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Analysis of Qr Code Technology Acceptance in Cocoa Production Forecasting Based on Motivation, Farmer Characteristics, and Innovation Nature

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ABSTRACT

QR Code technology is used to help record cocoa production forecasts efficiently and accurately, so that farmers can easily update data in real-time. However, in its application, farmers still record production forecasts manually, which often results in discrepancies between forecasts and actual results and takes a long time in the process. This study aims to analyze QR Code technology acceptance among farmers assisted by PT X in the process of forecasting cocoa production in terms of the influence of motivation, farmer characteristics, and the nature of the innovation contained in the technology. This study used a quantitative verification method, supported by the SEM-PLS analysis tool. Samples were taken using a census method from 108 cocoa farmers assisted by PT X in Bulungan Regency. The results of the study showed that motivation, farmer characteristics, and the nature of innovation have a direct, positive and significant effect on QR code technology acceptance. Furthermore, QR Code technology acceptance is positively and significantly influenced by farmer characteristics through motivation as a mediating variable. However, the nature of innovation does not have a positive and significant effect on QR Code technology acceptance through motivation, and the nature of innovation also does not have a direct, positive and significant effect on motivation. These findings confirm that farmer motivation and characteristics need to be improved to increase QR Code technology acceptance. This will enable production forecasting to generate accurate data to inform cocoa production decisions and ensure the availability of cocoa bean raw materials for processors.

Keywords*: motivation, nature of technological innovation, production forecasting, qr code, technology acceptance*

BACKGROUND

Cocoa (*Theobroma cacao* L.) is a plantation crop that has a significant role in supporting the national economy, both as a source of state income, a creator of job opportunities, and as a sector that provides sustainable livelihoods for farmers and Indonesia is the third largest cocoa producing country in the world after Ivory Coast and Ghana, with emissions in the provinces of Central Sulawesi, Southeast Sulawesi, South Sulawesi and West Sulawesi (Ministry of Agriculture of the Republic of Indonesia, 2023). However, cocoa is produced in almost all regions of Indonesia,

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including Kalimantan which is known as a center for palm oil production (Central Bureau of Statistics, 2025). Kalimantan cocoa beans have unique characteristics such as having a taste like nuts and fresh fruit, as well as a distinctive aroma of orange, apricot, and flowers so that the superior quality makes its identity and origin protected by a geographical indication (IG) certificate from the Ministry of Law and Human Rights of the Republic of Indonesia (East Kalimantan Plantation Service, 2022).

North Kalimantan Province as the youngest province that was split in 2012 from East Kalimantan Province, makes cocoa as the main commodity developed besides palm oil (Elviana & Inten, 2019; Mariati et al., 2023). Bulungan Regency is used as the center of cocoa production in North Kalimantan Province, because it has resources in the form of cocoa plantation land that was developed in the 1980s when it was still part of East Kalimantan (Mariati et al., 2023). Bulungan Regency continues to expand its cocoa plantations, from 512 hectares in 2021 to 1.005 hectares in 2023 (Central Statistics Agency of North Kalimantan, 2024). Based on field analysis, cocoa development in Bulungan Regency is assisted by a mining company (PT X) through a corporate social responsibility (CSR) program by providing assistance to 108 cocoa farmers from upstream to downstream subsystems. In an effort to provide market certainty for farmers, PT X established a cocoa bean processing plant into chocolate to accommodate farmers' harvests .

To maintain the quantity and quality of cocoa bean supply from farmers, PT X conducts socialization and training to assisted farmers regarding digital-based cocoa production forecasting using QR Code technology. Referring to the statement Patricia et al., (2022), forecasting farm production can not only be done by researchers using various methods, but can also be done by farmers through direct recording and observation. Forecasting cocoa production in Bulungan Regency, especially by farmers assisted by PT X, is important because the harvest is not only supplied to the processing factory owned by PT X, but also supplied to cocoa bean processors managed by the government and the community in Bulungan Regency (Mariati et al., 2023). However, cocoa forecasting assisted by QR Code technology has not been fully implemented optimally. There are still many farmers who do not scan QR Codes in recording production forecasts and often farmers still make forecasts by recording manually. In the end, there is a discrepancy between the forecast and the production results, causing uncertainty in the supply of beans to the processors. According to McCormack et al., (2021), the reason why farmers do not apply a technology in their business is due to the motivation of the farmers themselves. Motivation plays an important role in the tendency to use technology (Francisco et al., 2024).

