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Determinants of readiness for digital transformation in cooperatives: A case study in Thai Nguyen, Vietnam

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Abstract: This study explores the determinants influencing cooperatives' readiness for digital transformation in Thai Nguyen province, Vietnam, where empirical insights into this process remain limited. The purpose is to identify key internal and external factors that enhance or hinder readiness for digital change in the cooperative sector of a developing country. The research employed a mixed-methods design, combining online surveys and video interviews with 62 matured cooperatives between February and April 2025. Readiness was measured using a digital transformation index adapted from Vietnam's updated Decision 2158 framework, and a multiple linear regression model—supported by LASSO regression—was applied to identify significant predictors. Findings reveal that over 80% of the surveyed cooperatives achieved advanced levels of digital readiness. Key factors positively associated with readiness include effective internal training, digital process integration, leadership understanding of digital trends, financial investment in innovation, robust internet connectivity, and supportive legal environments. The study concludes that both organizational capabilities and enabling environments are critical to fostering digital transformation. Practically, the findings provide targeted insights for policymakers and cooperative leaders to design strategies that promote digital maturity, resilience, and competitiveness in the cooperative sector. These insights are especially valuable for scaling digital initiatives in resource-constrained settings.

Keywords: *Cooperative, LASSO regression, Multiple Linear Regression, Readiness for Digital Transformation, Web-Based Surveys.*

1. Introduction

Digital transformation is widely recognised as an irreversible process due to its demonstrated benefits in enhancing labour productivity, generating added value, and improving social welfare [1]. In developing countries such as Vietnam, cooperatives are emerging as an effective collective economic model. This model enables a shift away from the limitations of the traditional household economy—such as small-scale production and difficulty in resource mobilisation—while improving efficiency and competitiveness [2-4]. In the context of increasing digitalisation, digital transformation is seen as a cornerstone for improving the performance of organisations, including cooperatives.

Despite these advantages, the number of cooperatives in some Vietnamese provinces has declined in recent years. Thai Nguyen, for example, experienced the second-sharpest reduction in the number of cooperatives, with a decrease of 57.5%. It also ranked third among provinces with the highest number of cooperatives engaged in unprofitable business activities [5]. While digital transformation is considered critical for revitalising and enhancing the performance of cooperatives, most prior research has focused on its implementation in enterprises, with limited attention given to cooperatives [4, 6]. In Vietnam, a relevant study by Duong, et al. [7] examined the readiness for digital transformation among cooperatives in the Northeast. However, this research was conducted two years ago when the

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assessment framework was based on Decision 1970, issued by the Vietnamese Ministry of Information and Communication [8].

Recognising the limitations of the digital transformation assessment criteria defined in Decision 1970—limitations that were also identified in the study by Duong, et al. [7]—the Ministry issued Decision 2158 in 2023 to replace it MIC [9]. This update reflects a more comprehensive approach to evaluating digital readiness and underlines the need for updated, context-specific research.

The current study aims to address these research gaps by investigating the level of readiness for digital transformation among cooperatives operating in Thai Nguyen in 2025. It also examines the key determinants influencing this readiness for digital transformation. Through this effort, the study contributes to the limited but growing body of literature on digital transformation in the cooperative sector and offers insights for policymakers and cooperative managers aiming to enhance competitiveness and sustainability through digital means.

2. Research Design and Methodology

2.1. Research Design

The questionnaire was developed using Google Forms and distributed via multiple communication platforms, including email, Facebook, Zalo, Viber, and WhatsApp. The data collection period spanned from February 1st to April 1st, 2025. Due to resource constraints, the survey targeted 10% of the 771 active cooperatives operating in Thai Nguyen in early 2025 [5]. Stratified sampling was employed, with cooperatives categorised based on their sector and size, in accordance with criteria established by the Government [10]. Out of the cooperatives contacted, only 62 provided fully completed questionnaires or sufficiently reliable data for analysis. In addition to the survey, in-depth interviews were conducted with seven cooperative directors via video calls to further explore their perspectives on digital transformation.

The index of readiness for digital transformation employed in this study was adapted from two main sources: the ICT Development Index (IDI) developed by the ITU [11] and the framework issued by the MIC [9]. The IDI is widely recognised at the international level and provides a valuable benchmark for measuring ICT progress. However, it is not suitable for assessing the digital transformation readiness of a single organisation, such as a cooperative. In contrast, the MIC's framework, hereafter referred to as the MIC Index MIC [9], is designed to evaluate the readiness of individual organisations, including enterprises and cooperatives.

The MIC Index was revised in Decision 2158 to replace the earlier version specified in Decision 1970. This updated framework introduces several important enhancements. One notable improvement is the quantification of criteria using percentages ranging from 0 to 100, allowing for a clearer measurement of digital transformation readiness. Additionally, the number of assessment pillars has increased from six in Decision 1970 to seven in Decision 2158, enabling a more comprehensive and multidimensional evaluation.

Significant modifications have been made to the structure of the pillars. "Multi-channel sales" was added to the pillar "Digital experience for customers." The previous pillar titled "Digital strategy" was replaced by "Digital strategic orientation," and a new pillar, "Supply chain," was introduced. Moreover, the "Data and information property" pillar was redefined as "Information system and data management," while "Digital infrastructure and technology" was replaced with "Risk management and network information security." Similarly, "Digital operation" was substituted with "Management skills in finance, accounting, planning, legal, and human resources." Finally, the pillar "Digital transformation of enterprise culture" was revised to "Human and organization." These changes enable a broader, more integrated approach to assessing digital transformation efforts.

In the current study, the index was constructed by aggregating the scores across all seven pillars. Each pillar consists of several components, and each component includes multiple evaluation criteria. Although the revised MICI framework represents a significant improvement, there remain challenges—particularly regarding the interpretation of percentage-based criteria. To address this issue, the current

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study converted percentage scores into a five-point ordinal scale, where a score of 1 indicates little or no preparation for digital transformation and a score of 5 represents the highest level of readiness. The maximum total score that a cooperative could attain was 300.

Based on the total scores, cooperatives were classified into five readiness levels: Level 1 (Basic) for scores equal to or less than 60, Level 2 (Developing) for scores greater than 60 but not exceeding 120, Level 3 (Developed) for scores above 120 and up to 180, Level 4 (Advanced) for scores above 180 and up to 240, and Level 5 (Leading) for scores exceeding 240. Each cooperative's actual score was then compared against these thresholds to determine its corresponding level of digital transformation readiness. Further details on the scoring system and classification are presented in Table 1.

Table 1.
Index of readiness for digital transformation.

