Integrating the circular economy into public organisations: The impact of digital transformations and circular insights on resource-conscious innovative behaviour

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ABSTRACT

Despite growing attention to circular economy (CE) practices, there is limited research addressing how digitalisation enhances resource-conscious innovation behaviours among employees, a factor critical to CE adoption. Drawing on the literature on public administration and organisational knowledge creation, this study examines how digital transformation promotes circular insights development. We also explore the mediating role of circular insight development in the relationship between digital transformation and resource-conscious innovative behaviour and its influence on embedding CE practices in departmental strategies. The study also addresses bureaucratic constraints, proposing that employees' ability to navigate them moderates the relationship between resource-conscious innovative behaviour and CE integration. By answering key questions about the interplay of digitalisation, knowledge creation, innovation, and sustainability, this research contributes to the literature on public sector strategies for achieving environmental and operational efficiency.

1. Introduction

Public sector organisations increasingly face the challenge of redesigning existing activities and practices to transform how individuals and institutions consume and utilise resources (Klein et al., 2022a). Integrating circular economy (CE) principles into public sector operations remains particularly difficult (Droege et al., 2021). The CE is defined as a system of waste and material management focused on the recovery, redistribution, and reuse of end-of-life products, with the aim of achieving sustainable development (Kirchherr et al., 2017). Public organisations are facing increasing pressure to address the issues related to environmental risks such as reducing emission rate, and adopting CE practices, while keeping themselves up to date with modern technologies, including digital tools, platforms, artificial intelligence and data-driven insights that support process optimisation (Mikalef et al., 2023). These demands highlight the urgent need for more resource-

conscious and innovative behaviour to support the adoption of CE practices (Klein et al., 2022b).

Notably, digital transformations within organisations present a strategic opportunity to enhance resource efficiency, monitor waste generation, and implement regenerative practices (Nielsen et al., 2024). While policy initiatives are increasingly aimed at accelerating CE integration (Dagilienė et al., 2021; Tessitore et al., 2023), scholars argue that public organisations must also foster the internal conditions necessary for employees to support digital transformation (Giraldi et al., 2024) and drive CE initiatives (Shah and Rezai, 2023). However, researchers have offered limited insight into the mechanisms and conditions under which this integration can be effectively achieved.

A key challenge facing many public sector organisations is the integration of digital technologies to enhance service delivery while fostering change-oriented behaviour among employees. As Colvin et al. (2014) suggest, innovative behaviour involves proactively identifying

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problems and seeking creative solutions, which is a fundamental capability for the successful implementation of novel ideas. Within the context of the CE, resource-conscious innovative behaviour stresses sustainability and efficient use of resources (Srivastava and Shu, 2013). This requires individuals to actively innovate while remaining mindful of conserving resources, minimising waste, and promoting regenerative practices (Wu et al., 2014). Individual innovative behaviour plays a crucial role in realizing broader innovation outcomes (Scott and Bruce, 1994), particularly as transformative solutions such as CE are important to organisational change (Bocken and Konietzko, 2022). Despite this, CE practices in the public sector are rarely examined at the micro level (Droege et al., 2021), and there is limited research exploring how digital transformation influences employees' resource-conscious innovative behaviour (Fishenden and Thompson, 2013; Nielsen et al., 2024). To address this gap, we build on the traditional construct of innovative behaviour and adapt it to this study's context, conceptualising it as resource-conscious innovative behaviour.

The digital transformation is defined as a process of managing and upgrading new digital technologies that enable organisations to implement operational changes and make strategic decisions (Fernandez-Vidal et al., 2022). Despite of its importance, there is a scarcity of research on the relationships between digital transformations, administrative arrangements, and institutional changes necessary to enable the success of sustainability in public organisations (Krause et al., 2016, p. 115). Nevertheless, some scholars have recognised this paradigm shift (i. e. Bolger and Doyon, 2019) and noted that the managerial perspective in the digital transformation outcome raises a series of yet unanswered questions in the public administration literature (Klein et al., 2022a). For example, there is limited information on the knowledge management processes that may be necessary when managing digital transformation in public organisations or local government (Klein et al., 2022b), such as the development of circular insights. In line with this finding, Klein et al. (2022b) have called for a better understanding of the impact of digital transformation on innovation behaviours in public organisations regarding the delivery of new services. Finally, there is a scarcity of research on resource-conscious innovation behaviour – the focus of this study.

Innovative behaviour in public administration refers to the generation, championing, and implementation of new ideas, processes, products, and services (Thompson, 1965). Innovative behaviour can be defined as the capacity to adapt or change (Walker, 2008). Similarly, Walker et al. (2011) note that the most critical element for developing new administrative processes in a digitalisation environment is knowledge creation; in the context of this study, we classify this as circular insight development. The public administration literature suggests different resources to benefit from integrating an environmental sustainability perspective, such as knowledge utilisation, knowledge distribution, and leveraging collaboration (Bhuiyan and Perry, 2024), knowledge generation and the sharing of information for management decisions (Newcomer et al., 2023), generating and transforming policy related knowledge (Ege, 2019), and using internal knowledge resources to improve sustainability initiatives (Tosun et al., 2019).

Some researchers have proposed that a successful transition toward resource-conscious innovation behaviour requires a digital transformation within the organisation (Cozzarin, 2017; Klein et al., 2022b). They highlight the significance of a digital transformation for organisational knowledge creation; however, the mechanism related to integrating CE practices within public sector departments remains unexplored (Tessitore et al., 2023). Knowledge plays a crucial role in shaping organisational behaviour, and researchers have long recognised its importance in developing and adopting new processes (Pisano, 1994). Following Su et al. (2016), the concept of knowledge creation emphasises the continuous refinement and co-creation of new learning, and the subsequent application of the resulting insights. Digital technologies facilitate circular knowledge development by enabling the collection, processing, and sharing of data (Awan et al., 2021). To date,

the literature in public administration has primarily focused on collective knowledge management strategies (Kim and Lee, 2006; Newcomer et al., 2023), with limited discussions of its role in the development of resource-conscious innovative behaviour (Wang et al., 2019).

Furthermore, the public sector is often characterised by bureaucratic complexities (Morris and Farrell, 2007) that hinder innovative behaviour among employees and influence its outcomes (Hirst et al., 2011). This situation is particularly relevant in developing economies, such as Pakistan, which faces the problem of institutional voids (Khan et al., 2019). We argue that an employee's capacity to balance bureaucratic constraints can moderate the relationship between their resource-conscious innovation behaviour and the integration of CE practices into a departmental strategy.

This study builds on the theories of organisational knowledge creation (Nonaka and Takeuchi, 1995) and innovation behaviour (Scott and Bruce, 1994) to examine how a digital transformation facilitates CE integration in public organisations. Knowledge creation theory emphasises the continuous development and refinement of insights, which aligns with the concept of circular insight development, i.e. the process of generating and applying sustainability-focused knowledge within organisations. Innovative work behaviour involves employees' role in problem identification and proposing creative solutions, which can facilitate CE practices (Colvin et al., 2014). Additionally, institutional theory (DiMaggio and Powell, 1983) provides a framework for understanding how bureaucratic structures influence CE adoption. Public sector organisations often operate within rigid institutional frameworks that can either enable or constrain innovation, where employees' capacity to balance bureaucratic constraints determines their ability to integrate CE practices into departmental strategies. By incorporating these theoretical perspectives, this study presents a comprehensive and novel perspective on the interplay of digital transformation, knowledge creation, innovation behaviour, and institutional constraints in the public sector.