Then in the research of Sarie et al., (2023), it was stated that farmer characteristics such as age and education level of farmers are directly correlated with the likelihood of farmers adopting agricultural technology. Farmers who are young and educated will have a good understanding of technology, so they are more likely to integrate it into their agricultural practices. Thus, addresing psychological factors that are within the scope of important characteristics to be handled based on field analysis in order to create and increase farmer acceptance of a technology, in this case the acceptance of QR Code technology to help the process of recording production forecasts accurately which can support production optimization, effective and efficient resource planning, to improving the quality of harvest results.

Furthermore, according to McCaig et al., (2023), psychological factors, such as trust and risk aversion can hinder farmers' acceptance of technology. Farmers’ concerns about new

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technology make them reluctant to accept the technology, especially for farmers who feel they do not have sufficient understanding about the use and benefits of new tools (Setiawan et al., 2023). Based on the problems that have been described, it is important to analyze farmer acceptance of QR Code technology in the cocoa production forecasting process in terms of motivation, farmer characteristics, and the nature of the innovation, which so far has not been widely studied in the technology acceptance literature. This is because previous research has generally focused on primary food commodities with conventional technologies that only use standard analytical frameworks such as the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Ambong & Paulino, 2020; Larasati et al., 2024; Mariyono & Kuntariningsih, 2024; Salleh et al., 2024). Therefore, this study was conducted by analyzing the influence of motivation, farmer characteristics and the nature of innovation on the acceptance of QR Code technology among farmers in the cocoa production forecasting process in Bulungan Regency.

RESEARCH METHODS

This study applies a quantitative method through a verification approach, which, when referring to Baluta et al., (2021), the aim of this method is to verify the truth of a hypothesis through direct collection of field data. This study was conducted in Bulungan Regency, where the location was chosen based on the consideration that there were cocoa farmers who utilized the first and only QR Code technology in Bulungan Regency, North Kalimantan Province in recording cocoa production forecasts. Data were taken from 108 cocoa farmers who were fostered by a mining company (PT X) through a corporate social responsibility (CSR) program in cocoa development, including the application of QR Code technology which was utilized in the process of recording cocoa production forecasts in Bulungan Regency, North Kalimantan. Given the relatively small population, all subjects in this study used saturated sampling techniques or census methods, so that the 108 farmers were selected as respondents in this study (Syahza, 2021).

In this study, the types of data collected include primary and secondary data. Primary data is obtained from interviews with respondents and also using questionnaires, while secondary data comes from journals, books and statistics (Syahza, 2021). Then, the variables in this study were measured using a Likert scale that gave values from 1 to 5. Then, the variables in this study were measured using a Likert scale with scores ranging from 1 to 5. This scale describes the respondent's level of agreement with a statement, with categories ranging from strongly disagree (1), disagree (2), undecided (3), agree (4), and strongly agree (5). The categories were created and arranged based on the respondents' active participation in determining and evaluating the respondents' disagreement or agreement with a series of statements made based on research needs (Syahza, 2021).

The exogenous latent variables in this study are farmer characteristics and nature of innovation. The endogenous latent variables are motivation and QR Code Technology Acceptance for cocoa forecasting. Path analysis was applied in this study to test the influence of independent variables, namely farmer characteristics, and nature of innovation on dependent variables, namely motivation and QR Code Technology Acceptance for cocoa fruit forecasting. Path analysis was conducted based on structural equations (SEM) using PLS-SEM. SEM is a multivariate-based

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statistical method, designed to solve multiple regression especially when there are certain issues (Thakkar, 2020). According to Tang et al., (2024), to test the validity of the construct and the consistency of the instrument, a measurement model or outer model in the form of a confirmatory analysis factor was applied. Furthermore, the QR Code technology acceptance model for cocoa production forecasting in this study is as follows.

