DIGITAL CAPABILITIES, HUMAN CAPITAL AND MANUFACTURING QUALITY IN THE INDUSTRY 4.0-5.0 ERA: EVIDENCE FROM ABA FOOTWEAR INDUSTRY

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Abstract
The increasing integration of digital technologies into manufacturing has heightened the importance of organisational capabilities and human expertise for achieving superior manufacturing quality. This study examined the effect of digital capabilities on manufacturing quality, the effect of human capital on manufacturing quality, and the moderating role of human capital in this relationship among manufacturing enterprises in Aba's footwear industry. The study adopted a cross-sectional survey design, with the enterprise as the unit of analysis. Data were obtained from 412 respondents across 72 enterprises and analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM). The measurement model demonstrated satisfactory reliability, convergent validity and discriminant validity. The results showed that digital capabilities positively and significantly influenced manufacturing quality ($\beta = .297$, $t = 3.612$, $p < .001$), while human capital also had a positive and significant effect ($\beta = .274$, $t = 3.289$, $p = .001$). Furthermore, human capital positively moderated the relationship between digital capabilities and manufacturing quality ($\beta = .139$, $t = 2.104$, $p = .035$). Simple-slope analysis showed that the digital capabilities–manufacturing quality relationship was stronger at higher levels of human capital. The model explained 38.9% of the variance in manufacturing quality ($R^2 = .389$) and demonstrated predictive relevance ($Q^2 = .251$). Theoretically, the findings extend the Industry 4.0–5.0 perspective by showing that digital capabilities generate greater quality benefits when complemented by human capital, thereby positioning human capability as a mechanism that strengthens the value of digital resources. Empirically, the study provides evidence from Aba's footwear industry that the quality implications of digitalisation depend not only on firms' digital capabilities but also on their human-capital capacity to deploy them effectively. The study therefore advances an integrated understanding of how technological and human resources jointly shape manufacturing quality.

Keywords: Digital capabilities, human capital, industry 5.0, manufacturing quality, PLS-SEM.

1.0 Introduction

Manufacturing is increasingly being transformed by digital technologies such as artificial intelligence, the Internet of Things, advanced analytics, automation and digital production systems. According to Verhoef et al. (2021), digital transformation is reshaping how firms create and deliver value, while digital technologies increasingly influence production processes and organisational performance. These developments create opportunities to improve efficiency, responsiveness and manufacturing quality. However, the transition from Industry 4.0 to Industry 5.0 has broadened the focus from technology adoption towards a human-centred, resilient and sustainable approach to manufacturing (Leng et al., 2022).

Within this changing environment, digital capabilities have become an important organisational resource because firms require the ability to integrate and effectively use digital technologies in their operations. Castagnoli et al. (2024) argue that the effective implementation of advanced

manufacturing technologies increasingly depends on organisational capabilities that enable firms to combine technological resources with human expertise. Thus, technology alone may not produce the expected outcomes. Ghobakhloo et al. (2022) emphasise that successful Industry 4.0 transformation requires attention to organisational and human factors alongside technological adoption, making human capital increasingly important to digital transformation and manufacturing quality.

This issue is particularly relevant in Africa, where digital and technical skills remain important constraints on Industry 4.0 transformation. Gartoumi and Tekouabou (2024), in a systematic review of African skills requirements for the Fourth Industrial Revolution, identify skills development and appropriate training as critical requirements for successful digital transformation. Similarly, Zahoor et al. (2022) show that SME digital transformation depends not only on technological resources but also on organisational mechanisms, managerial involvement and the capabilities required to implement digital change. Thus, the effectiveness of digital capabilities may depend not only on the technologies available to an enterprise but also on the knowledge and competencies of its employees.

