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Research article

Institutional ICT Investment, Global Ranking Performance and Graduate Employability in Nigerian Universities: A Structural Investigation with Moderation Analysis

Inversión institucional en TIC, rendimiento en rankings globales y empleabilidad de los graduados en universidades de Nigeria: una investigación estructural con análisis de moderación

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Abstract

Introduction: This study examines whether institutional ICT investment in Nigerian universities is associated with graduate employability through two pathways: digital competence (human capital theory) and university ranking performance (signalling theory). It also explores the moderating role of institution type. **Methodology:** A quantitative, cross-sectional survey involving 625 participants from twelve Nigerian universities (six public and six private) was conducted. Respondents included postgraduate students, department heads, ICT and quality assurance personnel, and employer representatives. Data were analysed using latent-variable structural equation modelling and moderation analysis. **Results:** ICT investment was positively associated with digital competence (β = .64) and ranking performance (β = .38). Both digital competence (β = .43) and ranking performance (β = .22) were associated with employability. The ICT-to-ranking relationship was stronger in private universities (β = .48) than in public institutions (β = .27). Measurement invariance was established across all five stakeholder groups. **Discussion:** The findings support a dual-pathway model in which digital competence provides a stronger indirect association with employability than institutional rankings, with the human capital pathway outweighing the reputational pathway by approximately three to one. The greater ranking benefits observed in private universities are consistent with diminishing returns logic. **Conclusions:** ICT investment contributes to graduate employability through both digital competence development and institutional reputation. These findings highlight the importance of strategic digital investment adapted to institution type, particularly in resource-constrained higher education systems.

Keywords: Institutional ICT investment; graduate employability; university rankings; Nigeria; structural equation modelling.

Resumen

Introducción: Este estudio examina si la inversión institucional en tecnologías de la información y la comunicación (TIC) en las universidades nigerianas se relaciona con la empleabilidad de los graduados a través de dos vías: la competencia digital (teoría del capital humano) y el posicionamiento en los rankings universitarios (teoría de la señalización). Asimismo, analiza el papel moderador del tipo de institución. **Metodología:** Se realizó un estudio cuantitativo y transversal mediante una encuesta a 625 participantes de doce universidades nigerianas (seis públicas y seis privadas). La muestra incluyó estudiantes de posgrado, directores de departamento, personal de TIC y aseguramiento de la calidad, y representantes de empleadores. Los datos se analizaron mediante modelos de ecuaciones estructurales con variables latentes y análisis de moderación. **Resultados:** La inversión en TIC se asoció positivamente con la competencia digital (β = 0,64) y el posicionamiento universitario (β = 0,38). Ambas variables se relacionaron con la empleabilidad (β = 0,43 y β = 0,22, respectivamente). La relación entre inversión en TIC y posicionamiento fue mayor en las universidades privadas (β = 0,48) que en las públicas (β = 0,27). Se confirmó la invariancia de medida entre los cinco grupos participantes. **Discusión:** Los resultados respaldan un modelo de doble vía en el que la competencia digital presenta una asociación indirecta con la empleabilidad aproximadamente tres veces superior a la del prestigio institucional. Las universidades privadas obtienen mayores beneficios en posicionamiento, en consonancia con la lógica de los rendimientos decrecientes. **Conclusiones:** La inversión en TIC se relaciona con una mayor empleabilidad mediante el desarrollo de competencias digitales y la reputación institucional. Los hallazgos respaldan una inversión digital estratégica adaptada al tipo de institución, especialmente en sistemas universitarios con recursos limitados.

Palabras clave: Inversión institucional en TIC; empleabilidad de graduados; rankings universitarios; Nigeria; modelo de ecuaciones estructurales.

1. Introduction

Global university rankings and graduate employability have become the twin currencies through which universities earn legitimacy, funding, and student enrolment. Digital transformation has been widely prescribed as the route to competitive advantage in global university rankings and graduate employability (Mohamed Hashim et al., 2022a). As such, the consolidation of the "digital institution" is now treated as a precondition for a university's relevance rather than a discretionary enhancement of the system (Alenezi, 2023). Comparable arguments have been advanced across markedly different systems.

A systematic review spanning European and Latin American institutions characterises digital transformation as a strategic, institution-wide reorganisation rather than a technical upgrade (Benavides et al., 2020); evidence from Latin America shows that the reach of digital technologies in universities is limited above all by infrastructure, connectivity, and institutional readiness (Okoye et al., 2023); and the South African experience of the COVID-19 pandemic revealed how uneven digital capacity translates directly into uneven educational opportunity (Mhlanga & Moloi, 2020). Simultaneously, the labour market into which graduates emerge is being reshaped by the very technologies universities are urged to adopt, to the point that employability scholarship now frames its questions against the prospect of technological unemployment (Jung et al., 2024). Institutional ICT investment, therefore, sits at the junction of the two outcomes universities care most about; despite the aforementioned, the scholarship that should guide that investment remains divided into two literatures that rarely communicate.

The first literature operates at the level of the individual learner. Studies link institutional ICT adoption to student academic performance (Basri et al., 2018); digital skills acquisition has been shown to raise the employability prospects Nigerian students perceive for themselves (Joshua & Apuru, 2024). Employer surveys identify information and data literacy, problem-solving, and communication and collaboration as the digital competences most in demand but also most lacking among new graduates (Tee et al., 2024). A systematic review of digital competence research in higher education confirms that such competence is now treated as a core graduate attribute in European, Asian, and Latin American systems alike, although its conceptualisation and measurement remain fragmented (Zhao et al., 2021).

The second literature operates at the institutional level: digital transformation strategy underpins competitiveness and academic advancement (Al-Shamsi, 2024; Mohamed Hashim et al., 2022a, 2022b), and the digital visibility rewarded by ranking systems can be quantified through web-presence indicators (Orduña-Malea, 2013). More recent work shows that citation impact and research volume are among the strongest correlates of position across the principal global rankings (Szluka et al., 2023), and that ICT use is positively associated with the research productivity of lecturers in Nigerian universities (Oyefara et al., 2023). What the literature has not provided is an integrated model in which the same ICT investment simultaneously influences graduate employability through the competence it builds in individuals and the institutional standing it confers.