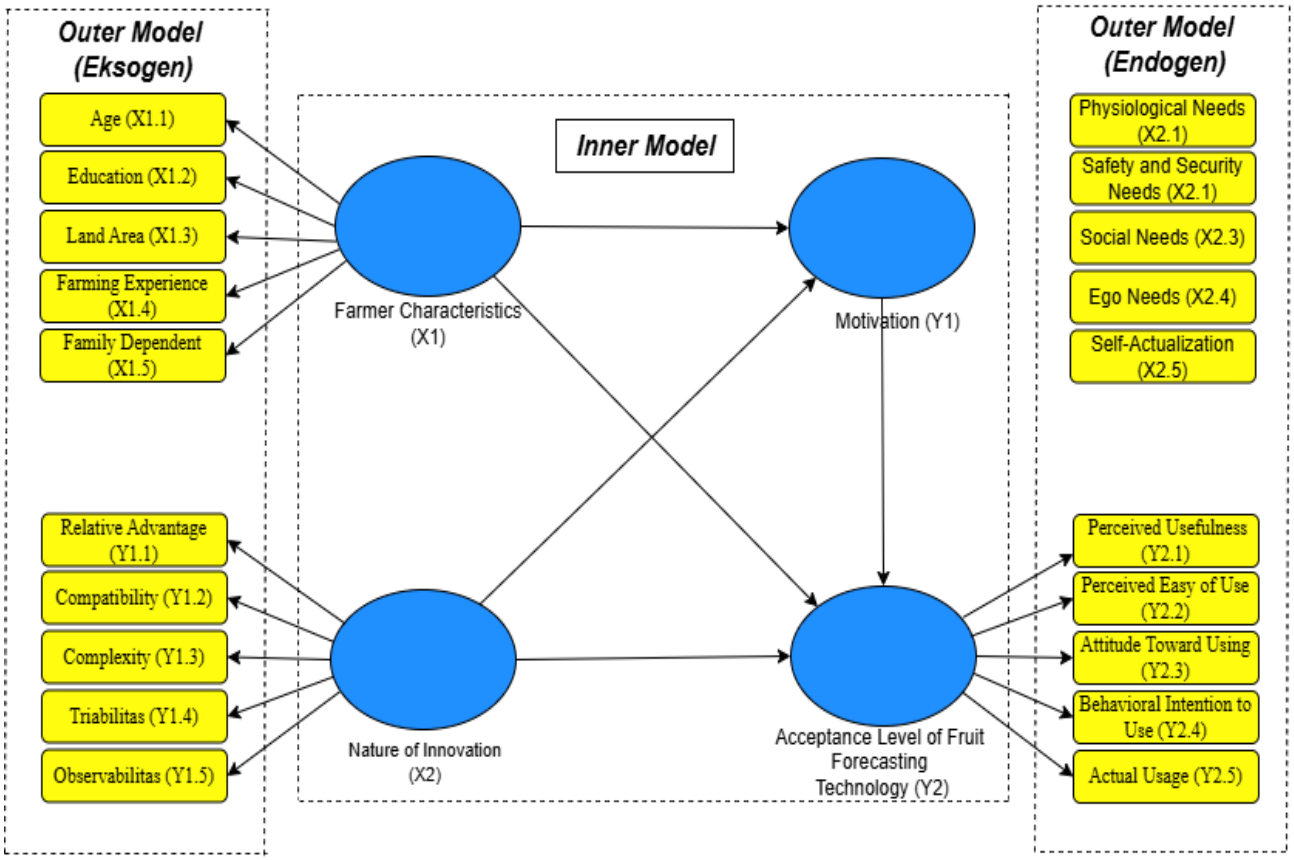

Figure 1. Research Model
Source: Secondary Data, 2025

Figure 1 explains the relationship between latent variables, namely farmer characteristics, innovation nature, motivation and QR Code Technology Acceptance, and manifest variables such as relative advantage, physiological needs, and others that are reflective. This model describes the interaction and influence between latent variables on manifest variables, providing deeper insight into the dynamics that occur in this study. The correlation between indicators and variable scores is an indication of convergent validity in the measurement model. An indicator can be said to be valid if the Average Variance Extracted (AVE) and outer loading are each greater than 0.5. Furthermore, in the reliability test, the composite reliability and Cronbach's alpha values must be greater than 0.70. The t-statistic and p-value values on the test parameters are obtained through the structural model (inner model) in predicting evidence of causality by applying the bootstrapping process (Thakkar, 2020). Hypothesis testing is carried out based on path analysis which is arranged according to the theoretical model designed through predetermined variables.

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Through this approach, it can accurately identify and evaluate the causal relationships that occur in each variable, so that researchers can draw conclusions with a strong basis. This approach can also help in developing more effective strategies based on an understanding of how farmer characteristics, the nature of innovation affect motivation and acceptance of QR Code technology in the cocoa production forecasting process. This approach not only has the potential to strengthen the validity of the findings, but also contributes to various literatures in the fields of agriculture and technology, as well as stakeholders in formulating more effective policies. The hypothesis to be tested in this study are listed in Table 1.

Table 1. Hypothesis

Hypothesis	Hypothesis Description
Hypothesis 1a	Farmer Characteristics Have a Positive and Significant Influence on Motivation
Hypothesis 1b	Farmer Characteristics Have a Positive and Significant Influence on QR Code Technology Acceptance
Hypothesis 2a	The Nature of Innovation Have a Positive and Significant Influence on Motivation
Hypothesis 2b	Nature of Innovation Have a Positive and Significant Influence on QR Code Technology Acceptance
Hypothesis 3	Farmer Characteristics Have a Positive and Significant Influence on QR Code Technology Acceptance Through Motivation
Hypothesis 4	Nature of Innovation Have a Positive and Significant Influence on QR Code Technology Acceptance Through Motivation
Hypothesis 5	Motivation Have a Positive and Significant Influence on QR Code Technology Acceptance

Source: Primary Data 2025

RESULT AND DISCUSSION