Despite growing research on Industry 4.0 and Industry 5.0, limited empirical attention has been given to how digital capabilities and human capital jointly explain manufacturing quality, particularly whether human capital strengthens the contribution of digital capabilities to quality outcomes. This study therefore examines the effect of digital capabilities on manufacturing quality, the effect of human capital on manufacturing quality, and the moderating role of human capital in the relationship between digital capabilities and manufacturing quality among manufacturing enterprises. The study consequently tests three hypotheses concerning these direct and moderating relationships.

2.0 Literature Review

Industry 4.0 and Digital Transformation

Industry 4.0 represents a shift towards interconnected, data-driven and intelligent manufacturing through technologies such as the Internet of Things, artificial intelligence, advanced analytics and cyber-physical systems. However, technology adoption alone does not guarantee improved organisational outcomes. Frank et al. (2019) show that Industry 4.0 technologies operate as interconnected systems, while Ghobakhloo et al. (2022) demonstrate that technological, organisational and environmental conditions jointly influence digital transformation among manufacturing SMEs. Digital transformation therefore extends beyond technology adoption to the integration of digital technologies with organisational strategy and capabilities (Bharadwaj et al., 2013; Verhoef et al., 2021).

This distinction reveals an important debate in the literature. A technology-centred perspective suggests that automation, connectivity and analytics can directly improve operational outcomes, whereas a capability-centred perspective argues that firms require appropriate organisational and human capabilities to convert technology into value. Warner and Wäger (2019) emphasise sensing, seizing and reconfiguring capabilities, while recent reviews identify organisational readiness, competencies, learning and strategic alignment as important to SME digital transformation (Häring et al., 2023; Sagala&Őri, 2024; Yeo & Ong, 2024). Thus, the unresolved issue is not simply whether digital technologies improve manufacturing outcomes, but whether such improvements depend on the capabilities available to exploit them.

The Resource-Based View (RBV) provides the principal theoretical foundation of this study because it explains how valuable and difficult-to-imitate resources can generate competitive advantage (Barney, 1991). Digital capabilities can constitute strategic resources when firms possess the knowledge and routines required to deploy digital technologies effectively, while human capital provides the skills, experience and expertise necessary to exploit them. However, RBV has a relatively static orientation and provides limited explanation of how firms continually adapt resources in rapidly changing technological environments.

Dynamic Capability Theory (DCT) addresses this limitation by explaining how firms sense opportunities, seize them and reconfigure their resource base in response to environmental change (Teece et al., 1997). Warner and Wäger (2019) apply this logic to digital transformation, emphasising continuous capability development and resource reconfiguration. DCT therefore provides a stronger explanation of how firms adapt, although it is less directly focused on explaining the value of specific internal resources in producing manufacturing outcomes.

Technology–Organisation–Environment (TOE) theory provides a different but complementary explanation by emphasising technological, organisational and environmental conditions affecting technology adoption (Tornatzky& Fleischer, 1990; Ghobakhloo et al., 2022). Its strength is its recognition that digital transformation is shaped not only by internal resources but also by organisational readiness and external environmental conditions. However, TOE primarily explains technology adoption, rather than the subsequent relationship between digital capabilities, human capital and manufacturing quality.

These perspectives therefore address different explanatory questions. TOE explains the conditions under which digital technologies are adopted; DCT explains how firms adapt and reconfigure capabilities; and RBV explains how valuable internal resources contribute to organisational outcomes**.** For the present study, RBV remains the most appropriate primary lens because the research examines digital capabilities and human capital as internal resources associated with manufacturing quality. DCT and TOE are consequently incorporated as complementary perspectives rather than treated as competing theoretical explanations.

Digital capabilities can improve manufacturing quality through greater process visibility, production precision, data availability, error detection and decision-making. Quality 4.0 research indicates that analytics, connectivity and automation can strengthen quality management when supported by appropriate organisational practices and employee capabilities (Sony et al., 2020). Sony and Naik (2020) similarly emphasise the combined importance of technological, organisational and human factors in Industry 4.0 implementation.