No.	Pillars	Components	Criteria
1	Digital strategic orientation	• Leadership's awareness of the benefits and trends of digital transformation to business operations; • The level of integration of digital transformation solutions into the overall strategy of the business.	4
2	Digital experience for customers & multi-channel sales	• The level of application of digital transformation solutions in marketing, distribution, and sales to enhance customer experience; • The level of application of data analysis solutions to measure and forecast business performance.	5
3	Supply chain	• The ability to apply digital transformation solutions to connect with customer needs and with the suppliers of the business; • The degree of applying digital transformation solutions to core business processes and operations.	7
4	Information system and data management	• The capability and ability to integrate the information system with other systems for upgrades; • The ability to update new digital transformation solutions available in the market; • The processes and policies regarding data governance.	5
5	Risk management and network information security	• Awareness of the risks when applying digital transformation solutions; • The extent of applying data analysis solutions and other solutions to assess risks in the business, including risks related to network information security.	4
6	Management skills in finance, accounting, planning, legal, and human resources.	• The level of application of digital transformation solutions in management, finance, accounting, planning, legal, and human resources; • The ability of the finance, accounting, planning, and legal departments to support the implementation of digital transformation for the enterprise.	3
7	Human and organisations	• The flexibility of the business in responding to changes in the business environment; • The capability of employees in the business to implement digital transformation; • The level of application of digital transformation solutions to connect between departments in the business.	6
Total		16	34

Source: Adapted by the authors from ITU [11]; MIC [9]; Schallmo and Daniel [12] and Wittenstein [13].

The readiness level for digital transformation in cooperatives is shaped by a combination of internal and external factors. Internal factors pertain to the characteristics of both the cooperative and its director, while external factors encompass policy-related influences and broader environmental conditions.

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2.2. Methodology and Regression Model

A multiple regression model was employed to analyse the influence of key determinants on the readiness for digital transformation within the cooperative, as formalised in Equation 1. This approach enabled a systematic assessment of how these factors collectively contributed to the cooperative's preparedness for adopting digital initiatives, adhering to the methodological framework established by Wooldridge [14].

$$Y_i = \alpha + \beta_i X_{1i} + \beta_i X_{2i} + \beta_i X_{3i} + \beta_i X_{4i} + \varepsilon \quad (1)$$

where:

Yi denotes the index/scores quantifying digital transformation readiness, derived from 16 components across the seven pillars outlined previously. X1i corresponds to the cooperative director's demographic characteristics, X2i to the cooperative's organisational characteristics, X3i to criteria evaluating the cooperative's digital transformation readiness, and X4i to external factors influencing this readiness. Demographic characteristics of directors (e.g., age (years), gender (1 = male), education (1 = tertiary education or above), and management experience (years)) are theorised to affect both cooperative operations and digital transformation outcomes, as evidenced by recent studies [15-17]. Organisational characteristics of cooperatives, critical to digital transformation, include sector classification (1 = Agriculture, 2 = Industry/Construction, 3 = Finance/Banking/Insurance, 4 = Trade/Services/Others), active member count (members), prior-year revenue (in VND billion; 1 billion VND ≈ 25,945.602 USD [18]), and capital reserves (VND billion) [13]. These variables collectively capture internal and external dimensions shaping readiness for digital transformation.

The current study also investigated the influence of factors outlined in Decision 2158—which are utilised to evaluate readiness for digital transformation—on the scores. These factors encompass both external and internal aspects and are comprehensively documented in the enclosed dataset and accompanying dictionary.

Given the cross-sectional nature of the data, the most appropriate regression specification is ordinary least squares (OLS). However, to ensure accurate and reliable results, potential biases associated with OLS needed to be addressed. Common sources of bias in parametric studies include endogeneity, which may stem from measurement error, omitted variable bias, or simultaneity (reverse causality) [13, 19-21]. While instrumental variables (IV) and two-stage least squares (2SLS) models are established methods to mitigate endogeneity [22, 23] the absence of suitable instruments in this study precluded their application. Instead, the following strategies were employed: Endogeneity—specifically, correlations between independent variables and the error term—was minimised through rigorous selection of theoretically grounded independent variables. Measurement error was addressed via a refined web survey design that incorporated a pilot study to optimise question clarity, response validation techniques, attention-check questions, and anonymisation to reduce social desirability bias. These steps improved data accuracy. Omitted variable bias was mitigated by integrating comprehensive control variables, including demographic characteristics of cooperative directors and cooperatives themselves, indicators assessing cooperatives' digital transformation readiness, and environmental factors. By accounting for potential alternative explanations, these controls reduced bias and bolstered the validity of the findings.

To identify the most relevant variables explaining the dependent variable, Stepwise regression (using AIC/BIC) and LASSO (Least Absolute Shrinkage and Selection Operator) were considered. However, given the high-dimensional nature of the dataset—111 independent variables relative to 62 observations—LASSO was selected due to its robustness in handling overfitting and collinearity in such scenarios [24, 25]. LASSO regression identified 48 variables as optimal predictors. Sensitivity analyses were performed to validate model assumptions.

First, the Durbin-Watson (DW) test [26] was applied to assess residual autocorrelation [26]. The DW statistic of 1.983 (close to the ideal value of 2) and its non-significant p-value (0.3074 > 0.05) suggest no evidence of autocorrelation. Second, the Shapiro-Wilk test [27] evaluated residual normality, yielding a statistic $W = 0.965$ and p-value = 0.07413 (> 0.05), indicating no significant

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departure from normality. Third, the studentized Breusch-Pagan test [28, 29] examined heteroskedasticity. With a test statistic of 45.44 (df = 49) and p-value = 0.6183 (> 0.05), homoskedasticity was retained. These results collectively support the model's validity.