The results of the analysis are used on data collected through the use of systematically designed testing instruments. The instrument is designed to ensure that every relevant aspect of the study can be measured accurately and consistently. In the process of designing the instrument, several stages are carried out, starting from identifying the variables to be measured and developing various appropriate question items, to testing to ensure validity and reliability. Thus, the instrument is used as a guarantee regarding the level of data trust in providing a clear picture of the research phenomenon (Fahrenberg, 2022; Ventura, 2019). In this discussion, a more in-depth description is presented regarding the use of the methodology including the development of the selected instrument and the results of the analysis obtained. This aims to provide a comprehensive understanding of the process carried out and the results obtained in this study. A more in-depth discussion is presented in the following description.

Measurement Model Test Result

The purpose of testing the measurement model is to transmit the validity and reliability of a construct in the study. This model is carried out to identify the relationship between the latent construct and its indicators. In this study, the measurement model is evaluated through factor loading analysis to review how well the items correlate with the expected. Then, the results of the analysis in this study include other analyzes such as Cronbach's Alpha, Composite Reliability and

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Average Extracted (AVE). Based on statements from Tang et al., (2024); and Thakkar (2020), Cronbach's Alpha functions as an assessment of the internal consistency of the instrument. Then, Composite reliability functions to provide an overview of the reliability of the measurement, while AVE describes and shows the proportion of variance that can be explained by each item in a construct. The results of these three measurements provide a comprehensive overview, as outlined in Table 2.

Table 2. Convergent Validity Test Result

Variables Laten	Composite Reliability	Cronbach's Alpha	AVE
X1 Farmer Characteristics	0.822	0.729	0.683
X2 Nature of Innovation	0.953	0.937	0.803
Y1 Motivation	0.868	0.813	0.771
Y2 QR Code Technology Accepteance	0.942	0.926	0.763

Source: Primary Data 2025

The results of the convergent validity test show that each variable as a whole has a Composite Reliability and Cronbach's Alpha value above 0.07. This refers to the statement of Tang et al., (2024), although a value of 0.6 is acceptable, as a general rule, the alpha value or composite reliability value should be greater than 0.7 to ensure stronger validity. Furthermore, the AVE value also shows that the proportion of variance explained by the items in the construct is within adequate limits, so that it can confirm the convergent validity used. In discriminant validity, it ensures that the manifest variables of various constructs do not have a high correlation, because a high correlation will indicate that the constructs are not really different (Thakkar, 2020).