This study contributes to the literature by advancing knowledge on digital transformations and CE integration, conceptualising circular insight development as a mediator between a digital transformation and resource-conscious innovation behaviour, with bureaucratic constraints as a moderating factor. While existing literature discusses CE initiatives and digital transformations separately, this study examines their relationship, providing new insights into how technology facilitates sustainability in public organisations. Further, it offers an empirical examination of public organisations in a developing economy, providing valuable insights into the technological, behavioural, and institutional factors influencing CE adoption.

By addressing these areas, this study aims to contribute to a deeper understanding of how public sector organisations can leverage digital transformation to foster resource-conscious innovation behaviour and enhance the integration of CE principles into their departmental strategy. This study seeks to contribute to the public organisation literature by addressing the following research question: How does a digital transformation impact resource-conscious innovation behaviour and subsequently influence the integration of CE practices within public organisations?

2. Theoretical background and hypothesis development

The integration of CE practices during a digital transformation of a public sector organisation can be understood through multiple theoretical lenses. This study primarily draws on organisational knowledge creation theory, conceptualisations of innovation behaviour, and institutional theory to explore how a digital transformation fosters resource-conscious innovation behaviour and the adoption of CE principles in bureaucratic environments.

Organisational knowledge creation theory (Nonaka and Takeuchi, 1995) highlights the importance of knowledge development, refinement, and application in organisational change. This theory provides a

foundation for understanding circular insight development, a concept introduced in this study to describe the process through which public sector employees generate, process, and apply sustainability-related knowledge to support CE integration. Digital transformation plays a pivotal role in enabling this process by facilitating data-driven decision-making, resource optimisation, and improved collaboration across departments (Awan et al., 2021).

Nonaka and Takeuchi (1995) proposed the SECI (socialisation, externalisation, combination, and internalisation) model to explain how organisations create and manage knowledge. This model is particularly relevant to understanding how public sector employees develop circular insights. Socialisation involves tacit knowledge-sharing through direct interactions, such as training sessions, workshops, and cross-departmental collaboration, where employees informally exchange sustainability-related knowledge. Externalisation refers to the process of articulating tacit knowledge into explicit concepts (Zhang et al., 2025); in the context of CE, it could involve documenting best practices for resource optimisation, creating guidelines for digital waste management, or formalising sustainability policies. Combination involves integrating various sources of explicit knowledge to form new frameworks or strategies. Public sector organisations can use digital technologies for tasks such as data compilation on resource use, and waste reduction trends, and create actionable insights for decision-makers. Internalisation is the process of embedding newly developed knowledge into daily operations and employee behaviour (Cerchione et al., 2024).

Digital transformation enhances each phase of the SECI model by providing technological tools that facilitate knowledge exchange, data analysis, and collaborative decision-making. The use of artificial intelligence (AI), big data analytics, and cloud-based platforms can improve the efficiency and accuracy of knowledge creation processes, ensuring that employees have access to real-time insights for the implementation and continued improvement of CE initiatives (Klein et al., 2022b). Moreover, digital transformation supports the co-creation of knowledge, where employees, stakeholders, and policymakers collaboratively develop solutions tailored to the sustainability challenges (Awan et al., 2022).

The concept of innovation behaviour underscores the role of individual and organisational innovation in fostering change (Scott and Bruce, 1994). This study contextualises resource-conscious innovation behaviour, emphasising how employees in public organisations proactively seek and implement innovative solutions that optimise resource use, reduce waste, and enhance CE practices. Prior research indicates that fostering innovative behaviour requires a supportive environment where employees are encouraged to challenge traditional practices and engage in creative problem-solving (Colvin et al., 2014; Wu et al., 2014). A digital transformation can facilitate such behaviour by providing tools and platforms that enhance efficiency, encourage collaboration, and enable the real-time monitoring of resource use (Nielsen et al., 2024).

Institutional theory (DiMaggio and Powell, 1983) offers insights into how bureaucratic structures influence organisational change. Public sector organisations are often constrained by rigid administrative frameworks, hierarchical decision-making processes, and regulatory complexities (Morris and Farrell, 2007). These limitations can hinder innovation and the adoption of CE practices. However, employees' capacity to balance bureaucratic constraints can play a critical moderating role, determining whether CE initiatives can be successfully integrated into departmental strategies. Employees who can navigate institutional restraints, leverage digital tools, and align sustainability goals with administrative requirements are more likely to drive meaningful change (Hirst et al., 2011).

Following these theoretical insights, this study examines how digital transformation enhances circular insight development, fosters resource-conscious innovation behaviour, and enables the integration of CE practices within public sector organisations. By bridging knowledge creation, innovation behaviour, and institutional constraints, this research offers a more comprehensive understanding of the mechanisms through which public organisations can transition toward sustainable and resource-efficient operations.

2.1. Digital transformation and circular insight development

The digital transformation has been identified as an important precursor to employees' willingness to explore and facilitate knowledge exchange, simplify communication, and improve information transparency. According to Nwankpa and Roumani (2016), digital transformation is defined as an organisational shift to big data, analytics, cloud, mobile and social media platforms. Nielsen et al. (2024) argue that without employees expressing their skills and capabilities in communicating and using digital tools, organisations may struggle to utilise the knowledge (Fishenden and Thompson, 2013). Consistent with knowledge creation theory (Nonaka and Takeuchi, 1995), the digital transformation strengthens every stage of the SECI model by leveraging technological tools that streamline knowledge sharing, data analysis, and collaborative decision-making. Digitalization enhances the efficiency and accuracy of knowledge creation and enables employees to acquire real-time insights that advance CE initiatives (Klein et al., 2022b). Furthermore, digitalization fosters the co-creation of knowledge, enabling employees and stakeholders to collaboratively develop solutions to enable the integration of circular practices (Awan et al., 2022).

The adoption of online digital platforms can drive change, foster problem identification and solving, and lead to the development of new insights (Cennamo et al., 2020). Existing literature suggests that adoption of digital technologies is directly related to generating valuable new knowledge (Fishenden and Thompson, 2013), i.e. circular insights in the context of this study. We define circular insight development as the process of gaining insight into the CE and how to shape a circular strategy. It refers to the process of fostering awareness, understanding, and innovative thinking aligned with the principles of the CE. It emphasises the cultivation of insights that support sustainable practices, resource efficiency, and regenerative systems. It highlights the importance of intellectual growth and proactive thinking in advancing sustainability goals within a CE framework. Previous research suggests that an employee's propensity to engage in creative activities is correlated with their ability to create knowledge and utilise it (Nonaka, 1994; Su et al., 2013). Digital transformation enables employees to explore and share information, allowing other members within an organisation to access the most essential information. Public service organisations can foster circular insight development through digital technologies enabling data-driven decision-making, process optimization, and enhanced stakeholder engagement (Medaglia et al., 2024).

