

Does Digital Competence Amplify the Resilience Benefits of Digital Access? Evidence from Agripreneurs in Southwest Nigeria

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Abstract

Digitalisation can reduce information asymmetries in agricultural markets, but access to digital tools and the capability to use them effectively are not necessarily equivalent. This study examines whether digital access and digital competence are independently associated with agripreneurial resilience and whether competence strengthens the access-resilience association. Survey data from 246 agripreneurs in six communities across Ogun, Ondo, and Osun States, Southwest Nigeria, were analysed within an Information Asymmetry Theory framework that treats access and competence as complementary dimensions of digital capital. In the principal robust regression, digital access ($\beta = 0.412$, $p < 0.001$) and digital competence ($\beta = 0.284$, $p < 0.001$) were each positively associated with resilience; the numerically larger access coefficient lacks a formal equality-of-coefficients test and is not treated as distinct. The access-by-competence interaction was small and non-significant ($\beta = 0.018$, $p = 0.742$), a pattern replicated across bootstrap OLS, quantile regression, beta regression, factor-score weighting, wild-cluster bootstrap, and mixed-effects specifications. This null result is imprecise: only 18 respondents (7.3%) occupy the high-access/low-competence quadrant, and post-hoc power was 0.12. The findings therefore support additive associations of access and competence more than a complementary interaction, without ruling out moderation in other samples. The study offers a cautious account of digital capital: infrastructure and capability may each matter for resilience, but the cross-sectional evidence here cannot establish that competence amplifies the return to access. Policy attention should therefore target connectivity, reliable power, digital competence, and entrepreneurial capacity, while causal claims await longitudinal or quasi-experimental evidence.

Keywords: Digital Access, Digital Competence, Digital Capital, Agripreneurial Resilience, Information Asymmetry.

Introduction

Digital technologies increasingly shape how agricultural enterprises acquire information, identify customers, transact, access finance, and respond to market disruption. Their potential value is particularly relevant in settings where agripreneurs face persistent information asymmetries, volatile prices, infrastructure constraints, climate-related disruptions, and limited access to formal market institutions. In such environments, mobile connectivity, digital financial services, online market information, and social-media-based business networks can reduce the cost of acquiring and transmitting information. Yet

digital access alone does not guarantee that information can be interpreted, verified, or converted into effective business decisions.

This distinction motivates a central question in the digital-agriculture literature: are digital access and digital competence separate sources of resilience, or does the value of access depend critically on the competence with which digital resources are used? Much empirical work treats digitalisation as a single adoption construct or focuses primarily on whether technologies are available and used. Such approaches can obscure an important distributional and organisational mechanism. Two agripreneurs may possess similar devices and connectivity while deriving very different benefits from them because their ability to search, evaluate, transact, protect information, and use digital platforms differs. Conversely, competence may have limited practical value when connectivity, devices, electricity, or affordable digital services are unreliable.

The distinction is especially important in Sub-Saharan Africa, where digital ecosystems are expanding while infrastructure and capability gaps remain uneven. Evidence from African agriculture indicates that digital tools can improve market participation and information access, but the benefits are conditional on institutional, infrastructural, and human-capital conditions (Ogutu et al., 2013; Nwangwu et al., 2024; Choruma et al., 2024). Recent studies further suggest that digital financial services and broader digital-economy development can contribute to agricultural resilience, although the mechanisms remain incompletely specified (Okadi et al., 2026; Chen & Ma, 2026).

The present study focuses on agripreneurs in Southwest Nigeria, a relatively connected and economically developed part of the country. This setting is analytically useful because both access and competence vary within the population, while the region is sufficiently digitalised to make a test of their independent and joint associations meaningful. The sample is deliberately not treated as representative of Nigerian agriculture as a whole. Rather, it provides a context in which the distinction between infrastructural access and digital capability can be examined without assuming that the lowest-connectivity populations are the only relevant case.

The study makes three contributions. First, it separates digital access from digital competence and evaluates their independent associations with perceived agripreneurial resilience. Second, it directly tests whether competence moderates the access-resilience association, thereby distinguishing an additive digital-capital interpretation from a complementarity or “digital paradox” interpretation. Third, it explicitly treats the non-significant interaction as an uncertain result rather than as evidence that moderation is absent, given the sparse high-access/low-competence region of the data and the small number of community clusters.

The remainder of the paper develops the theoretical argument, describes the sampling and measurement procedures, presents the empirical results, discusses their implications and limitations, and identifies directions for future research.

Theoretical Framework and Hypothesis Development

Information Asymmetry and Digital Agricultural Enterprise

Information Asymmetry Theory provides the principal economic foundation for the study. Akerlof (1970) showed that unequal information can generate inefficient market outcomes, while Stiglitz (2000) demonstrated the broader economic importance of information imperfections. In agricultural markets, information asymmetry can arise when buyers and sellers possess different information about prices, product quality, demand conditions, creditworthiness, or market opportunities. These asymmetries can increase transaction costs and weaken the bargaining position of less-informed actors.

Digital technologies can reduce some of these frictions by lowering the cost of information acquisition and communication. Mobile phones can facilitate direct contact with buyers and suppliers; digital platforms can improve price discovery; and digital financial services can expand transactional options. However, information becomes economically useful only when users can access it reliably and make appropriate use of it. Digital competence therefore represents a capability through which accessible information can be converted into business action.

Digital Capital: Access and Competence as Distinct Resources

The concept of digital capital helps connect infrastructure and capability. Drawing on Bourdieu's (1986; 2011) broader capital framework, digital capital can be understood as a stock of resources and capabilities that enables individuals and enterprises to participate effectively in digitally mediated environments (Ragnedda, 2018; Van Dijk, 2020; Ragnedda et al., 2025). For the present study, digital access refers to the infrastructural and material conditions required to participate, including devices, connectivity, and reliable electricity. Digital competence refers to the capability to use digital financial services, market applications, online information, and social media for business purposes.