Assessment of Goodness of Fit

In an effort to validate the whole, the goodness of fit (GOF) index is used for the suitability between the measurement model and the structural model (Amanathi et al., 2023). The GoF value criteria are 0.10, 0.25, and 0.36, which respectively indicate that the GoF is small, medium, or large and a high GoF value indicates a good fit of the model, meaning that the model can explain more effectively the variance in the data (Thakkar, 2020). The GoF calculation in this study involves complexity in statistical analysis, including model evaluation and parameter estimation. The GoF analysis in this study also helps researchers identify potential improvements in the model, so that researchers can try to improve the model's fit to the data through adjustments. The GoF calculation can be seen in Table 3.

Table 3. GoF value

Code	R^2	AVE
X1	-	0.683
X2	-	0.803
Y1	0.605	0.671
Y2	0.747	0.763
Rata-rata	0.676	0.730
GoF	**0.703**	

Source: Primary Data (2025)

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Table 3 shows that Gof obtained a value of 0.703, after the calculation of the community average was 0.703 which was then multiplied by R2 (0.676) and rooted. Therefore, this model can be said to be in the large category. According to Dong et al., (2024), the higher the GoF value is in line with the increasing accuracy of the model in representing the sample in this study. The results of the tests that have been carried out indicate that the data variance can be explained by the model built, and provides good confidence and confidence regarding the correlation between variables.

Structural Model Test Results (PLS)

Each relationship in the PLS model is tested through simulation on the sample using the bootstrapping technique. This test aims to overcome the problem of normality in the research data, thus allowing for a more robust analysis. With bootstrapping testing, sampling is done randomly with a return from the existing data and this helps researchers in estimating parameter distributions and obtaining confidence intervals The results of the PLS-SEM analysis bootstrapping test can be seen in Figure 2.