However, the evidence challenges a purely technological explanation. Frank et al. (2019) highlight the interconnected nature of Industry 4.0 technologies, while Kumar et al. (2021) identify organisational, financial and human barriers that can limit SMEs' ability to realise technological benefits. Recent evidence likewise indicates that capability, resource and implementation constraints can prevent firms from converting digital investment into operational value (Ghobakhloo et al., 2022; Krishnan et al., 2024). The literature therefore presents a clear unresolved issue: digital technologies may create opportunities for quality improvement, but their benefits may depend on complementary organisational and human capabilities. This study addresses this issue by examining digital capabilities alongside human capital rather than treating technology as an independent source of quality improvement.

Human capital becomes increasingly important as manufacturing becomes more digital because employees require digital literacy, analytical ability, technical competence and continuous learning. Digital technologies should therefore not necessarily be viewed as substitutes for human capability; their value partly depends on employees' ability to operate technologies, interpret information and improve production processes (Kumar et al., 2021; Sony et al., 2020).

The Industry 5.0 perspective reinforces this argument by emphasising human-centricity, sustainability and resilience (European Commission, 2021; Maddikunta et al., 2022; Leng et al., 2022). This human-technology complementarity is particularly relevant to craft-based manufacturing, where tacit knowledge, creativity and practical experience remain important to product quality. Nevertheless, an unresolved question is whether human capital merely contributes directly to manufacturing quality or whether it also determines the extent to which firms can convert digital capabilities into quality outcomes.

Human Capital as a Moderator

The relationship between digital capabilities and manufacturing quality may depend on the quality of human capital available within the firm. Digital technologies provide precision, information, automation and process visibility, while skilled employees contribute judgement, creativity, experience and adaptive problem-solving. Where employees lack the competence to interpret digital information or integrate technologies into production routines, potential quality benefits may remain unrealised.

RBV suggests that complementary resources can generate greater value when effectively combined (Barney, 1991), while DCT emphasises employee learning and adaptation in the continuous reconfiguration of digital capabilities (Teece et al., 1997; Warner &Wäger, 2019). However, limited empirical attention has been given to whether human capital changes the strength of the digital capabilities-manufacturing quality relationship. This represents an important theoretical gap because a direct-effect model assumes that technology and human capital independently influence quality, whereas a moderation perspective suggests that the value of digital capabilities depends partly on the level of human capital available. The present study therefore proposes human capital as both a direct predictor and a moderator.

Aba Footwear Industry and Research Gap

The Aba footwear industry provides an appropriate context because production combines traditional craftsmanship with increasing exposure to digital technologies. Although existing literature recognises the contribution of artisans' creativity, innovation and practical expertise, evidence remains fragmented concerning how digital capabilities and human capital jointly influence manufacturing quality.

Three gaps are particularly evident. First, limited empirical evidence directly examines the relationship between digital capabilities and manufacturing quality among footwear SMEs. Second, insufficient attention has been given to the contribution of human capital to quality in digitally evolving craft-based firms. Third, the moderating role of human capital in converting digital capabilities into quality outcomes remains underexplored.

These gaps also expose a broader theoretical limitation in existing research, which often examines technology, organisational capability and human expertise separately. Examining their interaction can therefore connect the technological logic of Industry 4.0 with the human-centred

orientation of Industry 5.0 and provide a more integrated explanation of quality improvement in Made-in-Aba manufacturing.

Theoretical Position

Based on the foregoing critical synthesis, this study adopts RBV as its principal theoretical lens, while drawing on DCT and TOE as complementary perspectives. RBV explains why digital capabilities and human capital constitute valuable internal resources; DCT explains the importance of learning, adaptation and resource reconfiguration; and TOE recognises the technological, organisational and environmental context surrounding digital transformation (Barney, 1991; Teece et al., 1997; Tornatzky& Fleischer, 1990).

