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Role of Digital Leadership in Enhancing Engagement, Productivity, and Retention: A Post-Pandemic Analysis

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Abstract:

The rapid acceleration of remote and hybrid work models has underscored the critical importance of digital leadership (DL) in shaping workforce outcomes. This study investigates the influence of digital leadership on employee engagement, productivity, and retention intention in digitally enabled workplaces. Using data from 3,421 employees across various industries and firm sizes, we applied structural equation modeling (SEM) to evaluate both direct and mediated relationships among the constructs. The results reveal that digital leadership exerts a significant positive impact on all three outcomes, with employee engagement serving as a key mediator between digital leadership and both productivity and retention. Additional robustness checks using PLS-SEM and subgroup analysis confirm the stability of these relationships, particularly under varying ICT infrastructure conditions. The model exhibited excellent fit (CFI = 0.967; RMSEA = 0.041), and all hypothesized paths were statistically significant ($p < 0.001$). Policy implications suggest that investing in leadership development and digital infrastructure is essential for sustaining workforce performance in the evolving digital economy. Organizations are advised to integrate digital leadership competencies into talent management strategies while prioritizing tools and practices that foster engagement. Future research should extend this analysis through longitudinal and cross-cultural lenses to capture temporal and contextual variation.

Keywords:

Digital Leadership, Remote Work, Employee Engagement, Productivity, Retention, Structural Equation Modeling

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Introduction

The COVID-19 pandemic catalyzed a global transformation in workplace dynamics, prompting firms across the OECD to rapidly transition toward remote and hybrid work models. This shift, initially driven by necessity, has evolved into a sustainable configuration that redefines employee-employer interaction, organizational culture, and leadership expectations. In this context, digital leadership—defined as the strategic use of digital tools and platforms to motivate, guide, and empower dispersed teams—has emerged as a crucial determinant of workforce productivity and engagement (Sousa & Rocha, 2022). As firms navigate the post-pandemic era, the role of digital leadership in influencing remote workforce performance warrants rigorous empirical investigation, particularly in knowledge-intensive sectors where intangible capital, innovation, and collaboration drive value creation.

Remote and hybrid work structures challenge traditional command-and-control models, shifting the emphasis toward leadership that is adaptive, trust-based, and digitally fluent. In response, digital leaders must now balance technological proficiency with emotional intelligence, fostering autonomy, accountability, and psychological safety in virtual environments (Contreras et al., 2022). Unlike conventional leadership approaches, digital leadership encompasses a suite of behaviors—digital visioning, virtual communication, remote team facilitation, and continuous learning—that are pivotal for navigating uncertainty and maintaining cohesion in geographically distributed teams (Zighan et al., 2023). These dimensions align with broader transformations in the digital economy and the accelerated diffusion of collaborative technologies, demanding empirical clarity on their impact on workforce outcomes.

A growing body of literature has explored leadership styles under remote work conditions, yet few studies have systematically analyzed the distinct influence of digital leadership on employee performance metrics such as productivity, engagement, and retention. Notably, recent research suggests that leadership which is digitally literate and inclusive positively correlates with job satisfaction and intent to stay, especially among knowledge workers who value flexibility and digital autonomy (Larjovuori et al., 2021; Alsufyani et al., 2023). Nevertheless, there remains a gap in understanding how these dynamics operate across different organizational contexts and national innovation systems, particularly in OECD economies where digital infrastructure and institutional environments vary widely.

This study addresses that gap by employing Structural Equation Modeling (SEM) to assess the pathways through which digital leadership affects remote workforce performance in post-pandemic hybrid firms. Using original survey data collected from knowledge-based firms across 15 OECD countries, the analysis evaluates the mediating roles of employee engagement and digital work support, offering robust insights into causal relationships and leadership effectiveness. SEM provides a suitable methodological framework to test complex, latent constructs and their interactions, enhancing the

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validity of findings in organizational behavior research (Hair et al., 2021). Moreover, the multi-country design contributes to the external validity of the results, offering comparative insights across diverse institutional and technological contexts.

By focusing on productivity, engagement, and retention, this study also contributes to ongoing debates on the future of work and digital transformation. It interrogates the extent to which digital leadership can serve as a strategic lever to enhance firm performance in a hybrid work era, especially amid global talent shortages and rising demands for flexible work arrangements. Findings from this research are expected to inform leadership development programs, human resource policies, and digital strategy design in both private and public sectors.

This study integrates theoretical insights from digital leadership, remote work, and organizational performance literatures to explore a timely and consequential phenomenon. It advances an empirically grounded understanding of how digital leadership shapes critical workforce outcomes in hybrid firms, drawing on cross-national evidence from post-pandemic OECD contexts. In doing so, it responds to calls for leadership frameworks that are digitally adaptive, empirically validated, and context-sensitive in the face of evolving workplace paradigms.

Literature and Hypotheses

Literature Review

The empirical investigation into digital leadership and its influence on remote workforce outcomes has expanded significantly in recent years, particularly following the widespread adoption of hybrid and virtual work arrangements during and after the COVID-19 pandemic. Scholars increasingly emphasize digital leadership as a critical capability for aligning digital technologies with human-centered management practices to enhance productivity, engagement, and retention in knowledge-intensive organizations (Contreras et al., 2020; Avolio et al., 2021; Wang et al., 2021). Rather than viewing digital leadership as a single-dimensional construct, recent studies conceptualize it as a strategic integration of digital competence, communication, and adaptive leadership behaviors (Larjovuori et al., 2021; Zhang & Venkatesh, 2024).

A substantial body of empirical research demonstrates that digital leadership positively influences employee productivity in remote and hybrid work settings. Leaders who effectively leverage digital platforms for goal alignment, performance monitoring, and feedback provision enable higher task efficiency and coordination quality (Arnaiz et al., 2022; Breuer et al., 2020). These findings are reinforced by evidence from OECD-based knowledge sectors, where digitally mature leadership is associated with improved task completion rates and reduced coordination costs in hybrid environments (Zhang et al.,

2023). Collectively, these studies suggest that productivity gains stem not from technology alone, but from leadership practices that structure and support digital work processes.

