Smart Society : Community Service and Empowerment Journal
Volume 6, Issue 1, 233-243.
e_ISSN: 2807-5757
https://www.journal.foundae.com/index.php/smartsoc/index

Digital Human Resource Management and Its Effect on Human Resource Efficiency: Empirical Evidence from Manufacturing Companies in Batam, Indonesia

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Article Info

Article history:

Received: December 25, 2025
Revised: February 28, 2026
Accepted: March 28, 2026

Keywords:

Digital HR;
HRIS;
HR Management Efficiency;
Manufacturing Industry;
PLS-SEM.

Abstract

Digital transformation has fundamentally reshaped human resource management (HRM) practices in the manufacturing industry. Although many organizations have adopted Human Resource Information Systems (HRIS), their utilization often remains limited to administrative functions, thereby constraining their strategic potential. This study aims to examine the impact of Digital Human Resource (Digital HR) implementation on Human Resource Management efficiency in manufacturing companies. Employing a quantitative explanatory research design, data were collected from 40 human resource practitioners in manufacturing firms in Batam, Indonesia, using a structured questionnaire with a five-point Likert scale and purposive sampling technique. Data were analyzed using Partial Least Squares–Structural Equation Modeling (PLS-SEM). The results reveal that Digital HR implementation has a positive and significant effect on HRM efficiency ($\beta = 0.670$; $p < 0.001$), with a moderate explanatory power ($R^2 = 0.449$) and a substantial effect size ($f^2 = 0.352$). Multidimensional analysis indicates that the most significant improvements occur in process integration and decision-making readiness, rather than merely in administrative speed and data accuracy. These findings suggest that Digital HR functions not only as an operational tool but also as a strategic driver for enhancing organizational efficiency. This study contributes to the literature by validating the applicability of the Electronic Human Resource Management framework and the Technology Acceptance Model in a labor-intensive manufacturing context. Practically, the findings offer valuable insights for organizations seeking to optimize HR performance through digital transformation initiatives.

To cite this article: Zamora, R., Nurhayati, N., & Mulyati, S. (2026). Digital Human Resource Management and Its Effect on Human Resource Efficiency: Empirical Evidence from Manufacturing Companies in Batam, Indonesia. *Smart Society: Community Service and Empowerment Journal, 6*(1), 233-243. https://doi.org/10.58524/smartsociety.v6i1.1084

INTRODUCTION

Industry 4.0, global competition, and the demand for operational efficiency have driven a radical transformation in the manufacturing industry (Felsberger et al., 2022). The quality of Human Resource Management (HRM) hinges on digital transformation and has become a strategic necessity rather than an optional improvement (Nicolás-Agustín et al., 2022; Zhang & Chen, 2024). The World Economic Forum (2023) reports that more than 60% of manufacturing companies in developing countries have accelerated their adoption of digital human resources management since 2020, but less than 30% have successfully utilized these systems beyond administrative functions. This transformation aligns with SDG Goal 8 (Decent Work and Economic Growth), which promotes efficient labor management as a driver of inclusive economic productivity, and SDG 9 (Industry,

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Innovation and Infrastructure), which calls for the adoption of technology to strengthen industrial performance, both of which are operationally relevant to the manufacturing context in developing countries like Indonesia (World Bank Group, 2024). Implementing effective labor management contributes to sustainable economic productivity.

The relationship between Digital Human Resource Management implementation and Human Resource Management efficiency is theoretically based on the Electronic Human Resource Management framework proposed by Bondarouk & Ruël (2012), which conceptualizes Digital Human Resource Management as the application of web-based technologies to support Human Resource professionals in recruitment, training, performance management, and workforce planning, with the primary goal of improving organizational effectiveness and efficiency. This framework positions Digital Human Resource Management as a transformative mechanism that shifts the Human Resource function toward a strategic organizational role. The Technology Acceptance Model developed by Davis (1989) complements this framework by explaining the conditions under which Digital Human Resource Management implementation results in tangible efficiency gains (Venkatesh et al., 2003). Companies implementing identical systems experience different outcomes depending on the digital competency and acceptance level of their Human Resource practitioners (Amoako et al., 2023; Minbaeva, 2017; Venkatesh et al., 2003). Overall, the Electronic Human Resource Management framework identifies what organizational outcomes are generated by the implementation of Digital Human Resource Management, while the Technology Acceptance Model explains why and under what conditions those outcomes are realized.

