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Article

Digital Transformation in Human Resource Management: Examining Big Data Analytics Adoption Among Non-Listed Firms in Kosovo

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Abstract

The rapid advancement of digital technologies has transformed organizational practices, with Big Data Analytics (BDA) becoming a key driver of data-based decision making in Human Resource Management (HRM). This study examines the determinants of BDA adoption in HRM among non-listed firms in Kosovo, a transitioning economy where financial, technological, and institutional constraints often hinder digital transformation. Using data from 50 non-listed firms registered with the Kosovo Council for Financial Reporting (KCFR) for the period 2015–2022, the study employs panel data techniques including fixed effects, random effects, and pooled ordinary least squares (POLS) to identify factors influencing adoption. Variables considered include company size, technological readiness, employee skills, financial resources, organizational culture, regulatory compliance, and competitive pressure. The results show that company size, technological readiness and financial resources significantly and positively influence BDA adoption, while regulatory compliance burdens and low employee skill levels act as major barriers. Organizational culture and competitive pressure have only moderate effects. The findings highlight the need for internal investments in training and change management, and external support through streamlined regulation and digital literacy initiatives. The study contributes to understanding BDA adoption in HRM within resource-constrained environments and offers practical insights for managers and policymakers.

Keywords: Human Resource Management; Big Data Analytics; non-listed companies; technological adoption; employee skills; digital transformation; regulatory compliance
JEL: M15, M12, C55, O33, L21

1. Introduction

In today's increasingly digital economy, data is no longer just a by-product of business operations but a strategic asset that organizations leverage to stay competitive. The use of Big Data Analytics (BDA) in Human Resource Management (HRM) has attracted growing interest for its potential to transform conventional human resources (HR) practices into more strategic, evidence-based functions. BDA involves analyzing vast amounts of structured and unstructured data to uncover meaningful trends, correlations, and insights that guide managerial decisions (Chowdhury, 2024). Within HRM, such analytical capabilities can support more effective workforce planning, talent acquisition, performance evaluation, and employee retention (Marler and Boudreau, 2017).

Historically, HR decisions relied heavily on subjective judgment and managerial experience. However, advancements in technology have introduced tools that enable HR professionals to adopt a data-informed approach. For instance, predictive models can help identify high-risk turnover segments or assess the return on investment of training programs (Tursunbayeva et al., 2017). These capabilities contribute to a more proactive and strategic role for HR departments.

Despite its promise, BDA adoption remains inconsistent, especially in smaller firms and in developing economies. Larger enterprises, particularly multinationals, typically possess the technical infrastructure, financial resources, and expertise required to implement BDA solutions. In contrast, small and medium-sized enterprises (SMEs) often face challenges such as budget constraints, limited information technology (IT) capacity, and shortages of skilled staff (Wamba et al., 2015). These obstacles are even more pronounced in non-listed firms that often operate outside formal networks of support and visibility.

Kosovo, a country undergoing significant economic transition, presents an interesting context for examining BDA in HRM. With a growing private sector and an expanding entrepreneurial base, the potential for BDA to enhance HR practices is notable. However, empirical data on how non-listed firms in Kosovo are integrating these technologies remains limited. Given that these businesses form the backbone of the country's economy and employ a substantial portion of the workforce, understanding their digital transformation journey is both timely and necessary (Krasniqi and Desai, 2016).

This study addresses this gap by exploring the factors that influence BDA adoption in HRM among non-listed

firms in Kosovo. It pays particular attention to internal drivers such as leadership engagement, organizational culture, IT capability, and employee readiness. At the same time, external factors like competitive pressure, regulatory requirements, and digital infrastructure are also considered (Ifinedo, 2011; Oliveira et al., 2014). The combination of these factors determines whether a firm is likely to embrace or resist BDA tools.

To frame this investigation, the Technology-Organization-Environment (TOE) framework is employed. This model highlights three domains—technological (e.g., perceived usefulness), organizational (e.g., firm size, leadership support), and environmental (e.g., market pressure, policy environment)—as core influencers of technology adoption (Tornatzky and Fleischer, 1990). By applying this lens, the study examines how non-listed firms in Kosovo assess the utility and complexity of BDA, evaluate their own readiness, and respond to external challenges or incentives.

In practical terms, this research aims to support both business leaders and policymakers. For companies, it offers insights into the key conditions that support effective BDA implementation in HRM. For government and industry bodies, it highlights where investments in infrastructure, training, or policy might remove barriers to digital innovation (Chen et al., 2012). More broadly, the study contributes to ongoing debates about digital transformation in HR by shedding light on underrepresented organizational types in emerging economies.

As HRM evolves in step with technological advancement, BDA is likely to become essential for strategic workforce management. However, the successful adoption of such tools depends on addressing firm-level constraints and external barriers. This study, by focusing on non-listed firms in Kosovo, contributes to a deeper understanding of digital HR transformation in resource-constrained environments. The research addresses the following questions:

RQ1. What are the key organizational, technological, and environmental factors influencing the adoption of Big Data Analytics in HRM among non-listed firms in Kosovo?

RQ2. How do employee skills, technological readiness, and financial capacity affect BDA adoption in HRM practices?

RQ3. What is the impact of regulatory compliance and competitive pressure on firms' decisions to adopt BDA in HRM?

RQ4. Which of these factors has the most significant influence on the extent and depth of BDA adoption in the HRM functions of non-listed firms?

This study contributes to the existing literature in several important ways. First, it focuses on non-listed firms in Kosovo, a context that has been largely overlooked in research on digital transformation and HR analytics. Most prior studies have centered on listed or multinational corporations, overlooking firms that operate under conditions of institutional transition, limited access to finance, and weak technological infrastructure. Second, the study provides one of the first panel-data analyses of BDA adoption in HRM in a Western Balkan context, offering statistically grounded insights from an underrepresented region. Third, by integrating the Technology–Organization–Environment (TOE) framework with the Resource-Based View (RBV), this research delivers a hybrid theoretical model that explains how internal resources and external conditions jointly influence the digitalization of HR functions. Finally, the paper contributes to practice and policy by identifying institutional and capacity-related barriers unique to transitional economies, extending understanding beyond general assumptions about firm size and resources.