Following Erdiaw-Kwasie et al. (2023), CE knowledge provides strategies for reducing waste through reuse, recycling, and upcycling. The organisational digital transformation process allows employees to track and optimise resources (Klein et al., 2022b). In particular, previous research has highlighted that restructuring organisational routines and tasks, e.g. digital change, supports learning and enhances the ability to consolidate new knowledge with past routines in the search for further insights (Newcomer et al., 2023).

Employees' experience with digital transformation facilitates their ability to support the coordination task, searching and sharing information to design and monitor policies that promote CE goals (Neligan et al., 2023). Therefore, digital transformation enables employees to explore and share information, enabling more effective and targeted CE strategies (Chauhan et al., 2022). Digital transformation positively influences circular insight development by enabling data-driven decision-making and process optimisation (Erdiaw-Kwasie et al., 2023). The implementation of advanced data analytics within digital transformation initiatives strengthens circular insight development by providing actionable insights into resource use and waste reduction (Awan et al., 2021). The integration of IoT and smart technologies as

part of digital transformation facilitates the real-time monitoring and tracking of waste generation (Anagnostopoulos et al., 2017), which significantly contributes to the development of circular insights in public services. Using AI in digital transformation initiatives can monitor and analyse resource use and waste generation, which may enhance circular insight development by identifying patterns and optimising resource cycles (Bag et al., 2021). Thus, we argue that,

Hypothesis 1. *Digital transformation in public organisations is positively related to circular insight development.*

2.2. Digital transformation and resource-conscious innovation behaviours

Digital transformation fosters learning and knowledge creation (Hackler and Saxton, 2007; Nwankpa and Roumani, 2016), utilising tools that facilitate exploration, leading to the development of new methods (Hackler and Saxton, 2007) and accelerating the process of understanding to support new initiatives (Bhuiyan and Perry, 2024). Some scholars argue that an increase in the digital transformation within an organisation may hinder employees from putting more focus on engaging in problem-solving activities (Cennamo et al., 2020; Hackler and Saxton, 2007; Nielsen et al., 2024), delaying the embrace of innovative approaches and ideas to perform their tasks (Wilson and Mergel, 2022). Innovative work behaviour refers to how individuals generate new ideas to perform their tasks better and improve overall organisational performance (De Jong and Den Hartog, 2010). Following De Jong and Den Hartog (2010) and Zhu and Zhang (2020), we define resource-conscious innovation behaviour as the deliberate and strategic efforts by organisations and/or employees to use resources to develop and implement innovative solutions that optimise resource efficiency, reduce waste, and promote sustainability. Such innovative work behaviours could have important implications for resource conservation initiatives and sustainable practices within the organisation (De Jong and Den Hartog, 2010). In general, resource-conscious innovative behaviour involves adopting policies and organisational practices that reduce environmental impacts (Kang et al., 2015; Scott and Bruce, 1994). This behaviour is characterised as a conscious effort to minimise resource consumption and maximise resource utilisation to promote CE principles (see, for example, Chiappetta Jabbour et al., 2020; Ferasso et al., 2020).

Wilson and Mergel (2022) and Nielsen et al. (2024) suggest that the rapid adoption and implementation of digital technologies enhance employee capacities to acquire knowledge, develop insights, and generate data to produce more innovative solutions (Shamim et al., 2025). These digital technologies enable employees to collaborate quickly with other departments (Hinings et al., 2018; Wilson and Mergel, 2022), and this cross-functional collaboration fosters creativity and motivates employees to make data-driven decisions (Øvrelid and Bygstad, 2019). However, the lack of scholarly attention to the digital transformation (Hackler & Saxton, 2007b; Wilson and Mergel, 2022) in public service organisations represents a critical oversight in the literature (Lee and Jin, 2023). Consequently, Hinings et al. (2018) have called for more research to explore the mechanisms by which digital transformations influence innovative behaviour. Digital transformation in public organisations can act as a means to monitor and optimise resource consumption, enabling employees to develop more resource-conscious innovation behaviour. Thus, we propose the following hypothesis:

Hypothesis 2. *Digital transformation in a public organisation is positively related to resource-conscious innovation behaviour.*

2.3. Resource-conscious innovative behaviour and integration of CE practices into department strategy

Arikan (2009) builds on the work of Smith et al. (2005) to suggest that innovation behaviour is a key step in developing employees'

planning process and can improve organisational planning efficiency and effectiveness. Kang et al. (2015) argued that an individual with innovative behaviours consistently finds ways to perform tasks, and, consequently, implements newly generated practices (Miao et al., 2018; Newman et al., 2018; Scott and Bruce, 1994). As the literature highlights, innovative behaviours are increasingly important for effectively implementing the activities (Lee and Jin, 2023) and supporting the organisation's long-term vision of circular practices (Kang et al., 2015; Miao et al., 2018).

Some scholars argue that innovative behaviours enable individuals to engage in the process of developing creative solutions (i.e. the reuse of materials; De Jong and Den Hartog, 2010; Wang et al., 2019), and this is likely to translate to more effective waste management planning aimed at contributing to CE principles (Dagilienė et al., 2021; Klein et al., 2022a).

We argue that employees who observe new practices, learn creative solutions to problems and initiate activities can result in the co-development and effective implementation of CE practices in public services (Droege et al., 2021; Krause et al., 2016). This view is consistent with the social learning theory, which posits that people learn through observation, imitation, and modelling of others' behaviours, attitudes, and emotional reactions. It emphasises the role of social interactions, experiences, and environmental influences in shaping human behaviour (Bandura, 1977). The process of creating innovative solutions leads to increased employee long-term vision of organisation targets (Kang et al., 2015; Scott and Bruce, 1994; Zhu and Zhang, 2020), which are necessary for the integration of activities such as circular practices (Klein et al., 2022b; Kör et al., 2021).

Resource-conscious innovation behaviour indicates a proactive approach to efficiency (Srivastava and Shu, 2013). Departments that encourage this behaviour actively seek ways to reduce material inputs, minimise waste generation, and improve resource use efficiency throughout the innovation lifecycle (from idea generation to product development and launch). This mindset is a fundamental building block for CE thinking (Awan et al., 2021), as CE practices operationalise resource efficiency at a strategic level. These practices, including closed-loop supply chains, design for disassembly, and product-as-a-service models, are concrete strategies and actions that put the principles of resource efficiency into practice (Murray et al., 2017). They represent the 'how' of achieving a more sustainable and resource-efficient system. It is logical to expect that departments with a strong internal focus on resource efficiency (resource-conscious innovation behaviour) will translate this focus into their strategic objectives. They will be more likely to formally integrate CE practices into their departmental strategy to guide their activities and demonstrate a commitment to sustainability.