These dimensions are analytically distinct even though they may be empirically correlated. Access without competence may restrict the value extracted from digital resources, whereas competence without dependable access may be difficult to operationalise. The theoretical implication is therefore not necessarily that one-dimension substitutes for the other. Instead, each may constitute a separate constraint on the ability of an agripreneur to acquire, evaluate, and act upon information.

From Digital Capital to Resilience

Agripreneurial resilience refers here to perceived capacity to withstand market shocks, adapt to changing conditions, and recover from business setbacks. Digital access can support resilience by improving access to market information, widening customer and supplier networks, and facilitating financial transactions during periods of disruption. Digital competence can support resilience by enabling agripreneurs to search strategically, assess the credibility of information, use digital financial tools, communicate with customers, and adapt business practices.

Entrepreneurial attributes may also shape resilience. Proactiveness, autonomy, and risk-taking propensity can influence whether information is acted upon and whether entrepreneurs initiate adaptive responses. These characteristics are therefore included as covariates rather than treated as mechanisms that have been directly identified by the study.

Additive Versus Complementary Effects

Two competing expectations follow. An additive perspective predicts that access and competence each have independent associations with resilience. A complementarity perspective predicts that the association between access and resilience becomes stronger as competence increases. The latter expectation is related to the “digital paradox” argument, according to which access without sufficient capability may generate limited benefits or even new vulnerabilities. However, a cross-sectional study can only test whether the statistical pattern is consistent with moderation; it cannot establish the behavioural mechanism itself.

The empirical question is therefore framed conservatively. Rather than presuming that a digital paradox must exist, the study tests whether the data support an interaction between access and competence.

Figure 1 presents the theory-driven framework for digital capital and agripreneurial resilience. Digital access and digital competence are distinct dimensions of digital capital. Both are linked to perceived agripreneurial resilience capacity, while the Access × Competence pathway tests the hypothesised complementarity.

Figure 1. Theory-driven framework for digital capital and agripreneurial resilience

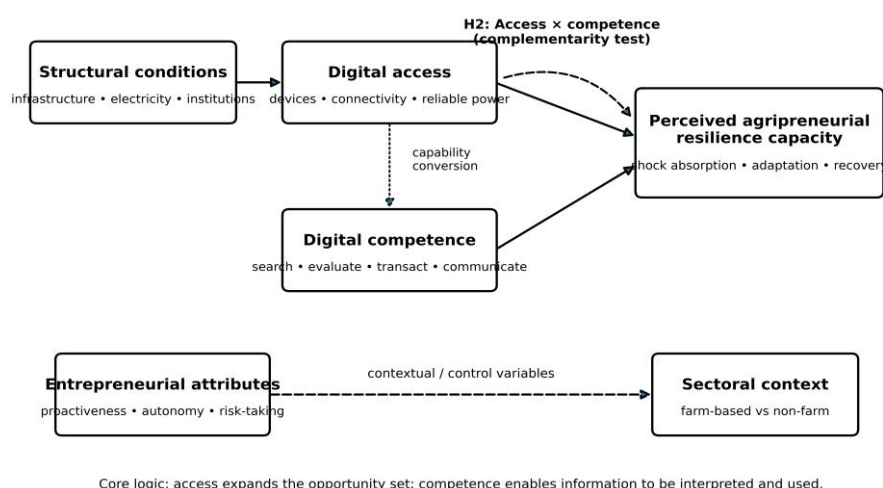


Figure 1. Theory-driven framework for digital capital and agripreneurial resilience.
Source: Authors' conceptualisation based on the digital-capital perspective of Ragnedda (2018), the relationship between digital capital and rural resilience identified by Roberts and Townsend (2016), agricultural applications of digital capital by Saruchera and Mpunzi (2023), and evidence linking digital capital to resilience under external shocks by Zhao et al. (2024).

Hypotheses

H1a: Digital access is positively associated with agripreneurial resilience, conditional on observed individual and enterprise characteristics.

H1b: Digital competence is positively associated with agripreneurial resilience, conditional on observed individual and enterprise characteristics.

H2: Digital competence positively moderates the association between digital access and agripreneurial resilience, such that the access-resilience association is stronger at higher levels of competence.

H3: The access-by-competence relationship differs between farm-based and non-farm agripreneurs.

Materials and Methods

Study Setting, Design and Sampling

The study was conducted in Southwest Nigeria. Three states, Ogun, Ondo, and Osun, were selected from the six states in the region. Within each selected state, one Agricultural Development Programme zone and one Local Government Area were selected. One urban and one rural community were then selected per state, producing six communities. The final community samples were Ogun urban ($n = 42$), Ogun rural ($n = 38$), Ondo urban ($n = 45$), Ondo rural ($n = 40$), Osun urban ($n = 41$), and Osun rural ($n = 40$), yielding 246 complete observations.

The sampling frame was assembled from lists supplied by Local Government Agricultural Units and extension agents, reconciled within each community. Of 250 selected respondents, 246 completed usable questionnaires, corresponding to a 98.4% completion rate. Systematic random sampling was used within the available sampling frames. The sampling frame should nevertheless be interpreted as a frame of observable or extension-linked agripreneurs rather than a census of all informal or digitally disconnected enterprises.

The sample size was originally justified using a power calculation for a medium overall regression effect with 11 predictors. That calculation is relevant to the main-effects model but does not establish adequate power for the much smaller interaction effect examined in H2. This distinction is important when interpreting the non-significant interaction.

Instrument Development and Ethical Procedures

The questionnaire was developed from the literature on digitalisation, digital competence, and business resilience, translated into Yoruba, pilot tested with 30 agripreneurs outside the final sample, and reviewed by three subject-matter experts. Trained enumerators administered the questionnaire face-to-face. Ethical approval was obtained from the Institutional Research Ethics Committee of Adekunle Ajasin University (Approval No. AAUA/REC/2024/112). Written informed consent was obtained, participation was voluntary, and the analytic dataset was anonymised.