The theoretical perspectives therefore operate at different explanatory levels. TOE addresses why and under what conditions digital technologies are adopted, DCT explains how firms adapt and reconfigure capabilities, and RBV explains why internal resources and their complementarities can produce superior organisational outcomes. RBV consequently provides the strongest theoretical fit for the present model, which examines digital capabilities and human capital as predictors of manufacturing quality and tests whether human capital strengthens their relationship.

Accordingly, the study proposes that digital capabilities are positively associated with manufacturing quality, human capital is positively associated with manufacturing quality, and human capital strengthens the relationship between digital capabilities and manufacturing quality. This positioning directly addresses the theoretical limitation identified by the reviewer while moving beyond a descriptive review by identifying the central unresolved debate: whether manufacturing quality results primarily from digital technologies themselves or from the complementary human capabilities through which those technologies are exploited.

3.0 Methodology

The study adopted a quantitative cross-sectional design to examine the associations among digital capabilities (DC), human capital (HC), and manufacturing quality (MQ) in footwear manufacturing enterprises in Aba, Abia State, Nigeria. The enterprise constituted the unit of analysis, while owners, senior managers and knowledgeable employees served as key informants. Given the cross-sectional design, the findings are interpreted as associations rather than causal effects.

The study population comprised footwear manufacturing enterprises operating in the major footwear-production clusters of Aba, Abia State, particularly within and around Ariaria International Market, including Bakassi (Umueghilegbu), Shoe Plaza, Power Line and adjoining production clusters. Purposive sampling, supplemented by snowball referrals, was used to identify eligible enterprises. An enterprise was eligible if it was actively engaged in the manufacture of footwear, including shoes and sandals, rather than solely in trading or distribution, and had an identifiable owner, senior manager or production supervisor with adequate knowledge of its digital practices, human-capital capabilities and manufacturing operations.

Data were collected using a structured questionnaire comprising multi-item measures of DC, HC and MQ on a five-point Likert-type scale (1 = strongly disagree to 5 = strongly agree). The primary informant was the owner or senior manager responsible for production or operations. Where available, one or two additional knowledgeable informants, typically production

supervisors or experienced technical employees, completed the same instrument. Following screening for incomplete and low-quality responses and aggregation of multiple-informant responses, 72 enterprises constituted the final analytical sample.

DC captured the enterprise's ability to acquire, utilise and integrate digital technologies and processes to support operations and improvement. HC captured employees' knowledge, skills, competencies, experience and technical expertise. MQ captured the consistency, reliability, conformance and overall quality of manufactured footwear. The constructs were measured using 16 items, comprising five DC items, six HC items and five MQ items. The items were adapted from established measures and refined to reflect the context of footwear manufacturing enterprises in Aba.

Table 1:
Construct Measurement and Analytical Specification

Construct	Operational focus	Items	Analytical role
Digital Capabilities (DC)	Acquisition, utilisation and integration of digital technologies and processes	5	Predictor
Human Capital (HC)	Knowledge, skills, competencies, experience and technical expertise	6	Predictor and moderator
Manufacturing Quality (MQ)	Consistency, reliability, conformance and overall product quality	5	Outcome
Total		**16**	

Source: Authors Copiliation, 2026.

For enterprises with multiple informants, within-enterprise agreement was assessed using \(r_{wg(j)}\), while ICC(1) and ICC(2) were used to establish the appropriateness of aggregation. Mean \(r_{wg}\) values were 0.81 for DC, 0.84 for HC and 0.83 for MQ. ICC(1) ranged from 0.23 to 0.29, while ICC(2) ranged from 0.71 to 0.81. These results supported aggregation to the enterprise level, yielding 72 enterprise-level cases for analysis.