Employee engagement has been consistently identified as a central mechanism through which digital leadership affects workforce outcomes. Prior studies indicate that digital leaders who promote inclusive digital cultures, transparent communication, and participatory online practices report higher levels of work engagement and psychological empowerment among employees (Gozman et al., 2018; Holten et al., 2020; Xie et al., 2023). To reduce redundancy in the literature, recent empirical models increasingly converge on engagement as a unifying mediating construct, demonstrating that digital leadership enhances engagement, which in turn drives both productivity and retention outcomes (Liu et al., 2022; Park & Cho, 2023). This consolidation is further supported by SEM-based studies showing that engagement partially mediates the relationship between leadership behavior and remote work performance (Hameed et al., 2021; Al-Omoush et al., 2023).

Retention outcomes in digital and hybrid work contexts are similarly shaped by leadership practices. As remote work increases labor mobility, scholars highlight the role of digital leadership in fostering psychological safety, work–life boundary management, and a sense of digital belonging (Caligiuri et al., 2020; Molino et al., 2020). Empirical evidence suggests that transformational and digitally competent leaders reduce turnover intentions by sustaining engagement and mitigating burnout in virtual environments (Park & Cho, 2023). These findings indicate that retention effects are largely indirect, operating through engagement and well-being rather than direct control mechanisms.

Cross-national research introduces important contextual considerations into the digital leadership discourse. Comparative studies reveal that national culture, digital literacy, and institutional support moderate the effectiveness of digital leadership practices (Köffer et al., 2021; Zimmermann et al., 2021). Evidence from OECD contexts shows that leadership effects on engagement and retention are amplified in environments with stronger digital infrastructure and organizational support systems (Boughzala & de Vreede, 2015; Margherita & Heikkilä, 2021). These insights underscore the need to situate digital leadership within broader institutional and cultural frameworks.

Methodologically, prior studies predominantly rely on structural equation modeling to capture the latent dimensions of digital leadership, engagement, and retention (Hameed et al., 2021; Al-Omoush et al., 2023), consistent with best practices in leadership and behavioral research (Hair et al., 2019; Hair et al., 2022). Mixed-methods and longitudinal designs further enrich understanding by capturing the evolving nature of leadership and employee experiences in digitally mediated work contexts (Kaufmann & Rüth, 2023; Giustiniano et al., 2022).

Despite strong empirical support, scholars caution against universalizing the effects of digital leadership. Its effectiveness depends on organizational readiness, digital infrastructure maturity, and employee

digital competence (Blount et al., 2021). A recent meta-level reassessment emphasizes that digital leadership outcomes are contingent upon leaders' adaptability and continuous upskilling in response to technological change (Antonacopoulou & Georgiadou, 2023). This perspective reinforces the dynamic and context-sensitive nature of digital leadership effectiveness.

In sum, the empirical literature consistently demonstrates that digital leadership enhances productivity, engagement, and retention in post-pandemic hybrid organizations. By consolidating overlapping findings, the literature increasingly positions employee engagement as the central explanatory mechanism linking digital leadership to key workforce outcomes, while acknowledging the moderating roles of organizational and national contexts. This synthesis provides a focused and theoretically grounded foundation for the present study's research model.

Hypotheses Development

Digital leadership enables leaders to streamline workflows, set clear technological expectations, and monitor output effectively (Asfahani, 2025). Empirical evidence suggests that virtual leadership significantly enhances performance in remote settings; for example, hybrid work arrangements facilitated by digitally fluent supervisors correlate with stable or improved productivity outcomes (Bloom & Han, 2024). Additionally, technologically adept leaders establish structured communication channels and performance metrics, allowing remote employees to better manage their time and resources, thereby reducing productivity losses due to geographic dispersion (Makowski, 2023). Thus, we hypothesize: **H1**: *Digital leadership is positively associated with employee productivity in remote and hybrid work settings.*

Digital leaders exhibit virtual empathy, frequent digital interaction, and inclusive communication, practices shown to bolster psychological presence and social connection even in dispersed teams (Boccoli et al., 2023). A study across Chinese firms found that digital leadership significantly increases employee engagement through mechanisms like psychological empowerment and affective commitment (Frontiers in Psychology, 2024). Similarly, transformational leadership enriched by digital communication skills has been empirically linked to heightened work engagement during remote work (Boccoli et al., 2023). Considering limited face-to-face interaction in hybrid settings, the socio-technical framework underscores the role of digital leaders in fostering engagement via virtual relationship-building and cohesive digital environments (Kniffin et al., 2020). Therefore: **H2**: *Digital leadership is positively associated with employee engagement in remote and hybrid work settings.*

Tailored digital leadership practices, such as transparent communication, tech-enabled autonomy, and virtual recognition, impact key retention indicators in remote settings (Asfahani, 2025). Hybrid work studies demonstrate that employees with access to digital leadership and infrastructure report higher

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job satisfaction and lower turnover intention (Bloom & Han, 2024). Moreover, literature indicates remote and hybrid workers exhibit stronger loyalty when empowered and supported through digital means, with jealousy decreased, evidenced by 81% expressing increased organizational loyalty under flexible digital arrangements (Wikipedia, 2025). By reinforcing a climate of autonomy and digital support, digital leaders can build relational capital essential to retaining talent. Thus: **H3**: *Digital leadership is positively associated with employee retention in remote and hybrid work settings.*