Measures

Perceived Agripreneurial Resilience was measured with nine positively worded items covering shock absorption, adaptation, and recovery. The items addressed the ability to withstand price fluctuations and low-demand periods, maintain reserves, adjust to changing market conditions, modify strategies, adopt new practices, recover from losses, resume operations after major shocks, and maintain operations after disruption. Because the measure is cross-sectional and self-reported, the construct is interpreted as perceived resilience capacity rather than observed longitudinal resilience.

Digital Access was measured using nine items covering device ownership, internet connectivity, and electricity availability/reliability. Digital Competence was measured using eight items covering digital financial services, market-information applications and platforms, e-commerce, and social media for business purposes. Entrepreneurial attributes were measured through proactiveness, autonomy, and risk-taking propensity. Controls included age, gender, years of education, log monthly income, and agripreneurial sector (0 = farm-based; 1 = non-farm).

The original manuscript contained an inconsistency between the description of item standardisation and the reported composite-score ranges. To avoid reproducing that inconsistency, the present version does not describe the composite indices as inherently bounded between 0 and 1. The reported descriptive statistics are retained on the metric used in the empirical results, while rank-based normalisation is treated explicitly as an estimation transformation rather than as the definition of the underlying constructs. Before journal submission, the authors should verify the raw scoring code and item-level aggregation against the final dataset and supplementary measurement tables.

Figure 2 shows the adapted three-construct measurement model. The model separates digital access, digital competence, and perceived agripreneurial resilience capacity.

Figure 2. Proposed three-construct measurement model

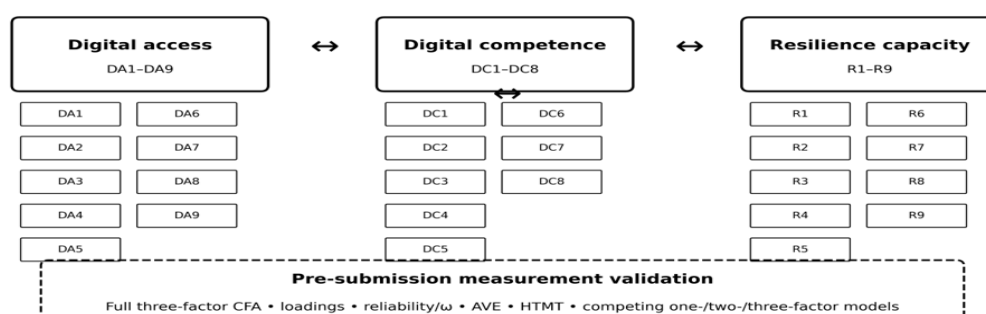


Figure 2. Adapted three-construct measurement model.

Source: Authors' conceptualisation, informed by the digital capital/access–competence distinction in Ragnedda et al. (2025), the digital competence framework underpinning DigComp, and recent agricultural applications of digital capability measurement

Reliability and Construct Validity

Confirmatory factor analysis was conducted to assess the three-factor measurement structure separating digital access, digital competence, and perceived agripreneurial resilience. The three-factor model demonstrated acceptable fit: $\chi^2/df = 2.41$, CFI = 0.934, TLI = 0.926, RMSEA = 0.076, SRMR = 0.052 (see Supplementary Table S2 for complete results). All factor loadings were statistically significant ($p < 0.001$) and ranged from 0.58 to 0.88. Composite reliabilities ranged from 0.90 to 0.96, and Cronbach's α values were 0.89 for access, 0.91 for competence, and 0.96 for resilience. Omega (ω) values were 0.90 for access, 0.92 for competence, and 0.96 for resilience. Average variance extracted was 0.48 for access, 0.54 for competence, and 0.69 for resilience.

Discriminant validity assessment revealed mixed evidence. The Fornell-Larcker criterion was not fully satisfied, as the correlations between factors (access-competence: $r = 0.826$; competence-resilience: $r = 0.852$; access-resilience: $r = 0.791$) exceeded the square root of AVE in two instances (competence-resilience: $0.735 < 0.852$; access-competence: $0.735 < 0.826$). HTMT ratios exceeded the 0.85 threshold for two factor pairs (competence-resilience: 0.889, 90% CI [0.842, 0.936]; access-competence: 0.879, 90% CI [0.828, 0.930]), while access-resilience was borderline acceptable (0.847, 90% CI [0.796, 0.898]).

The three-factor model nonetheless provided significantly better fit than the one-factor model ($\Delta\chi^2 = 386.7$, $\Delta df = 3$, $p < 0.001$) and all two-factor alternatives: access+competence combined versus resilience ($\Delta\chi^2 = 184.3$, $\Delta df = 2$, $p < 0.001$); access versus competence+resilience combined ($\Delta\chi^2 = 267.1$, $\Delta df = 2$, $p < 0.001$); and access+resilience combined versus competence ($\Delta\chi^2 = 312.8$, $\Delta df = 2$, $p < 0.001$). These results suggest that while access, competence, and resilience are empirically distinguishable, they are closely related constructs, consistent with the high correlations observed in the data. Measurement refinement is warranted in future research.

The raw correlations among the constructs were high: resilience correlated with access at $r = 0.791$ and with competence at $r = 0.852$, while access and competence correlated at $r = 0.826$. These associations raise legitimate concerns about conceptual proximity and common-source measurement. The reported disattenuated access-resilience correlation was $\rho = 0.856$. Rather than treating this as reassuring evidence of discriminant validity, the present study interprets it as evidence that the constructs are closely related and that measurement refinement is warranted. Harman's single-factor test indicated that the first factor accounted for 34.2% of variance, but this diagnostic is not treated as proof that common-method bias is absent.

