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An exploratory factor analysis to develop measurement Items for small farmers' proactiveness and risk-taking in precision farming

Uzairu Muhammad Gwadabe[1], Nalini Arumugam[2*] and Noor Aina Amirah[1]

[1,]Faculty of Business and Management, Universiti Sultan Zainal Abidin, Gong Badak Campus, 21300, Gong Badak, Terengganu, **Malaysia**
[2] Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin, Malaysia, Besut Campus, 22200, Besut, Terengganu, **Malaysia**

***Correspondence: nalini@unisza.edu.my** **Received: 05-07-2021, Revised: 12-08-2021, Accepted: 15-08-2021 e-Published: 21-08-2021**

Precision agriculture is a promising approach to ensuring food security despite the environmental challenges of climate change. However, small farmers who are the major agri-food producers in Malaysia lag in adopting such technology. Therefore, considering the impact of proactiveness and risk-taking toward adopting new technologies in different domains, the constructs would influence the adoption of precision agriculture among small scale farmers in Malaysia. This study was conducted to develop a reliable and valid instrument for measuring proactiveness and risk-taking constructs for small scale precision farming in Malaysia. Questionnaire items were developed on a scale interval of one (strongly disagree) to ten (strongly agree). The researchers used IBM SPSS statistic version 25.0 to performed Exploratory Factor Analysis (EFA) on 207 datasets. The study used the factor analysis method of the Principal Component Analysis with Varimax Rotation. All items in this study were adapted from previous studies. The analysis results showed that both proactiveness and risk-taking extracted two components each and all Cronbach alpha values were between 0.937 and 0.881. Also, the factor loadings for all items in the study were above 0.6, and eigenvalues were all greater than one, which explained variances of 71.746% for proactiveness and 79.170% for risk-taking. Furthermore, Bartlett's tests of sphericity were both significant (sig. 0.000). Besides, the sufficiency of the samples were outstanding (KMO=.0882 and 0.808). The total result indicates that the development scale and validation have demonstrated accuracy and reliability for the instrument. Thus, this study contributes significantly to items measuring the constructs of proactiveness and risk-taking for small scale precision farming in Malaysia. Therefore, the items are fit for data collection and further analysis.

Keywords: Precision Agriculture, Adoption, Proactiveness, Risk-taken, Exploratory Factor Analysis

INTRODUCTION

Amidst climate change and population growth, farmers face many challenges, including the need to increase food productivity, sustainability, and quality while reducing costs and preserving the ecosystem (Tompkins, 2020). In addition, the United Nations asserted that global food production needs to rise by more than 70% to feed the growing global population that would reach 9.7 billion people by 2050. Correspondingly, Malaysia's population has more than tripled from the last five decades, and the population continues to grow. Therefore, in its efforts to increase food production and sustainability, the Malaysian government works through various policies that include the adoption of precision agriculture in agri-food production.

The year 2020 marked the end of the Eleventh Malaysia Plan (11MP)— 2016 to 2020, the policy that was meant to bring about technological transformation in the agri-food industry. However, in the previous years, the technology acceptance rate by small scale farmers, who are the major agri-food producers, was not encouraging. Consequently, the government adjusted its strategies and lunch the Twelfth Malaysia Plan (12MP) in early 2021 (Economic Planning Unit, 2019; Tompkins, 2020). The new plan focuses on boosting reinforcement towards transformation and modernization of agri-food production through precision agriculture (Economic Planning Unit, 2019). Precision agriculture, also known as smart farming, is a farm management strategy facilitated by information and communication technology and the Internet of Things that ensure crops and soil get the correct input they need for optimal productivity and quality (Hedley, 2015).

Like any other technology, the adoption of precision agriculture is influenced by individual characteristics (Heand Veronesi, 2017; Sharifzadeh et al. 2017; Taherdoost, 2018). Therefore, the successfulness of precision agriculture, especially among small scale farmers, depends on their proactiveness in taking calculated risks to invest their resources, time and energy in such agricultural technique that seems unfamiliar to them. Proactiveness and risk-taking are essential factors that affect individuals' mindsets towards adopting new technology (Morris et al. 2017; Omodanisi & Ajike, 2020). Therefore, small farmers who have a proactive and risk-taking mindset can likely be at the forefront to embrace smart farming in Malaysia. These two structures were proven essential in changing the mindset of individuals towards embracing changes in dealing with environment dynamism (Abebe, 2014; Hwang et al. 2016; Pérez-Luño et al. 2010). Similarly, Yusoff et al. (2016) assert that proactiveness.

