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Digital communication competence and technology adoption: Drivers of performance among small-scale millennial farmers in Indonesia

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Abstract: Digital development in rural areas has become a driving force in increasing agricultural and rural economic productivity. However, the lack of digital communication competence among farmers remains a problem, causing market information asymmetry and an inability to effectively utilize information and communication technology (ICT) in the agricultural sector to increase business profits. Therefore, it is important to examine the use of ICT in the agricultural sector in 19- to 39-year-old age groups (or millennial farmers), as this generation is considered closest to digital technology. This study used a survey method with 345 millennial farmers in Bogor, Indonesia, and data were analyzed using partial least squares-structural equation modeling (PLS-SEM). The results of this study indicate that digital communication competence, as reflected by motivation, knowledge, and digital skills, plays a crucial role in enhancing the performance of millennial farmers both directly and indirectly through ICT utilization. Farmers possessing superior digital communication competencies exhibit a greater inclination to employ technology for communication, information acquisition, idea dissemination, and marketing in their agricultural pursuits, resulting in more informed decision making and potentially improved productivity and profitability. The results contribute to the understanding of the role of digital communication competence and ICT utilization in enhancing farmers' performance.
Keywords: *Digital communication competence, Digital divide, Millennial farmers, Rural development, Performance.*

1. Introduction

Advancements in digital information and communication technology (ICT) have provided various solutions to enhance agricultural efficiency, productivity, and sustainability. There are at least five groups of benefits from using ICT in farming [1], [2]: (1) current and accurate information about farming; (2) increased efficiency, productivity, and sustainability; (3) better marketing exposure; (4) optimization of inputs with reduced risk; and (5) improved networks and communication. However, although Internet penetration in Indonesia has reached 77% [3] and smartphone use among the younger generation has reached 96% [4], many farmers have not fully optimized these five potential digital devices because of limited digital skills. This phenomenon indicates a discrepancy between the rapid advancement of information technology and insufficient development of high-level competencies and self-directed learning capacities [5].

While ICT offers numerous benefits for enhancing agricultural practices, the digital divide, particularly between urban and rural areas, hampers the full realization of these advantages. This disparity underscores the importance of developing digital communication competencies among millennial rural farmers. The gap between urban and rural development also affects the digital divide between the two regions. This gap includes differences in farmers' use, development, and innovation capabilities of digital technology (digital literacy), which prevents them from effectively driving the agricultural transformation process. The strategic role of millennial farmers in realizing sustainability and food security in Indonesia through digital agricultural transformation is becoming increasingly important [6]. Millennial farmers have great potential to become agents of change because of their

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dynamic, optimistic, and adaptive characteristics towards technology [7]. They also have a positive view of income, social status, and work comfort in the agricultural sector, making them the main targets of digital transformation efforts in this sector [8].

In 2019, the Indonesian government through the Ministry of Agriculture, launched the Youth Entrepreneurship and Employment Support Service (YESS) program in collaboration with the International Fund for Agricultural Development (IFAD). This initiative aims to foster young rural entrepreneurs and to produce skilled workers in the agricultural sector. At the provincial level, West Java launched the Millennial Farmer Program in 2021 to support the regeneration and development of young farmers' capacity. Modernizing agricultural businesses depends on enhancing the capacity, competence, and ability of millennial farmers to use digital information and communication technology (ICT) in agricultural activities.

Previous studies have shown that ICT use by farmers has a positively impacts on agricultural productivity by increasing both income [9], [10], [11], [12], [13], [14], [15] and production [10], [12], [16], [17], [18], [19], [20], [21], [22], [23]. In addition, the use of ICT has also been shown to increase technical efficiency [24], [25], [26]. On the other hand, a major barrier that often prevents people from accessing ICT or getting full benefits when they go online is their lack of skill. Meaningful Internet use requires people to be digitally literate.

Studies on ICT among farmers have focused on aspects of technology, infrastructure, policies and agents of change or extension workers. In fact, farmers as the main actors in agricultural businesses are required to have adequate digital skills in order to be able to use and utilize ICT in agricultural businesses. Research [27], [28], [29] has shown that lack of skills causes suboptimal utilization of ICT to increase its capacity to support agricultural business activities.