Empirical research on Digital Human Resource Management has generated a substantial body of evidence, although the findings reveal a more complex picture than a simple positive relationship. Effectively implemented Electronic Human Resource Management systems have been shown to substantially reduce administrative burdens while expanding the strategic role of Human Resource departments in multinational organizations (Bondarouk & Ruël, 2012). This positive relationship between the integration of digital technologies into the Human Resource function and the quality of operational efficiency has been further strengthened across various sectors through systematic review evidence (Marler & Fisher, 2013). In organizations that have reached more advanced stages of digital maturity, algorithmically driven Human Resource systems have demonstrated an accelerated capacity to integrate processes and strengthen data-driven Human Resource capabilities (Bhatti et al., 2025; Meijerink et al., 2021). Furthermore, digital HR transformation has been found to enhance organizational agility and improve decision-making quality, particularly in data-intensive environments (Verhoef et al., 2021; Vial, 2019), while improved data integration and analytics capabilities contribute to higher employee performance and operational efficiency (Vesterinen et al., 2024; Wamba et al., 2017). In the manufacturing sector, digital HR adoption has also been shown to optimize workforce management and streamline HR processes, especially in labor-intensive industries (Puspita, 2024). Organizations with higher levels of digital HR maturity tend to exhibit stronger alignment between HR strategies and broader business objectives (Ruiz et al., 2024), and the effectiveness of such systems is further influenced by user readiness and technological acceptance (Shahreki & Lee, 2024).

However, the evidence supporting Digital Human Resource Management is not unconditional, as its effectiveness is highly dependent on contextual and organizational factors. In environments characterized by digital resistance and inadequate technological infrastructure, the implementation of Electronic Human Resource Management systems may paradoxically increase administrative burdens rather than reduce them, thereby undermining the expected efficiency gains (Obeidat, 2017). Furthermore, the realization of efficiency improvements is strongly influenced by employees' levels of digital literacy, particularly in public sector institutions (Jimoh, 2025). Organizational agility has also been identified as a critical moderating factor, as structurally rigid organizations are less likely to fully realize the benefits of digital HR systems regardless of their technological sophistication (Mahmoud et al., 2025). Despite these insights, a significant gap remains in understanding whether these patterns are equally applicable within labor-intensive manufacturing environments in developing countries, which differ substantially from the organizational contexts examined in prior studies.

Manufacturing firms in developing countries are an under-researched context. Existing research focuses on service industries and technology-intensive firms in high-income countries,

where organizational readiness, infrastructure quality, and workforce digital competencies differ significantly from those found in labor-intensive manufacturing environments in developing countries (Parry & Tyson, 2011). This focus is important because the conditions that determine whether Digital Human Resource Management (DHR) implementation results in efficiency gains, such as practitioner acceptance, systems integration capacity, and organizational agility are the most variable across these two contexts. Research addressing manufacturing environments in developing countries has focused more on adoption intentions than on efficiency outcomes from actual implementation, which are theoretically and empirically distinct phenomena (Kassim et al., 2012; Venkatesh et al., 2003). The direct impact of DHR implementation in the Indonesian manufacturing sector remains under-researched empirically. This study addresses this gap through a quantitative explanatory design based on evidence from manufacturing firms in Batam, Indonesia. This study aims to examine the impact of Digital HR implementation on HR management efficiency in manufacturing firms, focusing on manufacturing firms in Batam. These findings are expected to contribute to a more contextual understanding of how Digital Human Resource Management functions as a strategic efficiency driver in an environment largely overlooked by the existing literature, while providing evidence-based guidance to practitioners for aligning digital Human Resource investments with measurable operational outcomes.

METHOD

An exploratory quantitative research approach was used for this study based on methodological and organized epistemological concerns. Exploratory designs aim to examine and explain causal relationships among variables through the testing of explicitly formulated hypotheses (Sekaran & Bougie, 2019). A quantitative methodology was chosen because it allows for a systematic and standardized examination of research constructs, yields data that can be statistically analyzed, and produces empirical evidence that is reproducible and verifiable (Sugiyono, 2016). The study population consisted of all active Human Resources practitioners working in manufacturing companies operating in the Batam industrial area, Indonesia. Batam was selected as the research location based on its industrial significance. Batam is home to over 400 manufacturing companies and is one of the largest export-oriented industrial areas in Indonesia, with a workforce exceeding 100,000 employees in the electronics, shipbuilding, and general manufacturing sectors (Batam Indonesia Free Zone Authority, 2023). This concentration of manufacturing activity, combined with the evolving digital Human Resources adoption landscape, makes Batam a contextually appropriate and empirically relevant location to examine the impact of Digital Human Resources implementation (Yalenios & d'Armagnac, 2023). The respondent profiles for the sample were operationally defined as presented in Table 1.

