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Analyzing Rice Farmers' Intention to Adopt Modern Rice Technologies Using Technology Acceptance Model (TAM)

Ryan Mark A. Ambong[1*] and Maybelle A. Paulino[2]

[1]Divine Word College of San Jose, Occidental Mindoro State College, Philippines.
[2]University of Santo Tomas, Manila, Philippines.

Authors' contributions

This work was carried out in collaboration between both authors. Authors RMAA and MAP co-designed and managed the analyses of the study. Author RMAA performed the statistical analysis, wrote the protocol, managed the literature searches and wrote the first draft of the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

This paper analyzes rice farmers' intention to adopt modern rice technologies using the Technology Acceptance Model (TAM). Quantitative data were gathered through a survey among 404 rice farmers selected using three-stage sampling design. The empirical analysis was done using Partial Least Squares Structural Equation Modeling (PLS-SEM) via WARP PLS software version 3.0. The outcome of the hypothesized framework shows that perceived usefulness and relative advantage have a direct and significant influence on farmers' attitude towards modern rice technologies. This implies that the perceived usefulness and relative advantage of the technology influences the positive or negative attitude of the farmers toward the technology. On the other hand, the model suggests that perceived convenience of the technology does not influence farmers' attitude. Nevertheless, the hypothesized model demonstrates that farmers' intention influences their decision to adopt modern rice technologies. The paper suggests that further studies be conducted to incorporate external variables in TAM.

**Corresponding author: E-mail: ryanmark.ambong2017@gmail.com;*

Keywords: PLS-SEM; rice technologies; TAM; technology adoption; technology transfer.

1. INTRODUCTION

In countries like the Philippines, business giants have abandoned the rice processing venture which prompted the public sector to conduct research to deliver technology to the small entrepreneurs. Nevertheless, the rice industry has not been significantly regarded as a business by many researchers [1].

Studies on farm technologies in the Philippines were limited until the advent of the Green Revolution during the 1970s [2]. Even with the presence of various scientific researches that address technologies such as fertilizers, pesticides, conservation practices and sustainability, agroforestry innovations, agricultural machineries and new seed varieties, the method by which the analyses should be done is vague and not unified [3]. Technologies extended to farmers by extension professionals, academe, and government research institutions have a low extent of adoption due to various factors on the part of farmer-beneficiaries. A low level of adoption of improved processing technology is reflected by the low quality of locally processed. Hence, the lack of awareness is regarded a major factor for the adoption of modern rice processing methods [4]. The presence of operational methods and technologies used in agriculture creates a complex decision-making process on the part of rural farmers since they are the one who decides about how their business should be sustained [3]. Therefore, measuring and interpreting the impact of technology adoption among farmers in developing countries like the Philippines is difficult [5].

Agriculture is an essential sector which contributes to the attainment of country's inclusive growth [6]. Likewise, rice industry has a significant contribution in addressing the issues in food security. In support of the campaign of the Philippine government to empower Filipino farmers and combat hunger among Filipinos in the long run, this study analyzes the farmers' intention of adopting modern rice technologies in the context of the rice farmers in SAMARICA Area of Occidental Mindoro Province.

2. RESEARCH FRAMEWORK

Literature suggests various theoretical models and frameworks simplify the understanding of the factors affecting technology acceptance in the agricultural sector. Among these theoretical models are the Diffusion of Innovation Theory (DIT) and the Technology Acceptance Model (TAM).

The proliferation of information and communications technology (ICT) in developing countries helped agricultural policymakers and researchers to realize its importance in understanding agricultural and rural developments [7]. On the other hand, the study of agricultural technology adoption commenced in the 1970s during the era of Green Revolution [2]. Moreover, the predecessor of the current TAM used as a framework for various adoption studies is the Theory of Reasoned Action [8]. There is also a modified version of TAM called TAM 2 based on the Theory of Planned Behavior [9,10]. The most recent version of the model is the so-called Unified Theory of Acceptance and Use of Technology (UTAU) [11].

The basic model used as the basis for establishing the research framework of this study is the Technology Acceptance Model (TAM). Since, the goal of this paper is to measure the rice farmers' intention to adopt a technology, the TAM which is based on the Theory of Reasoned Action was considered. The theory posits that the behavioral intention can predict the behavior of an individual. Likewise, TAM suggests that behavioral intentions, attitude, perceived usefulness, and perceived ease of the use of technology have direct or indirect influence on the actual use of the technology [8]. Furthermore, literatures recommend TAM as a more suitable basis for theoretical design for Farmer Technology Acceptance Model for Developing Country [12]. In the original TAM, the Relative Advantage is not included since it is a component of the Diffusion of Innovation Theory (DIT). Relative Advantage is a key factor for the adoption of an innovation [13]. In other literature, Relative Advantage is used interchangeably with Perceived Usefulness which is a component of TAM [14]. In this study, Relative Advantage was incorporated into the modified TAM. As a result, Relative Advantage served as an independent variable together with the Perceived Convenience and Perceived Usefulness.