Three further gaps compound this lacuna. First, existing models lack moderation hypotheses that would specify when and for whom the pathways are stronger or weaker. Nigeria's higher education system is characterised by deep structural asymmetries between public and private universities in infrastructure, funding, and regulatory positioning (Ebiringa et al., 2024); institution type is therefore a theoretically motivated candidate moderator whose effect on the ICT-to-ranking pathway has not been tested.

Second, because ICT investment explains only a modest share of variance in ranking performance (a finding confirmed in the present data, $R^2 = .146$), the theoretical mechanism linking ICT specifically to rankings — distinct from library budgets, faculty qualifications, or historical reputation — requires careful justification beyond generic digital transformation rhetoric. Third, employability research relies overwhelmingly on single-informant, cross-sectional designs with student self-reports, which invite common-source inflation (Podsakoff et al., 2003) and obscure the systematically different understandings that institutions, students, government, and employers hold of the construct (Holmes, 2013; Römgens et al., 2020).

This study addresses these gaps by asking: to what extent is institutional ICT investment associated with university ranking performance and graduate employability in Nigerian universities, and does institution type moderate the ICT-to-ranking pathway? Five subsidiary questions structure the analysis: (RQ1) the association of ICT investment with graduate digital competence; (RQ2) its association with ranking performance; (RQ3) the associations of competence and ranking performance with employability; (RQ4) the mediating roles of competence and ranking performance in the ICT-to-employability relationship; and (RQ5) whether the five stakeholder groups differ in their construct assessments after measurement invariance has been established.

The study makes four distinct contributions: it provides the first integrated multi-stakeholder test of the dual-pathway hypothesis in Nigerian higher education; it advances signalling-theoretic explanation of the ICT-to-ranking mechanism beyond web-presence arguments; it introduces and tests institution type as a theoretically grounded moderator; and it applies full latent-variable structural equation modelling with post-hoc power analysis to strengthen methodological rigour.

1.1. Theoretical Integration

A model running from an institutional resource to an individual labour-market outcome cannot rest on a single theory. The resource-based view (RBV) holds that resources which are valuable, rare, and imperfectly imitable generate sustained competitive advantage (Barney, 1991); an orchestrated bundle of connectivity, learning platforms, digital libraries, and management information systems constitutes precisely such a resource for a university (Mohamed Hashim et al., 2022a, 2022b). RBV explains why institutions invest in ICT and what strategic returns that investment may confer. However, it is an institutional theory and says nothing about how resources translate into individual graduate outcomes.

Human capital theory provides the first transmission mechanism: education raises employment prospects by building productive skills in individuals (Becker, 1964), and in a digitalised labour market, those skills are increasingly digital (Tee et al., 2024). The link from institutional ICT investment to graduate competence is therefore a human capital argument: the institution creates the conditions — platforms, infrastructure, digital curricula — through which students acquire the skills employers value. Human capital theory, in turn, is silent about how employers evaluate candidates before productivity is observable.

Signalling theory addresses this directly: because employers cannot observe graduate productivity at the point of hiring, they screen on observable signals, of which institutional standing is among the most salient (Spence, 1973). Field-experimental evidence from Germany confirms that recruiters respond measurably to the signals conveyed by applicants' credentials when deciding whom to invite to interview (Piopiunik et al., 2020), and global rankings have become one of the most visible institutional signals available to employers and prospective students alike (Hazelkorn & Mihut, 2021).

This corresponds to what Holmes (2013) calls the positional perspective on employability — labour-market outcomes reflect where graduates stand within structures of institutional reputation, not only what skills they possess. The three theories are thus contiguous rather than overlapping: RBV explains the institutional investment decision; human capital theory governs the investment-to-competence-to-employability chain; signalling theory governs the investment-to-standing-to-employability chain. No pair of theories covers the full causal chain without the third, which justifies their joint deployment over any single-theory alternative.

A main theoretical concern in prior work is that the R^2 for ranking performance from ICT investment is modest (here, .146), which has been taken to suggest that ICT's role in rankings is undertheorised. The present study addresses this directly by specifying the mechanism more precisely: ICT investment operates on ranking performance not through a diffuse digital transformation effect but through three concrete, theoretically grounded channels. First, open-access digital repositories and research data platforms are prerequisites for web-presence indicators that feed into ranking metrics (Orduña-Malea, 2013); without the infrastructure to host and disseminate open scholarship, the institution's webometric footprint remains thin regardless of research quality.

Second, information systems that support research productivity — including research management platforms, citation tracking, and postgraduate supervision tools — reduce administrative friction, thereby increasing research throughput and the number of citeable outputs (Mohamed Hashim et al., 2022b; Oyefara et al., 2023). Third, digital visibility platforms amplify the discoverability of existing research outputs, increasing citation counts independently of new output production (Al-Shamsi, 2024; Szluka et al., 2023). These three channels are distinct from library budgets, faculty qualifications, or historical reputation — factors that also drive rankings but operate through separate pathways. The modest R^2 confirms that ICT is one among several ranking determinants, not the dominant one; the theoretical claim is that its contribution is real, specific, and mechanistically distinct, not that it dominates.

The structural asymmetry between public and private Nigerian universities provides the theoretical basis for moderation. Public universities receive recurrent government grants that fund baseline infrastructure regardless of strategic intent; private universities, by contrast, are tuition-dependent and must generate their own capital for ICT investment. This means that, at equivalent levels of ICT spending, private universities are closer to the margin at which incremental investment produces visible output. This diminishing-returns logic predicts a steeper slope between ICT and ranking for private institutions. The moderation hypothesis is therefore not merely a subgroup check but a theoretically motivated proposition about the contingent utility of digital investment under different resource regimes.

H1. Institutional ICT investment is positively associated with graduate digital competence.