Hypothesis 3. *Resource-conscious innovative work behaviour is positively related to the implementation of CE practices.*

2.4. The mediating role of circular insight development

Circular insight development (viewed as knowledge creation) refers to the process of fostering awareness, understanding, and innovative thinking aligned with the principles of the CE. It facilitates the ability to analyse data and apply insights to advance the resource regenerative practices (Awan et al., 2021). It has been viewed as a critical process of knowledge creation to achieve goals such as process improvement, product innovation and innovation behaviour (Arikan, 2009; Kim and Lee, 2006). According to Smith et al. (2005, p. 355), knowledge creation is defined as 'a process of combination and exchange leading to new knowledge'. Arikan (2009) argued that knowledge creation depends on the employees sharing ideas, insights, and expertise within the organisation and allowing the transfer of knowledge. The impact of knowledge creation on CE practices largely depends on the organisation's ability to implement and use digital technologies (Chauhan et al., 2022). It

involves identifying opportunities to minimise waste, optimise resource use, and create closed-loop systems by leveraging digital technology for data learning and insights development (Rusch et al., 2023). Empirical evidence suggests that digital transformation offers opportunities to develop new processes by sharing information on waste generation and recycling across departments. Following Aminoff and Pihlajamaa (2020), the development of circular insights involves the continuous integration of learning and innovation to adapt to CE practices. However, to successfully develop circular insights, an organisation requires the ability to generate knowledge through digital transformation.

Public organisations often face challenges in implementing new practices (Lee and Jin, 2023) and ideas that improve the efficiency, effectiveness, and responsiveness of public services (Trong Tuan, 2017). Despite evidence in the literature that digital transformation plays a critical role in developing employee resource-conscious innovative behaviour, little attention has been paid to how digital transformation impacts public managers, who have the power to shape and tailor them to improve work practices and service delivery (Nielsen et al., 2024).

Individual innovative behaviour refers to idea generation, exploration, and implementation (De Jong and Den Hartog, 2010). These actions have important implications for resource conservation initiatives and sustainable practices (Khodakarami and Zakaria, 2015). In general, resource-conscious innovative behaviours entail adopting policies and organisational practices that reduce environmental impacts. Following De Jong and Den Hartog (2010) and Scott and Bruce (1994), resource-conscious behaviour involves adopting practices and policies that minimise waste, reduce environmental impact, and optimise resource use, while still achieving organisational goals and delivering public services effectively.

Wu et al. (2014) suggest that innovative behaviour allows managers to push creative ideas and shape innovative outcomes. Some scholars argue that, through advanced digital transformation, employees in an organisation can more effectively collect, analyse, and interpret information (Hackler and Saxton, 2007; Hinings et al., 2018), enabling them to make informed decisions and increase individual innovative work behaviour (Kör et al., 2021). Smith et al. (2005) highlight a unique aspect of knowledge creation, describing how integrating and utilising existing knowledge can encourage and support new ideas and innovative behaviour. We argue that technology resources may be interpreted as increasing information flow and knowledge, allowing employees to translate ideas into a work context that may lay the foundation of innovative work (Nonaka et al., 2006).

We argue that digital transformation does not directly lead to resource-conscious innovation. It helps the development of circular insights, which in turn leads to more sustainable innovation processes. Digital technologies improve an organisation's ability to gather, analyse, and make sense of large amounts of data on how resources are used, how well products work, and how they affect the environment (Bag et al., 2021). For instance, IoT sensors keep track of material movements in real time, while big data analytics find patterns of waste and inefficiency. These new circular insights then guide and influence innovation efforts, which makes people more aware of how they use resources. Digital transformation offers the tools and technology, whereas circular insight development imparts the understanding (actionable knowledge), culminating in resource-conscious inventive conduct. Based on these arguments, we put forward the following hypothesis:

Hypothesis 4. *Circular insight development mediates the relationship between digital transformation and resource-conscious innovative behaviour.*

2.5. The moderating role of an employee's capacity to balance bureaucratic constraints

Bureaucracy, as theorised by Weber (1947), serves as a foundational structure for ensuring efficiency, predictability, and accountability in large organisations. However, bureaucratic systems are often characterised by rigid statutes, hierarchical decision-making, and procedural formalism, which can hinder innovation (Crozier, 1964). In the public sector, such bureaucratic rigidity is further institutionalised through legal mandates, hierarchical authority, risk-averse cultures, and compliance-driven accountability mechanisms (Hoggett, 1991; Mazzucato and Kattel, 2020). Such environments, where institutional logics prioritise procedural dependability over experimental approaches makes it very challenging to adapt resource-conscious innovation to promote CE practices.

In the context of this study, we conceptualise the capacity of an employee to balance bureaucratic constraints as a form of embedded agency (Battilana et al., 2009) enabling actors to operate within and against institutional structures. This refers to an individual's ability to navigate bureaucratic controls, interpret or selectively comply with procedural norms, mobilise institutional resources, and strategically frame innovation in ways that align with dominant logics. It is consistent with the concept of institutional entrepreneurship (DiMaggio, 1988), wherein actors initiate divergent change despite institutional pressures to maintain the status quo. Employees exhibiting high levels of this capacity are not merely compliant agents but act as institutional bricoleurs that tend to reconfigure existing structures to advance new logics, such as circularity and sustainability.

As such, this moderating mechanism is rooted in the tension between structure and agency. While resource-conscious innovation may possess intrinsic potential to facilitate CE integration, its realisation depends significantly on the institutional work (Lawrence and Suddaby, 2006) undertaken by employees to overcome, reinterpret, or circumvent bureaucratic impediments. For example, they may exploit discretion in rule interpretation, build coalitions across siloed departments, or rhetorically frame circular innovations as congruent with existing policy goals, thereby enhancing organisational receptivity to CE adoption.

Therefore, we argue that the relationship between resource-conscious innovation behaviour and the integration of CE practices is not uniform but contingent upon the degree to which employees can exercise institutional agency within bureaucratic constraints. When such capacity is high, employees can translate innovative intent into institutionalised change; when it is low, bureaucratic inertia may suppress the strategic realisation of CE ambitions.

Hypothesis 5. The positive relationship between resource-constrained innovative behaviour and the integration of circular practices is stronger when employees have a high capacity to balance bureaucratic constraints (Fig. 1.)).

3. Methodology

3.1. Sample and data collection

Data were collected from employees in different municipal corporations and waste management organisations in Pakistan. Respondents reflected their perception about their organisations. The current economic and socio-political situation in the country, along with improvements in waste management policies and digital infrastructure, has created a suitable environment for advancing sustainability initiatives (Iqbal et al., 2023). Furthermore, there are opportunities for local government departments to capitalise on systemic voids by offering efficient, locally adapted waste management and recycling solutions (Iqbal et al., 2022). In the context Pakistan's local government, digital transformation has progressed rapidly through key developments, including the several online reporting platforms and enhancements in internet infrastructure (Masood et al., 2014).