The relationship between digital communication competence and farmer performance is an important area of the current research. As the global discourse on Industry 4.0 and the disruption caused by artificial intelligence has become increasingly unstoppable, understanding how innovation is spread and adopted plays a crucial role in shaping farmers' capacity to face modern sustainable agriculture in the digital era. This study investigates the intersection of these aspects, highlighting how the principles of digital communication competence reflected by motivation, knowledge, and digital skills influence and drive the achievement of individual farmer performance outcomes, which ultimately contributes to broader dialogue on sustainable agricultural development.

Although previous studies have shown the positive influence of ICT on agricultural productivity, few have directly linked millennial farmers' digital communication competencies with ICT utilization and individual performance in the agricultural sector. A deep understanding of these competencies is essential for designing strategies that can support agricultural sustainability through millennial farmers' capacities to cope with change. With these considerations, this study aims to bridge this gap with the expectation of making an important contribution to the development of policies that encourage millennial farmers to optimize ICT to achieve better agricultural performance.

2. Theoretical Framework

This study integrates several important theories that form the basis for analyzing the influence of digital communication competence and ICT utilization on farmer performance Figure 1. These three integrated theories are digital communication competence (DCC), resource and appropriation theory (RAT), and individual work performance (IWP).

Competence generally refers to eligibility or the ability to perform [30]. In the realm of social and interpersonal interactions, the term competence refers to several different phenomena, including (1) the knowledge possessed by a social actor, (2) the abilities possessed by a social actor, (3) the behavior displayed by a social actor, (4) the impression or attribution made by a social actor, and (5) the quality of the overall interaction process, including various interrelated components (e.g., knowledge, motivation, skills, context, and outcomes). Thus, the term competence is used to identify a spectrum of concepts, ranging from a single perceptual variable to a complex constellation of elements involved in social interaction.

Spitzberg and Cupach (1989) define competence as consisting of skills, knowledge, and motivation: "an individual's interpersonal skills, together with the knowledge and motivation that accompany them, enable certain outcomes that are judged to be interpersonally competent in a given interactional context." Skills as the first element refer to repeated and intentional behavior rather than unintentional or accidental behavior. In other words, skills are usually learned through interactions with others and can be performed to achieve certain communication goals.

Skills depend on the second element, knowledge, which consists of two types: content and procedural knowledge, both of which are necessary for successful skill performance. Content knowledge involves knowing what, whereas procedural knowledge involves knowing how. Content knowledge includes information on language rules, social contexts, relational partners, and conversation topics. Procedural knowledge includes knowledge of how to select the right skill within a given interpersonal context. Knowing how to start a conversation, how to exit a conversation politely, and strategies for maintaining conversation are all parts of a procedural skill set.

The third element is motivation, which is the desire to do something or to behave in a certain manner. Motivation can be positive or negative. When motivation functions positively, people choose to communicate and move towards achieving their goals. When motivation is absent, people avoid communication due to fear, of communication, embarrassment, or other reasons. Spitzberg and Cupach emphasized that having skills, knowledge, and motivation does not guarantee competent communication performance because competence is determined by those who observe performance. This is in line with what was expressed by [31] the fact that competence is an assessment of an individual's ability to perform a particular activity.

Communication involving computer technology tends to be considered as computer-based communication [32]. This type of communication is often referred to as computer-mediated communication (CMC) and refers to any form of human communication achieved through or with the help of computer technology[33]. [34] explained that computer-mediated communication is the process of human communication through computers, which involves people, in a certain context, involved in the process of forming media for various purposes in certain contexts.

According to Spitzberg (2006) CMC, any form of human symbolic interaction is carried out or facilitated through digital technology. This is emphasized [36] in a broad sense: CMC can be any form of communication mediated by digital technology, and digital communication itself is the ability to communicate and collaborate with others using technology [37]. Based on these reviews, digital communication competence can be interpreted as the ability to communicate and collaborate with others by using digital technology.

The resource and appropriation theory was developed by [38] to understand the digital view as a broader issue than access to technology. This theory of resources and appropriation relates to the diffusion, acceptance and adoption of new technologies and consists of four core concepts: 1) a number of inequalities in personal categories and positions in society, 2) the distribution of resources relevant to this type of inequality, 3) different types of access to ICTs, and 4) a number of spheres of participation in society.