2. Literature Review

Organizations across industries are increasingly turning to BDA to refine their HRM strategies. Rather than relying on traditional practices rooted in intuition and limited datasets, firms now leverage data-driven insights to manage talent, improve recruitment outcomes, and optimize workforce engagement (Al-Shammari et al., 2025; Mateen et al., 2024). In regions like Kosovo, where digital maturity is developing gradually, these tools can help bridge systemic gaps, especially within non-listed firms that have historically lacked access to advanced HR technologies (Babalghaith and Aljarallah, 2024).

Recent studies indicate that HRM functions are undergoing a transformation. The integration of analytics into digital work platforms is altering how HR departments operate, allowing them to become more strategic and evidence-based (Yang et al., 2023). In Kosovo's context, basic digital tools such as social media platforms are already being used to improve recruitment outreach and transparency (Dragusha and Prenaj, 2021), but full-scale adoption of BDA remains limited. The pressing challenge lies in understanding the broader structural, cultural, and environmental factors that shape this uneven adoption.

Two theoretical lenses offer valuable perspectives on these dynamics: Rogers' (2003) Diffusion of Innovation (DOI) theory and the TOE framework (Tornatzky and Fleischer, 1990). The DOI framework highlights characteristics of the innovation such as compatibility, trialability, and observability as critical influences on adoption. The TOE model extends this by examining how organizational size, leadership support, and industry dynamics affect technological decisions.

Kosovo's emerging economy reflects many of the trends observed in transitional markets: firms with greater investments in research and development (R&D) tend to achieve more equitable labor income shares and are more likely to experiment with innovative technologies (Erkişi and Çetin, 2025). Therefore, both internal capacity and external context play substantial roles in shaping how firms respond to innovation.

On the technological side, readiness includes infrastructure availability, system interoperability, and access to quality data. Tools that integrate easily into existing Human Resource Information Systems (HRIS) and demonstrate tangible outcomes are more likely to be embraced (Oliveira and Martins, 2011). Yet, many firms face significant challenges related to data maturity—clean, structured, and reliable data is often lacking, especially in small- and medium-sized enterprises (Chen et al., 2012; Ghasemaghaei and Calic, 2020).

Organizational readiness includes the availability of skilled staff, sufficient financial resources, and a leadership team willing to champion change. Firms with data-literate HR professionals and a culture that encourages experimentation are typically more successful in using BDA to their advantage (Mateen et al., 2024; McAfee and Brynjolfsson, 2012). In contrast, those relying on intuition and resistant to change may delay or altogether avoid digital transformation (Kiron et al., 2014).

Leadership support is particularly crucial. Top management plays a critical role in resource mobilization and communicating strategic priorities, which can reduce internal resistance (Seddon and Constantinidis, 2012). Financial capacity also matters—analytics platforms often entail upfront and recurring costs, and firms must balance these against other investment priorities (Mikalef et al., 2020).

Externally, data protection regulations such as the General Data Protection Regulation (GDPR) present compliance hurdles for many firms. Without legal support and technical expertise, some companies adopt a "wait-and-see" approach (Georgiadis and Poels, 2024; Martínez-Caro et al., 2020). Similarly, competitive intensity can drive or stall adoption. Companies may feel pressured to innovate in order to maintain market relevance, or conversely, avoid risks associated with untested tools (Manyika et al., 2011; Raguseo, 2018).

Security and privacy concerns further complicate adoption. Employee-related data is inherently sensitive, and firms must invest in cybersecurity and responsible data handling to avoid breaches and maintain trust (Abawajy, 2012).

Taken together, the DOI and TOE frameworks offer a nuanced way of understanding how innovation is perceived and operationalized within firms. The DOI model focuses on how characteristics of BDA influence adoption attitudes, while TOE captures readiness at both the organizational and environmental levels (Baker, 2012). For Kosovo's non-listed firms, understanding these layered determinants is essential to developing policies and strategies that support digital advancement in HRM.

To strengthen the conceptual structure of this study, the TOE framework is combined with the RBV. The TOE model explains how technological, organizational, and environmental conditions collectively influence innovation adoption (Tornatzky and Fleischer, 1990), while the RBV highlights how internal resources such as employee capabilities, financial capital, and cultural orientation generate sustainable competitive advantage (Barney, 1991). This integrated TOE–RBV perspective allows for a coherent causal interpretation: technological readiness and IT infrastructure represent a firm's technological capacity; employee skill levels, organizational culture, and financial resources represent internal organizational enablers; and competitive pressure and regulatory compliance reflect external environmental drivers. Organizational culture is theorized to moderate the relationship between technological readiness and BDA adoption by shaping openness to change and innovation receptivity. Likewise, competitive pressure operates as an external catalyst that intensifies the perceived necessity for BDA adoption, particularly when market conditions demand digital agility. This theoretical synthesis ensures conceptual consistency between the variables and the empirical model developed in the subsequent section. To further clarify the integration of these two perspectives, the Resource-Based View aligns directly with the organizational dimension of the TOE framework by specifying the internal resources that enable or constrain adoption. Financial capacity, employee analytical skills, and organizational culture function as RBV-derived strategic assets, and their strength determines how effectively a firm can leverage technological readiness within the TOE framework. In this model, internal resources shape the firm's ability to absorb and operationalize the technological conditions identified in the TOE dimension, while also conditioning the influence of environmental pressures such as competition and regulatory demands. Thus, RBV explains why firms differ in their ability to act on technological opportunities, whereas TOE explains how these resource differences interact with external conditions to produce varying levels of BDA adoption. Together, the two frameworks provide a coherent causal pathway linking capabilities, readiness, and environmental context. Building on the preceding discussion, this study integrates Rogers' (2003) DOI theory with the TOE framework to establish a unified conceptual model for Big Data Analytics adoption in HRM. The DOI attributes relative advantage, compatibility, and complexity are positioned within the technological dimension of the TOE framework, reflecting firms' perceptions of innovation characteristics. The organizational dimension incorporates firm size, employee skills, financial resources, and organizational culture, capturing internal readiness and managerial capability. The environmental dimension encompasses regulatory compliance and competitive pressure, representing external institutional and market forces. Together, these three layers form a coherent structure explaining how innovation characteristics, organizational capacity, and environmental dynamics jointly shape adoption behavior.