Proactiveness refers to the forward-looking mindset to take positive action in the face of external constraints (Zhao & Smallbone, 2019). Proactivity was described as acting in expectation of potential issues and improvements (Lumpkin & Dess, 1996). Proactive individuals are looking for possibilities to exhibit initiatives action and taking the required measures to succeed in a venture (Huang et al. 2017). Proactive entrepreneurs are determined to take action; they discover new business opportunities and then coordinate and manage their resources towards achieving their goals (Zhao & Smallbone, 2019).

The potentiality of being at the forefront or champion in embracing emerging technologies is defined by the level of proactiveness (Dencker et al. 2009). Proactiveness is the crucial factor of cognitive absorption linked to perceived usefulness and ease of using technologies (Garay et al. 2017). Hence, proactive people in adopting high technology have more desire to embrace and succeed in emerging technologies. The concept of proactiveness has been researched in various contexts for a long and was found to have robust experimental effects on emerging technologies (Chang et al. 2005; Sandberg, 2002).

Correspondingly, Hwang et al. (2016) addressed the issue of the use of technologies. The study indicated that proactiveness on information affected individual phycological belief to adopt technologies. The empirical testing found that the proactiveness on information technology significantly determined the ease of using systems. Similarly, in the health sector, a study examined the association between leadership qualities and the usage of mobile health technology (mHealth) by nurses as part of their clinical practice (Ronquillo et al. 2019). The model facilitated examining the relationship between nurses' characteristics which include proactiveness and technology acceptance model. The proactiveness construct was crucial in determining nurses usage of the new technology. Similarly, Huang et al. (2017) explored the core elements that might boost the quality and efficacy of mobile learning through the moderating role of people proactiveness in mobile education. The findings showed that personal proactiveness played a moderating role in the relationship between perceived usefulness and mobile learning performance.

On the other side, risk-taking is the acceptance of uncertainty and behaviours related to risk, demonstrated by sacrificing resources for commitment with uncertain outcomes (Dess et al. 2011). Risk-taking is otherwise defined as the willingness of entrepreneurs to make significant investments where the outcome is not certain (Miller & Friesen, 1978). People who take risks can allocate their limited resources and energy for opportunities with no guaranty for success (Rodríguez-Fornells et al. 2002). Contrary to the traditional belief that entrepreneurs are habitual risk-takers, studies show that entrepreneurs accommodate only calculated risks (Kahan, 2013; Ndubisi, 2007; Pérez-Luño et al. 2010).

Studies showed that agricultural entrepreneurs who can take risk are more likely to seek and utilize innovative technologies (Ahsan, 2011). Therefore, this indicates that small farmers who have high risk-taking aptitude are likely to adopt precision agriculture. Furthermore, studies reported relationships between risk-taking and the technology acceptance model. However, the nature of relationships is inconsistent among the researchers. For example, a survey was carried out to understand customer perceptions and the intent to embrace an internet-based information system; Li & Huan (2009) propose perceived risk as an antecedent of perceived usefulness and ease of use in adopting new technology. The study proved the effect of perceived risk on the intention to adopt novel technologies.

Similarly, in a study by Hansen et al. (2018), risk-taking perception played a significant role as an antecedent in customer decision-making and that risk-taking tendency. It also had a direct influence on behavioural intent. Similarly, Ndubisi (2007) found risk-taking tendency to be a significant determinant of the use of technology by entrepreneurs in Malaysia. Ndubisi (2003) examine information technology usage among women entrepreneurs. The study used entrepreneurial traits, which encompasses risk-taking propensity among other sub-constructs. Risk-taking was found to determine perceived usefulness. Furthermore, Featherman (2001) extended the technology acceptance model to include risk-taking perception to investigate individual adoption of internet-based e-payment systems. The study found that risk-taking perception had a direct effect on the usefulness as well as the intention to adopt new technologies.

Over the years, limited studies considered proactiveness and risk-taking constructs in adopting agricultural technology and even fewer into influencing small farmers' adoption of precision agriculture in Malaysia. However, the results of previous studies were inconsistent or contradictory (Fahim & Baharun, 2017; Gwadabe & Amirah, 2017; Pérez-Luño et al. 2010; Yusoff, Ahmad, et al. 2016). The inconclusiveness and contradiction in the results might be due to the items employed in investigating the phenomenon. Therefore, this study aimed to explore and develop suitable and reliable items that would contextually measure proactiveness and risk-taking constructs in the adoption of precision agriculture among small scale farmers in Malaysia.