Concepts 1 and 2 are considered causes, and Concept 3 is the phenomenon to be explained together with Concept 4, which is a potential consequence of the overall process. As part of a process, concept 4 feeds back on concepts 1 and 2 because participation in some spheres of society will change the relationship between inequality of categories and the distribution of resources in society. Finally, the fifth factor that determines the type of inequality to be explained must be added as a side factor, namely, the specific characteristics of information and communication technologies. The core arguments of the dynamic model of inter-conceptual relationships can be summarized as follows: 1) categorical inequality in society results in an unequal distribution of resources; 2) unequal distribution of resources leads to unequal access to digital technologies; 3) unequal access to digital technologies also depends on the characteristics of the technology; 4) unequal access to digital technologies leads to participation gaps in society; and 5) unequal participation in society reinforces categorical inequalities and unequal distribution of resources. van Dijk and van Deursen (2014) argued that the digital divide had deepened. The gap in so-called physical access may be narrowing in some respects; however, other digital gaps are growing. The overall digital divide is deepening as the gap between digital skills and everyday digital media use is increasing. It can even be argued that as higher levels of universal access to digital media are achieved, differences in skills and usage also increase. van Dijk and van Deursen (2014) argued that digital skills are key to the entire process of using such technologies. These skills are essential for living, working, learning, and entertainment in an information-based society.

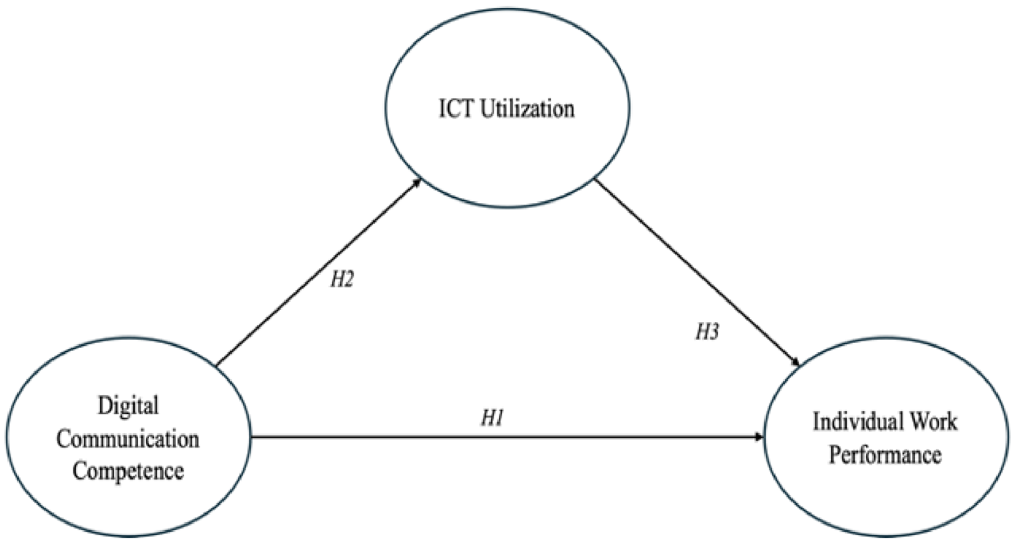

Figure 1.
Theoretical framework.

In the context of communication, this perspective emphasizes the need for communication competence, [40] which moves communicators into a realm where skills are more than just an inner process to realize desired development. Servaes (2020) explained that communication for development and social change is the maintenance of knowledge, which aims to create a consensus on actions that considers the interests, needs, and capacities of all parties. Communication media and ICT are important tools for achieving this social change, however, but their use is not an end goal.

According to [42], three approaches that can be used to evaluate performance: (1) effectiveness and productivity, (2) trait evaluation, and (3) behavioral evaluation. Allworth and Hesketh (1999); and Koopmans et al. (2014) stated that performance measurement can be performed through several dimensions: (1) task performance (quality of work, planning and organizing work, results-oriented, and working efficiently), (2) contextual performance (level of initiative, receiving and learning from feedback, working with others, and being creative), and (3) adaptive performance (level of resilience, providing creative solutions to new and difficult problems, keeping job knowledge up to date, constantly updating job skills, dealing with uncertain and unpredictable work situations, and adjusting work goals when necessary).