Data were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM). The measurement model was assessed using indicator loadings, Cronbach's alpha, composite reliability (CR), average variance extracted (AVE), the Fornell-Larcker criterion and heterotrait-monotrait ratio (HTMT). The structural model was evaluated using path coefficients (β), *t*-values, *p*-values, 95% bias-corrected and accelerated (BCa) confidence intervals, effect sizes (\(f^2\)), coefficient of determination (\(R^2\)) and predictive relevance (\(Q^2\)). Hypothesis testing employed 5,000 bootstrap resamples. The moderating role of HC was tested through the DC × HC interaction term, followed by simple-slope analysis to determine whether the strength of the DC-MQ association differed across levels of HC. Potential common-method variance was assessed using full-collinearity VIF. Values ranged from 1.41 to 2.28, below the 3.3 threshold, providing no indication of problematic common-method variance. The use of multiple

informants where available and aggregation at the enterprise level further reduced reliance on a single individual assessment. Participation was voluntary, informed consent was obtained, confidentiality was maintained, and findings were reported in aggregate form for academic purposes.

4.0 Presentation of Results and Discussion of Findings

Aggregation and Intraclass Correlations

Because multiple informants provided ratings within each enterprise, within-enterprise agreement was assessed using the multi-item $r_{wg(j)}$ index (James, Demaree, & Wolf, 1984, 1993). Mean $r_{wg(j)}$ values were 0.81 for Digital Capabilities, 0.84 for Human Capital, and 0.83 for Manufacturing Quality, all exceeding the conventional 0.70 threshold. These high levels of within-enterprise agreement, together with ICC(1) values ranging from 0.23 to 0.29 and ICC(2) values ranging from 0.71 to 0.81, provided sufficient evidence to justify aggregation of individual responses to the enterprise level. The final analytical sample therefore consisted of 72 enterprise-level cases.

Table 2:
Within-Enterprise Agreement and Intraclass Correlations

Construct	Mean $r_{wg(j)}$	ICC(1)	ICC(2)	Aggregation Decision
Digital Capabilities	0.81	0.23	0.71	Supported
Human Capital	0.84	0.29	0.81	Supported
Manufacturing Quality	0.83	0.26	0.76	Supported

Source: Authors' Compilation, 2026.

Common-Method Variance

Common-method variance was assessed using the full-collinearity VIF procedure. The VIF values ranged from 1.41 to 2.28, remaining below the 3.3 threshold. The results therefore provided no indication of problematic common-method variance based on this diagnostic.

Table 3:
Full-Collinearity VIF Assessment

Construct	Full-Collinearity VIF
Digital Capabilities	1.41
Human Capital	1.73
Manufacturing Quality	2.28

Source: Authors' Compilation, 2026.

Measurement Model

The measurement model was assessed for indicator reliability, internal consistency reliability, convergent validity and discriminant validity. All indicator loadings exceeded 0.70, while Cronbach's alpha and composite reliability values exceeded the recommended threshold of 0.70. AVE values were also above 0.50 for all constructs, indicating satisfactory convergent validity.

Table 4:
Measurement Model Evaluation

Construct	Items	Loading Range	Cronbach's α	CR	AVE
Digital Capabilities	5	0.798-0.847	0.881	0.913	0.678
Human Capital	6	0.782-0.839	0.894	0.919	0.655
Manufacturing Quality	5	0.809-0.851	0.889	0.918	0.692

Source: Authors' Compilation, 2026.

The results indicate that the three constructs were measured with adequate reliability and convergent validity. This provides a sound basis for examining the hypothesised structural relationships.

Table 5:
Discriminant Validity Using HTMT

Construct	Digital Capabilities	Human Capital	Manufacturing Quality
Digital Capabilities	—	0.598	0.531
Human Capital	0.598	—	0.562
Manufacturing Quality	0.531	0.562	—

Source: Authors' Compilation, 2026.

All HTMT values were below 0.85, indicating adequate discriminant validity among the constructs.

Table 6:
Fornell-Larcker Criterion

Construct	Digital Capabilities	Human Capital	Manufacturing Quality
Digital Capabilities	**0.823**	0.541	0.487
Human Capital	0.541	**0.809**	0.512
Manufacturing Quality	0.487	0.512	**0.832**

Note: Diagonal values in bold represent the square root of AVE.
Source: Authors' Compilation, 2026.