Fig. 1 shows the research framework of the study which was analyzed and tested.

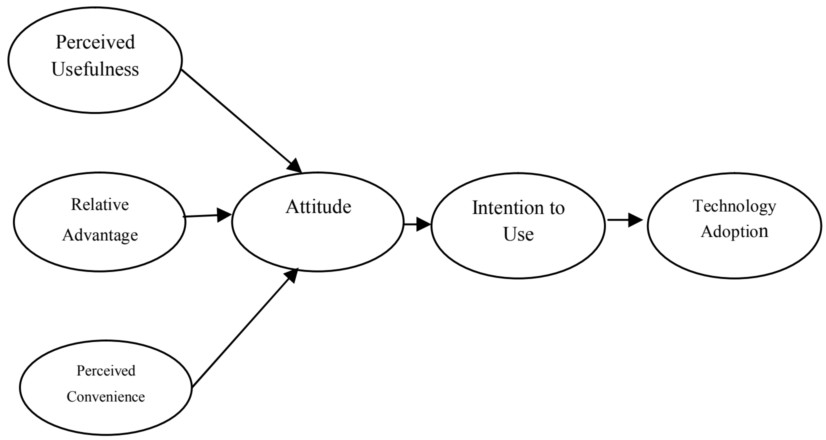

Fig. 1. Research framework

The construct of the framework is based on the established research problems obtained from reviewing existing literature and empirical studies. The arrows connecting the constructed figures represent the hypothesized causal relationships in the path of the arrow. The framework consists of independent variables, moderator variables, and dependent variables. There are three independent variables (perceived usefulness, relative advantage and perceived convenience), two moderator variables (attitude and intention to use), and technology adoption as the dependent variable. On the other hand, it is important to note that Relative Advantage is termed as Perceived Usefulness in other literature while Perceived Convenience is termed by other researchers as Perceived Ease of Use.

3. HYPOTHESES

The proposed hypotheses of the study are as follows:

H10: Perceived usefulness of technology does not predict attitude toward the technology.
H20: Relative advantage of technology does not predict attitude toward the technology.
H30: Perceived convenience of technology does not predict attitude toward the technology.
H40: Attitude toward technology adoption does not predict intention to use the technology.
H50a: Intention to use the technology does not predict the adoption of production technology.
H50b: Intention to use the technology does not predict the adoption of postharvest technology.

4. METHODS

4.1 Respondents

A survey was initially set to be conducted among 400 rice farmers selected using a three-staged sampling design. It follows the guidelines issued by the *Centro Internacional de Mejoramiento de Maize y Trigo* (CIMMYT) which recommends a sample size between 60-120 respondents for conducting formal surveys on agricultural technology adoption. The guidelines further states that an adoption study must be conducted 2-4 years after the release of a certain technology or initiation of the extension program. The sampling involved proportionate allocation, purposive selection, and random selection. Four hundred questionnaires were proportionally allocated among the four municipalities of the SAMARICA according to the total land area devoted to rice farming in each municipality. It follows the assumption that the number of farmers is positively related to the farm size [15]. Moreover, a selection criteria was established such that: the farmer must own the land, adopts monocropping system, has experience in rice production for at least five years, has contact with extension agents, or has attended training and seminars for minimum of two years. Lastly, the respondents were randomly selected from the selected municipalities. Originally, one municipality has a sample size of 56 farmer-respondents. To meet the requirement on sample size, the total respondents was adjusted from 400 to 404, adding six respondents to satisfy the minimum requirement of sample size in one study area [16].

4.2 Research Instrument

The structure of the survey instrument consists of three independent variables (perceived usefulness, relative advantage, and perceived convenience), two moderator variables (attitude and intention to use), and technology adoption as the dependent variable. The independent and moderator variables were measured using 21 items by each technology category by Likert scales ranging from strongly disagree to strongly agree. The variables are defined further in Table 1.

4.3 Validity of the Instrument

To ensure that the instrument used in this study is valid, the instrument was validated by licensed agriculturists, agricultural technicians, farmers, and researchers from the academe. Table 2 presents a summary of the validity test result.

Based on the result, the instrument attained the minimum requirement for validity index as revealed by the value of I-CVI and A-CVI/UA. With that, it is safe to conclude that the research instrument used in the study is valid.