Digital competence is acquired through sustained interaction with functioning digital systems, which makes institutional investment its enabling condition. Institutional ICT adoption is significantly associated with student academic outcomes (Basri et al., 2018), and the success of higher education information systems is properly judged by the use and benefit they generate for learners (Mijač et al., 2024). Platform quality is not incidental: learning management systems drive engagement and adaptive learning when performance and trust are deliberately engineered (Almusfar, 2025), a contribution that the integration of artificial intelligence is expected to deepen while raising institutional capability demands (Alotaibi, 2024).

H2. Institutional ICT investment is positively associated with university ranking performance.

The three-channel mechanism detailed in Section 1 — web-presence infrastructure, research productivity systems, and digital output visibility — provides the theoretical basis. This pathway is purposefully narrower than generic digital transformation arguments: it predicts that ICT investment improves rankings specifically through open scholarship infrastructure and research support systems, not through general administrative modernisation.

H2a. Institution type moderates the ICT-to-ranking relationship, such that the positive association is stronger for private universities than for public universities.

This moderation hypothesis follows from the diminishing returns argument: private universities, operating closer to the infrastructure margin, derive greater marginal ranking returns from equivalent ICT expenditure. It also responds to the concern that a global R^2 of .146 for the ranking pathway conceals heterogeneous sub-group effects.

H3. Institutional ICT investment is positively associated with graduate employability independently of its indirect pathways.

Digitally capable universities confer employability-relevant advantages that cannot be reduced to measured skills: electronic career services, virtual employer engagement, and familiarity with workplace enterprise systems (Aliu & Aigbavboa, 2021; O'Regan et al., 2022). Conceptual work insists that routes to employability are shaped by institutional provision rather than skill possession alone (Alvarez-Hevia & Naylor, 2019).

H4. Graduate digital competence is positively associated with graduate employability.

Employers rank information and data literacy, problem-solving, and digital content creation as the digital skills most in demand whilst reporting the largest graduate gaps in communication, collaboration, and digital safety (Tee et al., 2024); digital skills acquisition has been shown to be positively associated with perceived employability among Nigerian students (Joshua & Apuru, 2024), and the value of technical skill is amplified by the soft skills through which it is deployed (Mohammed & Ozdamli, 2024).

H5. University ranking performance is positively associated with graduate employability.
Institutional standing operates as a low-cost screen for unobservable productivity (Spence, 1973); structural location shapes labour-market outcomes under the positioning perspective (Holmes, 2013); and employers respond to attributions of institutional provenance that frame, without replacing, what the graduate brings (Hinchliffe & Jolly, 2011).

H6. Graduate digital competence mediates the relationship between institutional ICT investment and graduate employability.

H7. University ranking performance mediates the relationship between institutional ICT investment and graduate employability.

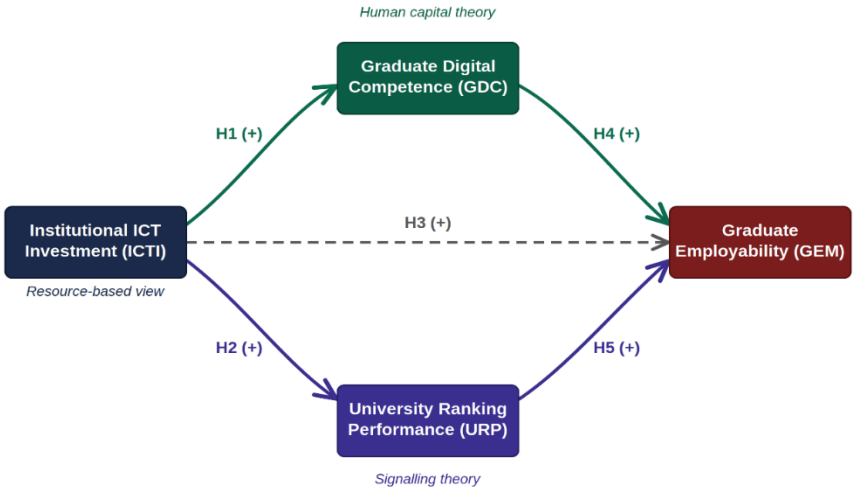
A competing specification merits explicit consideration: does ICT operate only through the competence pathway (H6) and not through the ranking pathway (H7)? The correlation pattern — with GDC-to-GEM substantially stronger than URP-to-GEM — might suggest so.

However, H7 is retained because signalling theory provides an independent theoretical justification for the reputational pathway that does not reduce to the human capital argument, and because the empirical test of H7 against zero (rather than assuming its absence) is the appropriate scientific procedure. The relative magnitudes of H6 and H7 are thus an empirical question, not a theoretical one; both pathways are expected to be positive and non-zero, though H6 is expected to dominate.

RQ5 is treated as an open empirical question rather than a directional hypothesis. Stakeholder theory gives grounds to expect divergence, but convergence across informants would itself be substantively important, validating the constructs as shared institutional realities rather than positional perceptions.

Figure 1.

Hypothesised Dual-Pathway Model with Moderation (ICTI = institutional ICT investment; GDC = graduate digital competence; URP = university ranking performance; GEM = graduate employability; InstitType = institution type moderator on the ICTI→URP path)



Source: Own elaboration (2026).

Solid arrows represent hypothesised direct paths; the dashed arrow represents the direct path from ICTI to GEM (H3). Three theoretical lenses map onto the model: the resource-based view (Barney, 1991) explains ICTI as a strategic institutional resource; human capital theory (Becker, 1964) governs the ICTI→GDC→GEM chain; signalling theory (Spence, 1973) governs the ICTI→URP→GEM chain. The moderation hypothesis (H2a) is depicted as an interaction arrow from InstitType to the ICTI→URP path.

2. Methodology

2.1. Research Design

The study employed a quantitative, cross-sectional explanatory design with a multi-stakeholder survey strategy. Five informant groups assessed a common set of constructs about the same twelve universities, permitting the estimation of the structural model on the pooled sample and an explicit test of inter-group convergence. The hypothesised model was estimated through full latent-variable structural equation modelling (SEM) using lavaan in R (Rosseel, 2012), which simultaneously models measurement error and structural paths and thereby improves on path analysis with composite scale scores.