Pakistan produces over 49.6 million metric tonnes of solid waste each year, making it a vital resource for facilitating CE initiatives (Pakistan, 2024). Despite this, the government must expedite efforts to improve waste separation and management processes (Pakistan, 2024).
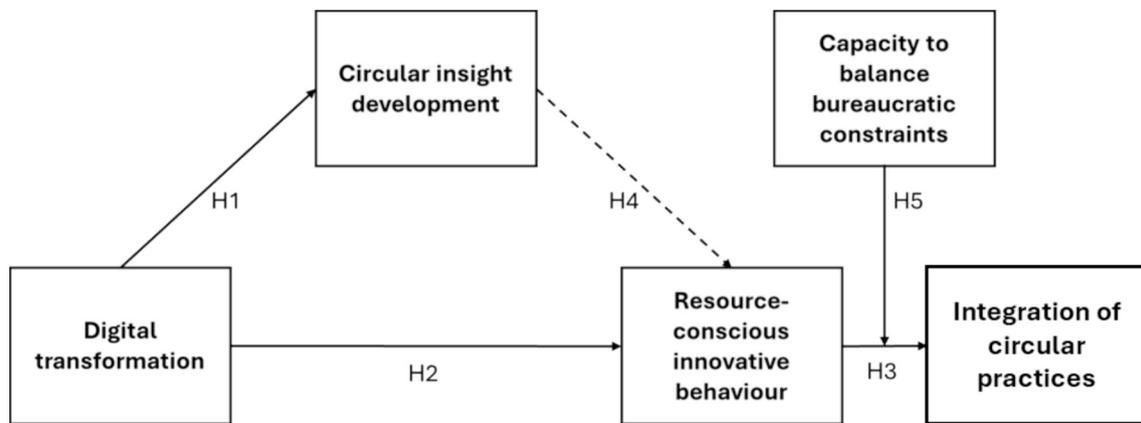
Fig. 1. Conceptual framework.

Notably, local governments are responsible for planning related to waste management and the development of CE initiatives.

The study focuses on employees in local government departments actively engaged in waste management and sustainability efforts, including solid waste management companies, water and sanitation agencies, municipal and metropolitan organisations. These departments were selected for their shared goals of sustainability, comparable access to infrastructure relative to population density, and their potential for innovation through leadership (Dagilienè et al., 2021).

The research design involved a multi-stage approach. A structured survey questionnaire was designed based on prior literature and adapted to the public service context. A pilot study involving 14 participants from municipal corporations and waste management organisations in Pakistan was conducted to identify potential issues in question wording, structure, and flow. The results indicated the survey was both clear and relevant, requiring no significant modifications. Following prior research on local government organisations (Klein et al., 2022a), a list was compiled of departments within the local government of Punjab, Pakistan, that are actively involved in CE initiatives. The sampling frame consisted of 319 employees from various public service departments, representing a diverse and comprehensive range of public organisations.

Questionnaires were distributed electronically between September and December 2024. Each participant received a link to the online survey platform, which facilitated efficient data collection. The final sample consisted of 183 usable responses, surpassing the minimum sample size of 100 suggested by prior research to ensure meaningful statistical analysis (Kousina et al., 2024). Our response rate for the survey was 57.37 %. This level of engagement suggests a moderate level of interest or willingness among the target population to complete the survey questionnaire.

We ensure the data validity by evaluated non-response bias by comparing early and late responses using independent sample t-tests. The results showed no statistically significant differences in the mean responses ($p = 0.89$), indicating that non-response bias did not affect the findings. The diverse geographic distribution of participants and the inclusion of multiple service domains provided a comprehensive representation of public sector organisations in Pakistan, enhancing the generalisability of the findings within this context.

3.2. Measures

Before finalising our survey questionnaires, and conducting pilot study with related sample, we conducted a pretest with eight academicians and five senior bureaucrats from public organisations. Their feedback was valuable in refining our constructs and ensuring clarity and relevance, thereby improving validity. One key insight from their suggestions was adjusting and contextualising the terminologies for innovative work behaviour, suggesting that resource-conscious

innovation behaviour and circular insight development for knowledge creation would more accurately reflect the emphasis on sustainability. Such contextualisation is consistent with prior studies (e.g. Arend, 2013; Konietzko et al., 2020). All adopted measures and key concepts were grounded in previously validated and widely accepted variables from existing research.

The digital transformation scale was assessed using a 5-item scale from Sheng et al. (2023) on a 7-point Likert scale. Respondents were asked to indicate the importance of digital transformation, with options ranging from 7 (strongly agree) to 1 (strongly disagree). The knowledge creation scale was adapted from Smith et al. (2005) and consisted of seven items that were modified to capture the context of circular insight development. Consistent with prior research (Kang et al., 2015; Kör et al., 2021), we adapted and contextualised a four-item scale to assess resource-conscious innovation behaviour.

In line with prior research on local government strategies to support a CE (Bolger and Doyon, 2019), we developed six items to measure an employee's capacity to balance bureaucratic constraints. We adopted four items to assess the integration of circular practices into department strategy (Eikelenboom and de Jong, 2022). A few items were deleted following consultations with experts on the subject. In total, three items of circular insight development, one item of resource-conscious innovation behaviour, and two items of employee capacity to balance bureaucratic constraints were removed from the final survey after receiving feedback from the expert panel and during the data analysis process, the latter due to low factor loadings and high VIF values. Following recommendations, we controlled for both the type and size of the public organisation as control variables (see Table 1). These controls are appropriate, as metropolitan corporations and municipalities differ in staffing levels due to variations in population density. Additionally, we controlled for managerial experience, as previous literature suggests that managers with more experience may have developed greater competencies to access and utilise knowledge effectively.

4. Results and findings

We ran PLS-SEM 4.0 to test the direct relationships between digital transformation, circular insight development, and the integration of CE practices. To test the mediation and moderation hypotheses, we used PROCESS (Hayes and Preacher, 2014) in SPSS with bootstrap confidence intervals (CIs) based on a sampling technique of 10,000, while controlling for organisation size and employee experience (Hair et al., 2020). We utilised PLS-SEM with SmartPLS software to assess the reliability and validity of the measurement model. This approach was chosen for its ability to handle complex models and provide comprehensive insights into both the measurement and structural components of the system. Our results demonstrated that all factor loadings provided a significant fit and that all items were loaded onto their respective

Table 1
The demographic profile of the respondents.

Managerial position	(%)
Municipal officer	11.5 %
Director Solid Waste Management	25.1 %
Deputy/Director Admin	23.0 %
Director/ Manager Operations	26.2 %
Director Planning and Development	10.4 %
Others	3.8 %

Job Experience	(%)
Less than 5	8.2 %
Between 6 and 10	21.9 %
11 and 15	39.3 %
More than 16	30.6 %

Public organisation categories	(%)
Solid Waste Management Companies	26.2 %
Water and Sanitation Agencies	30.6 %
Municipal and Metropolitan Organisations	23.5 %
Public Health Department	19.7 %

indicators, justifying convergent validity (Campbell and O'Connell, 1967).

Table 2 shows the heterotrait-monotrait ratio (HTMT). Using average variance extracted (AVE) and following recommendations drawn from previous scholarship (Fornell and Larcker, 1981), all AVE values were above the threshold (Hair Jr et al., 2013). More specifically, we used the HTMT following the recommendation of Roemer et al. (2021) to assess the discriminant validity of the measures. The results indicated that all HTMT values were below 0.80, suggesting that our data has no collinearity issues. Present Q^2 values for each endogenous construct, explaining whether the values suggest weak, moderate, or strong predictive relevance (Hair et al., 2020; Sarstedt et al., 2022). Furthermore, the model fit statistics, R-square, and F-square explain which variables significantly contribute to the variance in the endogenous variable. The range of F-square is between 0.11 and 0.0154.