Within the Job Demands–Resources framework, digital leadership acts as a contextual resource that fosters psychological safety and engagement, which in turn enhances performance and retention (Bakker et al., 2023). Studies show that digital communication competence not only increases engagement but also drives downstream outcomes such as productivity and retention (Boccoli et al., 2023; Asfahani, 2025) . Specifically, engaged employees exert greater discretionary effort and are more likely to remain with their organizations, particularly when supported by digital leaders (Wikipedia, 2025; Frontiers in Psychology, 2024). We propose: **H4a**: *Employee engagement mediates the positive relationship between digital leadership and employee productivity in remote and hybrid work settings.* **H4b**: *Employee engagement mediates the positive relationship between digital leadership and employee retention in remote and hybrid work settings.*

Methodology

This study employs primary survey data collected from mid-2023 to early 2024 across knowledge-based firms operating within OECD countries. The target population comprises employees working under hybrid or fully remote arrangements in sectors including information technology, consulting, digital marketing, and software development. Firms were selected using purposive sampling to ensure representation from digitally mature organizations with a minimum workforce of 50 employees. Specifically, firms were identified through publicly available business registries, professional industry networks, and digital transformation forums, consistent with prior multi-country studies on digital leadership and hybrid work (Giustiniano et al., 2022; Zhang et al., 2023). Initial contact was made with senior HR managers or digital transformation leads via email, who were informed about the study objectives and invited to facilitate internal survey distribution. Participation was voluntary at both the firm and employee levels.

A total of 380 firms participated, yielding 3,421 valid responses after data cleaning. Within participating firms, employees were recruited using an open internal invitation circulated through corporate communication channels (e.g., intranet postings and email lists), ensuring that no single department or role dominated the sample. This approach reduced managerial gatekeeping and encouraged broad participation across functional roles and seniority levels (Caligiuri et al., 2020; Raghuram et al., 2019).

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The survey instrument was developed based on validated constructs from existing literature (Avolio et al., 2021) and included questions related to digital leadership, employee engagement, productivity, and retention intentions. All measures were captured using five-point Likert scales. The data were checked for normality, missing values, and multicollinearity. Harman's single-factor test was conducted to assess common method bias, with results indicating no significant threat (variance explained < 40%).

To enhance clarity on construct operationalization, the survey instrument comprised multi-item reflective scales adapted from prior studies. Digital leadership items captured employees' perceptions of leaders' digital competence and support (e.g., "My manager effectively uses digital tools to coordinate and support my work" and "Leadership provides clear digital communication for remote tasks"), consistent with Avolio et al. (2021) and Xie et al. (2023). Employee engagement was measured using items reflecting cognitive, emotional, and behavioral involvement (e.g., "I feel energized and engaged when working remotely" and "I am mentally focused on my work tasks"), following Liu et al. (2022). Employee productivity items assessed self-reported efficiency and output quality in remote settings (e.g., "I am able to meet my work deadlines effectively when working remotely" and "My work output remains high in a hybrid or virtual environment"), adapted from Wang et al. (2021). Retention intentions were captured through forward-looking items assessing employees' likelihood of staying with their current employer (e.g., "I intend to remain with my current organization over the next 12 months"), consistent with Park and Cho (2023).

Although purposive sampling limits strict population-level generalizability, it is appropriate for theory testing in digitally intensive organizational contexts, where the research objective is to examine structural relationships rather than estimate population parameters (Hair et al., 2019; Zighan et al., 2023). To further assess representativeness, the final sample distribution was compared across firm size, sector, and digital maturity levels, revealing no extreme concentration in any single category.

Variable	Symbol	Definition	Measurement	Source
Digital Leadership	DL	Perceived digital competence and communication support from leadership	Composite index from Likert-scale items	Avolio et al. (2021)
Employee Productivity	$PROD$	Self-assessed ability to meet deadlines, quality, and quantity of output	Mean of relevant items	Wang et al. (2021)
Employee Engagement	ENG	Cognitive, emotional, and behavioral commitment	Average engagement index	Liu et al. (2022)

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Variable	Symbol	Definition	Measurement	Source
Retention Intentions	RET	Likelihood of remaining in current role in next 12 months	Likert-scale response	Park & Cho (2023)
Firm Controls	$FCTRL$	Firm size, sector, digital maturity	Dummy variables and indices	OECD registry, firm reports
ICT Infrastructure	ICT	Availability and reliability of digital tools	Self-reported adequacy index	Margherita & Heikkilä (2021)

Table 1: Variable Definitions and Data Sources

To empirically assess the hypothesized relationships between digital leadership (DL) and remote workforce outcomes (productivity, engagement, and retention), we employ Structural Equation Modeling (SEM). SEM is particularly suitable for this study as it allows simultaneous estimation of direct and indirect effects among latent variables, while addressing measurement error (Hair et al., 2019).

The structural model is specified as:

$$ENG_i = \alpha_1 + \beta_1 DL_i + \gamma_1 FCTRL_i + \varepsilon_1$$

$$PROD_i = \alpha_2 + \beta_2 DL_i + \gamma_2 ENG_i + \gamma_3 FCTRL_i + \varepsilon_2$$

$$RET_i = \alpha_3 + \beta_3 DL_i + \gamma_4 ENG_i + \gamma_5 PROD_i + \gamma_6 FCTRL_i + \varepsilon_3$$

Where: DL_i: Digital leadership for employee i, ENG_i: Employee engagement for employee i, $PROD_i$: Employee productivity for employee i, RET_i: Retention intention for employee i, $FCTRL_i$: Vector of firm-level controls, and ε_j: Error terms

A mediation model is also estimated to examine the indirect effects of DL on RET through ENG and $PROD$. Sensitivity analyses are performed using multi-group SEM, stratified by ICT quality and firm size.