Table 1. Respondent Profile

Category	Description	Frequency	Percentage
Industrial Sector	Manufacturing Company	40	100%
Position	HR Staff / Supervisor / Manager	40	100%
Work Experience	1–3 Years	26	65
Work Experience	> 3 Years	14	35

Instrument Development and Validation

The research instrument was developed through a systematic adaptation process based on validated scales from previous research. All questionnaire items were contextually modified to align with the characteristics of the manufacturing environment in Batam, without altering the theoretical substance of the constructs being measured. The research instrument was developed through a systematic adaptation process based on validated scales from previous research. The instrument comprises two constructs measured by a total of ten reflective indicators. The Digital Human Resource Management construct is operationalized through five indicators (DHR1–DHR5) adapted from Bondarouk & Ruël (2012), Kavanagh et al. (2019), and Marler & Fisher (2013). These indicators cover the utilization of Human Resource Information Systems, digital recruitment, technology-based training, Human Resource analytics, and cross-functional digital integration. The Human Resource Management Efficiency construct is operationalized through five indicators (EFF1–EFF5) adapted

from Marler & Fisher (2013), covering administrative speed, data accuracy, process integration, managerial decision-making readiness, and reduced HR process cycle time. All items are measured on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Content validity was assessed through expert review by two academics specializing in Human Resource Management and quantitative research methodology, who evaluated the relevance and clarity of the items to the theoretical definition of each construct. Following expert review, the instrument underwent a pilot test administered to ten respondents who shared characteristics with the main sample but were excluded from the final analysis, in accordance with the minimum threshold recommended for pilot testing in organizational survey research (Johanson & Brooks, 2010). The pilot test was conducted to detect linguistic ambiguity, item interpretation difficulties, and to obtain initial reliability estimates. Items that generated inconsistent responses or interpretation confusion were revised at the wording level without changing the substance of the construct. Construct validity and reliability were then confirmed through an evaluation of the full measurement model, which is reported in the Results section. Primary data were collected through a structured questionnaire distributed both in-person at the manufacturing company and via Google Forms throughout the data collection period (Ringle et al, 2015). All respondents provided informed consent before participation.

Data Analysis

Data were analyzed using Partial Least Squares–Structural Equation Modeling with SmartPLS version 3.3.9 (Ringle et al., 2015). This method was chosen over covariance-based Structural Equation Modeling for three methodological reasons: its proven performance with small samples and simple structural models (Hair et al., 2019), its freedom from the multivariate normality assumption, typically violated by ordinal Likert scale data (Chin & Marcoulides, 1998), and its suitability for predictive and confirmatory research purposes rather than theory development (Henseler et al., 2009). The analysis was conducted in two stages as summarized in Table 2.

Table 2. PLS-SEM model evaluation criteria

Evaluation Phase	Criteria	Threshold
Measurement Model — Convergent Validity	Factor loading	> 0,70
	Average Variance Extracted (AVE)	> 0,50
Measurement Model — Discriminant Validity	Fornell-Larcker Criteria	AVE > correlation coefficient between constructs
	Heterotrait-Monotrait Ratio (HTMT)	< 0,85
Measurement Model — Reliability	Composite Reliability (CR)	> 0,70
	Cronbach's Alpha (α)	> 0,70
Structural Model	Regression coefficient (β) & p-value	Significant ($p < 0,05$)
	Coefficient of determination (R^2)	Interpretation: weak (0,25), moderate (0,50), substantial (0,75)
	Effect size (f^2)	Small (0,02), medium (0,15), large (0,35)
	Predictive validity (Q^2)	> 0 indicates predictive relevance
	Bootstrapping procedure	5,000 subsamples, two-tailed test

Source: Adapted from (Chin & Marcoulides, 1998; Fornell & Larcker, 1981; Hair et al., 2019; Henseler et al., 2009)

To control for potential common method bias, which commonly arises in survey research using a single data source, Harman's Single Factor Test (Podsakoff et al., 2003) was conducted. If a single dominant factor does not account for more than 50% of the total variance, common method bias is not considered a serious threat to the validity of the findings. A bootstrapping procedure with 5,000 subsamples was used to calculate the standard error and confidence interval of the path coefficients in the hypothesis testing.