Table 3 summarises the standardised factor loadings, composite reliabilities, and AVE values. All composite reliabilities exceeded the recommended threshold of 0.7, as suggested by Nunnally (1994). Furthermore, all AVE values were above the benchmark of 0.5, in line with the criteria established by Hair Jnr et al. (2010). This result indicates that each construct sufficiently explains the variance in its indicators. The data also demonstrated adequate discriminant validity, with AVE values exceeding the squared correlations between each pair of constructs, in line with established guidelines. We measured and assessed the composite reliability for each construct, ensuring that all values were above the threshold of 0.70, as recommended by Nunnally (1994). We examined the structural model to evaluate the relationships between constructs and test the hypotheses, which involved analysing path coefficients, R^2 values, and assessing the significance of the relationships through bootstrapping procedures.

Table 2
Heterotrait-monotrait ratio (HTMT).

	CBBC	CID	DTF	ICE	RCIB
CBBC	1				
CID	0.345	1			
DTF	0.314	0.459	1		
ICE	0.327	0.223	0.382	1	
RCIB	0.597	0.573	0.496	0.522	1

CBBC: Capacity to balance bureaucratic constraints, CID: Circular insight development; DTF: Digital transformation; ICE: Integration of CE practices, RCIB: Resource-conscious innovation behaviour.

Hypothesis 1 suggested that digital transformation is positively related to the development of circular insights. We found that digital transformation is positively and significantly related to circular insight development ($\beta = 0.416$, $p < 0.05$). Thus, our results support the proposition that employees with access to digital databases, collaborative software, and knowledge management systems facilitate interactions across different departments, which is crucial for knowledge insight development (Cennamo et al., 2020; Fernandez-Vidal et al., 2022).

We found that digital transformation is significantly related to resource-conscious innovation behaviour ($\beta = 0.433$, $p < 0.05$), thus providing support for hypothesis 2. Our findings suggest that digital transformation within an organisation creates an environment that fosters confidence, enabling individuals to apply information to their routines. As a result, they are more likely to generate new ideas to perform their tasks effectively and efficiently. These findings support hypothesis 2. For hypothesis 3, we find a positive association between resource-conscious innovation behaviour and integration of CE practice ($\beta = 0.389$, $p < 0.05$). Our results show that resource-conscious innovative behaviour is a key determinant of the integration of CE practices.

We followed Baron and Kenny (1986) and Hayes and Preacher (2014) to examine the mediating role of circular insight development on the relationship between digital transformation and resource-conscious innovation behaviour. Following Preacher et al. (2007), we examined the significance of the indirect effects of digital transformation on resource-conscious innovation behaviour through the mediation of circular insight development. The results of the mediation analysis are presented in Table 4. We found that, after adding the circular insight development as a mediator, the direct path between digital transformation and resource-conscious innovation behaviour is positive and significant (DTF - > CID - > RCIB = 0.156, SE;0.035, CI:0.095,0.235). We concluded that circular insight development partially mediates the relationship between digital transformation and resource-conscious innovation behaviour.

According to the variance accounted for (VAF) analysis in our mediation model, the calculated VAF value is 0.43 (43 %). Since this falls within the range of 20 % ≤ VAF ≤ 80 %, our results provide evidence supporting a partial mediation effect. This result indicates that while the mediator explains a significant portion of the relationship, a direct effect remains. Our findings reveal that digital transformation plays a crucial role in fostering innovation, but its impact is significantly enhanced when firms develop strong capabilities in circular insight development. The results confirm that digital transformation has a direct positive effect on resource-conscious innovative behaviour; however, when circular insight development is introduced as a mediator, the relationship is partially mediated, meaning that firms benefit even more when they leverage circular insight development to translate digital transformation into integration of CE.

We then tested the moderation of employees' capacity to balance bureaucratic constraints in the relationship between resource-conscious innovative behaviour and integration of CE practices. The result of the moderation analysis is presented in the Table. 5. PLS-SEM in SmartPLS software was used to generate a confidence interval using 1000 bootstrap samples at a 95 % level. Following the procedures recommended by Aiken et al. (1991), we plot the result at 1 SD above and below to examine the significance of the slopes at high and low levels (see Fig. 2). Our results show a significant and positive moderating effect of employee's capacity to balance bureaucratic constraints on the relationship resource-conscious innovation behaviour and integration of CE practices, $P = 0.139$, SE: 0.069, $P = 0.043$, $t = 2.026$. Since the interaction effect is positive, it indicates that higher levels of capacity to balance bureaucratic constraints enhance the impact of resource-conscious innovative behaviour on the integration of CE practices. Our findings suggest that an employee's capacity to balance bureaucratic constraints acts as a critical enabler in strengthening the positive relationship between resource-conscious innovation behaviour and integration of CE.

Table 3
Scale and item factors, reliability, and validity.

Variable	Items	Factor loadings	Cronbach's α	CR	AVE
Digital transformation	DTF1- Our firm uses digital technologies such as big data, AI, cloud computing, and digital platforms to support new business activities	0.85			
	DTF2- Our firm uses digital technologies such as big data, AI, cloud computing, and social platforms to integrate business processes	0.88			
	DTF3- Our firm uses digital technologies such as big data, AI, cloud computing, and social platforms to support the communication of business information and digital transformation	0.87			
	DTF4- Our firm uses digital technologies such as big data, AI, cloud computing, and social platforms to redefine the digital architecture	0.86			
	DTF5- Our firm uses digital technologies such as big data, AI, cloud computing, and social platforms to improve environmental adaptability	0.82	0.91	0.93	0.73
Circular insight development	CID1- Employees meet frequently to share and refine ideas that support resource efficiency, reuse, or other circular economy practices	0.82			
	CID 2- Employees find it easy to come together to exchange and enhance insights on sustainability, recycling, and circular solutions	0.85			
	CID 3- Employees are consistently available to engage in discussions that advance knowledge for circular economy initiatives	0.83			
	CID 4- Employees feel free to reach out across departments or roles to sustain dialogue on innovations for circular economy practices	0.75			
	CID 5- Employees are proficient at iteratively combining, adapting, and recycling ideas to create opportunities aligned with circular economy principles	0.83	0.88	0.91	0.67
Resource-conscious innovation behaviour	RCIB1- Employees frequently discuss work-related ideas and developments aimed at making the most of limited resources	0.68			
	RCIB 2- Employees find ways to come together and exchange ideas on how to innovate despite resource shortages	0.81			
	RCIB 3- Employees are available to collaborate on ideas that addressed challenges caused by resource constraints	0.83			
	RCIB 4- Employees feel free to reach out across the organisation to discuss creative solutions for working with scarce resources	0.80	0.79	0.86	0.62
Integration of circular practices into departmental strategy	ICE1- My department has integrated circularity into its strategy	0.74			
	ICE2- My department has a long-term vision on circularity	0.85			
	ICE3- My department sets targets for circularity	0.78			
	ICE4- Progress against targets for circularity is clearly reported	0.75	0.79	0.86	0.61
Employee capacity to balance bureaucratic constraints	CBBC1- Employees are able to work effectively within organisational rules and procedures without compromising productivity	0.79			
	CBBC2- Employees skilfully navigate bureaucratic processes to keep projects moving forward	0.81			
	CBBC 3- Employees balance compliance with procedures and the need for timely decision-making	0.83			
	CBBC4- Employees find constructive ways to address bureaucratic barriers while maintaining organisational standards	0.85			
	CBBC5- Employees demonstrate flexibility in finding solutions that respected formal requirements while achieving desired outcomes	0.72	0.87	0.90	0.64

CBBC: Capacity to balance bureaucratic constraints, CID: Circular insight development; DTF: Digital transformation; ICE: Integration of CE practices, RCIB: Resource-conscious innovation behaviour.

