possibilities for food preservation and packaging materials [7].

Gaps in the Literature

While existing literature provides valuable insights into the general factors influencing technology adoption in agriculture, there is a paucity of research specifically addressing the adoption patterns among dairy farmers in South Bangka. Understanding the unique challenges and opportunities in this region is crucial for developing targeted interventions that align with the needs and circumstances of the local farming community.

METHODS

Research Type and Sample

This research was conducted in South Bangka, focusing on dairy farmers involved in the region's vibrant dairy farming sector. The study aimed to capture diversity within the farmer community by selecting a sample that represented a range of demographic characteristics, including age, education, and farm size. A quantitative research design was used to collect and analyze data on agricultural technology adoption among dairy farmers. This design allows for systematic data collection, statistical analysis, and identification of patterns and relationships. A stratified random sampling technique is used to ensure a representative sample. Strata will be defined based on key demographic variables, including age, education and farm size. The aim is to ensure that the sample reflects the diversity of the dairy farming community in South Bangka, the targeted sample size is 112 dairy farmers. This sample size was considered sufficient to conduct a robust analysis while providing a total of 150 survey questionnaires. Data was collected using a structured questionnaire designed to obtain information on demographic factors, farmer knowledge, motivational factors, and technology adoption rates. The questionnaire will be pre-tested to ensure clarity and relevance, and modifications will be made based on feedback from the pre-test.

Data Analysis

Quantitative data were analyzed using Structural Equation Modeling-Partial Least Squares (SEM-PLS) version 3. This powerful statistical technique is well suited for analyzing complex relationships among variables, making it ideal for investigating the interaction between demographic factors, farmer knowledge, and motivational factors on technology adoption. SEM-PLS allows the assessment of measurement models and structural models simultaneously. In the context of this study, the measurement model will evaluate the reliability and validity of the measurement instruments, ensuring that the constructs are accurately captured. The structural model will then analyze the relationships between the latent variables, providing insight into how demographic, knowledge and motivational factors collectively influence technology adoption.

RESULTS AND DISCUSSION

Descriptive Statistics

The demographic characteristics of the 112 dairy producers in South Bangka were varied. The age group of 31–45 years old accounted for 33.9 percent of all farmers, with 46–60 years old accounting for 28.6% of all farmers. The proportion of farmers who were over 60 years old (17.5%) and in the 18–30 age group (22.3%) was lower. When it came to education, secondary education made up the largest percentage of farmers' education (40.2%), closely followed by higher education (41.9%). The proportion with only an elementary education was lower (17.9%). The bulk of farmers (37.5%) owned medium-sized farms, which were followed by large farms (35.7%) and small farms (26.8%) in terms of farm size. A self-reported composite indicator of the adoption of different agricultural technologies was used to evaluate the general level of technology adoption among dairy producers in South Bangka. According to the findings, 15.2% of participants had a low degree of adoption, 53.6% had a medium level, and 31.2% had a high level. Regarding particular technology, the following adoption rates were observed: 28.6% for health monitoring equipment, 32.1% for precision feeding systems, 45.5% for automated milking systems, and 18.7% for other unspecified technologies.

Measurement Model

In this work, the validity and reliability of the latent constructs were evaluated using the measurement model. Specific indicators were used to assess demographic characteristics such as age, education level, and size of farm. The results demonstrated substantial factor loadings for each indicator, demonstrating the measurement model's reliability. Indicators of farmers' knowledge of agricultural technology were used to gauge their level of expertise. The measuring model for farmers' knowledge was found to be dependable, with significant factor loadings for every indicator. Specific indicators were used to quantify motivational elements such perceived benefits, financial incentives, and social impact. The measuring model demonstrated robustness, with each indicator significantly contributing to the latent construct. The measuring model of technology adoption was found to be dependable, with substantial factor loadings for every indicator. The indicators used to gauge farmers' claimed adoption of different agricultural technologies were related to the adoption of these technologies. Overall, the results of the measurement model supported the validity and reliability of the latent constructs, offering a strong foundation for the structural model analysis that followed.

Model Fit

The percentage of the variance in the endogenous variable (technology adoption) that is explained by the exogenous variables (farmers' knowledge, motivational factors, and demographic factors) is represented by the coefficient of determination (R^2) in the SEM-PLS analysis. The model's motivational components, farmers' knowledge, and demographic characteristics account for roughly 65.7% of the variance in the adoption of agricultural technology among dairy farmers in South Bangka, according to the R2 value of 0.657. The model has strong predictive relevance, as indicated by the Q^2 value of 0.526, which also shows that the exogenous variables included in the model have a considerable impact on forecasting the adoption of agricultural technology among South Bangka's dairy producers. A good fit is shown by the SRMR value of 0.067, as lower values correspond to a better model fit. Even though it is less than 1.0, the NFI score of 0.848 nevertheless indicates a good fit. The SEM-PLS model created for this study appears to be a reasonably good fit for explaining and forecasting the adoption of agricultural technology among dairy producers in South Bangka, based on the combined values of the R^2, Q^2, and model fit indices.

The structural equation model (SEM-PLS) created for this study appears to be a reasonably good fit for explaining and forecasting the adoption of agricultural technology among dairy producers in South Bangka, based on the combined values of the R^2, Q^2, and model fit indices. The significant R2 value and positive Q2 value suggest that the variables included have a major impact on understanding and predicting the adoption of technology. The model's ability to replicate the observed data and improve fit over a null model is further supported by the fit indices, especially the SRMR and NFI.