Research Flowchart

The research procedure charts the sequential development from literature review to conclusions through four phases: research design, instrument development and data collection, data analysis, and research findings. This flowchart is intended to provide a transparent overview of the methodological decisions made at each stage and their logical sequence. Figure 1 illustrates the research flowchart.

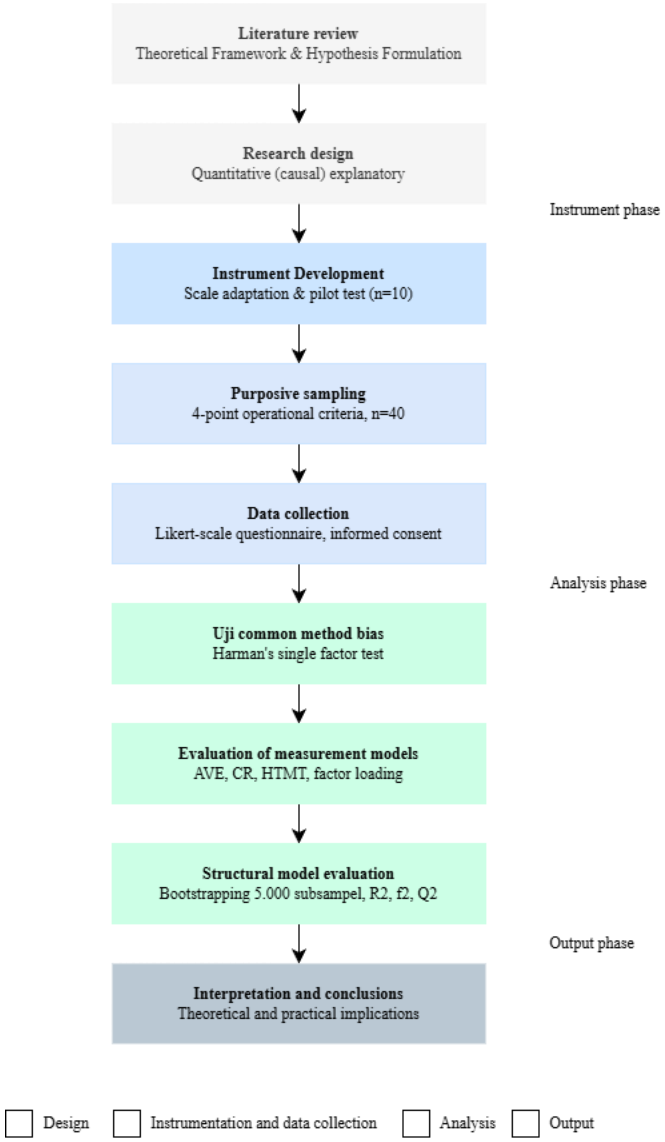

Figure 1. Research Flowchart

RESULTS AND DISCUSSION

Results

Respondent Profile Analysis

This study involved 40 HR practitioners from manufacturing companies in Batam as respondents. Respondent characteristics were based on industry sector, job title, and work experience with human resource practitioners working in manufacturing companies in Batam. The majority of respondents (65%) had between one and three years of experience using digital HR systems, indicating that most organizations are still in the early to intermediate stages of digital HR adoption. However, 35% of respondents reported more than three years of experience, indicating that most companies have reached a more mature stage in digital HR implementation.

Evaluation of Measurement Models

Before conducting the structural equation modeling analysis, we first present an overview of changes in respondents' perceptions of HR management efficiency before and after the implementation of Digital HR. This data was obtained through retrospective questions in the questionnaire and measured across the four dimensions of efficiency that constitute the research constructs. Descriptive statistics comparing the two conditions are presented in Table 3.