3. Results

3.1. The Level of Readiness for Digital Transformation in Thai Nguyen Cooperatives

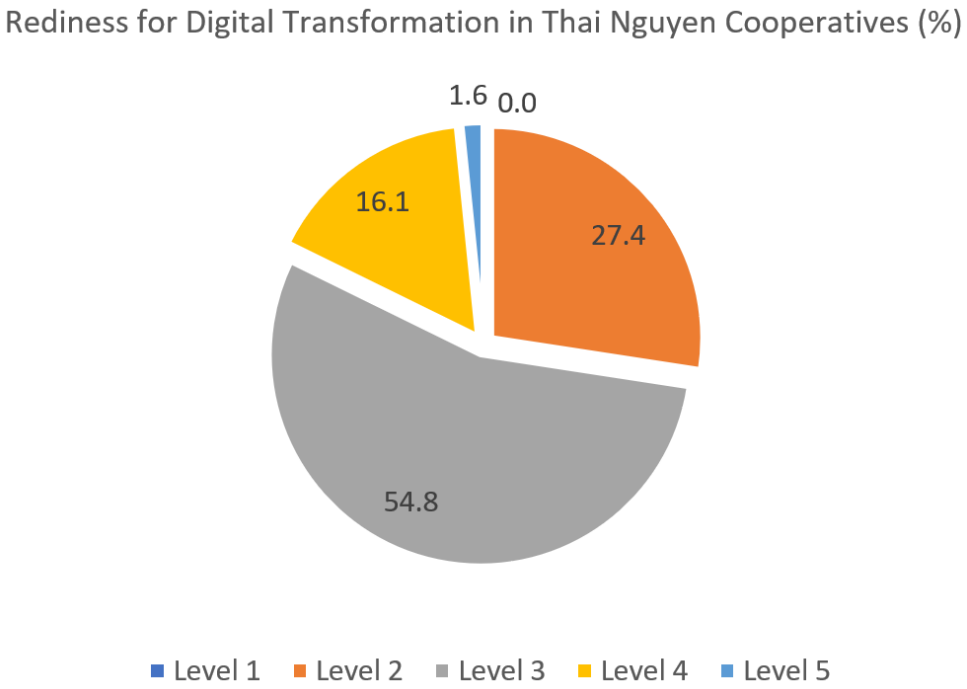

Figure 1.
The level of readiness for digital transformation in cooperatives (Measured in percentage).
Note: Levels 0 and 5 represent the lowest and highest levels of readiness for digital transformation, respectively.

The distribution of digital transformation readiness among Thai Nguyen cooperatives, shown in Figure 1, reveals a strong skew toward advanced preparedness, with 54.8% at Level 5 (highest readiness) and 27.4% at Level 4, collectively representing over 80% of cooperatives. A smaller proportion (16.1%) falls into Level 3 (intermediate readiness), while minimal participation is observed at lower levels—1.6% at Level 1 and 0.0% at Level 2, highlighting a notable gap between basic and intermediate stages. The absence of Level 2 cooperatives suggests potential barriers to incremental progress, while the marginal 1.6% at Level 1 underscores the need for targeted interventions to address lagging entities.

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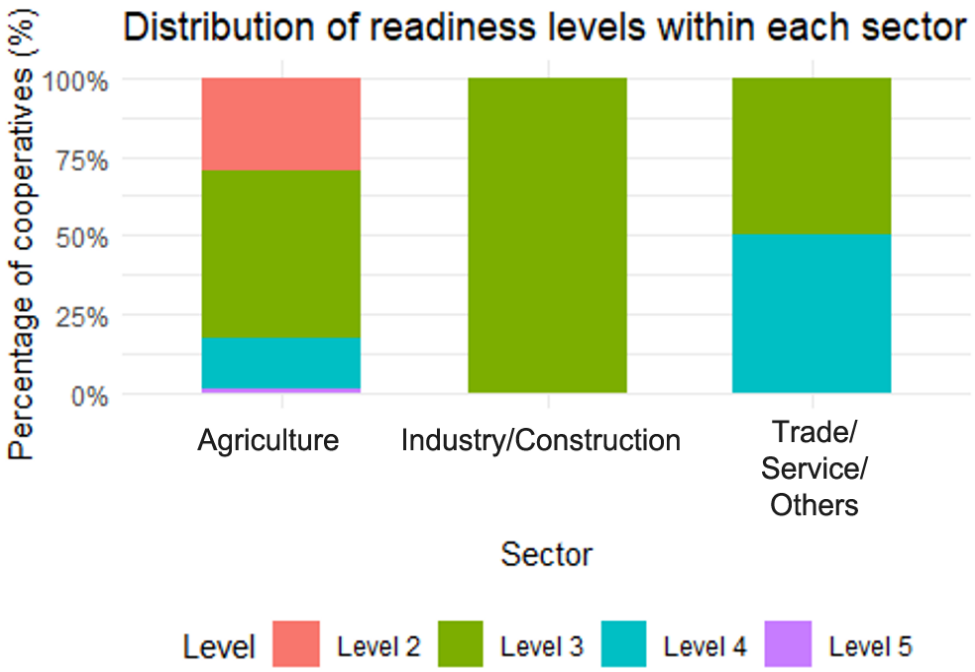

Figure 2.
Distribution of the levels of readiness for digital transformation within each sector.
Note: Levels 0 and 5 represent the lowest and highest levels of readiness for digital transformation, respectively.

Figure 2 complements the findings of Figure 1 (which identified 54.8% of Thai Nguyen cooperatives at Level 5 readiness) by examining sector-specific distributions of digital transformation preparedness. The figure emphasises how readiness levels vary across industries, with certain sectors aligning closely with the high-readiness trends observed in the aggregate data (Levels 4–5 in Figure 1). This sectoral analysis underscores the importance of tailored strategies to enhance digital adoption, leveraging the shared framework of Levels 0–5 (where 5 denotes peak readiness) for consistent evaluation. By identifying sectors that mirror the overall advanced preparedness, the figure reinforces opportunities for cross-sector learning and targeted resource allocation to sustain progress.

3.2. Determinants of Readiness for Digital Transformation in Cooperatives

The determinants of readiness for digital transformation in Thai Nguyen cooperatives were examined by applying the multiple linear regression model. Results are presented in Table 2.

Data analysis showed a statistically significant positive relationship between the number of digitalised processes in a cooperative and its readiness for digital transformation. The variable *Digitalised processes* had a regression coefficient of 1.4671 ($p = 0.0000$), indicating a highly significant effect at the 1% level. Each additional digitalised process increases the readiness score by approximately 1.4671 points, holding other factors constant. These findings suggest that adopting digital processes strongly predicts a cooperative's preparedness for digital transformation.

The regression analysis shows a statistically significant positive relationship between the level of digital transformation (DT) plans implemented and cooperatives' readiness for digital transformation. The coefficient for the independent variable Digital transformation plans is 1.4344 ($p = 0.0003$), indicating that a one-unit increase in DT plan implementation (e.g., from 20% to 40%) corresponds to an approximate 1.4344-point increase in readiness score. Given the p-value is less than 0.001, this effect is highly significant, demonstrating a robust and consistent pattern across the sample.

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Table 2.
Determinants of readiness for digital transformation in Thai Nguyen cooperatives.

