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ORIGINAL PAPER
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TWIN EFFECTIVENESS FACTORS IN THE PUBLIC SECTOR TO INCREASE THE ACTIVITIES OF THE CIRCULAR ECONOMY

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ABSTRACT

Motives: The transition toward a circular economy requires simultaneous digital and ecological transformation, which can be referred to as the twin transition. Understanding how digital readiness and organizational structures influence effectiveness in public sector organizations is crucial for implementing circular economy principles.
Aim: This study examines how digital readiness and self-management team characteristics influence organizational effectiveness in Polish municipal public services, with implications for the implementation of the circular economy.
Results: Using data from 26 municipal departments, results indicate that higher digital readiness correlates with improved goal achievement and employee engagement. Self-management team characteristics exhibited moderate development, with a mean self-management index of 2.70 on a five-point scale. Effective remote work implementation, supported by adequate ICT infrastructure, contributes to resource efficiency principles central to circular economy activities. Organizations with high digital readiness demonstrated superior performance in achieving organizational goals compared to those with low readiness. These findings suggest that the twin transition requires not only technological investment but also organizational restructuring toward more autonomous, self-managing teams.

Keywords: circular economy, twin transition, digital transformation, self-management teams, public sector effectiveness, remote work

INTRODUCTION

The European Union has positioned the twin transition as a cornerstone of its strategic vision for sustainable development. This transition encompasses two interconnected pathways: digital transformation and ecological transition toward a circular economy. The European Green Deal explicitly recognises that achieving circular economy objectives requires leveraging digital technologies to optimise resource use, extend product lifecycles, and enable new circular business models (European Commission, 2019). However, the public sector faces unique challenges in implementing these twin transitions due to bureaucratic structures, resource constraints, and traditional hierarchical management approaches.

The circular economy represents a fundamental shift from the traditional linear economic model

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of take-make-dispose to a regenerative system where resource input, waste, and emissions are minimised through slowing, closing, and narrowing material and energy loops (Geissdoerfer et al., 2017). In the public sector, circular economy principles manifest through various mechanisms, including reduced resource consumption, optimised space utilisation, decreased energy use in buildings, and enhanced service delivery efficiency (Kristoffersen et al., 2020). The COVID-19 pandemic accelerated the adoption of remote work arrangements, inadvertently demonstrating how digital technologies can support circular economy objectives through reduced commuting, lower office space requirements, and decreased resource consumption (Kniffin et al., 2021; Mokrá et al., 2023).

Digital transformation in public administration extends beyond mere technology adoption to encompass fundamental changes in organisational structures, work processes, and management approaches (Mergel et al., 2019). The literature identifies several dimensions of digital readiness crucial for effective organisational transformation, including technological infrastructure, digital competencies, organisational culture, and leadership support (Vial, 2019). However, research examining the interplay between digital readiness and organisational effectiveness in supporting circular economy activities remains limited, particularly in the public sector context.

Self-management teams represent an organisational form characterised by distributed decision-making authority, collective responsibility, and reduced hierarchical control (Langfred, 2004). These teams possess autonomy in planning, executing, and monitoring their work, making them potentially well-suited for the flexible, adaptive approaches required in circular economy implementation. The theoretical foundations for self-management teams draw from socio-technical systems theory, which emphasises the joint optimisation of social and technical subsystems (Trist & Bamforth, 1951). Contemporary research suggests that self-management can enhance organisational agility and innovation capacity, both essential for circular economy transitions (Lee & Edmondson, 2017).

Despite growing interest in both circular economy and digital transformation, empirical research examining their intersection in public sector organisations remains scarce. Most existing studies focus either on technological aspects of circular economy implementation or on organisational change management in isolation (Antikainen et al., 2018). Furthermore, the role of self-management teams as an organisational mechanism for facilitating twin transitions has received limited attention in the literature. This research gap is particularly significant given that public sector organisations differ fundamentally from private enterprises in their objectives, stakeholder relationships, and operational constraints (Bozeman, 1987).

This study addresses these gaps by examining how digital readiness and self-management team characteristics influence organisational effectiveness in Polish municipal public services, with particular attention to implications for circular economy activities. Drawing on data from 26 municipal departments across major Polish cities, the relationships between technological infrastructure, team autonomy, and operational performance indicators were investigated. The research aims to provide evidence-based insights for public sector leaders seeking to leverage the twin transition to enhance circular economy implementation.