Table 3. Evaluation of Measurement Models

Dimensions of HRE	Mean Before (Mean ± SD)	Post-test Mean (Mean ± SD)	Average Difference	Description
Digital HR Implementation	2,84 ± 0,71	4,12 ± 0,58	+1,28	Up
HR Data Accuracy	2,91 ± 0,68	4,18 ± 0,52	+1,27	Up
HR Process Integration	2,73 ± 0,74	4,05 ± 0,61	+1,32	Up
Decision-Making Readiness	2,65 ± 0,80	3,97 ± 0,63	+1,32	Up

Table 3 presents a comparison of descriptive statistics for each dimension of HR management efficiency between the conditions before and after the implementation of Digital HR, based on respondents' retrospective perceptions. Overall, the efficiency score increased from an average of 2.78 (SD = 0.64) to 4.08 (SD = 0.54), reflecting a mean difference of +1.30 points on a 5-point scale. The largest increases were recorded in the dimensions of HR process integration and readiness for data-driven decision-making (1.32 points each), followed by administrative speed and HR data accuracy (1.28 and 1.27 points, respectively).

Structural Model Analysis

The structural model indicates a positive and statistically significant relationship between Digital HR Implementation and Human Resource Management Efficiency, with a path coefficient of β = 0.67 ($p < 0.001$). The coefficient of determination ($R^2 = 0.45$) indicates that Digital HR Implementation explains 45% of the variance in human resource management efficiency. The results of the structural model (PLS-SEM) are explained in Figure 2.

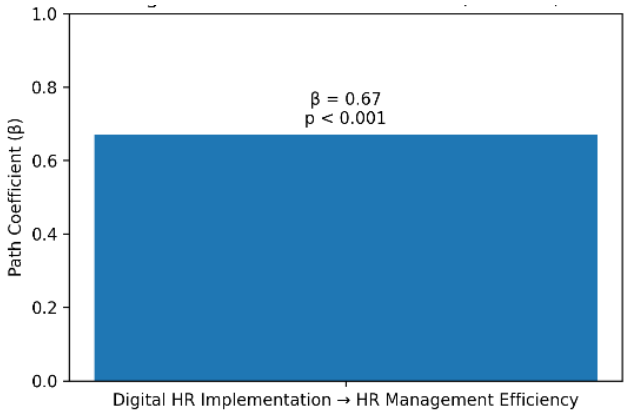

Figure 2. Structural Model Results (PLS-SEM) *(Implementation of Digital HR → HR Management Efficiency)* β = 0,67; p < 0,001

Figure 2 illustrates the results of the structural model obtained from Partial Least Squares–Structural Equation Modeling (PLS-SEM). The path coefficient from the implementation of Digital HR to HR management efficiency is positive and statistically significant (β = 0.67; $p < 0.001$). These results indicate that a higher level of Digital HR implementation substantially improves HR management efficiency in manufacturing companies. The magnitude of the path coefficient (β = 0.67) indicates a strong effect.

Improving Human Resources Management Efficiency

A clear improvement in HR management efficiency following the implementation of the digital HR system. Post-implementation results show higher efficiency scores compared to the pre-

implementation phase, indicating that the adoption of digital HR has a positive impact on HR operational performance. Figure 3 illustrates this improvement in HR management efficiency.

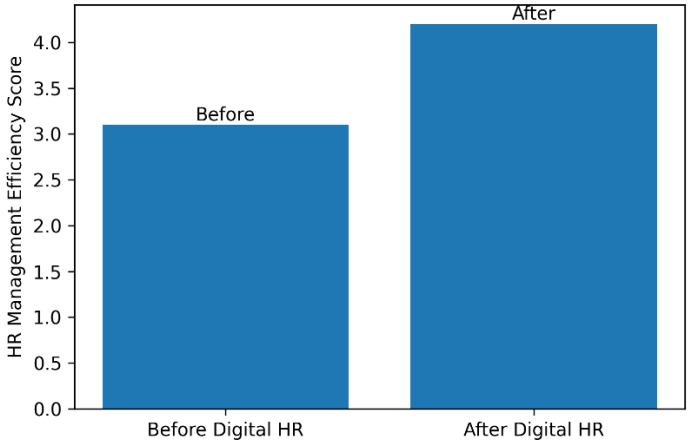

Figure 3. Improving Human Resource Management Efficiency (Before and After the Implementation of Digital HR)

Figure 3 provides further evidence that the implementation of Digital HR not only has a statistically significant effect on HR management efficiency but also yields observable and practical improvements at the operational level.