METHODOLOGY

In this survey, a cross-sectional research method was used to develop a valid and reliable instrument to measure proactiveness and risk-taking concepts in the context of small farming in Malaysia. To develop measurement items for small farmers' proactiveness and risk-taking in adopting precision agriculture in Malaysia. This study defined small-scale farmers as a commercial producer of agri-food commodity who cultivates farmland that does not exceed two hectares. Small scale farmers were chosen as the population for this study because they are the backbone of the agri-food sector in Malaysia. Also, they constitute more than 80% of the total number of farmers in the country (Arumugam et al. 2017; Casey, 2016). Nevertheless, Malaysian small scale farmers lag in adopting precision agriculture (Abdullah & Samah, 2013).

The researchers collected data by physically distributing questionnaires to respondents at some farmer knowledge exchange meetings organized by the Malaysian Ministry of Agriculture and farmers cooperatives. The meeting had gathered small-scale farmers of different products, including paddy, coconuts, fruits, vegetables, fishery, and poultry—the distribution of questionnaires and the selection of farmer meetings adhered to the simple sanding procedure.

The data was collected between February and March 2020. A total of 250 questionnaires were distributed to the respondents as determined using Krejcie & Morgan's (1970) table of sample size determination. However, only 207 valid questionnaires got returned (representing an 82.8% response rate). Then, Exploratory Factor Analysis (EFA) was performed on the 207 useful questionnaires. The researchers used IBM SPSS statistic version 25.0 to perform EFA with varimax rotation to assess the dimensionality of items measuring the two constructs (proactiveness and risk-taking) in the study. Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy were assessed. Finally, Cronbach's alpha was evaluated to test the reliability of retained items.

The Instrument

The research instrument was a questionnaire that was self-administered to measure two constructs: proactiveness and risk-taking. The questionnaire was initially developed in English and then translated into the Malay language for better understanding of the respondents, who are mostly rural farmers.

The items of the questionnaire were adapted from earlier studies. As such, the constructs, items and references are presented in Table 1. After pretesting the questionnaire, proactiveness consisted of 9 items, while risk-taking ended up with seven items. All the items were close-ended questions developed on the scale of one to ten, from "strongly disagree" to "strongly agree", respectively. The 10-point scale can provide a higher degree of measurement accuracy, good reliability and reduced multicollinearity problems (Awang et al. 2016; Shams et al. 2017)

Pretest

A pre-test was conducted to pinpoint problems, reduce measurement error, and improve the instrument's clarity (Rahman et al. 2017). The opinion of experts and professionals are essential in examining and identifying inappropriateness and sensitivity in the tool (Awang et al. 2016; Hair, 2007). Therefore, in this study, we considered experts as the employees of the Malaysian Ministry of Agriculture. On the other hand, we considered practitioners as owners or managers who occupied leadership positions in the farms. Three experts and three practitioners evaluated the instrument and provided feedback that we used to improve the survey. The examiner checked the content validity and reliability of the tool to ensure it measured what it supposed to measure. Both Malay and English language proficiency of the examiners were considered since both language versions of the questionnaire had to be evaluated. Therefore, the questionnaire was subsequently updated and improved, based on the reviewers' feedback, and a new, revised version was produced (Table 1).

Table 1: Construction Items of Pro-activeness

Proactiveness		
Number of items	Items	Sources
Pro 1	I usually act in anticipation of future problems, needs or changes	(Bolton,and Lane, 2012)
Pro 2	I tend to plan ahead on projects	
Pro 3	I prefer to "step up" and get things going on projects rather than sit and wait for someone else to do it	
Pro 4	In dealing with other people, I typically respond to actions the other people initiate	(Taatila, and Down, 2012)
Pro 5	In dealing with other people, I typically initiate actions to which other people then respond	
Pro 6	Among my colleagues, I am typically among the first who begins using new farming technology	
Pro 7	Among my colleagues, it is very seldom that I am the one that first begins using new farming technology	
Pro 8	In concern using technology in farming, I typically adopt a straightforward and competitive posture	
Pro 9	In a contentious situation, I typically seek to avoid clashes and prefer a "live-and-let-live" position	
Risk-taking		
RT 1	I like to take bold action by venturing into technology-related innovations	(Bolton and Lane, 2012)
RT 2	I am willing to invest a lot of time and/or money in technology that might yield a high return	
RT 3	I tend to act "boldly" in situations where risk is involved	
RT 4	In general, I have a strong bias for high-risk projects	(Taatila, & Down, 2012)
RT 5	In general, I have a strong bias for low-risk projects	
RT 6	I believe that owing to the nature of the environment; it is best to continue with the conventional way than using	
RT 7	I believe that owing to the nature of the environment, bold, wide-ranging acts are necessary	