The study makes several contributions to existing knowledge. First, it provides empirical evidence linking digital readiness to organisational effectiveness in a public sector context, addressing the limited research on this relationship. Second, it examines self-management team characteristics in Polish public administration, an organisational form that remains understudied in post-transition European contexts. Third, it explores how remote work arrangements, enabled by digital infrastructure, can contribute to circular economy objectives through resource efficiency improvements. Finally, the research offers practical implications for public sector leaders navigating the complexities of twin transition implementation.

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Based on the literature review and research gaps identified, this study tests the following research hypotheses:

H1: Higher levels of digital readiness are positively associated with organisational goal achievement in public sector organisations.

H2: Self-management team characteristics are moderately developed in Polish municipal public services.

H3: There is a positive association between the implementation of remote work practices and indicators of organizational resource efficiency within public administration units.

H4: Organizations with higher digital readiness demonstrate superior employee engagement and creativity compared to those with lower digital readiness.

MATERIALS AND METHODS

Research Design and Sample

This study employed a cross-sectional survey design to examine the relationships between digital readiness, self-management team characteristics, and organisational effectiveness in Polish municipal public services. The circular economy is analyzed at the organizational and behavioral level, not the material level (flows of materials). The research was conducted between February and May 2024, during a period when many public sector organisations maintained hybrid or fully remote work arrangements implemented during the COVID-19 pandemic. The sample consisted of department heads from municipal administrative and civil service units in major Polish cities, including Warsaw, Krakow, Poznan, Wroclaw, and Lodz. These cities were selected based on their size, economic significance, and representation of diverse regional contexts within Poland. The selection criteria for participating departments included: provision of knowledge-intensive services, team-based work organisation, high capacity for remote work implementation, and delivery of complex tasks requiring professional competencies.

A total of 26 department heads participated in the study, representing various functional areas including strategic planning, economic development, social services, education, and international cooperation. The participating departments ranged in size from 21 to 100 employees, with an average of 46 staff members. This sample size, while modest, represents approximately 15–20% of eligible departments in the surveyed cities that met the inclusion criteria.

Measurement Instruments

The research employed a structured questionnaire consisting of 61 items organised into seven thematic sections: technological infrastructure, competency development, work organisation, control mechanisms, motivational systems, organisational relationships, and demographic characteristics. Questions utilised five-point Likert scales or percentage-based response options to capture variation in organisational practices and outcomes.

Digital readiness was operationalised through two composite indicators: ICT equipment provision (availability of computers, monitors, cameras, microphones, and printers) and ICT infrastructure access (availability of shared databases, electronic documents, and integrated management systems). Responses ranged from 0, indicating no provision, to 5, indicating full access for all employees. Self-management team characteristics were assessed using four dimensions: power sharing processes, employee decision-making autonomy, task modification capability, and team-based task execution. Each dimension was measured on a five-point scale, with higher scores indicating greater self-management characteristics. A composite self-management index was calculated as the mean of these four dimensions. Organisational effectiveness was evaluated through multiple indicators, including goal achievement levels, employee engagement, creativity and innovation capacity, work-life balance, and time management efficiency. These measures captured both objective performance outcomes and subjective employee well-being indicators relevant to sustainable

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organisational functioning. Resource efficiency, as a proxy for circular economy contribution, was measured through indicators including the percentage of work time conducted remotely, improvements in time management efficiency, and work-life balance achievement. These variables reflect the reduced resource consumption associated with remote work arrangements, including decreased office space needs, lower energy consumption, and reduced commuting-related environmental impacts.

Data Collection Procedures

Data collection was conducted through an online survey platform distributed to department heads via official municipal communication channels. Survey invitations included information about the research objectives, confidentiality assurances, and instructions for completion. Respondents were asked to provide answers based on their department's actual practices and conditions over the preceding 12 months.

The survey instrument was pilot-tested with three department heads to ensure question clarity and appropriate response options. Minor modifications were made based on pilot feedback to improve instrument validity. The final survey required approximately 25–30 minutes to complete.

Data Analysis Methods

Data analysis proceeded in several stages. First, descriptive statistics were calculated for all variables, including means, standard deviations, and frequency distributions. Response categories were converted to numeric scales for quantitative analysis while preserving the ordinal nature of Likert-type items.

Second, a digital readiness composite score was created by averaging ICT equipment and infrastructure indicators for each organisation. Organisations were then categorised into three groups based on digital readiness levels: low (score < 2.0), medium (score 2.0–3.5), and high (score > 3.5). This categorisation facilitated comparison of organisational effectiveness outcomes across readiness levels.

Third, correlation analysis examined relationships between digital readiness, self-management characteristics, and effectiveness indicators. Pearson correlation coefficients were calculated to identify significant associations between variables. Given the ordinal nature of some variables and the small sample size, results were interpreted with appropriate caution regarding generalizability.