Table 4
Results of mediation analysis.

Path	Direct Effect (β)	Indirect Effect (β)	Total Effect (β)	t-value	Standard Error (SE)	95 % Confidence Interval	Result
DTF → CID	0.416	–	–	5.716	0.073	[0.279, 0.565]	H1-Accepted
CID → RCIB	0.374	–	–	5.817	0.064	[0.244, 0.495]	H2-Accepted
RCIB → ICE	0.389			4.143	0.094	[0.197, 0.567]	H3-Accepted
DTF → RCIB (Direct effect-without Mediator)	0.432	–	–	7.473	0.058	[0.320, 0.548]	
DTF → CID → RCIB	–	0.156	–	4.402	0.035	[0.095, 0.235]	H4-Partial Mediation
DTF → RCIB (Total effect with Mediator)			0.277	4.754	0.058	[0.162, 0.389]	

CBBC: Capacity to balance bureaucratic constraints, CID: Circular insight development; DTF: Digital transformation; ICE: Integration of CE practices, RCIB: Resource-conscious innovation behaviour.

Thus, our findings highlight the strategic importance of capacity to balance bureaucratic constraints as a moderating factor that enhances firms' ability to generate actionable innovation insights, enabling firms and employees to capitalise on their resource-conscious innovation behaviours and achieve successful integration of CE. The graph shows that the capacity to balance bureaucratic constraints strengthens the positive relationship between resource-conscious innovative behaviour and integration of CE practices. As the capacity to balance bureaucratic constraints increases, the slope of the relationship between resource-conscious innovative behaviour and integration of CE grows steeper.

Table 5
Moderation analysis results.

Path	Direct Effect (β)	Interaction Effect (β)	t-value	Standard Error (SE)	Moderation Type
RCIB → ICE	0.389	–	4.143	0.094	–
CBBC → ICE	0.125	–	1.56	0.080	–
RCIB × CBBC → ICE	–	0.139	2.026	0.069	Enhancing moderation

CBBC: Capacity to balance bureaucratic constraints, CID: Circular insight development; DTF: Digital transformation; ICE: Integration of CE practices, RCIB: Resource-conscious innovation behaviour.

5. Discussion and conclusion

The findings of this study provide empirical support for the proposed hypotheses and offer significant insights into the relationship between digital transformation, circular insight development, resource-conscious innovation behaviour, and integration of CE practices. The positive relationship between digital transformation and circular insight development is consistent with the existing literature (Cennamo et al., 2020; Fernandez-Vidal et al., 2022), reinforcing the idea that digital transformation enhances the accessibility and utilisation of knowledge, facilitating insight generation. Our findings suggest that a digitally enabled work environment not only enhances employees' confidence in utilising information but also encourages them to generate and apply new ideas efficiently. These results are consistent with Cennamo et al. (2020), who identify digital transformation as a driver of innovative behaviour within organisations. Our study contributes to this body of knowledge by demonstrating that digital transformation fosters an environment conducive to resource-conscious innovation behaviour, reinforcing its role as a mechanism for sustainable organisational practices.

Consistent with Kang et al. (2015), this study highlights that employees who seek new solutions to resource-related challenges are instrumental in driving CE integration within their organisations. This finding highlights the importance of fostering a culture that encourages innovative behaviours to achieve sustainability goals. The findings of mediation analysis suggest that while digital transformation has a direct impact on resource-conscious innovative behaviour, its effect is significantly enhanced when organisations actively develop circular insights. These findings highlight the need for firms to integrate circular insight development strategies to amplify the benefits of digital transformation in nurturing sustainable innovation practices. This finding is consistent with the existing literature, which suggests that the relationship between digital transformations and innovative outcomes can be mediated by knowledge creation (Shamim et al., 2021). Furthermore, the interaction effect suggests that as employees' capacity to balance bureaucratic constraints increases, the impact of resource-conscious innovation behaviour on CE integration becomes stronger.

5.1. Theoretical contributions

First, our study contributes to the literature by identifying circular insights development as a critical mediating mechanism in the relationship between digital transformation and resource-conscious innovative behaviour. Our findings indicate partial mediation, suggesting that while digital transformation has a direct positive impact on resource-conscious behaviour, its effectiveness is significantly enhanced when organisations actively engage in circular knowledge creation and learning processes. By highlighting circular insight development as a mediating mechanism, this research provides a more nuanced
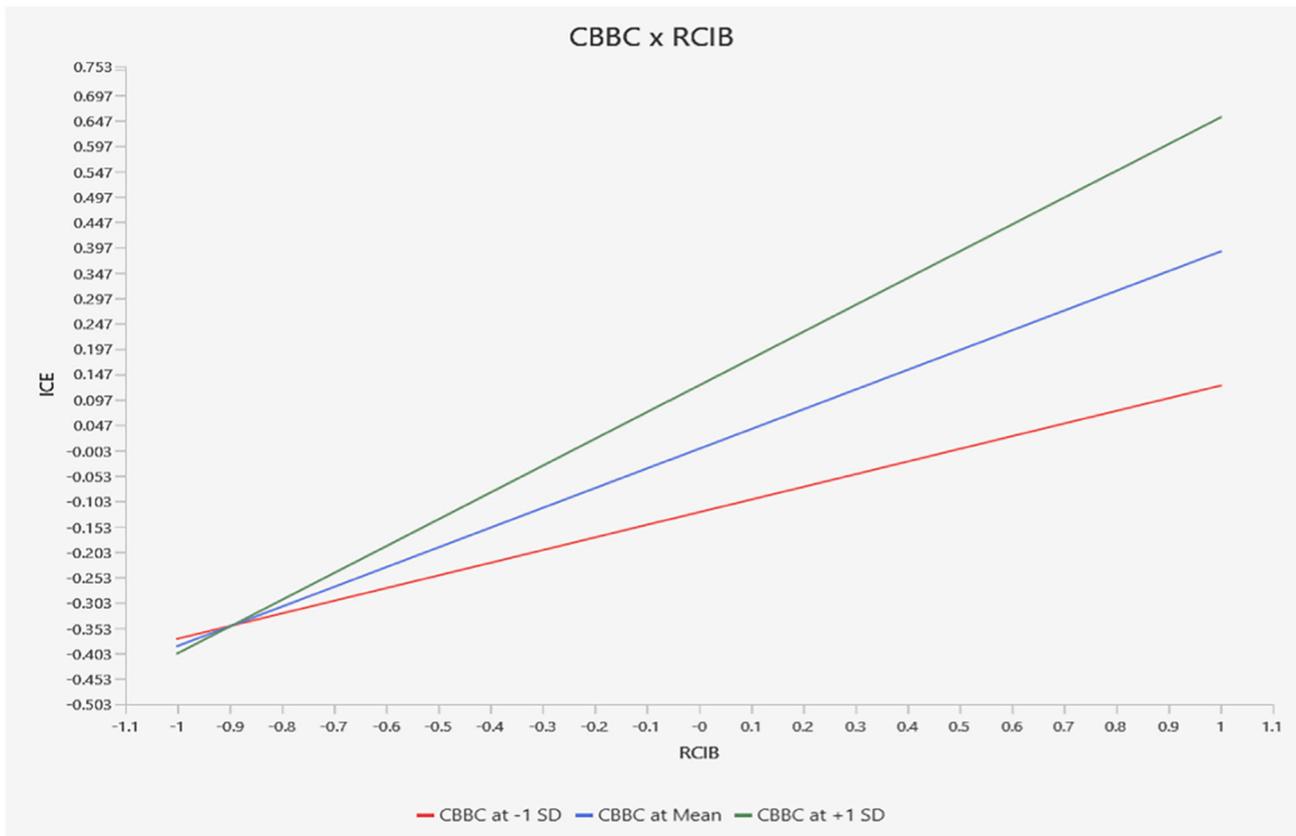