Discussion

The main findings of this study indicate that the implementation of Digital HR has a positive and significant effect on HR management efficiency (β = 0,670; p < 0,001), with a coefficient of determination of R^2 = 0.45, indicating that the implementation of Digital HR explains 45% of the variance in HR management efficiency in manufacturing companies in Batam. From the perspective of the e-HRM framework proposed by Bondarouk & Ruël (2013), these findings are consistent with the core proposition that the integration of web-based technology into HR functions does not merely automate administrative processes but comprehensively transforms the strategic capabilities of the HR department. The magnitude of the path coefficient (β = 0,670) reflects that this transformation is not marginal because Digital HR is a substantial determinant of efficiency. This is further reinforced by the descriptive data in Table 2, which shows that the largest post-implementation increases occurred in the dimensions of HR process integration and readiness for data-driven decision-making (each +1,32 points), rather than solely in administrative speed (+1,28). This pattern indicates that the benefits of Digital HR are multi-layered on the surface, it accelerates processes, but at a deeper level, it builds the organization's capacity to make faster, evidence-based decisions.

From the perspective of the Technology Acceptance Model (TAM) (Davis, 1989), an R^2 value of 0,449 implies that although the implementation of Digital HR is the primary predictor of efficiency, 55,1% of the variance is still explained by factors outside the model. This aligns with the argument by Venkatesh et al. (2003) that user acceptance and capability act as mediators between technology availability and the realization of its benefits. In other words, even a sophisticated Digital HR system will not fully realize its efficiency potential if the HR practitioners operating it lack adequate digital competencies. Minbaeva (2017) findings strengthen the argument about the strategic value of HR analytics, which is reflected in the data-driven decision-making readiness dimension in this study, namely the ability of practitioners to interpret and utilize system output effectively. The Technology Acceptance Model states that system availability alone does not determine efficiency outcomes, and that leadership support, organizational culture, employee digital competency, and infrastructure readiness serve as contextual conditions that shape whether an implemented system realizes its efficiency potential in practice.

The decrease in the standard deviation following implementation (from SD = 0.64 to SD = 0.54 for the overall score; Table 2) provides an additional relevant signal of greater homogeneity in respondents' perceptions after implementation, indicates that the benefits of Digital HR began to be distributed more evenly among users once the initial adaptation period had passed. This is consistent

with TAM's prediction that perceptions of technology's usefulness tend to increase and converge as usage experience accumulates (Venkatesh et al., 2003).

The results of this study are consistent with the findings of Bondarouk & Ruël (2012), which show that e-HRM systems effectively implemented in multinational organizations in Europe can significantly reduce administrative burdens while expanding the strategic role of HR departments. This study confirms the same pattern in the context of Indonesian manufacturing firms, but adds value by quantifying the effect via a path coefficient (β = 0,670) and employing multidimensional efficiency measures an approach not taken in the qualitative study by Bondarouk & Ruël (2012). Marler & Fisher (2013), through an evidence-based systematic review of 40 e-HRM studies, confirmed that the integration of digital technology into HR functions is positively correlated with operational efficiency and decision-making quality across various sectors. This study reinforces these meta-analytic findings by providing quantitative evidence from the Indonesian manufacturing context, where the geographical and sectoral gaps identified in the Marler & Fisher review are areas requiring further study.

Kavanagh et al. (2019) specifically confirmed that the implementation of an HRIS substantially improves an organization's operational efficiency and strategic capabilities. In line with these findings, this study not only replicates the findings of Kavanagh et al. in a different context but also expands upon them by decomposing efficiency into four measurable dimensions, administrative speed, data accuracy, process integration, and readiness for data-driven decision-making, thereby providing a more granular picture of where the greatest benefits of Digital HR are realized.

Masum et al. (2020) found that e-HRM practices have a positive impact on the performance of manufacturing companies in Malaysia, though it should be noted that this effect varies across companies depending on implementation characteristics. This pattern of variation is consistent with the low standard deviation observed in the post-implementation phase of this study (Table 2), indicating that the homogeneity of benefits increases once the system operates stably. (Ramadhani et al., 2024), in the more specific context of Indonesian manufacturing, also found that Digital HR transformation contributes positively to organizational performance, although he identified digital resistance as a barrier that weakens this effect. An important point of comparison is the findings of (Obeidat, 2017) in the context of the service sector in Jordan, which showed that infrastructure barriers and digital resistance can reverse the positive effects of e-HRM. Unlike Obeidat, this study found a significant and substantial effect. Previous studies supporting the positive effects of Digital Human Resource Management have largely relied on qualitative methods or one-dimensional efficiency constructs; this study quantifies these effects through path coefficients obtained through bootstrapped Partial Least Squares (PLS) models and operationalizes efficiency across four different dimensions, allowing for a more detailed assessment of where implementation gains are concentrated. These previous studies have also predominantly sampled service sector organizations or technology-intensive firms in high-income countries; this study provides one of the few quantitative tests of the core propositions of the Digital Human Resource Management framework in a labor-intensive manufacturing context in a developing country, addressing the geographic and sectoral gaps identified by Parry & Tyson (2011) as persistent limitations of the Digital Human Resource Management literature.