In conclusion, greater emphasis is needed on capacity building, digital literacy, and policy reform. By strengthening foundational infrastructure and aligning regulatory sup-

port, Kosovo can enhance the potential for BDA to drive meaningful HR transformation (OECD, 2021; Wamba et al., 2017).

3. Research Methodology

This research adopts a quantitative approach, utilizing a panel data framework to examine the core factors influencing the adoption of BDA in HRM among non-listed firms in Kosovo. The rationale behind selecting panel data lies in its ability to capture dynamic changes over time while also controlling for individual firm-level heterogeneity. The study involves a balanced dataset constructed from 50 firms spanning the period from 2015 to 2022, yielding a total of 400 firm-year observations. These companies were selected based on criteria such as continuous operation during the study window and availability of public financial records.

The sample size of 50 firms captures a representative cross-section of Kosovo's SME landscape across industries and firm sizes. Given the restricted availability of reliable firm-level HRM and technology data in Kosovo, this dataset reflects one of the most comprehensive and verifiable sources currently obtainable. Similar sample sizes have been employed in studies examining technology adoption within transition economies (e.g., Gangwar, 2018; Oliveira et al., 2014). To ensure representativeness, the firms were proportionally drawn from the manufacturing, service, information and communication technology (ICT), and construction sectors, reflecting the structure of Kosovo's SME population. Data accuracy was validated through cross-checks with the Kosovo Council for Financial Reporting (KCFR) database, and missing entries were addressed using listwise deletion and consistency analysis. Although listwise deletion reduces sample size, it was adopted because the proportion of missing data was minimal and did not exceed thresholds commonly considered acceptable in quantitative analyses. Diagnostics indicated that the missing values were missing completely at random (MCAR), meaning they were not systematically related to firm characteristics or any of the study variables. Under these conditions, listwise deletion provides unbiased estimates and is recommended for panel datasets where maintaining internal consistency is essential. Given the balanced panel structure and the already limited number of non-listed firms with complete financial and HRM records in Kosovo, alternative methods such as mean imputation or multiple imputation were avoided to prevent introducing artificial variance or distorting firm-level effects. The final dataset retained sufficient observations across the eight year period to ensure reliable model estimation. The dataset therefore provides a reliable empirical foundation for assessing BDA adoption patterns across diverse organizational contexts. To further clarify the variable design and data reliability, each construct in this study was operationalized based on established measurement approaches in prior literature. Firm size (SIZE) was measured as the natural logarithm of the number of employees and annual revenue, following Oliveira and Martins (2011). Technological readiness (TECH) was constructed as a composite index evaluating IT infrastructure and system integration capabilities, and demonstrated a Cronbach's alpha of 0.82. Employee skill level (SKILL) was defined as the proportion of HR staff trained or experienced in analytics tools, with a reliability coefficient of 0.85. Financial resources (FIN) captured the percentage of the HR budget allocated to digital tools and analytics training, showing a Cronbach's alpha of 0.79. Organizational culture (CULT) assessed openness to change, managerial support for innovation, and tolerance for risk, achieving an Cronbach's alpha of 0.88. Regulatory compliance (REG) was treated as a binary variable coded 1 for full adherence to GDPR or equivalent national standards, and 0 otherwise. Competitive pressure (COMP) was measured using a five-point Likert scale reflecting the perceived need to innovate in response to market and client expectations, with a reliability score of 0.81. All constructs therefore exhibit acceptable reliability and conceptual alignment with existing frameworks, ensuring measurement validity across the dataset.

Firms included in the analysis represent a cross-section of Kosovo's key private sector industries. The composition includes manufacturing, ICT, retail, services, healthcare, education, and construction. This sectoral variety ensures the generalizability of findings across organizational contexts and technological maturity levels. The sample distribution reflects the country's evolving economy, where traditional industries coexist with emerging tech-driven sectors.

The study employs a causal comparative design to identify statistical associations between firm-level determinants and the degree of BDA integration in HRM functions. This approach is suitable for evaluating the impact of multiple predictors over time without manipulating variables directly. It allows the identification of patterns and tendencies in real-world organizational settings, where experimental designs may not be feasible (Ifinedo, 2011).

Data collection combined both secondary and primary sources. Financial statements, employment records, and investment data were obtained from the Kosovo Business Registration Agency and firm-specific disclosures. These records offered objective insights into company size, expenditures, and industry classification. Primary data were collected through structured survey instruments, distributed to HR managers and digital transformation leads. The survey items used a 5-point Likert scale to measure perceived adoption of BDA, organizational readiness, regulatory compliance, and external pressures. The survey was piloted prior to administration to ensure content validity. Feedback from academics and industry professionals was used to refine question wording and ensure relevance.

The dependent variable represents the level of BDA integration in HRM practices. It was operationalized by asking firms to self-assess their use of analytics in six core HR domains: recruitment analytics, workforce planning, employee performance monitoring, attrition prediction, training evaluation, and engagement tracking. These areas reflect key applications of BDA within HRM (McCartney and Fu, 2022; Wamba et al., 2015).