Variables	Coef.[1]	S.E.[2]	p-value
Intercept	9.5898	3.1833	0.0108
Digital financial management software application (1=yes)	2.2600	0.7191	0.0085
Big data technology application (1=yes)	1.0054	1.0591	0.3612
Intelligent manufacturing management application (1=yes)	0.4104	0.7895	0.6127
Automation integration (1=yes)	0.9158	0.5671	0.1323
Digitalised processes (processes)	1.4671	0.2121	0.0000
Cooperative readiness to adopt new technology (1=not ready, 5=highest ready)	1.2844	0.3356	0.0024
Employee adaptation (1<=[3]20% employees, 5>=[4]90% employees adapted)	0.6616	0.2819	0.0369
DT plans (1<=20% DT plans, 5>=90% DT plans implemented)	1.4344	0.2841	0.0003
Personnel with tertiary/higher degree (1<=20%, 5>=90% personnel had tertiary/higher degree)	0.4397	0.4342	0.3313
Smart devices (devices)	0.0962	0.0255	0.0026
Internet connection speed (1=lowest, 5=highest speed)	1.8580	0.5179	0.0037
DT support funding (VND billion)	0.0031	0.0026	0.2457
Favourability of legal system for DT (1=very inconvenient, 5=very convenient)	2.2545	0.4503	0.0003
Participation in DT support programs last year (1=yes)	-0.6195	0.9671	0.5339
participation in DT financial support program last year (1=yes)	2.3286	0.8822	0.0216
Participation in DT programs with supplied technology or equipment last year (1=yes)	1.8331	0.6732	0.0185
Participation in DT training courses (courses)	0.0125	0.0306	0.6893
External technical support strategy consulting rating (1=very poor, 5=very good)	0.9816	0.7620	0.2219
External technical support for timely response and assistance rating (1=very poor, 5=very good)	2.1701	0.7650	0.0150
Frequency of cooperative current use of cloud computing (1=little/no use, 5=very often)	0.0159	0.3650	0.9660
Frequency of cooperative current use of online data storage services (1=little/no use, 5=very often)	1.4255	0.3700	0.0023
Frequency of cooperative current use of management software (1=little/no use, 5=very often)	0.8710	0.4399	0.0711
Frequency of cooperative current use of online communication & promotion (1=little/no use, 5=very often)	1.5024	0.4535	0.0062
Frequency of cooperative current use of QR (1=little/no use, 5=very often)	0.8196	0.4492	0.0931
Cooperative leaders understanding of DT trends and solutions (1=little/no, 6=full understanding)	1.2341	0.3761	0.0066
Cooperative leaders' inclusion of DT goals in key tasks over the past 2 years (1=no, 5>=90% inclusion)	0.4156	0.2954	0.1848
Budget invested in innovation or DT past 2 years (1=no, 5>=90% investment)	2.0870	0.5993	0.0045
DT and data analysis support for cooperative strategic decisions (1=no, 5>=90% decisions are supported)	1.9265	0.5239	0.0032
e-commerce solutions application level (1=not applicable, 5=highest applicable)	0.3388	0.3827	0.3934
DT customer care application (1=not applicable, 5>= 90% of expectations/targets are met)	1.4594	0.6602	0.0472
DT solutions for sales forecasting (1=no solutions, 5>= 90% of expectations/targets are met)	2.2452	0.8473	0.0212
DT solutions use for business and sales evaluation (1=no solutions, 5>= 90% of expectations/targets are met)	0.7507	0.9237	0.4322
DT supply chain application (1=not applicable, 5>= 90% of expectations/targets are met)	1.4984	0.7378	0.0650
DT support supply chain (1=not applicable, 5>= 90% of expectations/targets are met)	2.7458	1.0414	0.0217
Level of DT automation in operations and production (1=lowest, 5=highest)	-0.0789	0.5804	0.8941
DT support for optimal costs and profits (1=not applicable, 5>= 90% of expectations/targets are met)	3.6913	0.5534	0.0000
DT support for cost and profit analysis (1=not applicable, 5>= 90% of expectations/targets are met)	-0.3068	1.3107	0.8189

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DT support for human resource management (1=not applicable, 5>= 90% of expectations/targets are met)	2.3894	0.8856	0.0194
DT adoption impact on cost and efficiency (1=not adoption 5>= 90% of expectations/targets are met)	0.0477	0.6734	0.9446
Current DT integration (1=no integration, 5>= 90% of expectations/targets are met)	1.1563	0.7208	0.1347
Policy and process evaluation for DT (1=no policies are in place, 5>= 90% of the needs are met)	1.8852	0.5827	0.0071
Awareness of risks in DT (1=unaware, 5=highly aware)	0.4152	0.6533	0.5370
Cooperative security risk review capability (1=incapable, 5=highly capable)	2.9328	0.7347	0.0018
IT cybersecurity incident response effectiveness (1=ineffective, 5=highly effective)	1.8960	0.6723	0.0155
Personnel adaptability to DT (1=lowest, 5=highest adaptability)	1.3357	0.5676	0.0365
IT personnel policy effectiveness rating (1=ineffective, 5=highly effective)	-0.0351	0.8807	0.9689
Internal training effectiveness evaluation (1=ineffective, 5=highly effective)	4.3680	0.9201	0.0005
Lack of partner awareness and coordination (1=yes)	0.8027	0.6502	0.2407
Increased awareness of digital benefits (1=yes)	1.1206	0.8603	0.2172

Note: [1]Coefficient, [2]Standard Errors, [3]Less than or equal to, and [4]Greater or equal to.

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The regression analysis indicates a statistically significant and positive association between the perceived favourability of the legal system for digital transformation and cooperatives' readiness for digital transformation. The coefficient for "Favourability of legal system for digital transformation" is 2.2545 ($p = 0.0003$), meaning that a one-point increase on the 1 (very inconvenient) to 5 (very convenient) scale corresponds to an approximate 2.2545-point increase in readiness. This effect is significant at the 1% level, demonstrating a robust relationship between legal supportiveness and digital readiness.

The analysis revealed a statistically significant positive relationship between "Digital transformation support for optimal costs and profits" and cooperative readiness for digital transformation. The estimated coefficient of 3.6913 indicates that each one-unit increase in perceived support corresponds to an approximate 3.69-point increase in readiness score. This result is highly significant ($p < 0.01$, $p = 0.0000$), demonstrating that cooperatives perceiving stronger support for cost-effective and profit-optimised digital transformation are significantly more prepared to undertake such initiatives.

The regression analysis indicates a statistically significant and positive relationship between internal training effectiveness evaluation and cooperative readiness for digital transformation. The coefficient for "Internal training effectiveness evaluation" is 4.3680, meaning that a one-point increase in perceived training effectiveness (on a scale from 1 = ineffective to 5 = highly effective) corresponds to an approximate 4.3680-point increase in readiness score. This effect is highly significant at the 0.01 level ($p = 0.0005$), providing strong evidence that improved internal training evaluation is positively associated with cooperative preparedness for digital transformation.