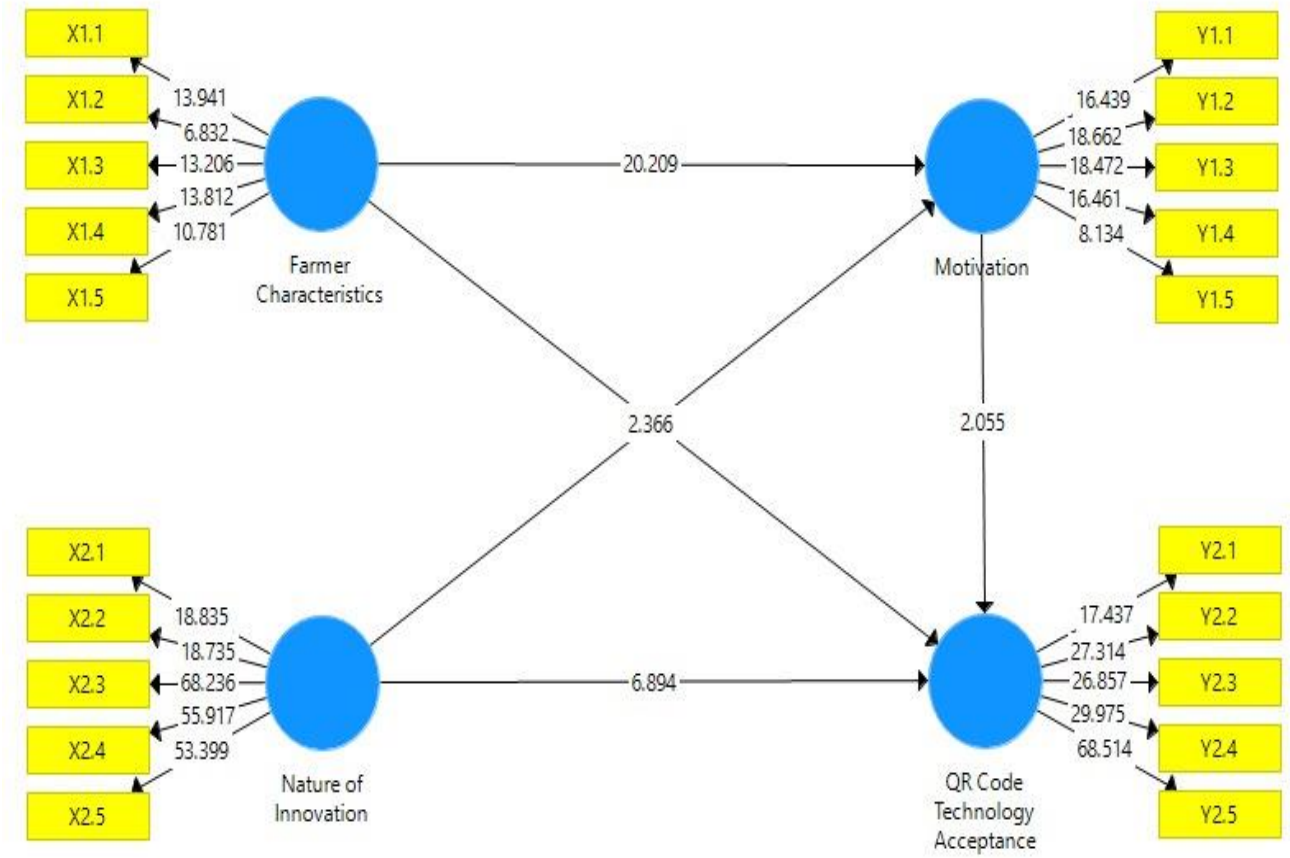

Figure 2. Bootstrapping Test Result.
Source: Data Analysis Results

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Hypothesis Test

Five hypotheses were tested in this study. Hypothesis testing uses two criteria, namely the t-statistic value and the path coefficient. A variable is said to have a positive influence on the variables that influence it if the path coefficient is positive, and vice versa. If the t-count value (t-statistic) is greater than the t-table for a prediction error of 5 percent, which is 2.62, it can be said that the hypothesis in this study is accepted.

Table 4. Results the Hypothesis Test

Hypothesis	Hypothesis Description	Path	t-value	p- value
1a	Farmer Characteristics → Motivasi	0.723	3.587	0.000
1b	Farmer Characteristics → QR Code Technology Acceptance	0.685	2.657	0.040
2a	Nature of Innovation → Motivation	-0.053	0.475	0.163
2b	Nature of Innovation → QR Code Technology Acceptance	0.251	3.066	0.018
3	Farmer Characteristics → Motivation → QR Code Technology Acceptance	0.211	3.162	0.037
4	Nature of Innovation → Motivation → QR Code Technology Acceptance	-0.126	1.003	0.185
5	Motivation → QR Code Technology Acceptance	0.361	5.061	0.000

Source: Primary Data, 2025

Effect of Farmer Characteristics on Motivation and QR Code Technology Acceptance

The results of the analysis show that farmer characteristics have a significant effect on motivation (p = 0.163), and also have a significant effect on QR Code technology acceptance (p = 0.018). This is because the motivation to use QR Code technology for farmers assisted by PT X in Bulungan Regency was created due to the positive characteristics of farmers formed through non-formal education activities such as counseling and training that they received, and these characteristics also influenced farmers in accepting QR Code technology in the process of recording cocoa production forecasts. This finding is in line with research Sarie et al., (2023), that farmer education is one of the characteristic indicators that can foster motivation as well as expand farmers' willingness to accept and adopt a technology.