Structural Equation Modeling (SEM-PLS) Analysis

SEM-PLS analysis was conducted to comprehensively examine the interrelationships among demographic factors, farmers' knowledge, motivational factors, and technology adoption.

Table 1. Hypothesis Testing

Path	**Path Coefficient**	p-values	Results
Demographic Factors → Technology Adoption	0.327	0.018	Significant
Farmers' Knowledge → Technology Adoption	0.432	0.006	Significant
Motivational Factors → Technology Adoption	0.567	0.001	Significant

The findings of the Structural Equation Modeling-Partial Least Squares (SEM-PLS) research shed light on the connections between South Bangka dairy farmers' motivational factors, farmer knowledge, and adoption of new technology.

There is a positive correlation between technology adoption and demographic characteristics, as indicated by the path coefficient of 0.327. This indicates that the adoption of agricultural technology among dairy farmers is influenced by a combination of demographic parameters, such as age, education level, and farm size. This link is statistically significant because the p-value of 0.018 is less than the traditional significance threshold of 0.05. Thus, it can be said that South Bangka's adoption pattern of agricultural technology is significantly shaped by demographic variables. The positive path coefficient suggests that there would be a rise in the adoption of technology when demographic variables like age, education level, and farm size grow. This emphasizes how crucial it is to comprehend the socioeconomic and educational backgrounds of farmers in order to support programs aimed at encouraging the adoption of technology.

There is a high and positive correlation between farmers' use of technology and their expertise, as indicated by the path coefficient of 0.432. This implies that farmers are more likely to adopt innovations if they are better knowledgeable about agricultural technology. The statistical significance of this association is indicated by the low p-value of 0.006, which highlights the role that farmer knowledge plays in influencing the adoption of new technologies. The substantial path coefficient highlights how crucial farmer knowledge is in promoting the uptake of new technologies. The adoption rate of new technology among dairy farmers in South Bangka is expected to benefit from efforts to increase farmers' awareness of its advantages.

The relationship between technology adoption and motivational factors (economic incentives, perceived benefits, and social influence) is strongly positive, as indicated by the path coefficient of 0.567. The statistical significance of this association is indicated by the very low p-value of 0.001, underscoring the significance of motivating variables in shaping technological adoption. The impact of motivating variables on technology adoption is highlighted by the huge path coefficient. Farmers are more inclined to use agricultural technologies if they believe there are financial rewards, advantages, and societal pressure. Interventions designed specifically to draw attention to these characteristics of motivation may raise adoption rates of technology.

Discussion

Adoption of technology is significantly positively correlated with demographic characteristics (age, education, and size of farm). Agricultural innovations are more likely to be adopted by younger and more educated farmers. This result is consistent with a larger body of research that highlights the importance of education and a willingness to adapt when it comes to adopting new technology. Because of their exposure to contemporary schooling and forward-thinking outlook, younger farmers may be more open to innovations, according to the positive association between age and receptiveness.

The noteworthy association shown between farmers' knowledge and their adoption of technology highlights the crucial influence of information in molding adoption behaviors. Farmers are more likely to adopt innovations if they participate in training programs, have access to extension services, and have a greater understanding of agricultural technology. The Diffusion of Innovations theory, which contends that knowledge is a major factor in the adoption process, is compatible with this conclusion.

Economic incentives, perceived benefits, and social influence are examples of motivational factors that have a significant impact on technology adoption. The analysis demonstrates a strong positive correlation, highlighting the significance of these elements in influencing adoption choices. Farmers are more inclined to embrace innovation if they are driven by financial rewards and see advantages in implementing the technology. This is consistent with the adoption from an economic standpoint, which highlights a logical decision-making process based on advantages that are seen.

Practical Implications

With this newfound understanding, policymakers and agricultural extension agents can create focused interventions that cater to the unique requirements and preferences of nearby farming communities.

The present study underscores the need to implement a comprehensive strategy in technology adoption endeavors. Adopting technology can be facilitated by including educational initiatives that increase farmers' knowledge, offer financial incentives, and create encouraging social networks. Taking into account the impact of demographic factors emphasizes the necessity of developing solutions that are specific to the varied histories and traits of farmers.

Limitations and Future Research

This study has limitations even if it offers insightful information. The data's cross-sectional format makes it more difficult to determine causes and effects. A longitudinal strategy could be used in future studies to better understand the dynamics of technology uptake across time. Furthermore, as the study's focus was on dairy producers in South Bangka, care should be taken when extrapolating the results to other areas.

CONCLUSION

In summary, this study adds important new understandings to the intricate network of variables affecting South Bangka dairy producers' use of agricultural technology. Positive correlations have been shown between farmers' knowledge, motivational variables, demographic factors, and technology adoption; these findings highlight the necessity for comprehensive solutions that take into account farmers' varied backgrounds and preferences. These findings can be used by policymakers, agricultural extension agencies, and practitioners to develop focused interventions that improve education, offer financial incentives, and build social networks of support. With the help of SEM-PLS analysis, the integrated model provides a strong foundation for directing programs meant to improve agricultural methods and promote regional economic development. It will be essential for sustainable development in South Bangka to comprehend and address the factors that influence technology adoption as it navigates the opportunities and challenges presented by its agricultural landscape.

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