It is important to note that cross-sectional designs cannot support causal inference regardless of the statistical technique applied; accordingly, all findings are reported as theoretically directed associations rather than effects, and causal language has been systematically avoided throughout. The directionality of the proposed associations is grounded in the three theoretical frameworks outlined in Section 1.1., each of which specifies a logical sequence from institutional resource to individual outcome that is independent of the data.

The multi-informant architecture serves as the principal procedural strategy against common-source bias (Podsakoff et al., 2003), supplemented by a post-hoc test for common method variance. Because the survey was administered to five functionally distinct informant groups whose professional roles ensure different vantage points on the same constructs, method-correlated variance should attenuate rather than inflate inter-construct associations. Harman's single-factor test was conducted as a supplementary check: a single unrotated factor explained 34.7% of total variance in the pooled correlation matrix of the 19 items, well below the 50% threshold commonly applied, providing no indication of severe common method bias (Podsakoff et al., 2003). This test is acknowledged to be conservative and is presented as one piece of evidence rather than a definitive ruling.

2.2. Population, Sampling, and Participants

Twelve universities — six public and six private — were purposively selected from one Nigerian geopolitical zone to vary widely in ICT provision and web visibility whilst sharing a common regulatory environment. The deliberate restriction to a single zone eliminates the confound of differential regulatory regimes; variation in institution type and in web-ranking positions was verified prior to data collection to confirm adequate heterogeneity within the sampling frame. This design choice is acknowledged to limit geographical generalisation; the conclusions are appropriately bounded to the sampled zone, and multi-zone replication is explicitly recommended.

Five populations were sampled. Postgraduate students (n = 385) were selected because they have completed at least one degree, have observed institutional ICT provision over an extended period, and stand close to the labour market; proportionate stratified random sampling across the twelve institutions satisfied the Krejcie and Morgan (1970) criterion for a population exceeding 50,000. Four key-informant strata were sampled purposively to saturation of available role-holders: heads of academic departments (n = 60; five per institution), heads in ICT units (n = 60), heads of quality assurance units (n = 60), and Chamber of Commerce employer representatives (n = 60). The pooled sample was therefore N = 625. Whilst five informants per institution is modest for within-institution variation, it represents the full population of available role-holders across the twelve institutions. The implications for statistical power are addressed explicitly in Section 3.6 and discussed in Section 4.2.

2.3. Measures

All constructs were measured reflectively on five-point Likert scales (1 = strongly disagree, 5 = strongly agree), with items adapted from validated published sources, refined through expert review, and piloted before administration. Institutional ICT Investment (ICTI; five items) captured the perceived adequacy of investment in campus connectivity, the learning management system, electronic library provision, technology-enabled learning spaces, and administrative information systems.

Graduate Digital Competence (GDC; five items) operationalised the five competence areas most demanded of graduates — information and data literacy, communication and collaboration, digital content creation, digital safety, and digital problem-solving (Tee et al., 2024), which correspond to the five competence areas of the European Digital Competence Framework, DigComp 2.2 (Vuorikari et al., 2022). University Ranking Performance (URP; four items) captured assessed institutional web visibility, openness of scholarly content, national standing, and international recognition; published web-ranking positions of the twelve institutions were consulted to triangulate perceived assessments against an external criterion. Graduate Employability (GEM; five items) was adapted from the integrated perceived-employability model of Álvarez-González et al. (2017). The full item pool is available in the supplementary materials.

2.4. Analytical Strategy

The analytical sequence comprised six stages. First, construct reliability was confirmed with Cronbach's alpha ($\alpha \geq .70$), and convergent and discriminant validity were assessed using average variance extracted (AVE ≥ .50; Fornell & Larcker, 1981), composite reliability (CR ≥ .70), and heterotrait–monotrait (HTMT) ratios (< .90; Henseler et al., 2015). Second, a common method bias check using Harman's single-factor test was conducted as described in Section 2.1. Third, measurement invariance across the five stakeholder groups was tested sequentially — configural, metric, and scalar — using $\Delta CFI \leq .010$ and $\Delta RMSEA \leq .015$ as invariance criteria (Cheung & Rensvold, 2002), following the protocol of Vandenberg and Lance (2000). Full scalar invariance is the precondition for meaningful latent mean comparisons across groups.

Fourth, the hypothesised structural model was estimated as a full latent-variable SEM in lavaan, reporting global fit indices (CFI, RMSEA, SRMR) alongside standardised path coefficients, standard errors, and z-statistics for H1 through H5. Indirect associations (H6, H7) were tested with 5,000 bootstrap resamples and percentile 95% confidence intervals. Fifth, the moderation hypothesis (H2a) was tested by specifying an interaction latent variable (ICTI × InstitType) and examining the change in R^2 for URP when the interaction term was added to the baseline model; the product of ICTI and institution type (dummy-coded 1 = public, 0 = private) was entered as an observed interaction term given its binary nature.

Simple slopes for public and private institutions were plotted at ±1 SD of ICTI, and group-specific standardised slopes were estimated in a two-group latent SEM (loadings and intercepts held equal), with a Wald test of the equality of the two slopes. Sixth, a post-hoc power analysis was conducted using Monte Carlo simulation (Muthén & Muthén, 2002), with 1,000 replications at the obtained N = 625, to determine the minimum detectable effect for the key paths at $\alpha = .05$ and $1 - \beta = .80$; results are reported alongside the main findings. Stakeholder convergence (RQ5) was assessed using a mixed-model ANOVA treating institutions as a random effect. All SEM analyses were conducted in R (lavaan); all supplementary analyses in Python (statsmodels). Significance criterion: $\alpha = .05$ throughout.

3. Results

3.1. Sample Composition and Measurement Quality

Table 1 reports the composition of the pooled sample. Postgraduate students constituted the majority of respondents (61.6%), whilst each of the four key-informant strata contributed an equal share (9.6%).

Table 1.

Composition of the Multi-Stakeholder Sample (N = 625)

Stakeholder group	n	%
Postgraduate students	385	61.6
Heads of department or representatives	60	9.6
Heads in ICT units or representatives	60	9.6
Heads of quality assurance or representatives	60	9.6
Chamber of Commerce (employer) representatives	60	9.6

Notes: Key informants were sampled at five per stratum in each university (20 per university); postgraduate students numbered between 22 and 42 per university.