The regression results indicate that the application of digital financial management software (coded as 1 = yes) has a statistically significant positive effect on cooperatives' readiness for digital transformation. The coefficient for this variable is 2.2600 with a p-value of 0.0085, demonstrating significance at the 1% level. This implies that, controlling for other factors, cooperatives using such software score approximately 2.26 points higher on the readiness scale compared to those that do not.

The analysis reveals a statistically significant positive relationship between cooperatives' readiness to adopt new technology and their overall digital transformation readiness. The coefficient for "Cooperative readiness to adopt new technology" is 1.2844 ($p = 0.0024$), indicating that a one-point increase on the 1-to-5 readiness scale corresponds to an approximate 1.2844-unit increase in digital transformation readiness. Since $p < 0.01$, this relationship is highly significant, demonstrating that technological openness strongly predicts digital transformation preparedness among cooperatives.

The regression analysis identified a statistically significant positive relationship between the number of smart devices used in cooperatives and their readiness for digital transformation. Specifically, the coefficient for Smart devices was 0.0962, indicating that each additional smart device corresponds to an increase of approximately 0.0962 points in the readiness score. The associated p-value was 0.0026, indicating significance at the 1% level. This suggests that greater access to or utilisation of smart devices is linked to enhanced digital transformation readiness among cooperatives.

The data analysis results indicate that Internet connection speed has a statistically significant positive effect on the cooperative's readiness for digital transformation. The coefficient for "Internet connection speed" is 1.8580, implying that each one-unit increase in internet speed (on a scale from 1 = lowest to 5 = highest) corresponds to an approximate 1.858-point increase in the readiness score, holding other variables constant. This relationship is statistically significant at the 0.01 level ($p = 0.0037$), indicating that faster internet connectivity is a strong predictor of digital readiness in cooperatives.

The regression analysis shows a statistically significant and positive relationship between the frequency of cooperative use of online data storage services and their readiness for digital transformation. The independent variable—"Frequency of cooperative current use of online data storage services," measured on a scale from 1 (little/no use) to 5 (very often)—has a coefficient of 1.4255 with a p-value of 0.0023. This indicates that each one-unit increase in the frequency of online data

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storage use corresponds to an approximate 1.4255-point increase in digital transformation readiness, holding other variables constant. Since the p-value is less than 0.01, this relationship is statistically significant at the 1% level, providing strong evidence that more frequent use of online data storage services is associated with greater digital transformation readiness in cooperatives.

The regression analysis identified a positive and statistically significant relationship between the frequency of cooperatives' use of online communication and promotion and their readiness for digital transformation. The independent variable, measured on a five-point Likert scale (1 = little/no use, 5 = very often), had a coefficient of 1.5024, indicating that each one-unit increase in frequency corresponded to an approximate 1.5024-point increase in readiness score. This relationship is statistically significant at the 1% level ($p = 0.0062$), demonstrating a strong association between more frequent use of online communication tools and greater digital transformation readiness among cooperatives.

The regression analysis showed a statistically significant positive relationship between cooperative leaders' understanding of digital transformation (DT) trends and solutions and the overall readiness score for digital transformation. Specifically, the independent variable "Cooperative leaders' understanding of DT trends and solutions," measured on a 6-point scale (1 = little/no understanding, 6 = full understanding), had a coefficient of 1.2341 and a p-value of 0.0066, indicating significance at the 1% level. This implies that, controlling for other variables, a one-unit increase in leaders' understanding of DT corresponds to an approximate 1.2341-point increase in the cooperative's readiness score.

The analysis reveals that the independent variable, "Budget invested in innovation or digital transformation (DT) over the past two years" (rated 1 = no investment to 5 = ≥90% investment), is positively and statistically significantly associated with cooperative readiness for digital transformation. The coefficient of 2.0870 ($p = 0.0045 < 0.01$) indicates that each one-unit increase in investment level corresponds to an approximate 2.0870-point increase in readiness score, controlling for other factors. This demonstrates a strong positive relationship between financial commitment to innovation and readiness among cooperatives.

The regression results show that the variable "DT and data analysis support for cooperative strategic decisions" is positively and significantly associated with cooperatives' readiness for digital transformation. Specifically, a one-unit increase in the degree of data analysis support (measured on a 1-to-5 scale, where 1 = no support and 5 = ≥90% of decisions supported) corresponds to an increase of approximately 1.9265 units in the digital readiness score. This relationship is statistically significant at the 1% level ($p = 0.0032$), providing strong evidence against the null hypothesis.

The regression analysis indicates that "Policy and process evaluation for digital transformation" is positively and significantly associated with cooperative readiness for digital transformation. The estimated coefficient of 1.8852 means that a one-point increase in the evaluation score (on a 1 to 5 scale) corresponds to an increase of approximately 1.8852 units in readiness, controlling for other factors. This effect is statistically significant at the 1% level ($p = 0.0071$), confirming a robust relationship between digital transformation policies/processes and cooperative readiness.

The analysis shows a statistically significant positive association between the cooperative's security risk review capability and its readiness for digital transformation. The variable "Cooperative security risk review capability," measured on a 5-point Likert scale (1 = incapable, 5 = highly capable), has a regression coefficient of 2.9328 ($p = 0.0018$). Holding other variables constant, each one-point increase in this capability corresponds to an average increase of approximately 2.9328 points in digital transformation readiness. Since the p-value is less than 0.01, this relationship is statistically significant at the 1% level, indicating a high confidence in the reliability of this finding.

The impact of the remaining factors is either modestly significant at the 10% level or statistically insignificant. This indicates that, although they may contribute to cooperative readiness for digital transformation, their influence is limited relative to the key predictors. Consequently, policy interventions and resource allocations should prioritise the most influential variables to achieve meaningful improvements in digital transformation outcomes.

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4. Discussion

The key finding of this study is the strong and statistically significant effect of digitalised processes on cooperatives' readiness for digital transformation (coefficient = 1.4671, p-value = 0.0000). This underscores the central role of internal digitalisation in shaping digital maturity. The results emphasise that advancing digital readiness requires more than acknowledging technology—it demands active integration of digital tools across cooperative functions. While prior studies Ancillai, et al. [30] and Morrar, et al. [31] have highlighted digital capabilities and infrastructure as drivers of agility and innovation, few have empirically examined this link within cooperatives, especially in developing contexts. This study addresses that gap by offering robust evidence from Vietnam's cooperative sector. Unlike earlier work focused on macro-level or industrial settings [32, 33] our analysis provides novel insights into grassroots, community-based organisations. It expands existing knowledge by illustrating how rural and semi-rural cooperatives translate digital adoption into transformation readiness. These findings not only fill an empirical void but also inform policy targeting digital transformation in agriculture and local economies. Furthermore, the study suggests that digital transformation is not merely infrastructural but closely linked to behavioral and managerial changes. Future research should explore causal links between specific digital tools (e.g., accounting software, e-commerce, inventory systems) and readiness factors like leadership commitment and workforce digital literacy. Longitudinal and mixed-methods designs could further reveal how digital maturity evolves and under what conditions it becomes sustainable and impactful.