The square root of the AVE for each construct exceeded its correlations with the other constructs, further supporting discriminant validity. Inner VIF values ranging from 1.35 to 1.87 also indicated that multicollinearity was not problematic.

Structural Model
The structural model was assessed using path coefficients, 5,000 bootstrap resamples, bias-corrected and accelerated confidence intervals, effect sizes and the coefficient of determination.

Table 7:
Structural Model Results

Hypothesised Path	β	t-value	p-value	95% BCa CI	f^2	Decision
DC → MQ	0.297	3.612	<0.001	[0.136, 0.451]	0.098	Supported
HC → MQ	0.274	3.289	0.001	[0.112, 0.429]	0.083	Supported
DC × HC → MQ	0.139	2.104	0.035	[0.011, 0.268]	0.035	Supported

Note: DC = Digital Capabilities; HC = Human Capital; MQ = Manufacturing Quality; BCa = bias-corrected and accelerated confidence interval.
Source: Authors' Compilation, 2026.

The results show that Digital Capabilities had a positive and significant association with Manufacturing Quality (β = 0.297, t = 3.612, p< .001). This finding suggests that enterprises with stronger digital capabilities tend to demonstrate higher manufacturing quality. The finding supports the proposition that digital technologies and related organisational capabilities can enhance firms' ability to improve production processes and quality outcomes.

Human Capital also had a positive and significant association with Manufacturing Quality (β = 0.274, t = 3.289, p = .001). This indicates that enterprises with stronger human-capital capabilities tend to achieve better manufacturing quality. The finding highlights the importance of employees' knowledge, skills and competencies in converting technological resources into improved operational outcomes.

The interaction between Digital Capabilities and Human Capital was positive and significant (β = 0.139, t = 2.104, p = .035; 95% BCa CI [0.011, 0.268]). This indicates that Human Capital

moderates the relationship between Digital Capabilities and Manufacturing Quality. Thus, the contribution of digital capabilities to manufacturing quality becomes stronger when enterprises possess higher levels of human capital.

Table 8:
Explanatory and Predictive Relevance

Endogenous Construct	**R^2**	**Q^2**
Manufacturing Quality	0.389	0.251

Source: Authors' Compilation, 2026.

The model explains 38.9% of the variance in Manufacturing Quality, indicating meaningful explanatory power. The positive Q^2 value of 0.251 indicates predictive relevance.

Moderating Effect of Human Capital
To clarify the significant interaction effect, the conditional relationship between Digital Capabilities and Manufacturing Quality was examined at low and high levels of Human Capital.

Table 9:
Simple-Slope Analysis

Level of Human Capital	**DC → MQ β**	**p-value**	**Interpretation**
Low Human Capital	0.158	0.094	Positive but not statistically significant
High Human Capital	0.436	<0.001	Positive and statistically significant

Source: Authors' Compilation, 2026.

The simple-slope analysis indicates that the relationship between Digital Capabilities and Manufacturing Quality was stronger at high levels of Human Capital ($\beta = 0.436$, $p < .001$) than at low levels ($\beta = 0.158$, $p = .094$). Although the conditional relationship at low Human Capital was not statistically significant, the significant interaction term confirms that the strength of the Digital Capabilities–Manufacturing Quality relationship varies according to the level of Human Capital.

Hypothesis Testing
Table 10:
Summary of Hypothesis Testing

Hypothesis	**Relationship**	**B**	**p-value**	**Decision**
H1	Digital Capabilities → Manufacturing Quality	0.297	<0.001	Supported
H2	Human Capital →	0.274	0.001	Supported

	Manufacturing Quality			
H3	Human Capital moderates Digital Capabilities → Manufacturing Quality	0.139	0.035	Supported

Source: Authors' Compilation, 2026.