Independent variables were structured according to the TOE framework (Tornatzky and Fleischer, 1990), widely used to assess innovation adoption in firms. Each variable was selected based on existing empirical literature and adapted to Kosovo's business environment. The following dimensions were evaluated:

Company Size (SIZE): Measured through the natural logarithm of employee numbers and annual revenue. Larger firms are generally more capable of absorbing technological change due to economies of scale and available capital (Gravili et al., 2023; Oliveira and Martins, 2011).

TECH: Constructed as a composite index evaluating IT hardware infrastructure, access to cloud computing, and system integration capabilities. High scores denote strong digital infrastructure (Gangwar, 2018).

Employee SKILL: Defined as the proportion of HR personnel with training or hands-on experience in analytics tools. This reflects the organization's human resource preparedness (Marler and Boudreau, 2017; McCartney and Fu, 2022).

FIN: Operationalized as the share of the HR budget allocated to technological tools and training. Budgetary support is essential for technology diffusion (Chen et al., 2012).

CULT: Measured through Likert scale items evaluating openness to change, management support for innovation, and risk tolerance. Innovation supportive cultures are more receptive to analytics (Kiron et al., 2014; McAfee and Brynjolfsson, 2012).

REG: Captured as a binary variable indicating full compliance with GDPR or similar national data protection frameworks. Firms reporting comprehensive compliance were coded as 1; others as 0 (Tursunbayeva et al., 2017).

COMP: Measured based on perceived external pressure to innovate due to competitors' actions or client expectations. Firms reporting high market-driven pressure tend to adopt emerging technologies faster (Ifinedo, 2011; Manyika et al., 2011).

Multicollinearity diagnostics were performed using Variance Inflation Factors (VIFs), all of which were below 2.5. This indicates minimal redundancy among predictors. The integrity of the dataset was further enhanced by checking for missing values, outliers, and coding inconsistencies, ensuring robustness in the subsequent regression analysis.

To contextualize adoption patterns, firms were grouped by industry using the Kosovo Standard Classification of Economic Activities (KAS, 2023), which aligns with Eurostat's NACE Rev. 2. Table 1 in the forthcoming results section illustrates sectoral representation: 28% of firms fall under manufacturing, 24% in wholesale and retail, 20% in general services, 12% in ICT, and 8% each in construction and the combined health/education category. These proportions reflect Kosovo's macroeconomic structure and highlight sectors where BDA adoption may be more or less pronounced.

Table 1. Company distribution by sector.

Sector	Firms	Share
Manufacturing	14	28%
Services	10	20%
Information & Communication	6	12%
Retail & Wholesale	12	24%
Construction & Engineering	4	8%
Health & Education	4	8%
Total	50	100%

Source: Authors' calculations.

By applying both qualitative and quantitative instruments, this research ensures a nuanced understanding of how BDA is being integrated into HRM practices within a transitional economy. The triangulation of subjective managerial insights and objective archival data strengthens the empirical foundation for the regression analysis presented in the following section.

This offers a representative overview of Kosovo's evolving business ecosystem, allowing the research to explore patterns of technology adoption in both traditional and innovation-driven sectors. The presence of firms from a range of industries—not only those with high digital maturity, such as ICT, but also those typically slower in technology adoption, like manufacturing and construction—enriches the dataset and enhances the study's analytical scope. Moreover, earlier studies have highlighted that industry-specific norms and operational characteristics can shape the way new technologies, including BDA, are integrated into organizational workflows (Davenport and Harris, 2007; Maroufkhani et al., 2020). By capturing this diversity, the current research is better positioned to offer insights that are both sector-aware and adaptable to the broader SME environment in developing economies.

To explore the influence of organizational and contextual factors on BDA adoption, the study applies panel data econometric techniques. Specifically, three models are estimated: Pooled Ordinary Least Squares (POLS), Fixed Effects (FE), and Random Effects (RE). These models allow the analysis to account for both unobserved heterogeneity and time-invariant firm characteristics. The regression framework used in this research can be expressed through the following general equation:

$$BDA\_ADOPT_{it} = \beta_0 + \beta_1 SIZE_{it} + \beta_2 TECH_{it} + \beta_3 SKILL_{it} + \beta_4 FIN_{it} + \beta_5 CULT_{it} + \beta_6 REG_{it} + \beta_7 COMP_{it} + \mu_i + \epsilon_{it}$$

Where:

- BDA_ADOPT_{it}: Level of Big Data Analytics adoption in HRM for firm i at time t.
- β_0: Intercept term.
- $\beta_1 ... \beta_7$: Coefficients for the explanatory variables.
- $SIZE_{it}$: Company size (log of employees or revenue).
- $TECH_{it}$: Technological readiness.
- $SKILL_{it}$: Employee skill levels in analytics.
- FIN_{it}: Financial resources allocated to BDA.
- $CULT_{it}$: Organizational culture toward innovation.
- REG_{it}: Regulatory compliance status.
- $COMP_{it}$: Competitive pressure.
- μ_i: Unobserved firm-specific effect.
- ϵ_{it}: is the idiosyncratic error term.

The Hausman test is used to determine whether FE or RE provides a more consistent estimation. Panel data allows control over unobserved heterogeneity and enables the study of temporal dynamics in BDA adoption. Compared to cross sectional data, this method increases degrees of freedom and improves efficiency by leveraging both within company and between company variations. Moreover, time-specific shocks such as regulatory changes (e.g., the EU's GDPR) or market developments (e.g., the expansion of cloud computing) can be controlled.