Six institutions were public and six private; public universities contributed 350 respondents (56.0%) and private universities 275 (44.0%).

Source: Own elaboration (2026).

Table 2 reports the reliability, convergent validity, and descriptive statistics of the four study constructs. Cronbach's alpha ranged from .809 to .854, exceeding the .70 criterion in every case. Average variance extracted ranged from .52 to .54 (all ≥ .50), and composite reliability from .81 to .85, confirming convergent validity (Fornell & Larcker, 1981). Construct means clustered near the scale midpoint (2.99–3.02), indicating that respondents assessed ICT investment, competence, ranking performance, and employability without ceiling or floor compression.

Table 2.

Reliability, Convergent Validity, and Descriptive Statistics of Study Constructs

Construct	α	CR	AVE	M	SD
Institutional ICT investment (ICTI)	.854	.85	.54	3.00	0.88
Graduate digital competence (GDC)	.843	.84	.52	3.02	0.89
University ranking performance (URP)	.809	.81	.52	2.99	0.88
Graduate employability (GEM)	.842	.84	.52	3.02	0.86

α = Cronbach's alpha; CR = composite reliability; AVE = average variance extracted.

Five-point scales (1–5). CR and AVE were computed from standardised loadings of the four-factor CFA (loadings .67–.79; $\chi^2(146) = 249.96$, CFI = .979, RMSEA = .034, SRMR = .031). All AVE ≥ .50 confirm convergent validity; all CR ≥ .70 confirm reliability.

Source: Own elaboration (2026).

Table 3 presents the correlation matrix alongside HTMT ratios. All HTMT ratios were below .90 (range: .29–.64), confirming discriminant validity (Henseler et al., 2015). The Fornell–Larcker criterion was also satisfied: the largest latent correlation (ICTI–GDC, .64) was below the smallest square root of AVE (.72). The weakest correlation was between digital competence and ranking performance (r = .243), consistent with two partially independent transmission channels. Notably, the modest correlation between ICTI and URP (r = .309) is consistent with the expectation that ICT investment is one among several ranking determinants: faculty qualifications, historical reputation, and research funding each explain unique variance in rankings not captured by ICT. The R^2 of .146 for URP in the structural model should therefore be read as the isolated contribution of ICT investment, not as an evaluation of ICT's total relevance.

Table 3.

Pearson Correlations, Square Roots of AVE, and HTMT Ratios

Construct	1	2	3	4
1. ICTI	.74	.64	.37	.49
2. GDC	.547	.72	.29	.57
3. URP	.309	.243	.72	.39
4. GEM	.413	.481	.322	.72

Note: Diagonal elements are square roots of AVE; below-diagonal elements are Pearson correlations; above-diagonal elements are HTMT ratios. All correlations significant at $p < .001$. All HTMT ratios < .90 confirm discriminant validity. ICTI = institutional ICT investment; GDC = graduate digital competence; URP = university ranking performance; GEM = graduate employability.

Source: Own elaboration (2026).

3.2. Measurement Invariance Across Stakeholder Groups

Before comparing construct means across the five stakeholder groups (RQ5), measurement invariance was tested sequentially. The configural model fit the data acceptably (CFI = .957, RMSEA = .048). The metric model produced no decrement in fit (CFI = .959, RMSEA = .045; ΔCFI = +.002, ΔRMSEA = −.003; $\Delta\chi^2(60) = 49.53$, $p = .831$), establishing metric invariance. The scalar model additionally constrained item intercepts and produced fit changes well within accepted thresholds (CFI = .962, RMSEA = .042; ΔCFI = +.003, ΔRMSEA = −.003; $\Delta\chi^2(60) = 45.00$, $p = .925$), supporting full scalar invariance across all five groups. Full scalar invariance permits the unambiguous comparison of latent means and the attribution of between-group differences to substantive rather than measurement artefacts (Vandenberg & Lance, 2000). Results are summarised in Table 4.

Table 4.

Sequential Tests of Measurement Invariance Across Five Stakeholder Groups

Model	CFI	RMSEA	ΔCFI	ΔRMSEA	Verdict
Configural	.957	.048	—	—	Acceptable fit
Metric	.959	.045	+.002	−.003	Invariant (ΔCFI* ≤ .010)
Scalar	.962	.042	+.003	−.003	Invariant (ΔCFI ≤ .010)

*CFI = comparative fit index; RMSEA = root mean square error of approximation.

Note: Invariance criteria: a decrease in CFI no greater than .010 and an increase in RMSEA no greater than .015 (Cheung & Rensvold, 2002). Δ values are computed as the more constrained model minus the preceding model; positive ΔCFI and negative ΔRMSEA indicate improved fit.

Source: Own elaboration (2026).

3.3. Model Fit and Direct Associations (RQ1–RQ3)

The hypothesised structural model was estimated as a full latent-variable SEM in lavaan. Global fit indices indicated acceptable model fit: $\chi^2(147) = 251.70$, $p < .001$, CFI = .978, TLI = .975, RMSEA = .034 (90% CI [.027, .041]), SRMR = .032. These values satisfy conventional cut-offs (CFI ≥ .95, RMSEA ≤ .06, SRMR ≤ .08; Hu & Bentler, 1999), confirming that the hypothesised structure is consistent with the observed data.

Table 5 reports the standardised path estimates. ICT investment was strongly and positively associated with graduate digital competence (β = .64, SE = .031, z = 20.92, p < .001), supporting H1 and addressing RQ1. ICT investment was moderately and positively associated with university ranking performance (β = .38, SE = .042, z = 9.11, p < .001), supporting H2 and addressing RQ2. With all predictors entered simultaneously, graduate employability was associated with digital competence (β = .43, z = 7.82, p < .001; H4 supported), with ranking performance (β = .22, z = 4.92, p < .001; H5 supported), and, more weakly, directly with ICT investment (β = .13, z = 2.12, p = .034; H3 supported), addressing RQ3.