3. Method

3.1. Research Design and Sample

This study employed a quantitative approach to collect data on millennial farmers' engagement in digital agricultural practices. A survey method was chosen to gather responses and data were collected through an online questionnaire using Google Forms. The sample size was calculated using Slovin's formula by applying a 5% margin of error, yielding a minimum of 325 respondents. This study was conducted in Bogor, Indonesia, targeting millennial farmers aged 19–39 years old. A purposive sampling technique was applied in this study, focusing specifically on millennial farmers in Bogor, Indonesia as the unit of analysis. This sampling method was chosen to ensure that the collected data reflected the experiences of millennial farmers who engaged in digital agricultural practices. After screening the responses, 345 samples were found to be suitable for analysis, exceeding the minimum sample size requirement and considered adequate for the study's objectives.

3.2. Research Instruments

To collect data, this study used a survey research design with a structured questionnaire administered through online distribution. The questionnaire consisted of two parts: the first part focused on farmers' profiles, and the second part consisted of statements related to digital communication competencies (DCC), ICT utilization, and statements related to millennial farmer performance (FP), rated on a 5-point Likert scale. Informed consent was obtained from all participating millennial farmers prior to the study.

Table 1.
Indicators and operational definition of variables.

Variable	Construct	Indicators	Reference
Digital communication competence	Digital motivation	MOV1 - MOV7	[32], [35], [45], [46]
	Digital knowledge	KNW1 - KNW5	
	Digital skills	SKL1 - SKL6	
ICT utilization	Information	INF1 – INF17	[46], [47], [48], [49], [50], [51]
	Communication	KOM1 - KOM3	
	Knowledge sharing	SHK1 – SHK13	
	Marketing	MKT1 – MKT13	
Millennial farmer performance	Productivity	PDV1 - PDV9	[43], [44]
	Contextual	KNT1 – KNT7	
	Adaptive	ADF1 - ADF10	

To develop the questionnaire, the latent variables were operationalized based on a review of the relevant literature (Table 1). Digital communication competence which focuses on motivation, knowledge, and digital skills [32], [35]; resource and appropriation theory, which focuses on attitude, material access, skills, and usage [51]; and individual work performance [43], [44], which focuses on productivity, contextual, and adaptive, forms the basis of the conceptual framework (Table 1).

3.3. Data Analysis

This study employed partial least squares-structural equation modeling (PLS-SEM), a statistical technique that allows us to understand the complex relationships between our variables, such as how digital communication competencies influence the use of ICT and, in turn, affect farmer performance. This approach was chosen because of some of the most attractive characteristics of PLS-SEM: (1) it does not require normally distributed data by default; (2) it obtains solutions with smaller sample sizes; and (3) it easily incorporates formatively (composite) measured constructs [52]. SmartPLS 3.2.9 version was used to assess the data for the analysis.

The relationship of the latent variables Figure 1 with each indicator was a second-order construct and unidimensional construct, following a general mediation model [53]. Each indicator in the first-level construct is unidimensional and does not overlap with other constructs in the measurement. This model is implemented with a reflective-reflective approach in PLS-SEM, where the first construct is reflected by its indicators and the latent variables are reflected by the first construct. This approach was used to capture the complexity of each latent variable, with several interrelated constructs. Each construct reflects the different aspects of each variable.

4. Results

4.1. Respondent Characteristics

Table 2 illustrates the distribution of millennial farmer characteristics, indicating variations in the profiles of the farmers involved in digital farming and their performance. Most farmers were under 36 years of age (84.92%), indicating that the involvement of millennial farmers in Bogor, Indonesia is dominated by relatively young age groups with relatively new farming experience. With variations in age and participation being quite distinct, this study offers comprehensive insights into the greater contribution of the younger generation to the application of digital information and communication technology and the performance of millennial farmers.

Table 2.
Demographics of millennial farmers.

Descriptor	Category	Freq	Percentage (%)
Gender	Male	166	48.12
	Female	179	51.88
Age	17–25 y.o	116	33.62
	26–35 y.o	177	51.30
	36–45 y.o	52	15.07
Education	Elementary school	36	10.43
	Junior high school	51	14.78
	Senior high school	202	58.55
	University	56	16.23
Land ownership	< 5000	299	86.67
	5000-10000	26	7.54
	> 10000	20	5.80
ICT ownership	Smartphone	338	97.97
	Tab/tablet	1	0.29
	Laptop	4	1.16
	Computer/PC	2	0.58
Internet access	< 1 hour/day	86	24.93
	1–4 hour/day	114	33.04
	> 4 hour/day	145	42.03

Most farmers had education up to the senior high school level (58.55%), reflecting a higher level of education and the potential for innovation and understanding of the application of digital farming technology. However, a significant percentage of the participants were junior high school (14.78%) and elementary school graduates (10.43%), indicating the inclusion of technology at various levels of education. Farmers with graduate degrees (16.23%) also contributed to the implementation of digital agriculture, creating opportunities for sustainable agricultural innovation in diverse educational backgrounds.