This study reveals a strong, positive association between cooperatives' implementation of digital transformation plans and their readiness for digital transformation. The key finding—that readiness rises significantly with greater plan implementation—supports the theoretical view that strategic planning is essential for digital maturity. This aligns with Vial [34] who characterised digital transformation as a socio-technical process requiring alignment between vision, planning, and execution. Similarly, Ben Slimane, et al. [35] showed that in SMEs, digital strategies are critical precursors to transformation outcomes. By applying this analysis to agricultural cooperatives in a developing country—an underrepresented context—this research extends existing literature. Unlike prior studies focused on private firms or public institutions, it addresses a gap by providing evidence from cooperatives often lacking digital resources and institutional support. The study advances current knowledge by empirically confirming the strategic role of digital planning in resource-constrained, collective enterprises. Notably, it suggests that even marginal improvements in planning can yield substantial gains in readiness—a crucial insight for policymakers and development agencies seeking to modernise rural economies. Future research should explore causal mechanisms using longitudinal data or quasi-experimental designs to determine whether planning drives readiness or if more mature cooperatives are simply more likely to plan. It should also investigate whether different types or scopes of plans (e.g., e-commerce vs. supply chain automation) differentially impact readiness across cooperative settings.

This study finds that perceived favourability of the legal system significantly influences cooperatives' readiness for digital transformation. A higher perception of legal convenience correlates strongly with greater preparedness for digital change, underscoring the importance of institutional support in driving digital innovation in the cooperative sector. This aligns with prior research highlighting the role of supportive regulatory environments in successful digital transitions [36]. However, unlike earlier studies focused on private firms or urban enterprises, this research offers new empirical evidence from rural cooperatives in emerging economies—an area with limited scholarly attention. By quantifying the impact of legal system favourability, it fills a key gap in the literature, advancing from theoretical assertions to empirical modeling. This enables more precise identification of institutional levers for policy interventions. The findings also suggest future research directions, such as investigating causal mechanisms via longitudinal or experimental designs, or examining legal components like digital property rights, e-signature laws, and legal aid. Ultimately, the study provides a more nuanced understanding of how external legal environments interact with internal organisational

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dynamics to shape digital transformation, offering practical insights for policymakers and cooperative leaders aiming to foster digital inclusion.

This study demonstrates a strong, statistically significant relationship between perceived support for digital transformation—specifically in optimising costs and profits—and cooperative readiness for digital change. The key finding underscores the importance of practical, results-driven support in enhancing readiness. Our research contributes to this evolving field by offering empirical evidence from agricultural cooperatives in developing contexts, an area with limited scholarly focus. Tsan, et al. [37] recognised the potential of digital agriculture but noted a lack of grassroots-level readiness data. By quantifying readiness and linking it to perceived cost and profit optimisation support, this study fills a critical gap. It advances the literature by providing micro-level, evidence-based validation of how targeted digital support influences readiness—moving beyond national indexes or anecdotal insights. Moreover, it reframes the conversation from abstract policies to actionable outcomes, showing cooperatives' positive responses to tangible benefits. The next frontier involves exploring how different support types—technical, financial, or managerial—interact with variables like cooperative size, governance, or market access. Future research should adopt mixed methods, including longitudinal and case studies, with experimental or quasi-experimental designs to identify causal pathways and evaluate policy impacts on digital transformation readiness in agricultural and rural cooperatives.

The results highlight the critical role of effective internal training in enhancing cooperatives' digital transformation readiness. The key finding—that internal training effectiveness significantly predicts digital readiness—confirms that building internal human capital is essential for digital initiatives. Cooperatives with higher internal training evaluations are more likely to report advanced digital readiness, emphasising capability-building as a key driver of digital success. These results align with previous research, such as Kane, et al. [32] which shows digitally mature organisations prioritise employee training and foster agile learning cultures. Addressing a notable gap—the lack of localised, quantitative studies on internal training's impact in cooperatives—this study advances current knowledge. Prior research tends to generalise training in broader organisational contexts or focus on urban enterprises, overlooking cooperative-specific, regional insights. By filling this void, the study positions internal training as a measurable, actionable core component of transformation strategies in rural, semi-formal settings. It reframes training from a supportive element to a central determinant of digital readiness, especially for under-resourced, community-based models. The findings suggest that beyond technological infrastructure, human-centered policies—such as training design and evaluation—are pivotal. Future research should explore how training formats (e.g., in-person vs. digital, technical vs. managerial) influence readiness and whether effects differ by cooperative type or location. Longitudinal studies could assess whether improved training effectiveness leads to sustained digital adoption. Including qualitative elements like employee feedback and engagement levels may further clarify how training functions within complex cooperative systems.

The findings show that adopting digital financial management software significantly enhances cooperatives' digital transformation readiness. Financial digitisation emerges not only as a component but also as a catalyst for broader digital capabilities. The strong statistical significance ($p = 0.008$) and effect size (coefficient = 2.260) demonstrate that even one digital practice can substantially impact readiness. This addresses a key gap in the literature: while prior research often emphasises macro-level factors (e.g., policy, infrastructure), few studies isolate micro-level practices like financial software use as predictors. By identifying a specific operational tool with statistically significant influence, this study bridges strategy and action in cooperative development. It advances understanding by showing that digital readiness is shaped not only by external factors but also through internal adoption of targeted technologies. This reframes digital transformation as driven not solely by policy but also by grassroots, software-based initiatives. Future research should examine which features of financial tools (e.g., cloud-based accounting, automated reporting, supply chain integration) most affect readiness. Longitudinal studies could assess how usage duration and intensity influence digital maturity over time. Expanding

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the sample across varied regions and economies could test generalisability, while qualitative insights from cooperative managers could shed light on mechanisms by which these tools foster transformation.