Based on field analysis, farmer characteristics such as attitudes towards risk affect motivation in using QR Code technology in the cocoa production forecasting process. This is because the characteristics of farmers assisted by PT X are built to be more aware of the risks that occur if they do not forecast production properly, one of which is the difficulty of planning input needs such as fertilizers and seeds which have an impact on cost efficiency, so this makes farmers motivated to apply technology in their farming efforts. These results are supported by the statement Patil & Veettil (2024); and Ullah et al., (2022), that farmers' awareness of risk is included in the positive characteristics of farmers which are able to encourage motivation in implementing agricultural technology.

The results of the field analysis also show that non-formal education taken by farmers can increase understanding of the benefits of QR Code technology in helping the cocoa production forecasting process, so that in turn farmers are more open to accepting and adopting the technology

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to be applied in their farming efforts. This finding is supported by research Larasati et al., (2024), which emphasizes that farmers' acceptance of a technology is closely related to farmer characteristics, one of which is supported by education.

Effect The Nature of Innovation on Motivation and QR Code Technology Acceptance

Based on the analysis that has been done, the nature of innovation does not have a significant effect on motivation (p = 0.163), but has a significant effect on QR Code technology acceptance (p = 0.018). The results of this analysis are in line with research Alisambatra et al., (2023), which states that the nature of technological innovation in the agricultural sector does not have a significant effect on motivation among farmers. These results were obtained because farmers assisted by PT X often felt worried about the innovative nature of technology in providing certainty in meeting their needs, both physiological needs and self-actualization, so that farmers' motivation tended to be low.

Then the results of the analysis are supported by research by Pedersen et al., (2024), that the nature of technological innovation influences the acceptance of technology. This is because, cocoa production forecasting based on QR Code technology has advantages in terms of adjusting needs, practicality of use, ease of testing and ease of observation, so that the nature of the technological innovation used can influence farmers' acceptance of the technology as an effort to facilitate farming activities.

Related to the results of the analysis, it was also stated by Schukat & Heise (2021), that farmer acceptance of technology depends on the nature of the innovation offered to farmers related to relative advantages, adjustments to farmer needs, low complexity, ease of testing and ease of observation. Field conditions indicate that the use of QR codes in cocoa production forecasting in Bulungan Regency can replace conventional recording by scanning QR codes on each tree using a smartphone. Data collection is carried out by recording four levels of physiological maturity: 25 percent, 50 percent, 75 percent, and 90 percent, as well as recording pest and disease attacks. Therefore, the application of this technology can simplify the process of recording production forecasts while increasing the accuracy of production forecast results.

Effect of Farmer Characteristics on QR Code Technology Acceptance through Motivation

The results of the analysis show that farmer characteristics significantly influence the QR Code technology acceptance through motivation (p = 0.037), which indicates a mediation effect. Supporting this finding, research by Huang & Fu (2023), states that there is an influence of Farmer Characteristics on the QR Code technology acceptance through Motivation. Field analysis shows that cocoa farmers assisted by PT X routinely undergo non-formal education, both from agricultural extension workers and from PT X itself through extension, training or demonstration of the use of QR Codes in the cocoa production forecasting process directly in the field, so that good characteristics are created from farmers and can foster motivation which ultimately influences the acceptance of technology.

Regarding the results of this analysis Huang & Fu (2023), provided a further statement that farmers who have positive characteristics such as good education and qualified experience tend to have high motivation in trying new technologies. In turn, this motivation increases farmers' trust in the benefits of technology, so that farmers are more willing to learn and accept the technology

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offered. This provides an explanation related to the results of the study, which basically the QR Code technology acceptance in helping the forecasting process is influenced by the motivation of farmers, and this motivation is built from the positive characteristics of farmers.

Then Sarie et al., (2023), added that motivation in making farming activities easier and more efficient will encourage farmers to seek various innovative solutions including the use of technology, and this motivation is created through the characteristics of the farmers themselves. So that the correlation between farmer characteristics and technology acceptance can be seen from how farmers are motivated to learn and adapt and are more open to new technologies. This illustrates that QR Code technology acceptance among farmers in the cocoa production forecasting process is determined by the characteristics of farmers which are the driving force behind the creation of farmer motivation in accepting and using this technology.