The majority of millennial farmers (97.97%) have smartphones as a means of communication, with internet access for more than four hours a day (42.03%), which reflects the great potential for the adoption of new technologies in agriculture, including digital farming, among young farmers. These data illustrate how access to and the use of digital ICT can influence opportunities to adopt modern and sustainable agricultural technology, as millennial farmers tend to be more open to adopting and using digital technology in agriculture.

Most millennial farmers (86.67%) have less than 5000 m^2 of land, which shows the high participation of small-scale farmers in the use of digital ICT. Meanwhile, 7.54% had land covering an area of 5000 m^2 to 10000 m^2, and 5.80% had land covering more than 10000 m^2. Farmers with limited land often adopt digital communication technologies to enhance productivity and profitability of farming practices.

4.2. Assessment of Measurement Model

Considering that the model is applied using a reflective-reflective approach, reflective constructs are assessed through the following steps [52]: (i) estimating loading factors, (ii) indicator reliability, (iii) internal consistency reliability, (iv) average variance extracted (AVE), and (v) checking discriminant validity using the HTMT.

The first step was to assess the loading factors. If the loading factor is above 0.70 for all research indicators, the constructs in the study demonstrate good credibility for all research indicators. Based on Table 3, several first-order indicator items had loading factors below 0.70. Therefore, these indicator items were removed from the model. The remaining indicators had loading factor values ranging from 0.711 to 0.936, indicating the good reliability of the indicators for a given construct [53].

Table 3.
Measurement model assessment: reliability and validity of latent variables.

Variable	Item	Loading factor	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
Motivation	MOV2	0.725	0.823	0.876	0.586
	MOV3	0.788			
	MOV4	0.761			
	MOV6	0.777			
	MOV7	0.774			
Knowledge	KNW1	0.883	0.899	0.926	0.717
	KNW2	0.857			
	KNW3	0.868			
	KNW4	0.899			
	KNW5	0.711			
Skills	SKL1	0.742	0.827	0.878	0.591
	SKL2	0.824			
	SKL3	0.792			
	SKL5	0.759			
	SKL6	0.791			
Communication	KOM1	0.874	0.877	0.924	0.803
	KOM2	0.910			
	KOM3	0.903			
Information	INF2	0.825	0.927	0.940	0.663
	INF3	0.841			
	INF4	0.836			
	INF5	0.848			
	INF6	0.856			
	INF8	0.764			
	INF9	0.762			
	INF10	0.774			
Knowledge sharing	SHK8	0.838	0.960	0.968	0.835
	SHK9	0.932			
	SHK10	0.936			
	SHK11	0.915			
	SHK12	0.936			
	SHK13	0.922			
Marketing	MKT3	0.809	0.941	0.951	0.683
	MKT4	0.766			
	MKT6	0.784			
	MKT7	0.740			

Variable	Item	Loading factor	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
	MKT8	0.892			
	MKT9	0.873			
	MKT10	0.919			
	MKT11	0.827			
	MKT12	0.812			
Productivity	PDV1	0.814	0.893	0.922	0.702
	PDV2	0.837			
	PDV3	0.848			
	PDV4	0.846			
	PDV8	0.764			
Contextual	KNT1	0.853	0.910	0.937	0.787
	KNT3	0.866			
	KNT4	0.882			
	KNT5	0.863			
Adaptive	ADF2	0.823	0.911	0.934	0.738
	ADF3	0.850			
	ADF5	0.848			
	ADF7	0.809			
	ADF10	0.865			

Internal consistency reliability was assessed using Cronbach's Alpha and Composite Reliability. Cronbach's alpha (α) and composite reliability (CR) were used to assess construct reliability and must exceed 0.70 to confirm the internal reliability of the study. As shown in Table 3, Cronbach's alpha (α) values ranged from 0.823 to 0.960, and CR values ranged from 0.834 to 0.968. These findings indicate strong internal consistency reliability.