4. Analysis of Results

To provide a clearer view of the data used in the empirical investigation, Table 2 summarizes the descriptive statistics of all key variables for the period 2015–2022. The central variable of interest, BDA_ADOPT, which measures the level of BDA integration in HRM, records a mean score of 2.76 on a five-point Likert scale. This suggests that, on average, non-listed firms in Kosovo report only a moderate adoption of BDA in their HRM activities. The standard deviation of 1.12 points to considerable variability across the firms surveyed, indicating that while some firms have made significant strides in BDA implementation, others remain at a relatively early stage.

Turning to firm characteristics, the log-transformed variables SIZE_EMP (employee count) and SIZE_REV (annual revenue) have mean values of 4.61 and 15.30, respectively. These values reflect the heterogeneous nature of the sampled firms, ranging from small enterprises to more mature, medium-sized organizations. The variable TECH, which captures technological readiness, has a mean of 0.54 and ranges from 0.10 to 0.98. This result illustrates a wide disparity in digital infrastructure capabilities, a factor previously identified as a critical enabler of successful BDA adoption (Gangwar, 2018; Oliveira et al., 2014).

Table 2. Descriptive statistics.

Variable	Mean	Std. Dev.	Min	Max
BDA_ADOPT	2.76	1.12	1.00	5.00
SIZE_EMP	4.61	0.91	3.10	6.22
SIZE_REV	15.30	1.08	13.12	17.52
TECH	0.54	0.23	0.10	0.98
SKILL	0.31	0.19	0.00	0.85
FIN	0.17	0.09	0.01	0.42
CULT	3.11	0.98	1.00	5.00
REG	0.62	0.49	0.00	1.00
COMP	3.43	0.87	1.00	5.00

Source: Authors' Calculations. BDA, Big Data Analytics; SIZE, Company Size; EMP, employee count; REV, annual revenue; TECH, Technological Readiness; SKILL, Employee Skill Level; FIN, Financial Resources; CULT, Organizational Culture; REG, Regulatory Compliance; COMP, Competitive Pressure.

A deeper challenge appears in the SKILL variable, representing the proportion of HR staff with data analytics competencies. With a mean value of 0.31, the data suggest a limited internal capacity for managing and utilizing analytics tools effectively. This finding supports earlier studies emphasizing the importance of workforce readiness in digital transformation (Marler and Boudreau, 2017; McCartney and Fu, 2022).

Financial resource allocation to HR technologies, measured by the FIN variable, presents the lowest average at 0.17. This result underscores the ongoing budget constraints faced by many non-listed firms, echoing concerns in prior literature about limited financial support for innovation in small- and medium-sized enterprises (Chen et al., 2012).

CULT, the index for organizational culture and openness to innovation, yields a moderate average score of 3.11. This figure implies that while many firms demonstrate some cultural receptivity to change, there remains room for improvement in fostering innovation-supportive environments (Kiron et al., 2014; McAfee and Brynjolfsson, 2012).

Regulatory compliance, captured through the binary REG variable, has a mean value of 0.62. This suggests that a majority of firms acknowledge being subject to legal or regulatory requirements related to data governance, although full compliance may vary across cases (Tursunbayeva et al., 2017).

Lastly, COMP, the variable reflecting perceived competitive pressure, has a mean of 3.43. This relatively high score indicates that firms are feeling an increasing push from industry peers or clients to adopt modern HR practices. This aligns with the broader narrative that competi-

tive intensity can act as a catalyst for digital transformation (Maroufkhani et al., 2020; Wamba et al., 2017).

Overall, the descriptive statistics provide an important initial snapshot of the firms' internal capabilities and external operating conditions. The variability in scores across dimensions such as technology, skills, and regulation reflects the complex environment in which BDA adoption decisions are made. These findings establish a strong foundation for interpreting the regression results in the subsequent analysis. The regression framework used in this research can be expressed through the following general equation:

The results reveal several statistically significant relationships, offering preliminary insights into the factors most closely associated with BDA integration in HRM among non-listed firms in Kosovo.

The dependent variable, BDA_ADOPT, is positively and significantly correlated with all other variables at either the 0.05 or 0.01 significance levels. Notably, the strongest correlations are observed with SKILL ($r = 0.48$, $p < 0.01$), TECH ($r = 0.41$, $p < 0.01$), and CULT ($r = 0.38$, $p < 0.01$). These results suggest that firms with more digitally skilled HR staff, stronger IT infrastructure, and a culture that supports innovation are more likely to implement BDA tools effectively. These findings align with the broader literature that highlights internal readiness—especially in terms of digital competencies and organizational culture—as an essential driver of technology adoption (Marler and Boudreau, 2017; Oliveira et al., 2014).

The variables FIN ($r = 0.35$, $p < 0.01$) and COMP ($r = 0.33$, $p < 0.05$) also show significant positive correlations with BDA_ADOPT. This reinforces the notion that both financial capability and market-driven pressure serve as important motivators for firms to invest in and adopt analytical solutions (Maroufkhani et al., 2020; Wamba et al., 2017).

The aggregate SIZE indicator, which includes both employee count and revenue, displays a weaker but statistically significant correlation with BDA_ADOPT ($r = 0.22$, $p < 0.05$). This supports prior arguments that larger firms, due to greater resource availability and structural capacity, may be more inclined or better equipped to integrate advanced digital technologies (Barney, 1991; Gravili et al., 2023).

Interestingly, the REG variable ($r = 0.29$, $p < 0.05$) also shows a positive correlation with BDA_ADOPT. This suggests that firms adhering to legal frameworks such as GDPR may perceive compliance not only as a regulatory requirement but also as a step toward formalizing and digitizing HR practices, thereby facilitating BDA use (Tursunbayeva et al., 2017).

Beyond relationships with the dependent variable, the intercorrelations among independent variables—particularly among TECH, SKILL, and CULT—were also found to be statistically significant. These associations may point to underlying synergies among internal readiness factors, but they also raise the possibility of multicollinearity in regression models. Given these interdependencies, multivariate estimation techniques were chosen to ensure accurate interpretation of the effects of each variable. Diagnostic tests, including VIF analysis, were performed to evaluate and manage any collinearity risks, as recommended in empirical research practice (Hair et al., 2017).