4.4 Reliability of Instrument

The questionnaire was pilot tested to 30 randomly selected farmers out of the sample. To determine the reliability of the instrument and the variables, Cronbach's Alpha was used. Table 3 presents the result of the reliability test.

The result of the test reveal that the item questions in the instrument are reliable attaining the minimum required value of the Cronbach's Alpha Coefficient.

Table 1. Operational definition of study variables

Variable	Definition	References
Perceived Usefulness	Extent in which farmer the farmer believes that using technology enhances job performance	Davis, 1987 Davis, Bagozzi & Warsaw, 1989
Relative Advantage	Extent in which the technology is perceived to be better than its antecedent	Rogers [13]
Perceived Convenience	Extent to which the farmer believes that using technology would require less effort	Davis, 1987 Davis, Bagozzi & Warsaw, 1989
Attitude	Positive or negative feelings towards the technology	Rogers [13] Adrian, Norwood & Mask, 2005
Intention to Use	Extent of farmer's motivation or desire to use the technology	Phillips, Calantone & Lee, 1994 Venkatesh & Davis, [10]
Technology Adoption	Decision-making process of the farmers whether to adopt or not to adopt technology	Rogers, 1983

Table 2. Result of validity test of a research instrument

Variable	Mean I-CVI		S-CVI/UA	
	Production technology	**Postharvest technology**	**Production technology**	**Postharvest technology**
Perceived Usefulness	0.917		0.750	
Relative Advantage	0.875		0.500	
Perceived Convenience	0.930		0.800	
Farmer Attitude	0.875		0.750	
Intention to Use	0.903		0.710	
Technology Adoption	0.900	0.900	0.600	0.800

Table 3. Result of reliability test of a research instrument

Variable	Cronbach's alpha coefficient (standardized items)	
	Production technology	Postharvest technology
Perceived Usefulness	0.931	0.918
Relative Advantage	0.951	0.956
Perceived Convenience	0.821	0.839
Farmer Attitude	0.890	0.852
Intention to Use	0.897	0.926
Technology Adoption	0.899	0.700

Table 4. The survey instrument – level of adoption of technology

Items	Cronbach's Alpha	Composite reliability	Average variance extracted
Production Technology			
Factor 1: Pre-planting	0.850	0.887	0.529
Factor 2: Care and management	0.791	0.882	0.719
Postharvest Technology	0.732	0.825	0.521

Table 5. The survey instrument – exogenous constructs (production technology)

Items	Cronbach's alpha	Composite reliability	Average variances extracted
Perceived Usefulness	0.752	0.844	0.575
Perceived Convenience	0.835	0.890	0.670
Relative Advantage	0.826	0.878	0.591
Attitude	0.818	0.880	0.649
Intention to Use	0.890	0.890	0.529

Table 6. The survey instrument – exogenous constructs (Postharvest technology)

Items	Cronbach's alpha	Composite reliability	Average variances extracted
Perceived Usefulness	0.797	0.868	0.624
Perceived Convenience	0.856	0.902	0.698
Relative Advantage	0.841	0.887	0.612
Attitude	0.890	0.924	0.752
Intention to Use	0.850	0.899	0.690

4.5 Statistical Treatment

Collected data were subjected to sorting and coding and were entered to Statistical Package for Social Sciences (SPSS). Quantitative data were analyzed using descriptive statistics such as frequency and measures of central tendency. Partial Least Square Structural Equation Modeling (PLS-SEM) was used to analyze study variables via WARP PLS Software version 3.0.

5. RESULTS AND DISCUSSION

5.1 Tests of Hypotheses

5.1.1 Measurement model evaluation

The quality and adequacy of measurement models were assessed by investigating convergent validity (item construct loading with value at least 0.5, associated with $p < 0.05$), reliability (acceptable alpha and composite reliability is at least 0.7) and discriminant validity. The endogenous variables (adoption of production technology and adoption of postharvest technology) and exogenous variables (perceived usefulness, perceived convenience, relative advantage, attitude, and intention to use) were examined based on their validity and reliability. Results are presented in Tables 4 to 6.

Based on the values presented in Tables 4 to 6, all items from the survey instrument have acceptable values of Cronbach's alpha and composite reliability of more than 7.0.

5.1.2 Empirical results for hypotheses

Figs. 2 and 3 present the structural model showing TAM variables hypothesized as predictors of technology adoption. The model has annotations of path coefficients (β) and the portion of the variance explained, represented by R2. Meanwhile, the result of the hypothesis testing which determines the significance of path coefficients is presented in Tables 5 and 6.