The average variance extracted (AVE) was used to assess convergent validity. An AVE of 0.50 or greater indicates convergent validity, which means that the construct captures at least 50% of the variance of its items. As shown in Table 3, all constructs had an AVE above 0.50, ranging from 0.586 to 0.835, which was greater than the recommended threshold. Therefore, the conditions of the convergent validity of the measurements were satisfied in this study.

Finally, to empirically determine the extent to which each construct in the model differs empirically, discriminant validity measurements must be assessed. Discriminant validity was assessed using the Heterotrait-Monotrait Ratio (HTMT) to calculate the average ratio of the correlation between indicators of different constructs to that between indicators within the same construct. The maximum acceptable threshold is 0.9. Table 4 presents the HTMT matrix, with values lower than 0.9, indicating satisfactory discriminant validity. Based on measurement model analysis, it was concluded that the constructed model achieved an acceptable level of validity and reliability.

Table 4.
Discriminant validity assessment using the Heterotrait-Monotrait ratio.

	ADF	COM	CTX	INF	KNT	SHK	KNW	MAR	MOV	SKL
ADF										
COM	0.597									
CTX	0.884	0.584								
INF	0.360	0.542	0.315							
SHK	0.365	0.560	0.373	0.718						
KNW	0.416	0.487	0.404	0.376	0.294					
MAR	0.271	0.466	0.340	0.521	0.613	0.243				
MOV	0.474	0.513	0.428	0.357	0.308	0.852	0.199			

PDV	0.859	0.644	0.862	0.409	0.410	0.422	0.395	0.502	
SKL	0.535	0.535	0.510	0.410	0.323	0.867	0.290	0.814	0.530

4.3. Assessment *of Structural Model*

After establishing the reliability and validity of the construct, the next step was to examine its components of the structural model. The PLS-SEM algorithm was used to assess the structural model based on its ability to predict the outcomes. Therefore, the following steps were taken to assess the structural model [52]: (1) check the model for collinearity; (2) evaluate the size and significance of the path; (3) assess the coefficient of determination (R^2); and (4) check the predictive power outside the sample.

Table 5.
Hypothesis testing results for structural model.

Path	Coeff.	f^2	95% Conf. int.	T values	P values
DCC -> Farmers' performance	0.306	0.117	[0.132, 0.457]	3.676	0.000***
DCC -> ICT utilization	0.467	0.279	[0.382, 0.552]	10.724	0.000***
ICT utilization -> Farmers' performance	0.404	0.204	[0.302, 0.506]	7.615	0.000***

Note(s): DCC was digital communication competence, and *** $p < 0.001$.

Calculating the variance inflation factor (VIF) value helped to examine the structural model to solve the collinearity issue. As suggested [54], a VIF rating of 5 or above denotes major collinearity problems, a number less than 3 denotes no collinearity, and values between 5 and 3 are reasonable given theoretical explanations. The VIF values for model construction varied from 1.465 to 3.395, indicating that the created model was reasonable and did not suffer from notable collinearity issues.

A second-order structural model was constructed to identify the path relationships among variables in the research model Figure 2. According to Shmueli et al. (2019), path coefficients (β) in the structural model, which range from 0 to .10, .11 to .30, .30 to 50, and >.50, indicate weak, modest, moderate, and strong effect sizes, respectively.

The subsequent phase involved testing three hypotheses aimed at elucidating the relationships betweeen millennial farmers' digital communication competency, digital ICT utilization, and farmer performance. The results of the hypothesis tests provide comprehensive insights into the factors of digital communication competency and ICT utilization that influence the productive, contextual, and adaptive performance of millennial farmers.

The results show that digital communication competence (β = .306, CI 95% [.132, .457]) and ICT utilization (β = .404, CI 95% [.302, .506]) were significant and positively related to farmers' performance, with moderate effect sizes. Digital communication competence (β = .467, CI 95% [.382, .552]) was also significantly and positively related to ICT utilization with moderate effect sizes.

After hypothesis testing, the coefficient of determination (R^2) was calculated to determine the extent of the variance explained by each endogenous construct. In this study, two endogenous constructs were examined, and as stated by [55], the R^2 values of 0.75, 0.50, and 0.25 indicate a substantial, moderate, and weak explanatory power, respectively. The results of the analysis showed that the endogenous construct of farmer performance had R^2 = 0.373 and ICT utilization had R^2 = 0.218.