Fourth, group comparisons analysed differences in effectiveness indicators across digital readiness categories. While the sample size limited statistical power for inferential tests, descriptive comparisons provided insights into performance patterns associated with varying levels of digital readiness.

Finally, generational workforce composition was analysed to understand demographic diversity in participating departments. Employee counts were categorised using standard generational cohorts: Baby Boomers (age 57+), Generation X (age 41–56), Generation Y/Millennials (age 26–40), and Generation Z (age 18–25). This analysis provided context for interpreting organisational adaptation to digital transformation.

The distribution of survey respondents across the five cities was as follows: Warsaw (8 departments, 31%), Krakow (5 departments, 19%), Poznan (5 departments, 19%), Wroclaw (4 departments, 15%), and Lodz (4 departments, 15%). Warsaw's higher representation reflects its status as the national capital and the greater number of specialised municipal departments in the largest Polish city. The remaining four cities contributed roughly equal shares, ensuring reasonable geographic diversity across different regional economic contexts. While the sample is not proportionally stratified, it offers a cross-section of large urban municipalities representing different parts of Poland. No statistically significant differences in digital readiness or self-management scores were found between cities, suggesting that the observed patterns are not driven by a particular urban centre.

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RESULTS

Digital Readiness and Technological Infrastructure

Table 1 presents descriptive statistics for key organisational variables examined in this study. The results indicate that participating organisations demonstrated moderate to high levels of ICT infrastructure readiness. The mean score for ICT infrastructure access was 3.85 (SD = 1.46) on a five-point scale, suggesting that most departments provided employees with access to necessary shared databases and integrated systems for remote work. ICT equipment provision showed a mean of 3.46 (SD = 1.63), indicating somewhat greater variability in hardware availability across organisations.

Digital readiness varied considerably across participating organisations, with composite scores ranging from 0.50 to 5.00. This variation reflects differences in organisational investment in technological infrastructure as well as disparities in institutional capacity and resources among municipalities of different sizes and economic conditions. Notably, the data reveal relatively low investment in training budgets for developing digital competencies, with a mean score of only 0.30 (SD = 0.47) on a scale where 1 represents 20% of departmental budget allocated to ICT training. This finding suggests that while organisations have invested in hardware and software infrastructure, human capital development for effective technology utilisation may be underfunded.

Self-Management Team Characteristics

The composite self-management index showed a mean of 2.70 (SD = 1.26) on the five-point scale, indicating moderate development of self-management characteristics in the surveyed departments. This suggests that while elements of self-management exist, public sector organisations in Poland have not fully transitioned to autonomous team structures.

Among the individual dimensions of self--management, power sharing demonstrated the highest mean (3.46, SD = 1.84), suggesting that department heads recognised the value of distributed decision-making authority. However, substantial variation in this measure indicates inconsistent implementation across organisations. Employee empowerment showed lower development (2.54, SD = 1.70), suggesting that while formal authority may be shared, employees may not yet feel fully empowered to exercise autonomous decision-making. Team-based work organisation, a fundamental characteristic of self-management, showed a mean of 2.85 (SD = 2.03). The high standard deviation indicates considerable variability, with some organisations maintaining individual-focused work structures while others have implemented more collaborative team approaches. This variability likely reflects differences in leadership philosophies, organisational cultures, and the nature of services provided by different departments.

Table 1. Descriptive Statistics for Key Organisational Variables (N=26)

Variable	Mean	SD	Min	Max
ICT Equipment Provision	3.46	1.63	0.00	5.00
ICT Infrastructure Access	3.85	1.46	1.00	5.00
Digital Readiness (Composite)	3.65	1.45	0.50	5.00
Self-Management Index	2.70	1.26	0.50	4.75
Goal Achievement	3.12	1.77	0.00	5.00
Employee Engagement	3.12	1.84	0.00	5.00
Creativity & Innovation	2.77	1.61	0.00	5.00

Source: own elaboration based on survey data.

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DISCUSSION

This study examined how digital readiness and self-management team characteristics influence organizational effectiveness in Polish municipal public services, with particular attention to implications for circular economy implementation. The findings provide several important insights regarding the twin transition in public sector organizations. The positive relationship between digital readiness and organizational goal achievement supports hypothesis H1 and aligns with previous research on digital transformation in public sector contexts (Mergel et al., 2019; Vial, 2019). Organizations that invested more substantially in ICT equipment and infrastructure demonstrated superior performance in achieving their objectives, suggesting that technological capacity represents a critical foundation for effective organisational functioning in contemporary public administration. However, the relationship between digital readiness and effectiveness is not uniformly positive across all dimensions. While goal achievement and employee engagement improved with higher digital readiness, creativity and innovation showed more complex patterns. This finding suggests that digital transformation alone may be insufficient to foster innovative capacity. Organisations must complement technological infrastructure with cultural and managerial practices that encourage experimentation, risk-taking, and knowledge sharing (Lee & Edmondson, 2017).