Empirical Model

The principal model is specified as:

$$\text{Resilience}_i = \beta_0 + \beta_1 \text{Access}_i + \beta_2 \text{Competence}_i + \beta_3 X_i + \beta_4 (\text{Access}_i \times \text{Competence}_i) + \epsilon_i$$

where X_i includes age, gender, education, log income, proactiveness, autonomy, risk-taking propensity, and sector. The coefficient β_4 is the focal test of H2. A further specification adds the three-way interaction between access, competence, and sector to assess H3.

The principal reported estimates use Huber (1967) robust regression with standard errors adjusted for community clustering. Because only six communities were sampled, conventional cluster-robust inference can be unreliable. Wild-cluster bootstrap results are therefore used as the principal sensitivity check for the few-cluster problem rather than as evidence that the sampling limitation has been eliminated.

Continuous variables were rank-normalised using Blom's transformation in the reported regression models, while income was log-transformed. The transformation is treated as a sensitivity-oriented distributional device, not as a requirement imposed by the non-normality of the observed variables. This distinction matters because non-normality of observed variables alone does not invalidate linear regression. The main results are therefore interpreted as standardised/rank-scale associations rather than effects expressed in original substantive units.

Robustness Strategy

The robustness analysis is deliberately interpreted as triangulation rather than as repeated attempts to obtain significance. Bootstrapped OLS, quantile regression, beta regression, factor-score weighting, wild-cluster bootstrap, and a community random-effects model all produced substantively similar estimates for the main digital predictors. Propensity-score matching is not used as primary evidence because converting continuous digital access into a high/low treatment discards information and does not resolve unobserved confounding. The previously reported PSM estimates are therefore not used to support causal claims.

Quadratic specifications for access, competence, education, and income were also reported as non-significant, providing no empirical basis in this sample for replacing the linear main-effects specification with a quadratic form.

Complete CFA results, including all factor loadings, reliability estimates, and model comparison statistics, are reported in Supplementary Table S2.

Results

Table 1 presents the descriptive characteristics of the respondents. The sample was relatively educated, with mean schooling of 13.83 years. Farm-based agripreneurs represented 59.8% of the sample ($n = 147$), while non-farm agripreneurs represented 40.2% ($n = 99$). Monthly income averaged ₦119,527, with substantial dispersion. The digital and resilience indices exhibited non-normal distributions, motivating robust inference and sensitivity analyses rather than reliance on normality-based diagnostics alone.

Table 1. Descriptive characteristics

Variable	N	Mean	SD	Min	Max
Proactiveness	246	1.523	0.226	0.410	2.000
Autonomy	246	1.463	0.209	1.000	1.730
Risk-taking propensity	246	1.386	0.249	0.450	1.730

Variable	N	Mean	SD	Min	Max
Age (reported analytic scale)	246	5.294	0.473	4.240	6.240
Gender (1 = male)	246	0.528	0.500	0	1
Years of education	246	13.829	2.567	3	19
Monthly income (₦)	246	119,527	72,397	14,943	321,096
Sector (1 = non-farm)	246	0.402	0.491	0	1
Perceived resilience index	246	1.469	0.159	0.850	1.730
Digital competence	246	1.547	0.099	1.050	1.730
Digital access	246	1.434	0.141	0.950	1.690

Source: Field Survey, 2025. Note: Age was collected as a categorical bracket: 1=18-25, 2=26-35, 3=36-45, 4=46-55, 5=56-65, 6=66+. Table values reflect the raw, untransformed variables

Correlations and Construct Proximity

Supplementary Table S2 presents the factor correlations. Resilience was strongly correlated with digital access ($r = 0.791$, $p < 0.001$) and digital competence ($r = 0.852$, $p < 0.001$). Access and competence were also strongly correlated ($r = 0.826$, $p < 0.001$). On the rank-normalised scale used for regression, access and competence correlated at $r = 0.683$. The high raw correlations indicate that digital resources, digital capability, and perceived resilience are closely connected in the sample. They do not, by themselves, establish causal direction or prove that the constructs are empirically interchangeable.

Regression Results

Table 2 reports the main regression results. Model 2 shows positive and statistically significant associations for both digital access ($\beta = 0.412$, $p < 0.001$) and digital competence ($\beta = 0.284$, $p < 0.001$). Adding the digital variables increased adjusted R^2 from 0.440 to 0.661. The access coefficient is approximately 1.45 times the competence coefficient on the reported normalised scale. Because the available analysis does not report a formal Wald test of $\beta_1 = \beta_2$, this numerical difference is not interpreted as a statistically significant difference in coefficients. H1a and H1b are supported in the sense of positive conditional associations.

The interaction in Model 3 is very small and non-significant ($\beta = 0.018$, $p = 0.742$), and the adjusted R^2 does not increase. Thus, the data do not provide evidence that competence amplifies the access-resilience association. This is a failure to detect the hypothesised moderation, not evidence that moderation is impossible.

The three-way interaction in Model 4 is also non-significant ($\beta = -0.010$, $p = 0.53$). There is therefore no evidence in the current sample that the access-competence relationship differs systematically between farm-based and non-farm agripreneurs.