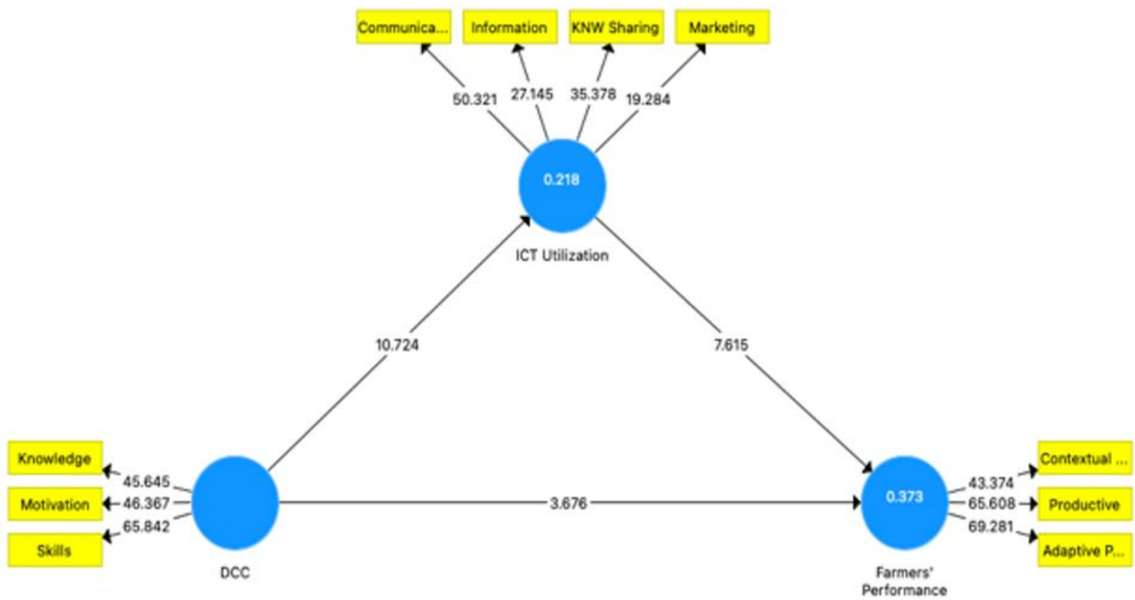

Figure 2.
Structural model output from PLS algorithm.

This study further assessed the effect size (f^2) of the exogenous construct, which contributed to the predictive power of the endogenous construct R^2. As a general guideline, effect sizes greater than 0.02, 0.15, and 0.35 indicate small, moderate, and large f^2 values, respectively [55]. The research findings show that the DCC construct → farmer performance has a small effect size (f^2 = 0.117), and the two constructs, namely DCC → ICT utilization (f^2 = 0.279) and ICT utilization → farmer performance (f^2 = 0.204), have a moderate effect size. These constructs contribute significantly to changes in the variance and predictive power of the endogenous construct, R^2.

Furthermore, the predictive accuracy of the PLS path model was assessed using Stone–Geisser Q^2, which measures predictive relevance. Based on the results of blindfolding with an omission distance of seven, all endogenous constructs showed Q^2 values greater than zero. According to the guidelines, Q^2 values above 0, 0.25, and 0.50 indicate small, medium, and large predictive relevance of the PLS path model, respectively [54]. In this study, all endogenous constructs showed moderate predictive relevance with Q^2 values of 0.127 and 0.308. This finding confirms that the developed model has a moderate predictive relevance.

The final step of the structural model analysis was to use PLSpredict to determine how well the model could predict things that were not present in the sample [54]. Through a 10-fold cross-validation, the study found that all Q^2_{predict} numbers were greater than zero. When comparing the indicators through PLS-MAE and LM-MAE [54], all had lower prediction errors in terms of the MAE. Therefore, the PLS model can predict results better than the naive LM benchmark. This demonstrates that the model exhibits a robust predictive capability and substantial external validity in comparable contexts.

5. Discussion

The findings of this investigation provide empirical evidence concerning the relationship between digital communication competence, ICT utilization, and millennial farmer performance in Bogor, Indonesia. The test results (Table 5) indicate that all relationships between the variables in the research model had a positive and significant effect, classifying the model as a complementary mediation [53]. These findings are relevant to the existing literature and contribute significantly to the understanding of the roles of DCC and the utilization of digital ICT in improving farmer performance in the digital era.