The relatively low investment in training budgets for digital competency development represents a concerning gap. While organisations have acquired the necessary hardware and software, insufficient attention to human capital development may limit the effectiveness of these technological investments. Research on technology implementation consistently demonstrates that successful digital transformation requires not only technical infrastructure but also user training, change management support, and ongoing skill development (Vial, 2019). The moderate self-management index scores (mean = 2.70) confirm hypothesis H2 and reveal that Polish municipal public services have not yet fully transitioned to autonomous team structures. While elements of self-management exist, particularly regarding power sharing, other dimensions, such as employee empowerment and team-based work organization remain less developed.

This pattern reflects the inherent tensions between traditional bureaucratic structures characteristic of public administration and newer organisational forms emphasising flexibility and autonomy (Bozeman, 1987). Public sector organisations face unique constraints, including legal frameworks, accountability requirements, and political oversight that may limit the extent to which they can adopt pure self-management approaches. Nevertheless, the variation in self-management characteristics across departments suggests that organisational culture and leadership philosophy significantly influence the degree of autonomy granted to employees. The strong correlations between empowerment, engagement, and creativity underscore the importance of self-management characteristics for organisational innovation capacity. Organisations that grant employees greater autonomy in decision-making appear better positioned to generate creative solutions and adapt to changing circumstances. This finding has particular relevance for circular economy implementation, which often requires innovative problem-solving and adaptation of standard processes to accommodate resource efficiency objectives (Antikainen et al., 2018).

The findings support hypothesis H3 regarding the contribution of digital transformation to resource efficiency outcomes. Remote work arrangements enabled by digital infrastructure resulted in reduced office space utilization, decreased commuting, and enhanced work-life balance. These outcomes align with circular economy principles emphasizing reduced resource consumption and improved human wellbeing (Geissdoerfer et al., 2017). However, the relationship between remote work and circular economy contributions extends beyond simple resource consumption metrics. The shift toward distributed work arrangements necessitates rethinking organizational processes, communication patterns, and service delivery methods. This process of organizational adaptation creates

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opportunities for identifying inefficiencies, eliminating redundant practices, and optimizing resource utilization in ways that extend beyond the immediate impacts of reduced office space and commuting.

The challenges identified regarding knowledge sharing frequency and time management efficiency highlight important obstacles to realizing the full potential of remote work for organizational effectiveness. Organizations must develop deliberate strategies for maintaining informal knowledge exchange, fostering team cohesion, and supporting effective time management in distributed work environments. These challenges are not insurmountable but require conscious attention from organizational leaders (Kniffin et al., 2021).

The concept of twin transition emphasizes the interconnection between digital and ecological transformations (European Commission, 2019). This study's findings illuminate several mechanisms through which these transitions reinforce one another in public sector contexts. Digital infrastructure enables work arrangements that reduce resource consumption, directly supporting circular economy objectives. Simultaneously, the pursuit of circular economy goals creates demand for data analytics, monitoring systems, and digital coordination tools that drive further digital transformation. However, the twin transition requires more than technological investment and environmental consciousness. The findings regarding self-management characteristics suggest that organizational structures and management approaches represent a third critical dimension. Autonomous teams with decision-making authority appear better positioned to identify and implement circular economy innovations within their spheres of responsibility. Hierarchical, rigid organizational structures may struggle to achieve the flexibility and adaptability required for effective circular economy implementation (Kristoffersen et al., 2020). Public sector organizations pursuing twin transition strategies should therefore consider organizational restructuring toward more autonomous team-based structures as an integral component of their transformation efforts. This restructuring need not eliminate all hierarchical elements but should grant operational teams sufficient autonomy to experiment with resource efficiency improvements and innovative service delivery approaches.