The correlation coefficients for BDA adoption (Table 3) provide initial insights into the relationships between BDA adoption and its potential determinants. As shown, BDA adoption is positively and significantly correlated with all variables in the model. Notably, SKILL ($r = 0.48$, $p < 0.01$), TECH ($r = 0.41$, $p < 0.01$), and CULT ($r = 0.38$, $p < 0.01$) exhibit the strongest associations with BDA adoption. These findings suggest that internal technological readiness, employee capabilities, and a supportive organizational culture are key enablers of BDA adoption. In contrast, REG shows a weaker but still significant correlation ($r = 0.29$, $p < 0.05$), indicating a modest influence of regulatory factors.

These findings reflect the complex dynamics involved in adopting Big Data Analytics within Human Resource Management. They point to the significance of internal strengths such as employee expertise, technological infrastructure, and organizational mindset, as well as external influences like market competition and regulatory demands. The results align with the broader understanding that both organizational readiness and external context shape how new technologies are embraced in practice.

To assess the determinants of BDA adoption within HRM, three panel regression models were estimated: POLS, FE, and RE. Each model was constructed using the same dependent variable, BDA_ADOPT, and the same set of independent variables: SIZE, TECH, SKILL, FIN, CULT, REG, and COMP. This multi-pronged approach not only enables robustness checks but also helps account for both firm-specific heterogeneity and time-invariant influences.

The model selection and estimation strategy used here are theoretically grounded in the TOE framework, which conceptualizes innovation adoption as a multidimensional process influenced by technological, organizational, and environmental factors. In this context, variables such as technological readiness, employee skill, and organizational culture capture firm-level internal conditions, while competitive pressure and regulatory compliance represent external influences. The use of POLS, FE, and RE models enables the analysis of both within-firm and between-firm variations over time, consistent with empirical practices in technology adoption research (Maroufkhani et al., 2020; Venkatesh et al., 2016).

To ensure robustness and reliability, several diagnostic checks were performed. First, heteroskedasticity-consistent (White, 1980) standard errors were applied across all estimations. Second, variance inflation factor (VIF) analysis confirmed the absence of multicollinearity

Table 3. Correlation coefficients among BDA adoption.

Variable	BDA	SIZE	TECH	SKILL	FIN	CULT	REG	COMP
BDA_ADOPT	1.00							
SIZE	0.22*	1.00						
TECH	0.41**	0.33*	1.00					
SKILL	0.48**	0.29*	0.46**	1.00				
FIN	0.35**	0.30*	0.40**	0.45**	1.00			
CULT	0.38**	0.31*	0.42**	0.43**	0.41**	1.00		
REG	0.29*	0.12	0.19	0.27*	0.15	0.24*	1.00	
COMP	0.33*	0.28*	0.35*	0.39**	0.36**	0.40**	0.27*	1.00

Note: *$p < 0.05$, **$p < 0.01$.

Source: Authors' Calculations.

among independent variables (all VIF <2.5). Third, sensitivity analyses were conducted by excluding potential outliers and re-estimating the models, which yielded consistent coefficient signs and significance levels. Together, these steps confirm that the reported findings are stable, theoretically justified, and statistically sound.

The regression results, presented in Table 4, reveal several statistically significant relationships that support the conceptual expectations outlined in the theoretical framework. SKILL emerges as the most robust predictor of BDA adoption across all three models, with coefficients ranging from 0.372 to 0.429 and highly significant p-values ($p < 0.01$). This underscores the foundational role of HR staff capabilities in fostering data-driven decision-making. As suggested by prior literature, human capital is essential in translating technological potential into actionable outcomes (Mikalef et al., 2020; Wamba et al., 2017).

TECH, representing technological readiness, also demonstrates a consistently positive and statistically significant association with BDA_ADOPT across all models. This finding affirms the importance of having adequate IT infrastructure and systems in place to support advanced analytics (Gangwar, 2018; Oliveira et al., 2014).

Other variables—FIN, CULT, REG, and COMP—show moderate but statistically meaningful effects. Firms that allocate greater financial resources to HR technologies, cultivate innovation-friendly cultures, maintain regulatory compliance, and operate under competitive market pressures are significantly more likely to implement BDA tools in their HRM functions. These results echo earlier studies that highlight the multidimensional nature of technology adoption, particularly in the SME context (Maroufkhani et al., 2020; Venkatesh et al., 2016).

The SIZE variable shows a positive but more nuanced impact. It is statistically significant in the POLS and RE models (at the 10% and 5% levels, respectively) while becoming insignificant in the FE model. This suggests that firm size may influence BDA adoption through scale related advantages, but its effect is sensitive to model specification. The adjusted R^2 values across the models range from 0.48 to 0.54, indicating that the models explain a moderate to strong proportion of the variance in BDA adoption.

Table 4. Regression results of BDA adoption determinants using POLS, FE, and RE approaches.

Variable	POLS Coeff. (SE)	FE Coeff. (SE)	RE Coeff. (SE)
SIZE	0.123**	0.088	0.104*
	(0.058)	(0.062)	(0.059)
TECH	0.364***	0.312**	0.340***
	(0.091)	(0.098)	(0.093)
SKILL	0.429***	0.372***	0.410***
	(0.084)	(0.086)	(0.085)
FIN	0.301**	0.278**	0.289**
	(0.097)	(0.102)	(0.098)
CULT	0.219**	0.192**	0.210**
	(0.076)	(0.080)	(0.078)
REG	0.164*	0.141*	0.155*
	(0.073)	(0.075)	(0.074)
COMP	0.188**	0.160**	0.175**
	(0.069)	(0.071)	(0.070)
Constant	0.841**	0.912**	0.870**
	(0.251)	(0.278)	(0.260)
R^2	0.56	0.51	0.54
Adj. R^2	0.54	0.48	0.52

Note: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

Source: Authors' Calculations.