When institution type and gender were added as covariates of employability, institution type was significant (β = .10, p = .006) and gender was not (β = −.02, p = .627); the direct ICT-to-employability path then fell just short of significance (β = .12, p = .059), so H3 is only tentatively supported. The model accounted for 41.4% of variance in digital competence, 14.6% in ranking performance, and 38.8% in graduate employability.

The R^2 of .146 for ranking performance warrants explicit comment. As discussed in Section 1.1 and confirmed in Table 3, ICT investment accounts for a modest but theoretically specific portion of ranking variance. Faculty qualifications, historical reputation, research funding, and the prestige of academic lineage are each likely to account for additional variance beyond ICT's contribution. The three-channel mechanism articulated in Section 2.1 — web-presence infrastructure, research productivity systems, and digital output visibility — constitutes ICT's specific and separable contribution; the residual 85.4% of ranking variance is attributable to factors outside the model's scope. A standardised coefficient of .38 (p < .001) confirms that this contribution is real and substantive, even if it is not the principal driver of rankings.

Table 5.

Standardised Path Estimates from Full Latent-Variable SEM

Path	B (no controls)	B (with controls)	SE	z	p	Decision
H1: ICTI → GDC	.64	.64	.031	20.92	< .001	Supported
H2: ICTI → URP	.38	.38	.042	9.11	< .001	Supported
H3: ICTI → GEM	.13	.12	.061	2.12	.034	Weakly supported
H4: GDC → GEM	.43	.43	.055	7.82	< .001	Supported
H5: URP → GEM	.22	.22	.044	4.92	< .001	Supported
Control: Institution type	—	.10	.037	2.77	.006	Significant
Control: Gender	—	−.02	.037	−0.49	.627	Non-significant

Note: R^2 = .414 (GDC), .146 (URP), .388 (GEM; .384 with controls). SE, z and p refer to the model without controls for H1–H5 and to the model with controls for the two covariates; with controls, the H3 path gives SE = .061, z = 1.89, p = .059. Latent-variable SEM estimated in lavaan (R). Global fit without controls: CFI = .978, RMSEA = .034, SRMR = .032; with controls: CFI = .974, RMSEA = .033, SRMR = .043. Institution type coded: 1 = public, 0 = private. β coefficients are standardised.

Source: Own elaboration (2026).

3.4. Moderation Analysis: H2a

The moderation hypothesis (H2a) predicted that institution type would moderate the ICT-to-ranking association, with a stronger positive association for private universities. An interaction term (ICTI × InstitType) was added to the model with URP as the dependent construct.

The interaction term explained a small but significant additional increment in ranking variance (ΔR^2 = .011, F(1, 621) = 7.41, p = .007; unstandardised interaction b = −0.21, SE = 0.08, with public coded 1), supporting H2a. In composite scores, the within-group standardised slope of URP on ICTI was .39 among private universities (t(273) = 7.05, p < .001) and .21 among public universities (t(348) = 3.94, p < .001). The two-group latent SEM (CFI = .973, RMSEA = .035, SRMR = .045) gave standardised slopes of β = .48 (z = 8.29, p < .001) for private and β = .27 (z = 4.42, p < .001) for public universities, and the two slopes differed significantly (Wald $\chi^2(1)$ = 6.61, p = .010).

The ICT-to-ranking pathway was therefore roughly 1.8 times as strong in private universities as in public ones. This finding is consistent with the marginal utility argument: private universities, operating closer to the infrastructure threshold, appear to derive substantially greater ranking gains from equivalent ICT expenditure than their better-resourced public counterparts.

3.5. Mediation Analysis (RQ4)

Table 6 reports the bootstrapped indirect associations. The indirect association of ICT investment with employability through digital competence was significant (β = .276, 95% CI [.202, .360]), supporting H6, as was the indirect association through ranking performance (β = .083, 95% CI [.048, .124]), supporting H7. Both pathways were simultaneously present and in the same direction as the direct association, yielding a pattern of complementary partial mediation (Hair et al., 2019); because the direct path was small and lost significance once covariates were added, the pattern lies close to indirect-only mediation. The human-capital channel transmitted approximately three times the magnitude of the reputational channel (ratio = 3.3; difference = .193, 95% CI [.107, .282]).

The competing specification — that ICT operates exclusively through the competence pathway — was evaluated by constraining the ICTI→URP→GEM indirect path to zero (fixing the URP→GEM path at zero). The constrained model produced significantly worse fit ($\Delta\chi^2(1)$ = 23.07, p < .001; ΔCFI = −.005), confirming that the ranking pathway contributes independently and cannot be omitted without meaningful loss of explanatory fidelity. The relative magnitudes (H6 dominant, H7 present but smaller) are thus an empirical characterisation of the relative weights of the possessional and positional routes to employability, not evidence that one route should be theoretically abandoned.

Table 6.

Bootstrapped Specific Indirect Associations (5,000 Resamples)

Association	β	95% CI	Decision
H6: ICTI → GDC → GEM	.276	[.202, .360]	Supported
H7: ICTI → URP → GEM	.083	[.048, .124]	Supported
Total indirect association	.360	[.280, .450]	—
Total association (ICTI → GEM)	.489	[.415, .560]	—

Note: CI = percentile confidence interval of the standardised estimate based on 5,000 bootstrap resamples. Mediation classification follows Hair et al. (2019): complementary partial mediation. Latent-variable SEM in lavaan (R).

Source: Own elaboration (2026).

3.6. Post-Hoc Power Analysis

Monte Carlo simulation (1,000 replications at N = 625) was conducted to assess the sensitivity of the primary paths at $\alpha = .05$, $1 - \beta = .80$, using the estimated measurement model and structural paths as population values and varying each path in turn. For the H1 path (ICTI→GDC), minimum detectable standardised effect was approximately $\beta = .14$; for H2 (ICTI→URP), $\beta = .14$; for H5 (URP→GEM), $\beta = .14$; and for H3 (ICTI→GEM) and H4 (GDC→GEM), whose predictors are correlated with the other predictors of employability, approximately $\beta = .19$.