This study underscores a key finding: cooperatives with higher technological readiness are significantly more prepared for digital transformation. The strong, positive, and statistically significant coefficient ($\beta = 1.28437$, $p = 0.00241$) indicates that technological readiness is a primary driver of digital capability, not merely a supporting factor. This aligns with previous research, such as Vial [34] which emphasises early technology adoption as vital to institutional agility and digital change. By focusing on agricultural cooperatives in a developing region—a context largely overlooked in prior studies centered on corporations or government institutions—this research fills an important gap. It quantifies the effect of technological readiness on digital preparedness and advances the literature by operationalising a context-specific readiness construct for cooperatives and rural digitalisation. Contrary to assumptions that rural resource constraints hinder digital transitions, the findings highlight the pivotal role of attitudinal and strategic readiness. Moreover, this study shifts the narrative from infrastructure-centric views of digital transformation to one rooted in organisational mindset and preparedness. It also suggests future research explore other soft factors—such as leadership vision, innovation culture, or network embeddedness—that may influence digital readiness. Longitudinal studies examining the evolving role of technology adoption, along with qualitative research into overlooked barriers and enablers, would provide deeper insights.

The current study shows that the availability and use of smart devices significantly enhance cooperatives' readiness for digital transformation. A key finding—a positive and statistically significant coefficient of 0.096243 for Smart devices—indicates that increasing smart device usage within a cooperative measurably improves digital readiness. This supports the hypothesis that technological infrastructure is a core enabler of digital transformation in agricultural organisations. Consistent with prior studies emphasising the role of digital tools in driving innovation and capacity building [38, 39] this research addresses a specific gap by quantifying the impact of smart device ownership at the cooperative level, especially in a developing country context like Vietnam. While previous research often focused on broader or urban settings, this study provides micro-level empirical evidence on how foundational technology access drives transformation in small-scale agricultural organisations. It highlights the need for strategies that prioritise basic digital infrastructure—alongside advanced technologies like AI or blockchain—in under-resourced rural sectors. The findings also inform digital transformation policies targeting cooperatives. Future research could use longitudinal data to assess how sustained smart device integration influences transformation over time, and experimental designs to explore causal mechanisms, such as whether training on device usage amplifies impact. Including variables like internet connectivity, member digital literacy, and leadership digital mindset would offer a more comprehensive view of the enablers and barriers to cooperative digital transformation.

This study finds that internet connection speed significantly influences cooperatives' digital transformation readiness, with each unit increase in speed raising readiness scores by 1.86 points. This underscores infrastructure quality as a key enabler of digital progress, aligning with prior research highlighting digital infrastructure as a prerequisite for adoption in rural and cooperative sectors [40]. By providing statistically robust evidence from Thai Nguyen cooperatives, this research fills a gap where many assessments remain descriptive or qualitative. Unlike earlier frameworks treating digital infrastructure as a background factor, this study elevates it to a measurable, impactful predictor. The findings quantify how connectivity improvements drive organisational readiness, suggesting rural cooperatives should prioritise infrastructure alongside digital skills and strategy. Furthermore, results invite exploration of nonlinear or threshold effects—whether minimum internet speeds catalyse disproportionate readiness gains. Future research should examine this relationship across provinces, cooperative types, and digital policy contexts, as well as longitudinally assess if better connectivity leads to actual adoption, deepening understanding of infrastructure's role in digital transformation in emerging economies.

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This study reveals a strong, significant positive link between cooperatives' frequency of using online data storage and their digital transformation readiness. Specifically, a one-point increase in usage frequency corresponds to a 1.43-point increase in readiness, underscoring the enabling role of cloud-based infrastructure. This aligns with prior findings identifying cloud adoption as a key enabler of digital transformation in SMEs and cooperatives [41, 42]. Such technologies offer scalability, flexibility, and help establish foundational digital habits that drive organisational change [43]. Our findings contribute by focusing on agricultural cooperatives in emerging economies—a less explored context compared to larger enterprises or urban service sectors [44]. By addressing this gap, we empirically link ICT usage (online data storage) with digital readiness, suggesting a measurable pathway from technology adoption to institutional preparedness. Moreover, our results suggest that basic digital tools, when consistently integrated, may actively cultivate rather than merely reflect digital readiness, shifting digital transformation from a top-down process to one driven by incremental, organic adoption. Future research should explore causality via longitudinal or experimental designs, examine if this relationship holds across cooperative sizes, sectors, or ecosystems, and investigate mediators like leadership, training, or network effects to better understand how digital habits evolve into organisational capabilities.

This study underscores the strong impact of digital communication behaviors on cooperatives' digital transformation readiness. Frequent use of online communication and promotional tools correlates positively and significantly with higher readiness levels, highlighting the vital role of digital platform engagement in modernising cooperative operations. These results align with prior research emphasising digital engagement's importance in organisational transformation. For example, Kraus, et al. [44] and Merín-Rodrigáñez, et al. [45] show that digital marketing and communication strategies enhance customer outreach and foster internal readiness for broader digital adoption. Addressing a notable gap, this study focuses on cooperatives in developing regions like Thai Nguyen, Vietnam, extending insights beyond corporate or SME contexts typical of advanced economies. It advances understanding of how grassroots organisations leverage digital tools to boost transformation readiness. Moreover, it challenges the assumption that substantial capital investment is necessary, demonstrating that consistent digital communication practices alone can significantly improve readiness in low- to mid-resource organisations. Future research should employ longitudinal designs to explore causal links between digital communication use and sustained transformation capabilities, and qualitative case studies to examine how specific tools—such as social media, messaging apps, or e-commerce platforms—affect readiness differently. Expanding this inquiry across diverse regions and cultures will deepen understanding of digital transformation pathways in cooperatives.

The statistically significant positive relationship between cooperative leaders' understanding of digital transformation (DT) trends and solutions and the overall digital readiness score underscores the crucial role of leadership in advancing DT readiness. Leaders with stronger DT knowledge are more likely to guide cooperatives toward higher digital maturity. This aligns with literature highlighting managerial competence and strategic vision as key to organisational digital maturity. Parviainen, et al. [46] emphasised leadership's central role in orchestrating digital transformation, especially in traditionally lagging sectors like agriculture. Similarly, Vial [34] stressed leaders' cognitive capabilities in fostering organisational agility and innovation through digital means. Our findings add empirical evidence within agricultural cooperatives—a sector underrepresented in DT studies—addressing a gap where prior research focused mainly on large enterprises or public institutions. This study advances knowledge by showing that even in resource-constrained settings, leaders' internal capabilities and awareness significantly influence digital trajectories. Moreover, enhancing leadership knowledge in digital domains emerges as a strategic intervention to catalyse broader agricultural DT. This insight suggests policy should prioritise capacity-building for leaders rather than relying solely on infrastructure or external solutions. Future research could examine how leadership learning interventions or peer-exchange models affect not only readiness but actual digital adoption and outcomes, with longitudinal and quasi-experimental studies testing causality and durability over time.