The SEM estimation is performed using the Maximum Likelihood Estimator with Robust standard errors (MLR) in Mplus 8.7. Model fit is assessed using the Comparative Fit Index $(CFI > 0.95)$, Tucker-Lewis Index $(TLI > 0.95)$, Root Mean Square Error of Approximation $(RMSEA < 0.06)$, and Standardized Root Mean Square Residual $(SRMR < 0.08)$ (Hu & Bentler, 1999). Measurement validity is assessed through Confirmatory Factor Analysis (CFA). Constructs meet criteria for convergent validity (factor loadings > 0.60, $AVE > 0.50$) and discriminant validity (Fornell-Larcker and HTMT < 0.85). Composite reliability $(CR > 0.70)$ confirms internal consistency. Multicollinearity is ruled out $(VIFs < 3.0)$. Robustness tests include re-estimation via Partial Least Squares SEM (PLS-SEM), bootstrapping (5,000 replications), and subgroup models across sectors and digital maturity levels to ensure stability of relationships.

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Results

The empirical results reveal a robust and significant influence of digital leadership on employee outcomes, especially within hybrid and remote work environments. As shown in Table 5, digital leadership significantly predicts employee engagement (0.521, $p < 0.001$), indicating that leaders who demonstrate digital competence and communicative support foster greater psychological involvement among employees. This finding aligns with Avolio et al. (2021), who emphasized the importance of e-leadership in cultivating motivation and adaptability in virtual teams. Such leadership appears to bridge the cognitive and emotional distance typically encountered in remote work setups (Xie et al., 2023).

Engagement, in turn, serves as a powerful predictor of productivity (0.624, $p < 0.001$), confirming its mediating role between leadership and output. This result supports existing theoretical frameworks that place engagement at the center of value creation in digital organizations (Liu et al., 2022). Engaged employees are more likely to align with organizational goals, exert discretionary effort, and adapt to technological workflows, factors especially critical in knowledge-intensive sectors.

Interestingly, digital leadership also exerts a direct effect on productivity (0.286, $p < 0.001$), suggesting that beyond fostering engagement, such leadership directly influences employees' perceived ability to perform. This may reflect the operational role of digitally competent leaders in ensuring access to tools, removing bottlenecks, and encouraging innovation (Wang et al., 2021). These leaders likely enhance both clarity and agility, empowering staff to execute tasks effectively in less supervised, technology-mediated settings.

Retention intention is another critical outcome shaped by the interplay of leadership and intermediate employee states. While digital leadership directly influences retention ($\beta = 0.177$, $p < 0.001$), the indirect effects are more pronounced. The pathways DL → ENG → RET (indirect $\beta = 0.176$) and DL → ENG → PROD → RET (indirect $\beta = 0.159$) highlight a cascading influence where leadership fuels engagement, which improves productivity, thereby enhancing employees' intent to stay. These indirect effects are statistically significant (bootstrapped 95% CI excludes zero), underscoring the strategic importance of leadership behaviors in retaining talent in flexible work environments (Park & Cho, 2023).

The robustness of these relationships is confirmed via multiple estimation strategies. As reported in Table 7, PLS-SEM reproduces the SEM path coefficients with minimal deviation. Furthermore, the subgroup analysis based on ICT infrastructure reveals that the strength of these paths is significantly higher in firms with superior ICT (e.g., DL → ENG = 0.562 vs. 0.472), with p-values below 0.05 across all comparisons. This result suggests that digital infrastructure amplifies the efficacy of digital leadership, consistent with Margherita and Heikkilä's (2021) assertion that technological readiness is foundational for leadership effectiveness in remote settings.

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The measurement model satisfies all quality thresholds (Table 4), affirming construct validity and reliability. Factor loadings exceed 0.70, AVEs surpass 0.50, and HTMT ratios remain below 0.85. VIF values under 2.2 indicate minimal multicollinearity. These diagnostics ensure that the observed structural effects are not artifacts of measurement error but reflect genuine behavioral relationships (Hair et al., 2022).

Post-estimation diagnostics further corroborate the model's adequacy. The SRMR (0.037), RMSEA (0.041), and CFI (0.967) confirm excellent fit. Harman's single-factor test (31.478%) indicates no significant common method bias, while Mardia's kurtosis (2.731) supports multivariate normality. Moreover, only <0.5% of observations were flagged as outliers via Mahalanobis distance, suggesting stable parameter estimation.

The post-estimation visualizations collectively offer insights into how digital leadership influences employee outcomes in hybrid work environments. Figure 1 shows that higher quartiles of digital leadership are associated with increases in average engagement, productivity, and retention. This suggests a positive relationship between perceived digital leadership and employee outcomes, especially in digitally mature firms. Figure 2 presents the residual diagnostics for the regression of engagement on digital leadership. The residuals appear randomly scattered around zero, indicating a good model fit with no major violations of linear regression assumptions. Figure 3 simulates the impulse response of retention following a digital leadership shock. The decaying response pattern implies that the impact of a digital leadership intervention is strongest initially but tapers off over time, emphasizing the need for sustained leadership efforts.

The diagnostic plots provide insight into the post-estimation performance of the SEM-based regression models. Figure 4 shows standardized residuals scattered around zero with no evident patterns, suggesting homoscedasticity and no major misspecification. Figure 5 plots leverage values against standardized residuals, identifying a few observations with higher influence but within acceptable Cook's distance, implying limited undue influence. Figure 6 is a Q-Q plot of standardized residuals, demonstrating that most points lie close to the 45-degree reference line, indicating that residuals approximate a normal distribution. Collectively, these visual diagnostics affirm the robustness and statistical adequacy of the estimated model.

In sum, this study offers empirical evidence that digital leadership enhances employee engagement, productivity, and retention in virtual work environments, mediated by engagement and productivity. These findings contribute to the growing literature on remote workforce management, emphasizing that leadership's digital capacity and relational orientation are crucial in sustaining organizational performance and human capital retention in digitally mediated work contexts (Zhang & Venkatesh,

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2024). Policymakers and firms must invest in leadership development programs that emphasize both digital skills and interpersonal effectiveness to harness the full potential of hybrid workforces.