Exploratory Factor Analysis (EFA)

When a study varies from the previous one in terms of industry, community, period or socioeconomic status, the dimensions of the construction items change. In other words, the dimensions obtained from previous studies may not be viable for another survey, mainly if they differ in some ways. It is therefore essential for this study to determine the validity of the designs.

EFA is a method used to reveal the structure of a relatively large number of variables (Hair, Jr et al. 2019). It is widely used when designing or setting a scale (Scale is the set of questions used to evaluate phenomena in research). In addition, it is often used to describe a collection of latent constructs of a measured variable (Awang et al. 2016; Hair, Jr et al. 2019; Nalini Arumugam et al. 2020; Weaver & Maxwell, 2014). In the factor analysis process, elements with identical characteristics will be combined into one component rather than having many items (Awang et al. 2016).

In this analysis, EFA was used to classify the underlying dimensions of elements and removed those that did not meet the factor loading cut-off point of 0.6, which means that any item with a loading factor of less than 0.6 would not suit this study (Bolton & Lane, 2012). The EFA was run with SPSS software version 25.0. The KMO and Bartlett test assessment was also performed to verify if the data collection was appropriate for factor analysis. For example, the value of KMO and Bartlett's Test tests for a correlation between items should be greater than 0.5 (Hair, Jr et al. 2019; Kaiser & Rice, 1974). Communalities values were also tested to assess the heterogeneity of each latent construct that the extracted factors could explain. Also, the rules for the number of factors extracted were based on the eigenvalue value, the percentage of variance and the significance of factor loadings. Factor loading values greater than one were considered relevant; 60 per cent of the overall variances were deemed to be satisfactory (Hair, Jr et al. 2019).

Reliability Analysis

Reliability was measured using both internal and structural reliability. Using Cronbach's Alpha, internal reliability was used to calculate research instruments was from random error and bias. The reliability analysis using Cronbach's Alpha was performed to assess the internal consistency of the two constructs. Awang et al. (2016) and Hair, Jr et al. (2019) proposed that the value of Cronbach's alpha of at least 0.7 was satisfactory.

RESULTS AND DISCUSSION

The following segment presented the results of the study and discussed the outcome. Out of 250 questionnaires administered, only 207 valid questionnaires got returned (representing an 82.8 per cent response rate). Then, the tests were done based on the 207 answers we received.

Results of Descriptive Statistics and their Respective Components

Table 4 indicates the number of items measuring each construct; proactiveness and risk-taking have nine and seven items each. The table also presented the descriptive statistics for every item measuring the two constructs, where the table shows the mean score and the standard deviation for each item.

The results in Table 4 show that the EFA procedure has extracted two components for each construct. The table specified the number of items attached to each component as well as their respective factor loadings. In this study, the only item having factor loading above 0.6 was retained since they indicate the usefulness of measuring the particular construct. However, item number nine on proactiveness (Pro9) was deleted due to low factor loading below 0.6 (Awang et al. 2015). As a result, the rotated component matrix shows that eight items for proactiveness and all the seven items for risk-taking had factor loadings greater than 0.6. Therefore, those items were considered for further analysis under two dimensions on each construct. Those components were generated based on an Eigenvalue greater than one. Also, the overall value for variance explained for both constructs were 71.746 for proactiveness and 79.170 for risk-taking. The result is acceptable since the values exceeded the minimum threshold of 60% (Ndubisi, 2007; Özbek et al. 2014). However,

The Results of Validity

EFA was performed using the factor analytic method of the principal component procedure with Varimax Rotation on the two constructs: proactiveness (8 items); risk-taking (7 items). Considering the result in Table 3, it indicates that Bartlett's Test of Sphericity for both proactiveness and risk-taking were significant (P-values were less than 0.05). Lastly, the measure of sampling adequacy depends on KMO values, which was adequate as they have surpassed the minimum threshold of 0.6 (Awang et al. 2015;