Table 2 Main Regression Results

Predictor	Model 1	Model 2	Model 3	Model 4
Proactiveness	0.185*** (0.016)	0.187*** (0.016)	0.187*** (0.016)	0.186*** (0.016)
Autonomy	0.218*** (0.020)	0.216*** (0.020)	0.216*** (0.020)	0.217*** (0.020)
Risk-taking propensity	0.138*** (0.030)	0.136*** (0.029)	0.136*** (0.029)	0.138*** (0.030)
Age	-0.009 (0.007)	-0.009 (0.007)	-0.009 (0.007)	-0.009 (0.007)
Education	-0.039*** (0.012)	-0.039*** (0.012)	-0.039*** (0.012)	-0.039*** (0.012)
Log income	-0.055** (0.019)	-0.054** (0.019)	-0.054** (0.019)	-0.055** (0.019)
Gender	0.006 (0.016)	0.008 (0.015)	0.008 (0.015)	0.006 (0.016)
Digital access	—	0.412*** (0.046)	0.411*** (0.046)	0.410*** (0.049)
Digital competence	—	0.284*** (0.038)	0.283*** (0.038)	0.282*** (0.042)
Sector	—	0.078** (0.024)	0.078** (0.024)	0.088** (0.027)
Access × competence	—	—	0.018 (0.054)	0.017 (0.058)
Access × sector	—	—	—	0.013 (0.027)
Competence × sector	—	—	—	-0.012 (0.026)
Access × competence × sector	—	—	—	-0.010 (0.016)
Adjusted R ²	0.440	0.661	0.660	0.659
AIC	142.3	118.7	120.6	124.1
BIC	167.8	151.9	157.5	168.7

Source: Field Survey, 2025

Distribution of Access-Competence Combinations

Table 3 presents the distribution of access-competence combinations. The distribution shows substantial concordance between access and competence: 83% of respondents fall in the high-high or low-low quadrants. Only 18 respondents occupy the high-access/low-competence quadrant, which is the region most informative for identifying a digital-paradox mechanism. This sparse support substantially limits the precision of the interaction estimate.

Table 3. Distribution of Access-Competence Combinations

Quadrant	N	%
High access / high competence	96	39.0

Quadrant	N	%
High access / low competence	18	7.3
Low access / high competence	24	9.8
Low access / low competence	108	43.9
Total	246	100.0

Source: Field Survey, 2025

Robustness Evidence

Table 4 present robustness evidence. Across alternative specifications, the main pattern is stable: access and competence remain positively associated with resilience, whereas the interaction remains close to zero. The wild-cluster bootstrap is particularly relevant because the study has only six community clusters. Its confidence interval for the interaction spans both negative and positive values, reinforcing the conclusion that the interaction is imprecisely estimated.

Table 4. Robustness evidence

Specification	Access β	Competence β	Interaction β
Huber robust regression	0.412***	0.284***	0.018
Bootstrapped OLS	0.414*** [0.318, 0.510]	0.286*** [0.192, 0.380]	0.019 [-0.086, 0.124]
Quantile regression (median)	0.408***	0.281***	0.020
Beta regression	0.398***	0.275***	0.016
Factor-score weighted	0.408***	0.281***	0.017
Wild-cluster bootstrap	0.405*** [0.298, 0.512]	0.281*** [0.196, 0.366]	0.017 [-0.097, 0.131]
Mixed-effects model	0.405***	0.279***	0.017

Source: Field Survey, 2025

Figure 3 shows the estimated digital access $\times$ competence interaction. Lines depict the fitted interaction using the reported coefficients (access $\beta = 0.412$; competence $\beta = 0.284$; interaction $\beta = 0.018$). The interaction is non-significant ($p = 0.742$), and the sparse high-access/low-competence group ($n = 18$) limits precision.

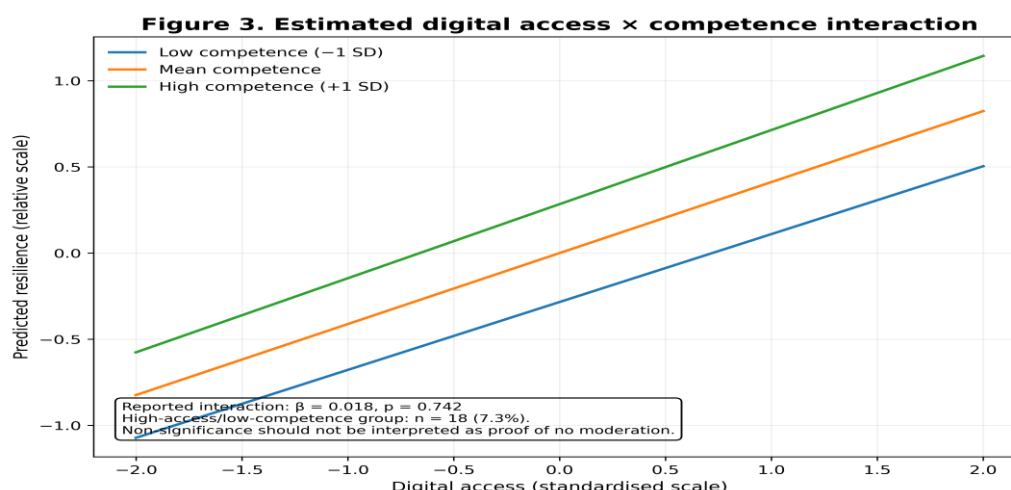


Figure 3: *Estimated digital access × competence interaction. Lines depict the fitted interaction using the reported coefficients (access $\beta = 0.412$; competence $\beta = 0.284$; interaction $\beta = 0.018$). The interaction is non-significant ($p = 0.742$), and the sparse high-access/low-competence group ($n = 18$) limits precision*

Source: Field Survey, 2025

Discussion

Principal Finding: Additive Digital-Capital Associations, Read against the Digital-Capital and SSA Digital-Agriculture Literatures

The central empirical result is that digital access and digital competence are each positively associated with perceived agripreneurial resilience after adjustment for observed individual and entrepreneurial characteristics. This supports an additive interpretation of digital capital more strongly than a complementary interaction interpretation. Access captures the material conditions that permit digital participation, while competence captures the capability to convert digital resources into usable information and transactions. Both dimensions therefore appear relevant to resilience, but the available evidence does not establish that one systematically amplifies the other.