Effect The Nature of Innovation on QR Code Technology Acceptance through Motivation

The Influence of innovation nature on QR Code technology acceptance through Motivation obtained a p-value of 0.185. This value is greater than the 5 percent significance level. So, the conclusion is that there is no significant influence of innovation nature on QR Code technology acceptance through motivation.The results of this analysis are in line with Alisambatra et al., (2023), who stated that the nature of innovation of a technology does not have a significant influence on acceptance of technology through motivation. Based on conditions in the field, the cause of the nature of technological innovation being unable to increase QR Code technology acceptance in the cocoa production forecasting process is because there are economic factors that hinder motivation.

Research by Pedersen et al., (2024), also stated that the nature of innovation does not have a significant effect on technology acceptance through motivation. This result often occurs because of the readiness of farmers to use technology. Although QR Code technology offers various effective and efficient advantages, if farmers assisted by PT X find it easier to use previous methods and techniques in forecasting cocoa production, then the motivation of farmers to apply new technology tends to be lower and in turn affects the acceptance of QR Code technology.

The results of this analysis are also in line with Park et al., (2022), who stated that the nature of innovation does not have a significant effect on technology acceptance through motivation. The results of the analysis in the field are concerns about QR Code technology innovation in supporting cocoa production forecasting which is often considered different from previous innovations, this affects the motivation of use and ultimately technology acceptance will also be low.

Effect of Motivation on QR Code Technology Acceptance

The research results show that motivation has a significant influence on the QR Code technology acceptance, as indicated by a p value of 0.000 ($p < 0.05$). In line with the research of Sarie et al., (2023), that motivation is a very influential thing on QR Code technology acceptance. This is because economic incentives and perceived benefits of QR Code technology in helping farmers record cocoa production forecasts have a substantial positive correlation with technology adoption, so farmers are more likely to embrace the technology if they recognize the potential for profitability and benefits.

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The results of this analysis are also supported by the research of McCormack et al., (2021), which states that motivation has a significant effect on technology acceptance. Sarie et al, (2023), also added that increasing farmer motivation related to technology use is in line with farmer acceptance of the technology. This is the same as what happened in the field, that the QR Code technology acceptance is in line with the high motivation of cocoa farmers assisted by PT X in Bulungan Regency to apply technology in their farming activities as an effort to facilitate production forecasting.

Motivation to use a technology can be created if the technology is able to provide convenience for farmers in achieving various needs, starting from basic needs, the need for a sense of security both in their business and in their family's economy, social needs, the need for appreciation, and is able to fulfill the needs of farmers in actualizing themselves and their business (Schukat & Heise, 2021). This aligns with field observations, which indicate that farmer acceptance of QR Code technology is supported by tangible benefits. Scanning QR Codes using a smartphone allows for quick and convenient recording of cocoa production forecasts and generates more structured data on fruit quantity, ripeness levels, and pest and disease outbreaks. Therefore, these perceived benefits are the primary reason cocoa farmers accept and utilize QR Code technology to aid their production forecasting activities.

CONCLUSION AND SUGGESTION

Based on the results and discussion, it can be concluded that QR Code technology acceptance among farmers assisted by PT X is positively and significantly influenced by motivation, farmer characteristics, and the nature of innovation. Furthermore, QR Code technology acceptance is positively and significantly influenced by farmer characteristics through motivation. However, QR Code technology acceptance is not positively and significantly influenced by the nature of the innovation through motivation, nor is motivation directly and significantly influenced by the nature of innovation. To increase the QR Code technology acceptance in cocoa production forecasting, programme evaluation is needed to get feedback from farmers, so that further planning can be adjusted to the constraints and basic needs of farmers. In addition, effective communication media is needed, such as making video tutorials that can help farmers understand the ease and benefits visually and practically. Successful implementation of QR Code technology will improve forecasting accuracy and increase competitiveness in the market. Furthermore, the motivation and characteristics of farmers need to be improved to further encourage QR Code technology acceptance among farmers in the cocoa production forecasting process, which in turn will produce accurate production forecast data as a basis for production decision-making among farmers while providing certainty of supply of cocoa bean raw materials to processors which will then be processed into chocolate.

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