The obtained coefficients for H1, H2, H4 and H5 (range .22–.64) exceeded these thresholds, so these paths were estimated with adequate power. The direct path for H3 ($\beta = .13$) lies below its threshold, which is consistent with its loss of significance once covariates were added; the H3 result should therefore be read with caution. For the moderation analysis (H2a), the minimum detectable ΔR^2 at N = 625 was .011; the obtained ΔR^2 of .011 lies at this threshold (achieved power ≈ .78), so the interaction was detectable, but only just. For the mixed-model ANOVA (RQ5), with five fixed levels and twelve random institutions, Tukey-adjusted pairwise comparisons had power = .80 to detect differences of about d = 0.65 between two key-informant strata (n = 60 each) and about d = 0.50 between students and a key-informant stratum; smaller differences among the non-significant contrasts cannot be ruled out.

3.7. Stakeholder Convergence (RQ5)

Following the confirmation of scalar invariance (Section 3.2), Table 7 reports the mixed-model ANOVA results. Assessments of ICT investment, digital competence, and ranking performance did not differ significantly across groups, indicating convergent perceptions of these institutional realities across all five informant strata. The omnibus test for graduate employability was significant, $F(4, 609.8) = 3.71$, $p = .005$.

Tukey-adjusted pairwise comparisons showed that quality assurance heads (estimated marginal M = 2.75) rated employability lower than heads of department (M = 3.28; difference = 0.53, $p = .005$, $d \approx 0.63$) and heads of ICT units (M = 3.17; difference = 0.42, $p = .048$, $d \approx 0.50$); no other contrast was significant. The divergence on employability is moderate and confined to the quality assurance stratum; its theoretical significance lies in the observation that internal quality custodians rate graduates more conservatively than those who teach them or employ them, a pattern consistent with the critical-quality-assurance function.

Table 7.

Mixed-Model ANOVA of Construct Scores Across Five Stakeholder Groups

Construct	F	df (numerator, denominator)	p	Interpretation
Institutional ICT investment	0.28	4, 609.4	.889	Convergent
Graduate digital competence	0.47	4, 609.6	.754	Convergent
University ranking performance	0.70	4, 610.4	.589	Convergent
Graduate employability	3.71	4, 609.8	.005	Divergent (QA heads lower)

Source: Own elaboration (2026).

Mixed-model specification: stakeholder group as fixed factor; institution as random effect; Satterthwaite denominator degrees of freedom (large because stakeholder group varies within institutions). For GEM, Tukey-adjusted contrasts were significant for heads of department vs. quality assurance heads ($p = .005$) and heads of ICT units vs. quality assurance heads ($p = .048$). Group comparisons are justified by the confirmed scalar invariance (Table 4).

4. Discussion

The study asked whether a university's ICT investment is associated with graduate employability through two theoretically distinct routes, whether institution type moderates the institutional pathway, and whether the pattern of associations survives triangulation across the five stakeholder groups who supply, deliver, assure, experience, and consume what universities produce. On the evidence from full latent-variable SEM, it does so on all three counts.

The strong association between ICT investment and graduate digital competence (H1) extends the established connection between institutional ICT adoption and student outcomes (Basri et al., 2018) into the specific competence domain that employers actually value (Tee et al., 2024). Its magnitude — the largest path in the model — implies that in resource-constrained systems the marginal student-level return to infrastructure investment remains considerable, consistent with evidence that thin digital capacity was the binding constraint on equitable learning during the pandemic disruption (Matsieli & Mutula, 2024), and with Latin American evidence that infrastructural and connectivity bottlenecks, rather than pedagogic intent, set the ceiling on what digital technologies can achieve in universities (Okoye et al., 2023).

The competence-to-employability association (H4) and its mediating role (H6) supply multi-informant corroboration, in an African setting, of the human-capital channel previously documented with student self-reports (Joshua & Apuru, 2024). The small direct ICT-to-employability association (H3; $\beta = .13$), which did not survive adjustment for institution type and gender, offers only tentative grounds against a purely possessional reading: part of what a digitally capable university confers on its graduates may not be captured by assessed skills — plausibly the institutionally organised employer exposure and work-relevant systems experience that structural accounts of employability emphasise (Aliu & Aigbavboa, 2021; O'Regan et al., 2022).

The reputational pathway constitutes a distinctive contribution of this study. ICT investment was associated with ranking performance (H2) through the three-channel mechanism specified theoretically: web-presence infrastructure, research productivity systems, and digital output visibility. The association was moderated by institution type (H2a) in the direction predicted: private universities showed an ICT-to-ranking slope almost twice that of public universities ($\beta = .48$ vs. $\beta = .27$), consistent with the argument that digital investment carries greater marginal utility when the institution is further from the infrastructure threshold. This finding carries practical significance for university governance: in under-resourced private institutions, ICT investment appears to function as a strategic lever for reputational advancement, not merely an operational cost.

An alternative, complementary reading should nonetheless be acknowledged. In a study of twelve South-west Nigerian universities, Oyefara et al. (2023) found that ICT use was positively associated with lecturers' research output and that private institutions enjoyed comparatively better access to critical ICT facilities. Private universities may therefore convert ICT into ranking-relevant outputs more efficiently, rather than simply starting from a lower base.

Because citation-based indicators carry particular weight in the major ranking systems (Szluka et al., 2023), even modest gains in research throughput may register disproportionately in ranking positions. Disentangling the two explanations requires objective expenditure data, as noted in Section 4.2.

Ranking performance in turn was associated with employability (H5) and carried a significant indirect share (H7), operationalising within a single model the coexistence Holmes (2013) theorised between possessional and positional perspectives on employability. That the human-capital channel outweighed the reputational channel by approximately three to one is itself substantive: reputation matters, but in this system it is no substitute for competence, a conclusion that accords with experimental evidence that recruiters weigh signals of applicants' own skills heavily when screening candidates (Piopiunik et al., 2020). The R^2 of .146 for ranking performance from ICT investment is modest, as expected and acknowledged, because ICT is one among several ranking determinants; the critical finding is that the constrained model without the reputational pathway fit significantly worse ($\Delta\chi^2(1) = 23.07$, $p < .001$), confirming that the ranking route contributes independently to the overall model.