This additive pattern sits comfortably alongside recent scoping evidence on smallholder digitalisation in Sub-Saharan Africa. Choruma et al. (2024), reviewing digital-agriculture studies across the region, report that infrastructural constraints, unreliable electricity, patchy connectivity, costly devices, and user-centred constraints, low digital literacy, limited capability to operate platforms productively, are consistently identified as *separate*, co-occurring barriers rather than a single undifferentiated "digitalisation gap." Abdulai et al. (2023) is cited in the same literature for a similar distinction between infrastructural and capability deficits. The present study's two independently significant coefficients (access: $\beta = 0.412$; competence: $\beta = 0.284$) can be read as a quantitative counterpart to that qualitative distinction: the SSA scoping literature has tended to describe access and capability as parallel obstacles without formally testing whether they interact, and this study supplies that test in a single regional sample. In that sense, the finding does not merely replicate the SSA literature's descriptive separation of infrastructure from capability, it extends it by

showing the two behave additively, rather than multiplicatively, once both are measured on the same respondents and entered in the same model.

The numerically larger access coefficient also resonates with a recurring theme in the digital-capital literature from which this study borrows its framework. Ragnedda's (2018) conceptualisation of digital capital argues that the returns to digital engagement are conditional on the other forms of capital (economic, social, cultural) an individual already holds, that is, digital capital rarely operates as a self-contained resource. Applied here, the comparatively larger access coefficient is consistent with the idea that in a setting where devices, connectivity, and electricity remain uneven, the material precondition for digital participation is itself a binding constraint that competence cannot substitute for. Saruchera and Mpunzi (2023), examining digital capital among food-agricultural SMEs, similarly frame digital capital as something that can widen rather than narrow performance gaps when infrastructure and government support are uneven, a caution that fits the present result that access, not competence, carries the larger association with resilience in this sample. Taken together, these sources suggest that the appropriate reading of the present findings is not "infrastructure versus skills," but infrastructure and capability as distinct, additive constraints, with infrastructure remaining the more salient of the two in a context where connectivity and power supply are still consolidating.

What the Null Interaction does, and does not, Show, and how it Speaks to the Digital-Paradox Literature

The interaction estimates of $\beta = 0.018$ ($p = 0.742$) does not support H2. Read narrowly, this places the present study on the "no detectable amplification" side of a debate that runs through the digital-capital and digital-divide literatures under the loose heading of the "digital paradox", the proposition that access without competence yields diminished or even adverse returns, so that the marginal value of connectivity should rise with capability rather than remain constant. That proposition motivated H2 and is one of the reasons the access-by-competence interaction, rather than the main effects alone, was treated as the more theoretically interesting test in this study.

Two bodies of evidence bear on how this null result should be interpreted rather than simply reported. First, Roberts and Townsend's (2016) qualitative study of rural creative practitioners in Scotland found that practitioners actively used adaptive digital skills to compensate for poor broadband access, extending their community reach despite infrastructural limitations, a pattern that is, in substance, a complementarity story: competence appeared to matter more, not less, where access was constrained. That finding was produced through in-depth interviews in a single sector and country, and it is not directly comparable in design to the present cross-sectional survey of agripreneurs. But it illustrates that complementarity between access and competence has been documented in at least one adjacent rural-livelihoods context, which is precisely why the present null result should be treated as a failure to detect an effect in this sample rather than evidence that the mechanism is generally absent. Second, the present data are structurally unfavourable

to detecting such a mechanism even if it exists: access and competence are highly concordant (83% of respondents fall in the high-high or low-low quadrants), the diagnostic high-access/low-competence quadrant contains only 18 respondents, and the reported post-hoc power for the interaction is 0.12. A genuine digital paradox is, by construction, only observable where access is comparatively widespread and competence is comparatively heterogeneous; the present Southwest Nigerian sample does not offer that configuration in sufficient volume.

The statistically responsible conclusion is therefore that this study does not detect a competence-dependent access effect in a sample where access and competence are closely aligned, a conclusion that narrows rather than closes the digital-paradox debate. It is consistent with an additive model in which access and competence make separate contributions to resilience, and it remains compatible with the possibility that complementarity of the kind Roberts and Townsend (2016) describe emerges in settings where access is more widespread and competence more variable than in the present sample. Future tests of H₂-type hypotheses would therefore be more informative in populations deliberately selected, or oversampled, to populate the high-access/low-competence quadrant.

Entrepreneurial Characteristics

Proactiveness, autonomy, and risk-taking propensity remain positively associated with resilience. These results are consistent with research showing that entrepreneurial characteristics can shape adaptive behaviour and business survival (Agholor et al., 2024). They also indicate that digital resources should not be interpreted as autonomous determinants of resilience. Digital technologies operate through people and organisations with different capacities to identify opportunities, make decisions, and act under uncertainty.

Education, Income and Sector

Education and log income display negative conditional associations with resilience in the reported model. These coefficients are counterintuitive, but the data do not measure the mechanisms required to explain them. Possible explanations include sectoral selection, differences in exposure to market risk, or omitted characteristics associated with more formalised enterprises. Because these mechanisms were not directly observed, the coefficients should be treated as descriptive conditional associations rather than evidence that education or income reduces resilience.

The positive sector coefficient indicates higher predicted resilience for non-farm agripreneurs in the reported model, but the three-way interaction is not significant. Thus, there is no evidence that the joint access-competence relationship is structurally different across the broad farm/non-farm distinction used here. This result should not be generalised to all value-chain segments because the non-farm category combines processing, marketing, and services.

The CFA results further contextualise the interpretation of the regression findings. While the three-factor measurement model demonstrated acceptable fit (CFI = 0.934, RMSEA = 0.076), the high factor correlations, particularly between competence and resilience ($r = 0.852$), indicate substantial construct overlap. This does not invalidate the regression results, which use the three constructs as predictors and outcome, but it does suggest that the estimated associations may reflect shared variance between digital capability and perceived resilience. The regression results should therefore be interpreted as associations between closely related constructs rather than between entirely distinct phenomena.