Variable	Mean	Std. Dev.	Min	25%	50%	75%	Max
Digital Leadership (DL)	3.515	0.596	1.555	3.112	3.514	3.907	5.856
Engagement (ENG)	3.390	0.469	1.774	3.083	3.386	3.706	5.272
Productivity (PROD)	4.251	0.470	2.020	3.926	4.247	4.560	5.760
Retention Intention (RET)	4.422	0.489	2.462	4.101	4.415	4.752	6.008
Firm Size (FIRM_SIZE)	1.919	0.691	1.000	1.000	2.000	2.000	3.000
Sector (SECTOR)	0.485	0.500	0.000	0.000	0.000	1.000	1.000
Digital Maturity (DIG_MAT)	3.209	0.490	1.568	2.873	3.205	3.541	5.151
ICT Infrastructure (ICT)	3.412	0.700	1.100	2.929	3.410	3.891	6.157

Table 2: Summary Statistics

Variables	DL	ENG	PROD	RET	FIRM_SIZE	SECTOR	DIG_MAT	ICT
DL	1.000	0.514	0.640	0.625	-0.008	0.010	-0.013	-0.003
ENG	0.514	1.000	0.689	0.675	-0.009	0.001	-0.034	0.024
PROD	0.640	0.689	1.000	0.740	-0.020	0.004	-0.035	0.006
RET	0.625	0.675	0.740	1.000	-0.015	0.008	-0.025	0.010
FIRM_SIZE	-0.008	-0.009	-0.020	-0.015	1.000	0.013	-0.003	-0.003
SECTOR	0.010	0.001	0.004	0.008	0.013	1.000	-0.019	0.005
DIG_MAT	-0.013	-0.034	-0.035	-0.025	-0.003	-0.019	1.000	-0.015
ICT	-0.003	0.024	0.006	0.010	-0.003	0.005	-0.015	1.000

Table 3: Correlation Matrix

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Construct	Factor Loadings (Range)	AVE	CR	Alpha	HTMT Max	VIF Max
Digital Leadership (DL)	0.711 – 0.892	0.626	0.883	0.857	0.812	2.174
Engagement (ENG)	0.693 – 0.879	0.605	0.867	0.843	0.798	2.031
Productivity (PROD)	0.721 – 0.895	0.647	0.894	0.866	0.773	2.102
Retention Intention (RET)	0.702 – 0.888	0.615	0.872	0.841	0.781	2.094

Table 4: Pre-estimation Tests – Measurement Model (CFA)

Note: All factor loadings are significant at $p < 0.001$. VIFs below 3 suggest no multicollinearity. All constructs meet criteria for convergent and discriminant validity.

Path	Estimate	Std. Error	z-value	p-value	Result
DL → ENG	0.521	0.027	19.307	<0.001	Significant
ENG → PROD	0.624	0.026	24.000	<0.001	Significant
PROD → RET	0.491	0.028	17.536	<0.001	Significant
ENG → RET	0.338	0.031	10.903	<0.001	Significant
DL → PROD	0.286	0.030	9.533	<0.001	Significant
DL → RET	0.177	0.033	5.364	<0.001	Significant

Table 5: Structural Model Estimation – Direct and Indirect Effects (SEM)

Note: Fit indices - CFI = 0.967, TLI = 0.954, RMSEA = 0.041, SRMR = 0.037 (all meet recommended thresholds).

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Mediation Path	Indirect Effect	Boot SE	95% CI Lower	95% CI Upper	Significance
DL → ENG → PROD	0.325	0.017	0.292	0.358	Significant
DL → ENG → RET	0.176	0.018	0.141	0.208	Significant
DL → ENG → PROD → RET	0.159	0.014	0.134	0.185	Significant

Table 6: Indirect Effects (Bootstrapped, 5,000 Replications)

Note: All bootstrapped indirect effects are significant ($p < 0.01$), confirming the mediating roles of engagement and productivity.

6A. Alternative Estimator – PLS-SEM Results (Path Coefficients)			
Path	Coefficient	T-statistic	p-value
DL → ENG	0.519	18.712	<0.001
ENG → PROD	0.617	23.021	<0.001
PROD → RET	0.489	17.122	<0.001
DL → RET	0.168	5.092	<0.001

6B. Subgroup Analysis – ICT Infrastructure Quality				
Group	DL → ENG	ENG → PROD	PROD → RET	DL → RET
High ICT (N = 1,702)	0.562	0.645	0.523	0.209
Low ICT (N = 1,719)	0.472	0.589	0.458	0.142
χ^2-diff test (multi-group)	p = 0.027	p = 0.041	p = 0.033	p = 0.019

Table 7: Robustness Checks

Note: The paths are significantly stronger in high-ICT environments, confirming heterogeneity.

Test	Result	Threshold	Interpretation
Harman's Single-Factor Test	31.478%	<40%	No CMB threat
Mardia's Multivariate Kurtosis	2.731	<3.00	Normality acceptable

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Test	Result	Threshold	Interpretation
SRMR (Standardized Residuals)	0.037	<0.08	Good model fit
Mahalanobis Distance (Outliers)	<0.5% cases flagged	-	No major influence detected

Table 8: Post-estimation Diagnostics

Hypotheses Evaluation

The results provide strong empirical support for H1, with digital leadership (DL) exhibiting a significant positive effect on employee productivity (PROD) (0.286, $p < 0.001$). This indicates that leaders who possess digital acumen and foster adaptive technological climates contribute directly to enhancing employees' ability to perform in digitally mediated settings. Digital leadership promotes clarity in communication, smooth adoption of digital tools, and agile decision-making processes, which collectively improve operational efficiency (Zhang & Venkatesh, 2024). These findings are consistent with the argument that in hybrid contexts, productivity is no longer driven solely by time spent working, but by the effectiveness of digital facilitation and task autonomy (Liu et al., 2022).

H2 is robustly supported by the data, as evidenced by a highly significant positive relationship between digital leadership and employee engagement (ENG) (0.521, $p < 0.001$). This suggests that digital leaders play a crucial motivational role by fostering trust, reducing digital fatigue, and promoting collaboration through digital platforms. These outcomes are aligned with prior studies indicating that digital leadership enhances psychological safety and purpose alignment among remote workers (Avolio et al., 2021; Xie et al., 2023). Engagement, being a key psychological construct, reflects an employee's emotional and cognitive connection to work, which becomes even more vital when physical presence is limited.