A separate set of hypotheses was formulated for the production and postharvest technology. From the modified TAM, Perceived Usefulness (PerUse), Relative Advantage (RelAdv) and Perceived Convenience (PerConv) serve as the independent variables. On the other hand, Attitude and Intention to Use serve as moderator variables while technology adoption serves as the dependent variable.

5.1.3 Hypotheses (Production technology)

The outcome of the hypothesized framework for the production technology adoption shows that Perceived Usefulness ($p < 0.01$, $\beta = 0.250$) and Relative Advantage ($p < 0.01$, $\beta = 0.533$) had direct and significant relationship with Attitude. On the other hand, the model shows that Perceived Convenience does not predict Attitude (see Table 7 and Fig. 2). The result contradicts the findings of Chang, Yan, and Tseng [17], who found that Perceived Convenience had a significantly positive effect on Attitude. However, the same study supported the significantly positive effect of Perceived Usefulness on Attitude. Consequently, Attitude was supported by the model to predict the Intention to Use. This result corroborates with Far and Rezaei-Moghaddam [18], Chang, Yan, and Tseng [17], Liu, Liao, and Peng [19] and Wu and Wang [20]. Similarly, the outcome of the hypothesized framework reveals that the Attitude ($p < 0.01$, $\beta = 0.861$) of the farmers towards production technologies could predict their intention to use. This is further supported by the significance of the causal path between Intention to use and the adoption of production technology ($p < 0.01$, $\beta = 0.647$; ($p < 0.01$, $\beta = 0.318$). In general, the model explains that all independent variables except for Perceived Convenience could predict the Attitude of the farmers which also influences their Intention to use and adoption.

According to OECD [21], Technology Adoption is a broad concept that is affected by many factors such as how the technology was developed, disseminated, and applied at the farm level. There are also other influencing factors such as farm capital and resources, education, training, advice and information that serve as the source of knowledge of the farmers [2,22-25].

The study of shows that technology and the local environment must be compatible, and its price should be competitive to its alternatives [26]. Hence, it is also important to consider that these technologies were developed outside the farm sector that is why adoption can be challenging and dynamic [21].

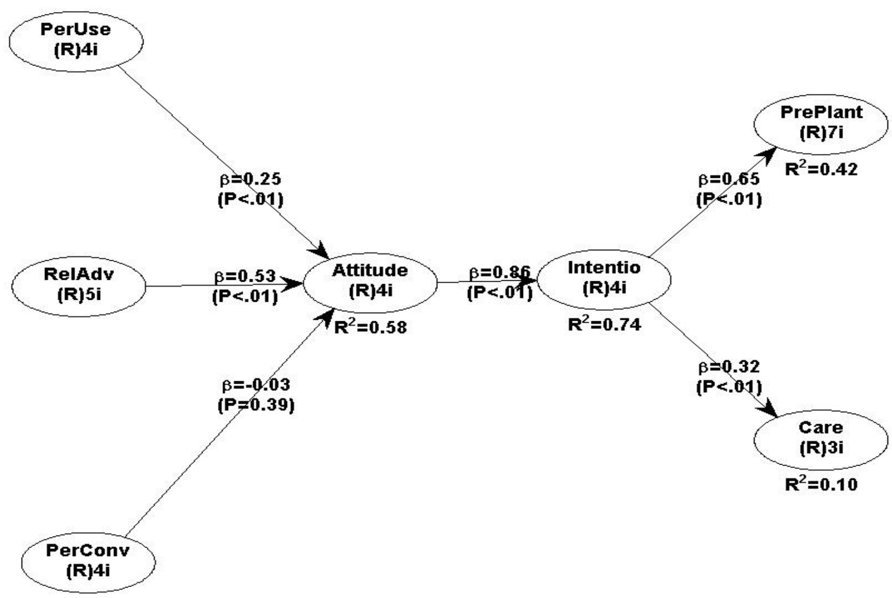

Fig. 2. Outcome of hypothesized framework (Production technology)