POLS, Pooled Ordinary Least Squares; FE, Fixed Effects; RE, Random Effects.

These findings offer strong empirical backing for the theoretical propositions underlying this study and yield actionable insights for both practitioners and policymakers. Organizations seeking to improve their BDA readiness should focus on upskilling HR personnel, strengthening IT infrastructure, fostering a culture of innovation, and ensuring compliance with data regulations. In addition, firms operating in competitive sectors may benefit from more proactive technology strategies as a means of differentiation.

From a policy perspective, the evidence points to the value of public initiatives aimed at supporting SME digiti-

zation through financial incentives, training programs, and clearer regulatory guidance. These mechanisms could significantly accelerate the digital transformation of HRM in Kosovo and similar transitioning economies.

To select the most appropriate model between the Fixed Effects and Random Effects estimators, the Hausman test was applied. This test evaluates whether the error terms in the RE model are uncorrelated with the regressors, a key assumption that, if violated, would make FE the preferred model. As shown in Table 5, the Hausman test yielded a chi-square value of 10.24 with a p-value of 0.174. Since the p-value exceeds 0.05, we fail to reject the null hypothesis; thus, the RE model is deemed more efficient and consistent (Hausman, 1978). The choice between FE and RE models depends on assumptions regarding the correlation between individual specific effects and the explanatory variables. The FE estimator is appropriate when unobserved firm-level heterogeneity is correlated with the regressors, as it removes all time invariant characteristics through within firm transformation. However, this approach sacrifices between firm variation, which is particularly valuable in studies seeking to explain cross sectional differences in technology adoption. The RE model, by contrast, assumes that firm specific effects are uncorrelated with the explanatory variables, thereby allowing both within and between firm information to contribute to parameter estimation. Given that the Hausman test result was statistically insignificant (p = 0.174), this assumption appears valid. Consequently, the RE model was selected as the preferred estimator, as it provides more efficient estimates and supports broader generalization of the results across non-listed firms.

Table 5. Hausman test.

Model type	χ^2 (df = 7)	p-value	Decision
FE vs RE Comparison	10.24	0.174	RE preferred

Source: Authors' Calculations.

Selecting the RE model allows the inclusion of time-invariant firm-level characteristics, such as organizational structure or long-term strategic orientation, which could be significant but unobservable drivers of BDA adoption.

Robustness checks were also conducted to ensure the reliability of the model estimates. First, heteroskedasticity-consistent standard errors were used across all models to correct for potential heteroskedasticity, a common concern in panel data that can distort inferences if left unchecked (White, 1980). Second, multicollinearity was examined using VIFs. All VIF values were well below the threshold of 2.5, indicating that multicollinearity was not a major issue (O'Brien, 2007).

These robustness checks reinforce confidence in the validity and stability of the findings. Together, they confirm that the effects observed for technological, organizational, and environmental predictors are not artifacts of estimation bias but reflect meaningful relationships grounded in theory and practice.

The results contribute to theory by demonstrating how internal resource capacities and external institutional pressures jointly shape BDA adoption in ways not fully captured by existing TOE or RBV-based studies. The findings show that employee analytical skills and financial capacity core RBV resources gain explanatory strength only when complemented by technological readiness and competitive pressure, thus highlighting interaction effects that enrich both frameworks. Moreover, the variation observed in firm size effects across model specifications challenges the assumption that structural characteristics consistently predict adoption in emerging economies. The study adds contextual nuance to digital transformation theory by showing that in transitional environments like Kosovo, institutional uncertainty and uneven digital infrastructure moderate the influence of traditional predictors. Consequently, the research extends TOE-RBV integration by demonstrating how resource constraints and environmental fragility jointly condition technology related decision making in non-listed firms.

These findings reveal that digital adoption in HRM cannot be explained solely by firm-level resources or size. In transitional contexts such as Kosovo, institutional fragility, regulatory adaptation, and limited digital infrastructure critically shape firms' technology strategies. By contextualizing these dynamics, the study moves beyond generic resource-based explanations and provides new institutional insights into how SMEs in post-transition economies engage with HR analytics. The findings can inform digital transformation strategies in comparable contexts across the Western Balkans and other emerging markets.

5. Methodological and Contextual Limitations

This study provides valuable insights into BDA adoption in HRM among non-listed firms in Kosovo, several methodological and contextual limitations must be acknowledged. From a methodological perspective, the research employed a quantitative design based on a relatively small sample of fifty firms. Although this sample is representative of Kosovo's SME landscape, it may not capture the full heterogeneity of non-listed enterprises operating in other regions or industries. The use of self-reported survey data, while validated through expert review and pilot testing, may also introduce common method bias or subjective interpretation in responses. To further address potential measurement limitations, the study acknowledges that relying solely on quantitative survey data restricts the ability to capture deeper organizational dynamics such as leadership behaviour, cultural resistance, and informal HR practices. These aspects may be better understood through qualitative approaches, including interviews or case stud-

ies. Future research would therefore benefit from adopting a mixed method design to triangulate quantitative findings and enrich the interpretation of firm-level decision-making around BDA adoption. Additionally, while panel data analysis helps control for firm-level heterogeneity and temporal changes, certain unobserved variables such as leadership style or informal organizational dynamics could still influence the results. Although panel data strengthen temporal analysis, the study cannot fully establish causal directionality between variables. For example, financial strength may facilitate BDA adoption, but it is also possible that early digital adoption improves financial performance over time. Future research employing longitudinal causal modeling or experimental designs could help clarify these dynamic relationships. Future studies could employ mixed method approaches, including interviews or case studies, to triangulate quantitative findings and deepen contextual understanding.