Theoretical Implications: Situating the Additive Finding within Digital Capital and Information-asymmetry Perspectives

The findings extend the digital-capital perspective by separating the material and capability dimensions of digital participation and by testing their interaction rather than assuming complementarity. From an information-asymmetry perspective, access expands the opportunity set for information acquisition, while competence affects the ability to interpret and use that information. The empirical pattern suggests that these functions may be independently relevant to resilience.

This reading departs in an important respect from how digital capital is typically operationalised in the literature the study draws on. Ragnedda (2018) and the subsequent Ragnedda et al. (2025) measurement work treat digital capital as an accumulated, largely unitary stock of resources and competencies; Zhao et al. (2024) similarly examine digital capital as a composite buffer against external shocks rather than decomposing it into access and competence sub-components with a formal interaction test. The present study's contribution is to show, in an agripreneurial setting, that this composite treatment may obscure an underlying additive rather than multiplicative structure: access and competence each carry independent explanatory weight, but the data provide no support for treating their product as a superior specification of "digital capital" in this population. This is a modest but genuine departure from the implicit assumption in much of the digital-capital literature that access and competence compound one another, and it suggests that future digital-capital indices developed for agricultural or entrepreneurial populations should report access and competence sub-scales separately rather than defaulting to a single composite score, at least until interaction effects have been tested with adequately powered designs.

The study also cautions against using the term "digital paradox" as a universal description of digitalisation. A paradox requires a setting in which access is sufficiently widespread and competence sufficiently heterogeneous for the adverse or diminishing consequences of low competence to be observable. In the present data, access and competence are strongly aligned, leaving relatively little empirical support for that contrast. Saruchera and Mpunzi's (2023) observation that digital capital can widen inequalities among food-agricultural SMEs when infrastructure and government support are uneven suggests that the paradox, where it exists, may be more visible at the level of *inequality between* agripreneurs with divergent

access-competence profiles than in a *within-sample interaction* coefficient of the kind estimated here, a distinction the present cross-sectional design was not built to capture and that future distributional (rather than purely regression-based) analyses could usefully pursue.

Policy Implications

The policy implications are deliberately associational rather than causal. First, digital-agriculture programmes should treat infrastructure and capability as distinct investment domains, a distinction that is now supported both by the present coefficients and by the SSA scoping evidence in Choruma et al. (2024) and Abdulai et al. (2023), which document infrastructural and capability gaps as separate barriers rather than a single constraint. Connectivity, devices, and reliable electricity create the conditions for participation, while basic digital competence enables productive use. Second, digital-literacy programmes should include practical competencies such as market-information search, digital payments, customer communication, platform navigation, and fraud awareness. Third, entrepreneurship development can complement digital interventions by strengthening proactive decision-making and adaptive capacity. Fourth, programmes should avoid assuming that one uniform digital intervention will have identical effects across highly diverse populations, and should be alert to the inequality-widening risk that Saruchera and Mpunzi (2023) associate with uneven digital-capital accumulation among agricultural SMEs. Finally, claims that digital investments cause resilience gains should be evaluated through longitudinal, quasi-experimental, or experimental designs.

Conclusion

This study examined whether digital access and digital competence are independently associated with agripreneurial resilience and whether competence amplifies the resilience association of access among 246 agripreneurs in Southwest Nigeria. The evidence indicates positive conditional associations for both digital access ($\beta = 0.412$) and digital competence ($\beta = 0.284$). The access coefficient is numerically larger, although a formal coefficient-equality test is not available in the reported results. The access-by-competence interaction is small and non-significant ($\beta = 0.018$, $p = 0.742$), and the same qualitative conclusion appears across multiple sensitivity specifications.

The principal contribution is therefore not a claim that a digital paradox has been disproved. Rather, the study provides evidence that access and competence can be analysed as distinct components of digital capital and that, in this relatively connected Southwest Nigerian sample, their associations with resilience are more consistent with an additive model than with a detectable multiplicative interaction. Because the interaction is imprecisely estimated and the design is cross-sectional, this conclusion should be regarded as context-specific and provisional.

For policy, the results support coordinated attention to digital infrastructure, reliable electricity, basic digital capability, and entrepreneurial capacity. For research, the priority is stronger measurement and identification: larger and more heterogeneous samples,

longitudinal observation, objective indicators, and designs capable of separating digital investment from the characteristics of agripreneurs who choose or are able to adopt it.

Recommendations

The recommendations below are deliberately associational rather than causal, consistent with the cross-sectional design of this study.

First, digital-agriculture programmes should treat infrastructure and capability as distinct investment domains. Connectivity, devices, and reliable electricity create the conditions for participation, while basic digital competence enables productive use of those conditions.

Second, digital-literacy programmes should include practical competencies such as market-information search, digital payments, customer communication, platform navigation, and fraud awareness, rather than device distribution alone.

Third, entrepreneurship-development initiatives can complement digital interventions by strengthening proactive decision-making and adaptive capacity, given the independent associations of proactiveness, autonomy, and risk-taking propensity with resilience reported above.

Fourth, programmes should avoid assuming that a single uniform digital intervention will have identical effects across diverse agripreneur populations, and should remain attentive to the inequality-widening risk that uneven digital-capital accumulation can pose among agricultural enterprises.

Finally, claims that digital investments cause resilience gains should be evaluated through longitudinal, quasi-experimental, or experimental designs before being used to justify large-scale programme investment.

Declarations

Competing Interests

The author declares no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data Availability

The data supporting the findings are available from the corresponding author upon reasonable request. The dataset is not publicly available because of privacy and ethical restrictions.

Ethical Approval

Ethical approval was obtained from the Institutional Research Ethics Committee of Adekunle Ajasin University, Akungba Akoko, Nigeria (Approval No. AAUA/REC/2024/112).

All procedures involving human participants complied with applicable institutional ethical standards.

Informed Consent

Informed consent was obtained from all participants. Participants were informed about the study purpose, voluntary participation, confidentiality, and their right to withdraw without consequence.