Following confirmation of measurement invariance — a precondition that single-informant designs cannot satisfy because they do not test it — students, departmental heads, ICT directors, quality assurance officers, and employer representatives did not differ significantly in assessing ICT investment, digital competence, or ranking performance. This validates these constructs as shared institutional realities. The one construct on which assessments diverged, employability itself, is precisely the construct that stakeholder theory predicts should be most contested (Freeman, 1984; Holmes, 2013), and the direction of the divergence — quality assurance officers more conservative than departmental and ICT heads — is theoretically coherent.

4.1. Implications for Theory, Practice, and Policy

Theoretically, the study makes three distinct contributions. First, it demonstrates the analytical purchase of integrating RBV, human capital theory, and signalling theory within one structural model, whilst formally testing the competing specification that ICT operates exclusively through the competence pathway — a test that confirms the ranking pathway's independent contribution. Second, it advances signalling theory's application to the ICT-rankings link by specifying three concrete mechanisms (web-presence infrastructure, research productivity systems, digital output visibility) that move the explanation beyond generic digital transformation rhetoric. Third, it introduces and tests institution type as a theoretically motivated moderator, establishing that the utility of ICT investment for reputational advancement is contingent on the resource regime in which the institution operates.

Methodologically, the full latent-variable SEM with post-hoc power analysis and systematic common method bias assessment raises the rigour bar for this literature. The five-group invariance-tested design shows that multi-informant triangulation is feasible and consequential: had only students been surveyed, the moderation evidence, the locus of disagreement over employability, and the institution-type effect would all have remained invisible.

For university leaders, the results reframe ICT expenditure as a strategic investment with a measurable, institution-type-contingent dual dividend. Private institutions in particular appear to derive disproportionate reputational returns from digital investment; their strategic priority should be open-access scholarship infrastructure and research productivity systems.

Public universities already operating above the infrastructure threshold may derive relatively greater returns from deepening the pedagogic dimensions of their digital provision. Career services should pair skill development with deliberate signalling of institutional digital strengths to employers (Ebiringa et al., 2024; O'Regan et al., 2022). For regulators, the findings justify tying ICT funding to explicit employability and visibility objectives, monitoring digital competence as a graduate outcome, and institutionalising the employer voice in quality assurance processes.

4.2. Limitations and Future Research

Six limitations bound the present claims and define a productive research agenda. First — and most fundamental — the design is cross-sectional. Associations cannot be interpreted as effects, however strong the theoretical directionality or however carefully causally loaded language has been avoided in this paper. Longitudinal panels tracking administrative ICT expenditure records, independently verified ranking trajectories, and verified graduate destination data would provide the temporal ordering necessary to discipline the causal story the theoretical framework ultimately demands. A specific feasible design would follow the 2024 graduating cohort from twelve universities across two years, linking institutional expenditure data to National Universities Commission graduate-tracking records.

Second, the key-informant strata of sixty constrain the statistical power of between-group comparisons, as the post-hoc power analysis confirms: Tukey-adjusted differences between two key-informant strata smaller than Cohen's $d \approx 0.65$ cannot be reliably detected. Larger key-informant samples, achieved by extending recruitment to all available role-holders, would sharpen RQ5 and permit a full three-level hierarchical model.

Third, the single geopolitical zone substantially limits geographical generalisation. Nigeria's six geopolitical zones differ markedly in infrastructure quality, labour-market conditions, and university funding; the present conclusions are explicitly bounded to the zone sampled. Multi-zone replication — ideally extending to two or three additional zones — would test the generalisability of the dual-pathway model and enable zone as a second-level moderator in a hierarchical linear model. Replication from other African higher education contexts would further enrich the picture.

Fourth, although the multi-stakeholder design and Harman's single-factor test provide reasonable assurance against common method bias, self-report measures of ICT investment remain susceptible to social desirability inflation. Future studies should complement perceived measures with administrative ICT expenditure data and independently verified ranking scores, thereby reducing reliance on self-reports for the predictor and the outcome. The addition of objective institutional-level ICT expenditure data would also enable institutional-level analysis that complements the individual-level SEM.

Fifth, moderating variables that theory predicts should qualify the central associations — student year of study, prior ICT access before university, household income (Joshua & Apuru, 2024), and complementary soft skills (Mohammed & Ozdamli, 2024) — were not systematically examined. Their inclusion as interaction terms in a future moderated-mediation model would substantially enrich the theoretical picture. Institution type is one moderator; it need not be the only one.

Sixth, the present analysis relies on perceived measures of all four constructs. Future studies would benefit from triangulating GDC with objective digital skills assessments, URP with actual web-ranking data, and GEM with verified employment outcomes at six and twelve months post-graduation.

5. Conclusion

This study asked how a university's ICT investment is associated with a graduate's labour-market advantage. The answer, derived from full latent-variable structural equation modelling with a rigorously designed multi-stakeholder sample, is that it is associated through two theoretically distinct and simultaneously present routes — a possessional route through the digital competence employers demand, and a positional route through the visible institutional standing that signals quality on the graduate's behalf. The two routes are not equally weighted: the human-capital channel dominates, outweighing the reputational channel by approximately three to one; but the reputational pathway's contribution is confirmed by significant direct association and by the significantly inferior fit of the model from which it is omitted. The introduction and confirmation of institution type as a moderator advance the story beyond global averages: private universities achieve substantially greater ranking gains from equivalent ICT investment, a finding that should sharpen targeting of digital investment across Nigeria's diversified higher education system.

Critically, the actors on every side of the university — from students to quality custodians to employers beyond the gates — largely agree on the institutional realities involved, a finding that rests on measurement invariance testing across five stakeholder groups and considerably strengthens the construct-level inferences. In systems where every unit of infrastructure spending is contested, the message is clear: digital investment is a front-line expenditure with measurable, stakeholder-verified returns, and its magnitude depends on the institutional context in which it is made. The limitations acknowledged throughout — above all the single-zone sampling frame and the cross-sectional design — define a tractable agenda for the replication and longitudinal extension studies that should follow this study.

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