First, the relationship between DCC and farmer performance shows that DCC, which are reflected by three indicators, namely motivation, knowledge, and skills, play a significant role in improving the work performance of millennial farmers. The path coefficient indicates that increasing digital communication competence directly increases farmers' performance (FP). This result supports hypothesis one (H1) that DCC have a significant direct effect on farmer performance. DCC allows farmers to be more efficient in managing information and adapting to technology, thereby contributing to improved agricultural performance.

This finding is in line with the results of [56], [57], which revealed that farmers' ability to communicate digitally has a significant impact on their farming business performance. These results also emphasize that millennial farmers with strong digital communication skills tend to be better equipped to use information and effectively interact with extension workers, markets, customers, and other related parties, thereby increasing their productivity and adaptability when facing challenges in the agricultural sector.

Second, the relationship between DCC and digital ICT utilization demonstrates that increasing DCC exhibits a strong positive correlation with increasing ICT utilization. This relationship supports hypothesis (H2) that DCC play a significant role in enhancing farmers' capacity to utilize information and communication technology. Farmers with superior digital communication competencies have a greater propensity to employ technology for communication, information acquisition, idea dissemination, and marketing in their agricultural endeavors. Consequently, farmers with advanced DCC are better positioned to access real-time market information, weather forecasts, and agricultural best practices, leading to more informed decision making and potentially improved crop yields and profitability.

This finding aligns with research by [58], which revealed that mastery of digital communication skills is key to effectively using information technology in the agricultural sector. Farmers with knowledge and skills in digital communication are more likely to utilize digital technology tools such as online agribusiness platforms, agronomy applications, and market monitoring software, all of which can support their operational success [59], [60], [61]. Additionally, small farmers widely use Internet-connected mobile phones to access agricultural and market information sources [19], [23], [62], [63], [64], [65], thereby increasing their market access.

Third, the relationship between ICT utilization and farmer performance (H3) yielded significant results. Greater use of ICT by farmers to communicate with other, obtain information, ide disseminaton, and marketing their product significantly improves their performance. This is in line with many studies that show that ICT facilitates access to information [19], [66], [67], [68], [69], product sales [70], [71], [72], and resource management [73], [74], which ultimately increases farmers' productivity.

The findings suggest that digital communication competence exerts a significant influence on both the direct and mediated relationships with farmer performance. Information and communication technology utilization was observed to mediate the relationship between DCC and performance, lending support to the hypothesis that digital proficiency is essential for contemporary agricultural success. Subsequent analyses revealed that millennial farmers with higher digital communication competence demonstrated a greater propensity to effectively utilize ICT, resulting in enhanced productivity, adaptability, and contextual performance. The structural model exhibits robust reliability and validity with significant path coefficients, which corroborates the theoretical framework.

6. Conclusion

This study corroborates the significance of digital communication competence and ICT utilization in enhancing millennial farmers performance. Digital communication competence not only directly influences farmer performance but also exerts an indirect impact through productive ICT utilization. Subsequent research should investigate the long-term effects of digital skills training in agriculture with an emphasis on the sustainability and scalability of ICT solutions to broader regions and other agricultural sectors.

This study contributes to the literature on digital communication competence by providing empirical evidence on its substantial role in the agricultural sector. Specifically, it elucidates how DCC influences ICT utilization and subsequently impacts the performance of millennial farmers. These findings are crucial for policymakers aiming to promote digital agriculture, particularly in developing countries where the agricultural sector plays a critical role in economic development.

Furthermore, this study addresses the fragmented nature of previous research on ICT and agriculture by integrating the concept of DCC, thereby offering a more comprehensive understanding of how digital skills affect agricultural performance. The policy implications of this study suggest that governments and agricultural institutions should invest in digital communication training programs tailored to millennial farmers to ensure that they can fully utilize ICT in modern farming practices.

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HOS: Conceptualization of ideas, data collection, formal analysis, writing, review, and editing preparation; AMS: Conceptualization of ideas, advisers, supervisors of data collection and analysis and reviewed the manuscript; WBP and PM: Advisers, supervisors of data collection and reviewed the manuscript.

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