This study makes three identifiable contributions. It validates the e-HRM framework (Bondarouk & Ruël, 2012) in the context of manufacturing firms in developing countries, a context that has been underrepresented in empirical testing of the framework, which has primarily drawn on multinational firms in developed countries (Parry & Tyson, 2011). These findings reinforce that the core propositions of the e-HRM framework are cross-contextual and not limited to organizational environments with mature digital infrastructure. The Digital HR implementation strategy that generates the most value is not one focused on automating individual tasks, but rather one designed to integrate all HR functions into a single interconnected data ecosystem. The theoretical contribution of this study lies in demonstrating that the core propositions of the Electronic Human Resource Management framework implemented in Digital Human Resource Management drive multidimensional efficiency improvements and position the Human Resource function as a strategic partner of the organization, empirically proven in a manufacturing context largely overlooked by previous research. The finding that process integration and decision-making readiness show the greatest improvement after implementation provides direct empirical support for the framework's

claim that the strategic value of Digital Human Resource Management exceeds its administrative automation function. Its practical contribution is that manufacturing companies in Batam and comparable industrial zones will maximize efficiency returns from their Digital Human Resource Management investments not by prioritizing task-level automation, but by designing implementation strategies oriented toward cross-functional data integration and the development of analytical competencies of Human Resource practitioners, the two organizational capabilities most directly related to the dimensions that show the greatest measurable improvements.

LIMITATION

This study has several limitations that should be considered when interpreting the findings. The sample size is relatively small and focuses on HR practitioners from manufacturing companies located in Batam. While this context provides relevant insights into an important industrial region, the findings may not be fully generalizable to other sectors or geographic regions. This research relies on self-reported data collected via a questionnaire, which may be susceptible to response bias. Participants' perceptions regarding the implementation of Digital HR and HR management efficiency may differ from objectively measured performance indicators. Future research could supplement survey data with archival or system-based performance data to improve measurement accuracy. This research model still focuses on a single independent variable, whereas HR management efficiency is likely influenced by additional organizational factors such as leadership support, organizational culture, and employee digital literacy.

CONCLUSION

This study provides empirical evidence that the implementation of Digital Human Resource Management has a significant positive impact on Human Resource Management efficiency in manufacturing firms in Batam, Indonesia ($\beta = 0.670$; $p < 0.001$; $R^2 = 0.449$; $f^2 = 0.352$), supporting the hypotheses derived from the integrated Electronic Human Resource Management framework and the Technology Acceptance Model. Multidimensional efficiency measures revealed that the greatest post-implementation improvements occurred in process integration and decision-making readiness rather than administrative speed alone, suggesting that Digital Human Resource Management serves as a strategic organizational driver.

This study's contribution lies in validating the cross-context applicability of the Electronic Human Resource Management framework in a labor-intensive manufacturing environment that is substantially underrepresented in the Digital Human Resource Management literature. Future researchers are encouraged to explore longitudinal designs that track efficiency outcomes across various stages of adoption rather than retrospectively measuring perceptions at a single point in time to further strengthen causal inferences.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to the manufacturing companies and human resources professionals in Batam who agreed to participate in this study and provided valuable data and insights. We would also like to thank the University of Riau Islands for its institutional support, which facilitated the completion of this study.

AUTHOR CONTRIBUTIONS

RZ was responsible for the conceptualization and design of the study, as well as data collection, data curation, formal analysis, and the preparation of the original manuscript draft. NH contributed to data collection, data validation, and the interpretation of the results, as well as reviewing and revising the manuscript critically. SM contributed to data verification, data interpretation, and provided input in refining the analysis and presentation of the findings.

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