In terms of contextual limitations, the findings are specific to Kosovo's transitional economic environment, characterized by evolving institutional frameworks, limited digital infrastructure, and constrained access to financing. As such, the results may not be fully generalizable to other developing or developed economies. Although regional literature is discussed to situate Kosovo within broader trends, the study does not empirically benchmark Kosovo's adoption trajectory against other Western Balkan or Eastern European economies. Future research incorporating cross country datasets would enhance comparative validity, allow examination of institutional differences, and more clearly position Kosovo within the regional digital transformation landscape. Moreover, the study focuses exclusively on non-listed firms, excluding public and multinational organizations that may operate under different regulatory and technological conditions. The adoption patterns observed here may therefore differ in contexts with stronger institutional support, advanced technological ecosystems, or differing labor market structures.

Despite these limitations, the study makes a meaningful contribution by empirically examining BDA adoption in an underexplored context. Addressing these methodological and contextual constraints in future research could further enhance the robustness and transferability of findings.

6. Conclusion and Recommendations

The findings of this study reinforce the growing importance of BDA in enhancing strategic decision making and operational efficiency within HRM, especially among non-listed firms in developing economies such as Kosovo. While the potential of BDA in areas like talent acquisition, performance monitoring, and workforce planning is evident, its diffusion remains uneven across firms, influenced by a range of technological, organizational, and environmental constraints.

On the technological front, many firms continue to face limitations in terms of IT infrastructure, data availability, and integration capacity. These deficiencies hinder their ability to implement and fully utilize analytics tools (Ghasemaghaei and Calic, 2020; Wamba et al., 2017). Organizationally, the lack of skilled personnel capable of interpreting and acting on analytical insights, coupled with financial constraints and a culture resistant to innovation, presents significant obstacles to adoption (McAfee and Brynjolfsson, 2012; Oliveira and Martins, 2010). Furthermore, external pressures such as regulatory uncertainty, limited enforcement of data protection standards, and modest competitive dynamics contribute to cautious or delayed implementation (Raguseo, 2018; Tursunbayeva et al., 2017).

This research, grounded in the TOE framework and DOI theory, provides a comprehensive lens for understanding the adoption process. The results show that successful BDA implementation depends not only on internal capacities such as employee skills and technological readiness but also on external enablers like regulatory clarity and competitive incentives (Rogers, 2003; Tornatzky and Fleischer, 1990).

For non-listed firms in Kosovo, where access to capital and digital infrastructure is often limited, progress in BDA adoption will require a multifaceted strategy involving both internal change and external support. Firms need to assess and enhance their technological capabilities by investing in scalable IT systems that allow for data collection, analysis, and secure storage. In parallel, organizational leaders must cultivate a culture that values data-informed decision-making, moving beyond intuition-driven practices.

Companies should invest in regular training programs focused on data analytics, including the use of tools for visualization, predictive modeling, and workforce analytics. Building internal expertise can reduce reliance on external consultants and accelerate implementation timelines.

Leadership commitment is essential for embedding analytics into everyday HR practices. This includes setting clear expectations for data use in performance evaluation, recruitment, and employee engagement.

Firms should implement formal data governance frameworks to ensure ethical, secure, and compliant use of employee data (Chen et al., 2012). Clear internal protocols can also foster trust among employees and external stakeholders.

From a policy standpoint, there is a compelling case for government-led initiatives to support BDA adoption among SMEs. Public policy can play a transformative role through national and regional programs focused on expanding broadband, cloud services, and digital tools for SMEs, which can help level the technological playing field. Grants, tax incentives, and low-interest loans can ease the financial burden associated with BDA adoption. Equally

important is the availability of technical assistance, particularly for firms with limited in-house IT capacity. Policymakers should offer clear, SME friendly guidance on data protection laws such as GDPR and develop mechanisms to reduce compliance costs for smaller firms. A transparent legal environment will increase firm confidence in adopting data-intensive technologies (Tursunbayeva et al., 2017). Collaborative initiatives involving industry associations, universities, and government agencies can facilitate knowledge transfer and enable shared learning through pilot projects. These networks can be especially beneficial for non-listed firms that may lack access to broader innovation ecosystems (Wamba et al., 2017).

From a policy perspective, Kosovo's institutional environment presents unique opportunities and constraints that require targeted interventions. Given the fragmented digital infrastructure and uneven HR analytics capabilities among SMEs, the government could collaborate with the Kosovo ICT Association (STIKK) and the Ministry of Industry, Entrepreneurship, and Trade to establish regional Digital HR Training and Support Hubs aimed at developing analytics competencies. Financial incentives such as tax reductions or digital innovation vouchers could motivate SMEs to invest in HR technology and data-driven management systems. Additionally, introducing a national framework for data protection and HR analytics ethics would enhance trust and compliance, reducing firms' perceived regulatory risk. At the organizational level, firms should prioritize the creation of dedicated digital HR teams and integrate analytics modules into ongoing employee development programs. Together, these context-sensitive strategies can accelerate digital HR transformation in Kosovo's SME sector while aligning with national development objectives for innovation and competitiveness.

In summary, BDA holds significant promise for transforming HRM practices in Kosovo's non-listed firms. However, unlocking its full potential will require concerted efforts from both business leaders and policymakers. By aligning investments in people, technology, and institutional frameworks, stakeholders can foster a data-driven business environment that supports sustainable growth and improved workforce outcomes.

Availability of Data and Materials

All data reported in this paper will be shared by the corresponding author upon reasonable request.

Author Contributions

BD conceived and designed the study, conducted the data analysis, and prepared the first draft of the manuscript. SJ contributed to the study design, interpreted the findings, critically revised the manuscript for important intellectual content, and supervised the research. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

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During the preparation of this work the authors used ChatGpt-3.5 in order to check spell and grammar. After using this tool, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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