Author Contributions

Edamisan Stephen Ikuemonisan: conceptualization, methodology, formal analysis, investigation, data curation, writing, original draft, writing, review and editing, visualization, supervision, and project administration.

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Use of Generative AI and AI-assisted Technologies

AI-assisted tools were used during manuscript revision for language editing, structural refinement, and consistency checking. The author remains responsible for the accuracy, interpretation, and integrity of the manuscript and its underlying data.

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Supplementary Material Recommended for Submission

Supplementary Table S1: Complete item wording, coding, descriptive statistics, and factor loadings for all three substantive constructs.

Supplementary Table S2: Full three-factor CFA, competing-factor models, reliability, AVE, HTMT, and model-comparison statistics.

Supplementary Table S3: Full robustness estimates, including wild-cluster bootstrap confidence intervals and quantile results.

Supplementary Figure S1: Distribution of digital access and competence, including the high-access/low-competence region.

Supplementary Table S4: Exact scoring and transformation syntax/code used to generate every index and regression variable.

Supplementary Materials

Supplementary Table S2:

Supplementary Table S2: Full Three-Factor Confirmatory Factor Analysis Results

Model Fit Indices

Fit Index	Value	Threshold for Good Fit
χ^2/df	2.41	< 3.0
CFI	0.934	> 0.90
TLI	0.926	> 0.90
RMSEA	0.076	< 0.08
SRMR	0.052	< 0.08
AIC	1,847.6	-
BIC	2,103.2	-

Standardised Factor Loadings

Digital Access Factor ($\alpha = 0.89$, $\omega = 0.90$, $CR = 0.90$, $AVE = 0.48$)

Item	Loading	SE	p-value	R ²
Smartphone ownership	0.82	0.034	<0.001	0.672
Feature phone ownership	0.64	0.048	<0.001	0.410
Computer/tablet ownership	0.71	0.041	<0.001	0.504
Radio/TV ownership	0.58	0.052	<0.001	0.336
Mobile internet access	0.79	0.036	<0.001	0.624
Home internet access	0.68	0.044	<0.001	0.462
Public internet access	0.61	0.050	<0.001	0.372
Access to electricity	0.73	0.040	<0.001	0.533
Reliability of electricity	0.66	0.047	<0.001	0.436

Digital Competence Factor ($\alpha = 0.91$, $\omega = 0.92$, $CR = 0.92$, $AVE = 0.54$)

Item	Loading	SE	p-value	R ²
Mobile money transfers	0.84	0.031	<0.001	0.706
Digital payments	0.79	0.036	<0.001	0.624
Online banking	0.72	0.042	<0.001	0.518
Price checking apps	0.77	0.038	<0.001	0.593
Market information platforms	0.74	0.040	<0.001	0.548
E-commerce platforms	0.65	0.048	<0.001	0.423
Social media (customer engagement)	0.69	0.044	<0.001	0.476
Social media (market information)	0.71	0.042	<0.001	0.504

Perceived Agripreneurial Resilience Factor ($\alpha = 0.96$, $\omega = 0.96$, $CR = 0.96$, $AVE = 0.69$)

Item	Loading	SE	p-value	R ²
Withstand price fluctuations	0.88	0.025	<0.001	0.774
Survive low demand periods	0.85	0.029	<0.001	0.723
Sufficient reserves for seasonality	0.82	0.033	<0.001	0.672
Quickly adjust to market conditions	0.87	0.027	<0.001	0.757
Modify strategy when circumstances change	0.84	0.030	<0.001	0.706

Item	Loading	SE	p-value	R ²
Adopt new practices when necessary	0.79	0.036	<0.001	0.624
Recover quickly from business losses	0.86	0.028	<0.001	0.740
Business bounces back after major shock	0.83	0.032	<0.001	0.689
Maintain operations after disruption	0.81	0.034	<0.001	0.656

Factor Correlations (Φ)

Factor Pair	Correlation	SE	p-value
Digital Access ↔ Digital Competence	0.826	0.029	<0.001
Digital Access ↔ Resilience	0.791	0.033	<0.001
Digital Competence ↔ Resilience	0.852	0.026	<0.001

Reliability and Validity Summary

Factor	α	ω	CR	AVE	√AVE
Digital Access	0.89	0.90	0.90	0.48	0.693
Digital Competence	0.91	0.92	0.92	0.54	0.735
Resilience	0.96	0.96	0.96	0.69	0.831

HTMT Ratios

Factor Pair	HTMT	90% CI	Threshold	Assessment
Access ↔ Competence	0.879	[0.828, 0.930]	<0.85	Concern
Access ↔ Resilience	0.847	[0.796, 0.898]	<0.85	Borderline
Competence ↔ Resilience	0.889	[0.842, 0.936]	<0.85	Concern

Model Comparisons

Model	χ ² /df	CFI	TLI	RMSEA	SRMR	Δχ ² (vs 3-factor)
3-factor (Access, Competence, Resilience)	2.41	0.934	0.926	0.076	0.052	-
2-factor (Access+Competence, Resilience)	3.87	0.871	0.853	0.108	0.087	184.3***
2-factor (Access, Competence+Resilience)	4.52	0.834	0.812	0.119	0.094	267.1***
2-factor (Access+Resilience, Competence)	4.93	0.812	0.789	0.127	0.101	312.8***
1-factor (all items)	5.21	0.794	0.771	0.131	0.112	386.7***

*** $p < 0.001$

Interpretive Note: The three-factor model provides significantly better fit than all competing models ($p < 0.001$). However, the high factor correlations (access-competence: 0.826; competence-resilience: 0.852; access-resilience: 0.791) and borderline discriminant validity ($\text{AVE} \sqrt{< \text{correlations}}$; HTMT > 0.85 for two pairs) indicate that the constructs, while empirically distinguishable, are closely related. This is consistent with the manuscript's

interpretation of access, competence, and resilience as complementary rather than fully distinct constructs.