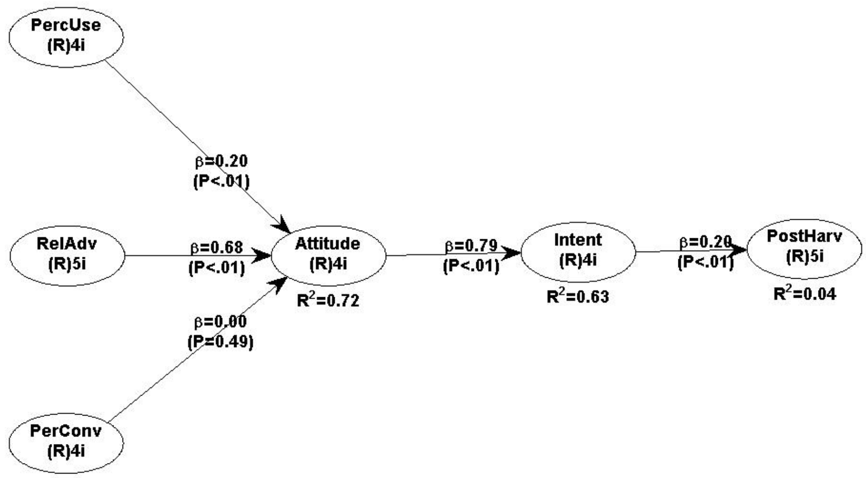

Fig. 3. Outcome of hypothesized framework (Postharvest technology)

Table 7. Empirical results for hypotheses (Production technology)

Causal path	Hypothesis	Expected sign	Path coefficient	p-value	Interpretation
Perceived use→ attitude	H_{01prod}	+	0.250	<0.01	Significant
Relative advantage→attitude	H_{02prod}	+	0.533	<0.01	Significant
Perceived convenience→ attitude	H_{03prod}	+	-0.033	0.39	not significant
Attitude→intention to use	H_{04prod}	+	0.861	<0.01	Significant
Intention to use→adoption of production technology (pre-planting)	$H_{05}a_{prod}$	+	0.647	<0.01	Significant
Intention to use → adoption of production technology (care and management)	$H_{05}b_{prod}$	+	0.318	<0.01	Significant

Table 8. Empirical results for hypotheses (Adoption of postharvest technology)

Causal path	Hypothesis	Expected sign	Path coefficient	p-value	Interpretation
Perceived use→ attitude	$H_{01posth}$	+	0.201	<0.01	Significant
Relative advantage→attitude	$H_{02posth}$	+	0.680	<0.01	Significant
Perceived convenience→ attitude	$H_{03posth}$	+	0.002	0.49	not significant
Attitude→intention to use	$H_{04posth}$	+	0.794	<0.01	Significant
Intention to use → adoption of postharvest technology	$H_{05posth}$	+	0.204	<0.01	Significant

5.1.4 Hypotheses (Postharvest technology)

The empirical result for the hypotheses tested for the adoption of postharvest is the same as the result of the tested hypotheses of production technology (see Table 8 and Fig. 3). The hypothesized framework for the postharvest technology adoption explains that Perceived Usefulness ($p < 0.01$, $\beta = 0.201$) and Relative Advantage ($p < 0.01$, $\beta = 0.680$) are directly and significantly related to Attitude which means that the latter can be predicted by how farmers perceive the usefulness and relative advantage of the technology. Moreover, the Perceived

Convenience ($p = 0.49$, $\beta = 0.002$) does not necessarily prompt the farmers to have either a positive or negative attitude towards technology. However, the positive or negative attitude ($p < 0.01$, $\beta = 0.794$) of the farmers towards postharvest technology was proven to predict how farmers intend to use it. Consequently, Intention to use ($p < 0.01$, $\beta = 0.204$) could predict the farmers' adoption of postharvest technology.

Technology adoption of famers is influenced by many factors. These factors such as technical trainings, attendance to meetings, trust of farmers to technicians and their belief about the technology influence adoption [27]. Even if farmers perceive technologies to be beneficial for them, they are constrained with a lack of capital and support from the government.

6. CONCLUSION

This research follows the framework of the Technology Acceptance Model (TAM) to analyze the rice farmers' intention to adopt modern rice technologies. The adoption of this theoretical model is based on the recommendation of literatures that state TAM is a more suitable basis for theoretical design for the Farmer Technology Acceptance Model for developing countries like the Philippines.

Based on the empirical results of the hypothesis tests for endogenous and exogenous variables, the use of TAM as a theoretical model is important in understanding the farmers' intention to adopt modern rice technologies in SAMARICA, Occidental Mindoro, Philippines. The model proved that the attitude of the farmers towards technology is predicted by their perception of the usefulness and relative advantage of the technology. On the other hand, the perception of the farmers regarding the convenience of adopting the technology does not predict their attitude towards the adoption of modern rice technologies. Nevertheless, attitude of the farmers was found to influence their intention of whether to adopt or not to adopt modern rice technologies disseminated by the government and non-government extension professionals. This paper further proved that the farmers' intention of using a technology influences their adoption. TAM postulates that there are other externals factors that influence behavioral intention and actual adoption which are also being mediated by perceptions of usefulness and convenience. Hence, a further study may be conducted by incorporating external factors to explore how these influence rice farmers' perception, attitude, and intention.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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