Hypothesis Testing

Table 11:

Summary of Hypothesis Testing

Hypothesis	Relationship	β	p-value	Decision
H1	Digital Capabilities → Manufacturing Quality	0.297	<0.001	Supported
H2	Human Capital → Manufacturing Quality	0.274	0.001	Supported
H3	Human Capital moderates Digital Capabilities → Manufacturing Quality	0.139	0.035	Supported

Source: Authors' Compilation, 2026.

The findings support all three hypotheses. H1, which proposed that digital capabilities significantly influence manufacturing quality, was supported ($\beta = 0.297$, $p < 0.001$). This indicates that enterprises with stronger digital capabilities tend to achieve better manufacturing-quality outcomes.

H2, which proposed that human capital significantly influences manufacturing quality, was also supported ($\beta = 0.274$, $p = 0.001$). This demonstrates that employees' knowledge, skills, and competencies constitute important organisational resources for achieving improved manufacturing quality.

H3, which proposed that human capital moderates the relationship between digital capabilities and manufacturing quality, was supported ($\beta = 0.139$, $p = 0.035$). The positive and significant interaction effect indicates that human capital strengthens the relationship between digital capabilities and manufacturing quality. Thus, the contribution of digital capabilities to manufacturing quality is greater when enterprises possess stronger human-capital capacity.

Taken together, the findings suggest that digital capabilities and human capital are complementary sources of manufacturing quality. Digital capabilities provide the technological foundation, while human capital enables enterprises to effectively deploy and translate these capabilities into quality outcomes. The study therefore concludes that manufacturing enterprises

seeking improved quality should pursue digital transformation alongside deliberate investment in employees' knowledge, skills, and competencies.

5.0 Conclusions and Recommendations

The study examined the associations among digital capabilities, human capital and manufacturing quality in footwear manufacturing enterprises in Aba, Abia State, Nigeria. The findings show that digital capabilities and human capital were positively and significantly associated with manufacturing quality. Human capital also significantly moderated the relationship between digital capabilities and manufacturing quality, with the association being stronger at higher levels of human capital. The study therefore concludes that digital capabilities and human capital are important organisational resources for manufacturing quality, while employee competence strengthens the value derived from digital capabilities.

This study examined the relationships among digital capabilities, human capital and manufacturing quality in Aba's footwear industry within the context of Industry 4.0–5.0. The findings showed that digital capabilities were positively and significantly associated with manufacturing quality, indicating that enterprises with stronger digital capabilities tend to achieve better manufacturing quality. Human capital was also positively and significantly associated with manufacturing quality, demonstrating the importance of employees' knowledge, skills and expertise in supporting quality outcomes. Furthermore, human capital significantly moderated the relationship between digital capabilities and manufacturing quality, suggesting that the benefits of digital capabilities are enhanced when enterprises have a capable and appropriately skilled workforce. The study therefore concludes that improving manufacturing quality in Aba's footwear industry requires complementary investment in digital capabilities and human capital, supported by a human-centred approach to digital transformation.

Based on these findings, footwear manufacturing enterprises in Aba should invest in appropriate and affordable digital technologies, digital process monitoring, data-management systems and technology-enabled quality-control tools that support production accuracy, consistency and quality. They should also strengthen human capital through continuous technical training, structured apprenticeship and digital-skills development. Experienced footwear craftsmen should be encouraged to transfer practical production knowledge to apprentices, while apprentices and existing workers should receive training in computer-aided design, digital production tools, quality control and basic data management.

Given the moderating role of human capital, technology acquisition should be accompanied by training, mentoring and apprenticeship programmes to ensure that workers possess the skills required to translate digital capabilities into improved manufacturing quality. Government agencies, footwear associations and SME-support institutions in Abia State should complement these efforts through programmes that combine access to affordable digital technologies with practical technical training, structured apprenticeship and digital-skills development. Such programmes should be delivered through Aba's established footwear clusters and industry associations to strengthen the industry's existing skills-transfer system and improve its readiness for Industry 4.0–5.0 manufacturing.

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