The generational composition of the surveyed departments warrants specific discussion in relation to the twin transition. The workforce in the participating units was predominantly composed of Generation X and Millennial employees (age 26–56), who together accounted for the majority of staff. Baby Boomers (age 57+), while present, represented a smaller fraction. This demographic profile has implications for digital readiness: younger employees generally exhibited greater comfort with digital tools and remote work arrangements, while older cohorts sometimes required additional support and training to fully leverage available ICT infrastructure. The data indicate that departments with a higher proportion of Generation Y and Generation Z employees tended to score somewhat higher on the digital readiness composite, though the small sample size limits the strength of this inference. These findings are consistent with broader research on generational differences in technology adoption (Vial, 2019). Age-related variation in digital competencies underscores the importance of inclusive upskilling programmes that address the needs of all generational cohorts, rather than assuming uniform digital literacy across the workforce. Future research should explicitly measure the relationship between age composition and twin transition outcomes, ideally through larger, multi-organisation samples.

The twin transition also carries a set of risks for the public sector and its employees that should be acknowledged alongside the opportunities identified in this study. From an organisational standpoint, accelerated digitalisation may widen the gap between departments that have the resources and leadership capacity to invest in ICT infrastructure and those that do not, potentially producing a two-tier public administration with unequal service quality. Furthermore, the move toward self-managing, remote-capable teams may erode traditional accountability mechanisms if not accompanied by appropriate governance frameworks and performance

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monitoring systems. For individual employees, the most immediate risks involve job displacement or skill obsolescence, particularly for older workers or those in administrative roles that are susceptible to automation. The intensification of remote work, while contributing to resource efficiency, also raises concerns about work-life boundary erosion, digital fatigue, and reduced access to informal learning and collegial support. The low training budget scores observed in this study (mean = 0.30) suggest that many departments are not yet investing adequately in managing these human capital risks. Public sector leaders should therefore approach the twin transition not only as a technological and environmental project, but as a change management challenge that requires deliberate attention to workforce wellbeing, equity, and skill development.

This study has several limitations that warrant acknowledgment. First, the relatively small sample size of 26 departments limits statistical power and generalizability of findings. While the sample represents a reasonable proportion of eligible departments in major Polish cities, caution is warranted in extrapolating results to smaller municipalities or different national contexts. Second, the cross-sectional design prevents causal inference regarding relationships between digital readiness, self-management characteristics, and organizational effectiveness. Longitudinal research tracking organizations over time would provide stronger evidence regarding the temporal dynamics and causal mechanisms underlying the observed associations. Third, reliance on department head reports introduces potential common method bias. Future research would benefit from incorporating multiple data sources including employee surveys, objective performance metrics, and direct observations of organizational practices. Such triangulation would enhance confidence in research findings. Future research should address these limitations through larger, longitudinal, multi--method studies. Additionally, the study does not include direct environmental performance indicators. Comparative research examining twin transition processes across different national and organizational contexts would illuminate how institutional frameworks, cultural factors, and policy environments shape transformation pathways.

CONCLUSIONS

This study demonstrates that the twin transition toward digital and circular economy in public sector organizations involves interconnected technological, organizational, and managerial dimensions. Digital readiness, as measured through ICT infrastructure and equipment provision, shows positive associations with organizational goal achievement and employee engagement. However, technological capacity alone proves insufficient for comprehensive organizational transformation. Self-management team characteristics, while moderately developed in Polish municipal public services, demonstrate significant influence on innovation capacity and employee engagement. The strong relationships between empowerment, engagement, and creativity suggest that organizational structures granting employees greater autonomy may enhance capacity for circular economy innovation and implementation. Remote work arrangements enabled by digital infrastructure contribute to circular economy objectives through reduced resource consumption while simultaneously presenting challenges for knowledge sharing and time management. Organizations must develop deliberate strategies for maintaining organizational effectiveness in distributed work environments. The findings have several practical implications for public sector leaders. First, investments in digital infrastructure should be accompanied by comparable investments in human capital development through training and competency building programs. Second, organizational restructuring toward more autonomous team-based structures may facilitate both digital transformation and circular economy implementation. Third, deliberate attention to maintaining knowledge sharing, team cohesion, and time management in remote work settings is essential for realizing the full benefits of digital transformation. The twin transition represents both a challenge and an opportunity for public sector organizations.

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Success requires not merely adopting new technologies or implementing environmental policies but fundamentally rethinking organizational structures, management approaches, and work arrangements. Organizations that successfully navigate this complex transformation may achieve improvements in operational efficiency, employee wellbeing, and environmental sustainability simultaneously.

Future progress toward circular economy objectives in the public sector will depend significantly on the degree to which organizations can leverage digital technologies to enable more flexible, adaptive, and resource-efficient operations. The moderate development of self-management characteristics observed in this study suggests substantial room for further organizational innovation. Public sector leaders should view the twin transition as an opportunity to modernize organizational structures and management practices in ways that serve multiple objectives simultaneously.

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