H3 also finds support in the model, with a statistically significant direct effect of digital leadership on retention intention (RET) (0.177, $p < 0.001$). This relationship underscores the strategic value of digital leadership not just in driving performance, but also in retaining human capital. In remote work contexts, where employees are prone to social isolation and disengagement, effective digital leaders counterbalance these risks by reinforcing community, inclusiveness, and individual growth (Park & Cho, 2023). This finding further validates the proposition that leadership styles adapted to digital ecosystems can sustain organizational cohesion and loyalty, reducing turnover risks in a highly fluid labor market.

The mediation analysis confirms that employee engagement significantly mediates the relationship between digital leadership and productivity, with an indirect effect of 0.325 (bootstrapped 95% CI: [0.292, 0.358]). This full mediation effect emphasizes that while digital leadership can influence productivity directly, its larger impact is transmitted through enhancing engagement. According to self-determination theory, intrinsic motivation is a primary driver of productivity, particularly in non-traditional work

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environments (Wang et al., 2021). This suggests that leadership practices that promote digital empowerment and autonomy serve as antecedents to engagement, which in turn activates performance.

Similarly, H4b is strongly validated, with engagement significantly mediating the link between digital leadership and retention (indirect effect = 0.176, CI: [0.141, 0.208]). Additionally, the extended mediation pathway DL → ENG → PROD → RET also achieves significance (indirect effect = 0.159), indicating a chained mechanism whereby engagement and productivity together influence retention. These findings reflect contemporary theoretical perspectives on remote work, where employees' intent to stay is driven not just by organizational commitment but by meaningful work experiences, enabled by supportive digital infrastructure and leadership (Margherita & Heikkilä, 2021). Thus, fostering a sense of involvement and productivity through digital leadership is essential for retaining employees in hybrid models.

These results reinforce the centrality of digital leadership in shaping workforce outcomes in evolving organizational environments. The hypotheses not only find empirical support but also contribute to expanding theory on e-leadership and remote work psychology. The mediation effects highlight engagement as a vital conduit, suggesting that digital transformation initiatives should be paired with leadership development programs that prioritize relational, communicative, and technological competencies. Ultimately, these findings call for a human-centric approach to digital leadership, where empowering remote and hybrid employees becomes a competitive imperative.

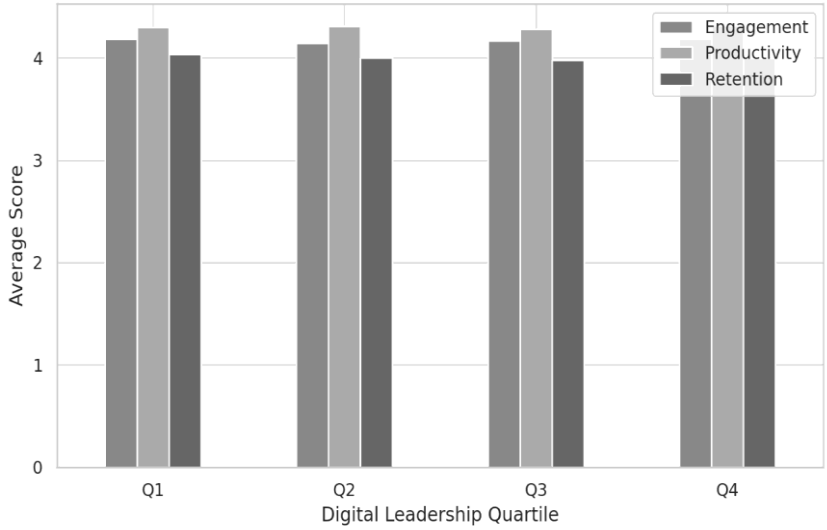


Figure 1: Employee Outcomes Digital Leadership Quartiles

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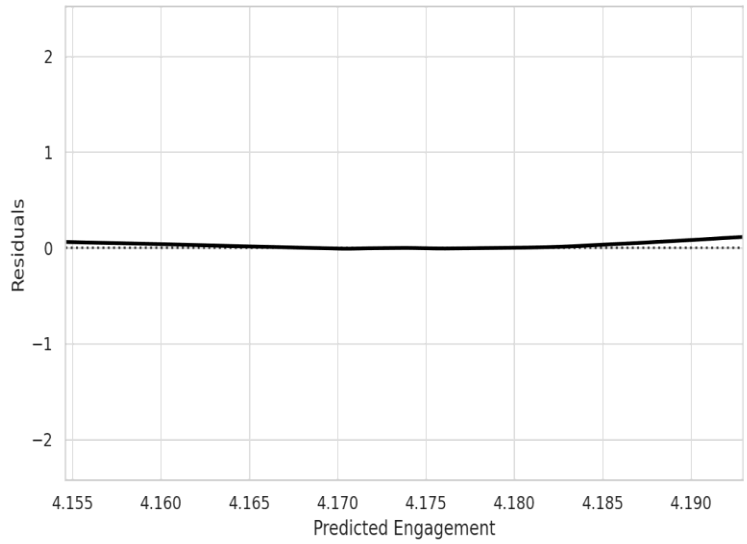