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This study reveals a significant positive link between financial investment in innovation or digital transformation over the past two years and cooperative readiness for digital transformation. Budget allocation emerges as a key enabler, supporting prior findings that resource commitment is critical for technology adoption [41]. By focusing on Vietnamese cooperatives—often with limited finances and low digital maturity—this research fills a gap left by studies centered on large enterprises or government sectors [47, 48]. It shows that even modest increases in innovation funding markedly improve readiness in small-scale agricultural cooperatives. Advancing beyond qualitative or descriptive insights, this study quantifies readiness tied to investment behavior and suggests a threshold effect where readiness only improves with financial commitment. Future research should explore marginal effects at varying investment levels and examine moderating factors like cooperative type, size, or sector. Longitudinal designs could clarify causal or time-lag effects, while qualitative work might investigate how investments—e.g., in training, infrastructure, or software—drive transformation success. Ultimately, this study underscores financial investment's strategic role in advancing cooperatives' digital transformation, highlighting policy implications for development programs and government funding priorities.

This study finds that increased use of digital technologies and data analytics to inform strategic decisions is a key driver of cooperatives' readiness for digital transformation. Cooperatives systematically applying data-driven decision-making show significantly higher preparedness for adopting digital innovations, underscoring analytical capability's central role in enabling change. Prior research highlights digital competencies as vital in organisational transformation; for example, Vial [34] defines digital transformation as a process enabled by digital technologies that enhance an organisation's ability to adapt, innovate, and respond to market dynamics. However, few studies focus on agricultural cooperatives in emerging markets like Vietnam, where digital transformation remains nascent. This study fills that gap with empirical evidence from cooperatives in Thai Nguyen province, where strategic data use significantly predicts digital readiness. This suggests that digital transformation in such contexts depends less on technology acquisition and more on integrating data into core decision-making. Our findings shift focus from infrastructure or external factors (e.g., policy support, funding) to internal capacity, especially information use. Moreover, this study extends understanding by emphasising organisational behavior and decision culture's role in enabling transformation, showing that internal practices like data-informed governance are equally, if not more, influential. Future research should explore causal links between data use and readiness, using longitudinal or experimental designs, and investigate moderating factors such as leadership quality, digital literacy, or network partnerships to deepen insights into how and when data-driven decision-making fosters transformation.

The analysis shows that well-established policies and processes for digital transformation strongly predict higher digital readiness among cooperatives, underscoring the role of institutional commitment and strategic planning in driving digital change. This aligns with prior research Kraus, et al. [44] and addresses a gap by focusing on operational readiness in agricultural or rural cooperatives, especially in developing economies. While earlier studies (e.g., Vial [34]) broadly discuss digital transformation enablers, empirical evidence linking internal policy evaluation to readiness scores in cooperatives remains limited. By quantifying this relationship, our study fills a significant gap and offers actionable insights for policymakers and cooperative leaders. Notably, the results extend current knowledge by highlighting policy development and evaluation—not just technology adoption—as key levers for transformation. This shifts the discourse beyond infrastructure and skills to governance and strategic planning, suggesting new directions for readiness frameworks. Future research should explore causal mechanisms, using qualitative case studies or mixed methods to examine how policy features (e.g., clarity, alignment, enforcement) influence success. Longitudinal and cross-country comparative studies could further assess whether improved policy frameworks sustain digital growth across diverse contexts.

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The findings reveal a strong, statistically significant link between cooperatives' security risk review capabilities and their readiness for digital transformation. Specifically, cooperatives with greater competence in identifying and managing security risks show higher readiness, with a coefficient of 2.933 and a p-value of 0.0018. This underscores security competence as crucial for technological adoption in cooperatives. The study adds to research highlighting organisational capabilities as key to digital transformation [34, 49]. While prior work has focused on leadership, digital infrastructure, or strategic vision [50, 51] few have examined risk management in cooperative enterprises in developing countries. By quantifying this capability's impact on readiness, this research fills an empirical gap. Compared to previous literature, it integrates security risk management—often viewed as peripheral—into core transformation determinants, refining frameworks for cooperatives and broadening readiness assessments beyond technology access and digital skills. Focusing on cooperatives in Thai Nguyen, Vietnam, it offers insights into digital transformation in emerging economies, an underexplored area [44]. This highlights security capability as a pivotal yet overlooked factor, suggesting capacity building in security risk management as a high-leverage intervention. Future research could explore causal mechanisms via longitudinal or experimental designs, qualitatively examine how cooperatives manage security risks, or compare patterns across regions and sectors. Integrating digital maturity models with risk management frameworks may yield more holistic readiness evaluation tools for cooperatives and similar organisations.

5. Conclusion

This study set out to examine the factors influencing the readiness for digital transformation among cooperatives in Thai Nguyen province, Vietnam—a region where cooperatives are increasingly expected to adopt digital innovations for improved competitiveness and sustainability. Despite the global push for digital adoption, empirical studies on the drivers of digital transformation readiness within the cooperative sector, particularly in developing countries, remain limited. Addressing this gap, data for the study were collected through online surveys and video calls with 62 matured cooperatives operating in Thai Nguyen between February 1st and April 1st, 2025. The most up-to-date digital transformation framework was adapted to assess cooperative readiness, ensuring relevance to contemporary digital development standards.

The study employed a multiple linear regression model to evaluate the impact of various influential factors on digital transformation readiness. To enhance model robustness and variable selection, LASSO regression was applied to identify key predictors, and sensitivity tests were conducted to confirm the adequacy and reliability of the final model. The analysis found that cooperatives in Thai Nguyen demonstrate a high level of readiness overall, with significant variation across sectors. Readiness was strongly associated with factors related to internal capabilities, technological infrastructure, leadership awareness, financial commitment, and external support systems. These findings provide clear, evidence-based guidance for where cooperative management and policymakers should focus their resources to support digital transformation effectively.

The results have important implications. They highlight the need for targeted interventions that promote internal capacity building—such as training and leadership development—while also improving access to supportive external infrastructure like favourable legal frameworks and digital financial tools. The study also emphasises the value of fostering a strategic digital mindset across all organisational levels. By identifying key enablers of readiness, the findings offer a roadmap for stakeholders aiming to scale digital transformation in the cooperative sector and reinforce the importance of coordinated, well-supported digital strategies.

In conclusion, Thai Nguyen cooperatives show encouraging levels of digital transformation readiness, and this research has clarified which factors most meaningfully support that progress. These insights contribute to a deeper understanding of digital readiness in developing-country contexts and can inform both national policy and local cooperative strategies. While the study is cross-sectional and therefore cannot confirm causality, it provides a solid foundation for future work. Longitudinal research

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and in-depth qualitative studies should be conducted to further explore the dynamics of digital transformation over time, identify evolving challenges, and refine policy recommendations tailored to cooperative organisations.

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Transparency:
The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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