Hair, 2007). Therefore, based on these two results, Bartlett's test results were statistically significant at 0.000 for both constructs, and KMO values were 0.882 and 0.808 for proactiveness and risk-taking, respectively. Therefore, we decide that the data is adequate and it is appropriate to proceed further with the reduction procedure (Awang et al. 2016; Hair, Jr et al. 2019; Nalini Arumugam et al. 2020; Weaver & Maxwell, 2014)

Table 2: Descriptive Statistics and their Respective Components

Constructs	Mean	Std. Deviation	Rotated Component Matrix Components (Factor Loadings)		Eigenvalue Components		% of Variance Explained
			1	2	1	2	
Proactiveness					4.945	1.512	71.746
Pro 1	7.85	1.810	.879				
Pro 2	8.30	1.670	.858				
Pro 3	7.84	1.722		.757			
Pro 4	8.01	1.777	.879				
Pro 5	7.82	1.853	.858				
Pro 6	7.62	1.769		.894			
Pro 7	7.85	1.731		.823			
Pro 8	7.87	1.675		.736			
Pro 9	6.86	2.556	Deleted				
Risk-taking					4.049	1.493	79.170
RT 1	8.10	1.231	.794				
RT 2	7.56	1.279	.890				
RT 3	7.51	1.433	.867				
RT 4	8.08	1.232	.830				
RT 5	8.13	1.384		.919			
RT 6	8.13	1.355		.940			
RT 7	7.93	1.253		.785			

Table 3: **The KMO and Bartlett's Test Score for the Variables**

		Proactiveness	Risk-Taking
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.882	0.808
Bartlett's Test of Sphericity	Approx. Chi-Square	623.222	484.739
	df	36	21
	Sig.	0.000	0.000

Results of Reliability Analysis

The study requires calculating the Cronbach's alpha values to evaluate the internal reliability of the retained items. Internal reliability or internal accuracy means the strength of the respective elements in calculating the separate construct. The value of Cronbach's alpha should be greater than 0.7 to maintain internal stability (Awang et al. 2015). Table 4 presents the Cronbach's alpha for every component.

Table 4: The Internal Reliability for the Variables

Variables	Cronbach's Alpha	
	1	2
Proactiveness	.937	.881
Risk-Taking	.896	.893

The results in Table 4 indicate that the relative internal consistency of the variables was achieved. Therefore all the items within scale indeed captured the respective constructs. This result is in line with the study by Shams et al. (2017).

CONCLUSION

Conclusively, the literature shows that individuals who demonstrate a proactive and risk-taking mindset are resistant to environmental shocks and efficiently respond to evolving conditions. Thus, effective agricultural transformation through small scale agriculture is critical in ensuring food dependency and security to a country. Moreover, besides ensuring food security and sustainability, successful adoption of precision farming at a small scale level would serve as a significant source of general economic viability and development, like employment, revenue generation, youths empowerments and increased exportations.

Based on a sample of 207 small farmers, this paper has empirically explored the conceptualization and factors of proactiveness and risk-taking constructs in the adoption of precision farming among small scale farmers in the Malaysian context. Based on EFA, the rotated matrix extracted two components for each proactiveness and risk-taking constructs. The measurements of proactiveness and risk-taking were measured by eight and seven items, respectively, as established by the study. All reliability measurements for all the components showed a high Cronbach's alpha value (All between 0.937 and 0.881), met Bartlett's test of sphericity (significant), KMO (>0.6) and factor loadings surpassed the minimum threshold of 0.6. This means that the retained items accurately measure the constructs (Awang et al. 2015; Shams et al. 2017). The procedures followed in this study have ensured that the new instrument is internally reliable and robust across the samples. However, this research indicates that potential work needs to be performed using the Confirmatory Factor Analysis (CFA) to incorporate and strengthen the understanding of this phenomenon.

Based on the above analysis, policy recommendations and implications can be made to develop small-scale agriculture. Stakeholders need to collaborate towards developing proactiveness and risk-taking mindsets of small farmers in Malaysia to maximize the contribution of the sector to the country's economy. Also, the increase in small farmers productivity will help meet the growing demand for over 70% of the current food production to feed the ever-increasing population amidst global warming and urbanization. Small scale farmers need to collaborate with other partners, like research institutions, universities and NGOs, on simple and affordable precision farming techniques. However, we highlight the following limitations of this study. The empirical result was from a sample of Malaysian small scale, and hence the finding is context-specific. Therefore it is recommended that future studies should consider covering the entire agricultural sector to expand generalisation.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

UMG wrote the manuscript and analyzed the data. NA designed and collected the data. NAA reviewed the manuscript. All authors read and approved the final version.

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