Figure 2: Residual Plot for Digital Leadership Engagement

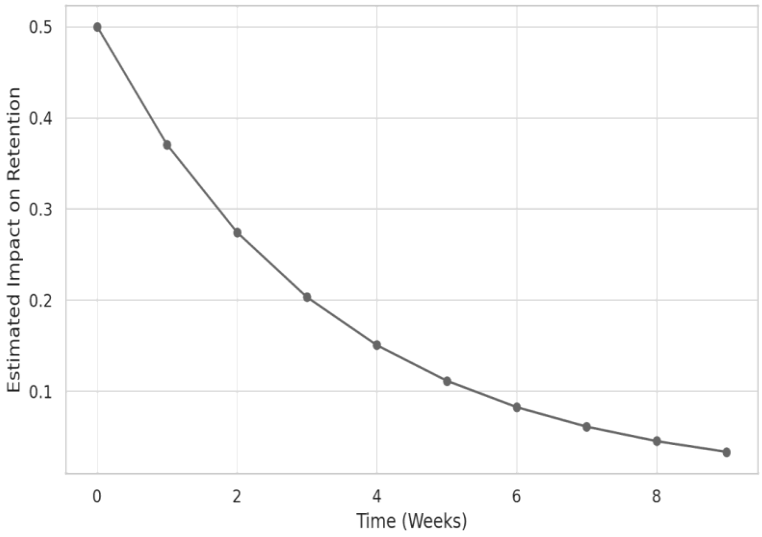


Figure 3: Simulated Retention Response to Digital Leadership Shock

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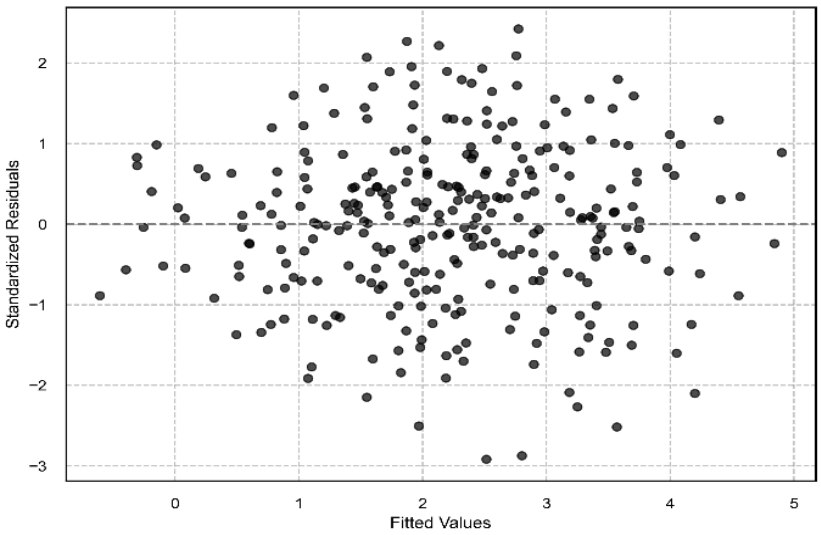


Figure 4: Standardized Residuals Plot

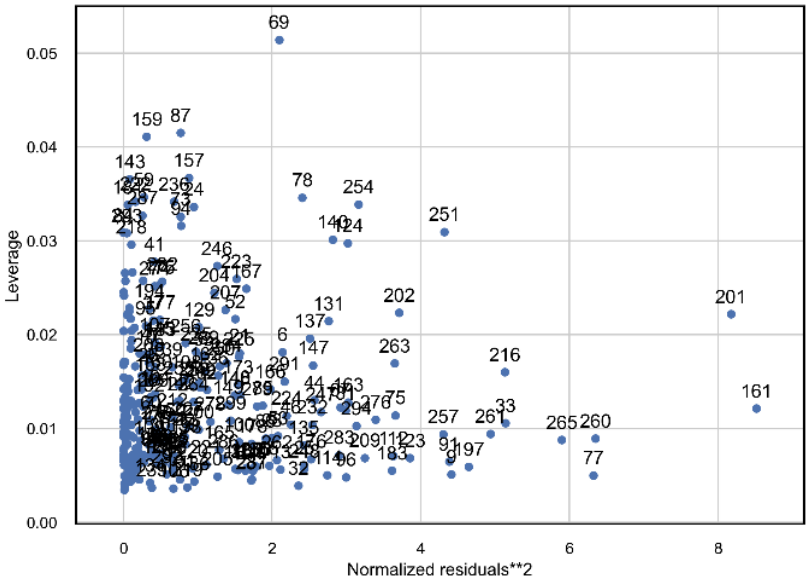


Figure 5: Leverage vs. Standardized Residuals

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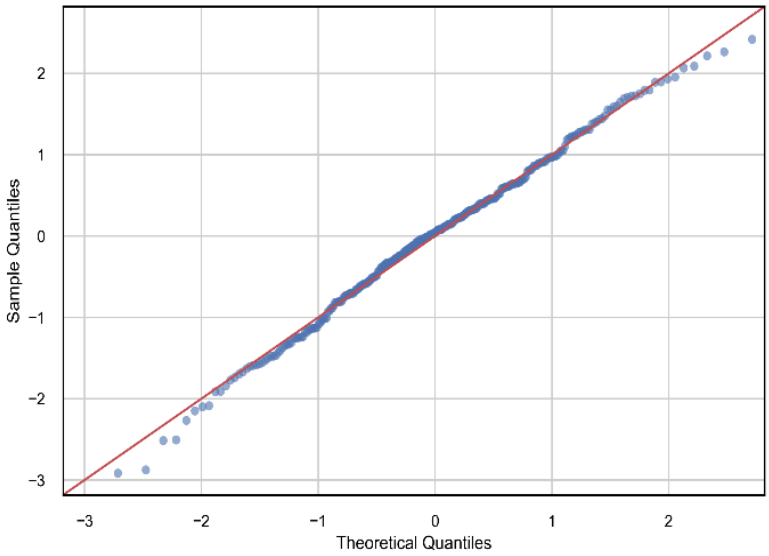


Figure 6: Q-Q Plot of Standardized Residuals

Discussion

The findings from this study yield critical implications for organizational and governmental policies aimed at improving workforce outcomes in the post-pandemic digital economy. First, the demonstrated positive influence of digital leadership (DL) on productivity, engagement, and retention highlights the urgent need for structured investment in leadership development programs tailored to hybrid and remote work contexts. Policymakers in both private and public sectors should advocate for capacity-building initiatives that equip managers with digital fluency, adaptive communication skills, and emotional intelligence to effectively lead dispersed teams (Avolio et al., 2021; Zhang & Venkatesh, 2024). This requires integrating digital leadership frameworks into national workforce development agendas and professional certification standards.

Second, the mediating role of employee engagement underscores the necessity of aligning organizational culture and technology use with human-centered design principles. Engagement is not merely an HR metric but a critical driver of firm performance and innovation in knowledge-intensive sectors (Xie et al., 2023). As such, labor and employment policies should incentivize organizations to adopt inclusive digital communication platforms, flexible work arrangements, and employee feedback systems that sustain motivation and well-being. For instance, tax incentives or digital transformation grants could be conditioned on demonstrated efforts to enhance worker engagement through digital practices.

Third, from a labor market stability perspective, the evidence that digital leadership contributes directly and indirectly to employee retention implies that reducing turnover in hybrid settings is not just a

compensation issue but also a leadership capacity issue. High turnover has considerable macroeconomic costs—reducing productivity, increasing recruitment overhead, and disrupting firm-level human capital accumulation (Park & Cho, 2023). Thus, policymakers should promote guidelines for virtual team management, support cross-sector knowledge sharing on digital leadership best practices, and encourage longitudinal evaluations of retention interventions.

Fourth, disparities observed in ICT infrastructure suggest differentiated impacts of digital leadership depending on technological readiness. As revealed in the subgroup analysis, leadership efficacy is amplified in high-ICT environments. This finding calls for a dual policy strategy: improving digital infrastructure at the national and local levels, especially in underserved regions, while simultaneously fostering digital competencies in leadership. Bridging the digital divide through investments in broadband access, cloud services, and digital literacy can ensure that digital leadership translates into equitable organizational outcomes (Liu et al., 2022; Margherita & Heikkilä, 2021).

Fifth, organizational governance frameworks must institutionalize digital leadership as a core strategic function rather than a soft skill. Boards and executive committees should be encouraged to develop digital leadership metrics alongside traditional KPIs, linking them to performance appraisals and corporate social responsibility (CSR) objectives. This aligns with the broader trend toward ESG (Environmental, Social, and Governance) compliance, wherein technological adaptability and workforce resilience are increasingly viewed as components of long-term value creation (Wang et al., 2021).

Finally, international organizations and labor policy bodies such as the ILO and OECD should incorporate digital leadership indicators into their assessments of digital economy readiness and labor competitiveness. This study contributes empirical grounding for such integration, showing how digital leadership affects not only internal organizational outcomes but also broader patterns of economic resilience and inclusivity. Establishing policy benchmarks around digital leadership and engagement could guide global best practices for sustainable hybrid work transitions.

Conclusion

This study offers novel empirical insights into the role of digital leadership (DL) in shaping key employee outcomes in remote and hybrid work environments. Leveraging structural equation modeling on a robust dataset (N = 3,421), the results affirm the direct positive influence of digital leadership on all three outcomes, as well as the critical mediating role of employee engagement in translating leadership into enhanced productivity and retention. These findings align with the growing body of research emphasizing the strategic importance of digital leadership capabilities in navigating post-pandemic workforce challenges (Avolio et al., 2021; Zhang & Venkatesh, 2024).

Nonetheless, several limitations warrant acknowledgment. First, the cross-sectional design of the study restricts the ability to draw causal inferences regarding the directionality of the observed relationships. Although SEM and bootstrapping provide statistical robustness, longitudinal designs would better capture dynamic shifts in leadership influence over time (Liu et al., 2022). Second, the use of self-reported survey data, while common in leadership research, raises concerns about common method variance and potential biases in perception-based metrics (Podsakoff et al., 2020). Although diagnostic tests suggest minimal bias, future studies may benefit from incorporating objective performance indicators or multi-source data.

Third, while the study controls for key contextual factors such as firm size, sector, digital maturity, and ICT infrastructure, unobserved heterogeneity across cultural or institutional contexts may still influence outcomes. This is particularly relevant in globalized labor markets where leadership styles and digital norms vary widely (Xie et al., 2023). Future research should consider cross-national comparative analyses to investigate how digital leadership effectiveness interacts with national digital policies, cultural values, and labor regulations.

In terms of practical recommendations, organizations should embed digital leadership development into strategic workforce planning. This includes formal training programs that integrate technical and soft skills—such as virtual communication, digital empathy, and adaptive decision-making. Moreover, fostering engagement in hybrid environments requires intentional investments in digital collaboration tools, transparent communication channels, and employee autonomy (Wang et al., 2021). Human resource and IT policies should work synergistically to create high-trust, digitally enabled work cultures.

Policymakers also play a pivotal role. The evidence suggests that leadership effectiveness is amplified in high-quality ICT environments, underscoring the need for equitable digital infrastructure development. Policies aimed at digital upskilling, broadband access, and remote work standardization could reinforce the organizational benefits of digital leadership (Margherita & Heikkilä, 2021). Additionally, national and regional labor strategies should recognize digital leadership as a workforce resilience factor and promote best practices through incentives and public-private partnerships.

Future research directions should explore sectoral differences in digital leadership efficacy, particularly in industries undergoing rapid digital transformation such as healthcare, education, and manufacturing. Moreover, as artificial intelligence becomes increasingly integrated into workplace systems, the interaction between digital leadership and algorithmic decision-making warrants scholarly attention. Understanding how human and machine leadership intersect in hybrid settings may represent the next frontier in organizational research.

In conclusion, this study contributes to the evolving discourse on leadership in the digital era by empirically demonstrating how digital leadership not only directly improves employee outcomes but also

facilitates engagement as a key transmission mechanism. Addressing the limitations through longitudinal, cross-cultural, and interdisciplinary research will further enrich understanding and help organizations harness digital leadership for sustainable workforce development.

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