Fig. 2. Result of the moderating effect of capacity to balance bureaucratic constraints.

understanding of the link between digital transformation and resource-conscious innovation. We build upon the findings of prior studies (Kang et al., 2015; Kör et al., 2021; Sarwat and Abbas, 2020) by suggesting that its impact is significantly enhanced when organisations actively engage in developing circular insights. We find that the development of circular insights through digital transformation is also a sufficient condition for fostering innovative work behaviour. In doing so, our study extends the understanding of how and why digital transformation promotes resource-conscious behaviour by emphasising the role of knowledge creation. This research contributes to the understanding of the micro-foundations of organisational change by focusing on individual employee capabilities and their interaction with the organisational context.

Second, the conventional innovation management literature predominantly emphasises economic performance and market competitiveness (Rosenbusch et al., 2011). This study advances theoretical discourse by integrating sustainability considerations into innovation processes, demonstrating the role of digital technologies in enabling resource-conscious innovation. By examining the association between digital transformation and CE principles, we extend innovation management literature by incorporating sustainability as a core dimension within innovation management frameworks and operationalising CE principles through digital technologies. By doing so, we contribute to a more comprehensive theoretical understanding that captures the multidimensional impact of digital transformation, extending beyond traditional economic paradigms.

Third, we build on O'Toole Jr and Meier (2010) by examining the moderating role of 'employees' capacity to balance bureaucratic constraints in the relationship between resource-conscious innovation behaviour and the integration of circular practices into department strategy. It offers several key theoretical contributions, particularly within public administration, organisational behaviour, and innovation literature. Consistent with Wijayasundara et al. (2022), our findings demonstrate that implementing CE practices necessitates the capacity to balance bureaucratic constraints, which can facilitate the development of plans for implementing new ideas, thereby leading to a greater integration of CE. This research contributes by explicitly addressing the unique challenges of innovation within bureaucratic organisations, such as those in the public sector. It acknowledges that the effectiveness of innovation is not solely dependent on the generation of new ideas but also on the ability to navigate organisational constraints, bridging the gap between innovation and implementation. This research directly addresses how employee capacity acts as a bridge between innovation behaviour and strategic integration, particularly in bureaucratic settings. It also contributes to the understanding of bureaucratic capacity by highlighting a specific dimension, namely the ability of employees to balance constraints while pursuing innovation, thereby improving upon traditional measures of bureaucratic capacity (e.g., efficiency, rule adherence) and focusing on the dynamic capacity to adapt and innovate.

This research contributes to the understanding of the micro-foundations of organisational change by focusing on individual employee capabilities and their interaction with the organisational context. It shows how individual agencies can influence organisational-level outcomes, such as the adoption of circular practices. It builds on research on employee proactivity by examining how organisational context (bureaucratic constraints) moderates the relationship between proactive behaviour (resource-conscious innovation) and organisational outcomes (strategic integration).

Furthermore, many CE initiatives are driven by top-down policies and strategies. This research underscores the significance of bottom-up initiatives driven by employee innovation and the necessity of empowering employees to overcome bureaucratic obstacles. This study emphasises the importance of human capital in driving the transition to a CE. It suggests that developing employees' capacity to navigate bureaucratic constraints is a crucial investment for organisations seeking to adopt circular practices.

5.2. Practical implications

Our findings offer several practical implications for managers in public service organisations aiming to integrate CE principles through digital transformation. We advise management and department heads responsible for the success of digital transformation to prioritise digital literacy and foster a culture of continuous learning. Public sector leaders should prioritise investments in digital technologies that directly support circular insight development, such as data analytics tools for tracking resource usage or digital platforms for fostering collaborative innovation. Public firms can use digital technologies such as big data, AI, cloud computing, and digital platforms to support new business activities, integrate business processes, support the communication of business information, redefine the digital architecture, and improve environmental adaptability.

We advise managers to implement more dashboards to visualise resource flows and waste reduction strategies, driving greater progress toward CE development. By introducing real-time dashboards for resource flows, this would have a profoundly positive impact on sharing experiences, feedback, and successes through digital technology. Further, it would help employees develop and implement creative solutions, as well as find alternative pathways to optimise processes, reduce waste, and repurpose existing assets. Organisations should implement targeted training programmes and workshops to enhance employees' awareness of CE principles and their ability to apply resource-conscious innovation in their roles. Empowering employees with relevant knowledge and skills is crucial for embedding sustainability into daily operations.

Our findings reveal the importance of employee's capacity in navigating bureaucratic constraints, which plays a crucial role in fostering individual creativity, knowledge application, and innovative initiatives. Public organisations seeking to implement CE should not only foster resource-conscious innovation but also invest in developing employees' institutional navigation skills. Training in policy interpretation, cross-boundary collaboration, and strategic framing can enhance employees' change agency within bureaucratic settings. Moreover, organisational supports such as middle-manager empowerment, flexible procedural interpretations, and innovation champions can enhance this moderating capacity. Public organisations should make sure that employees are able to work effectively within organisational rules and procedures without compromising productivity. Leaders should empower employees skilfully navigated bureaucratic processes to keep projects moving forward and find constructive ways to address bureaucratic barriers while maintaining organisational standards.

5.3. Limitations and future research directions

While this study provides valuable insights into the intersection of digital transformation and CE principles in public services, it is not without limitations. The study focuses primarily on public service organisations, which may limit the generalisability of the findings to other sectors, such as private or non-profit organisations. Future studies could examine how the dynamics of digital transformation and CE integration differ across various sectors, including private and non-profit organisations. Our study offers generalisability to the local institutional context. Future research may focus on other specific contexts and broader settings by considering the leveraging of AI in their work routines and its impact on their learning capabilities and data-driven decision-making.

For this study, we collected cross-sectional data and found support for the direct effect of digital transformation and the development of circular insights. It is, therefore, possible that this relationship may change at some point; consequently, researchers should collect longitudinal data to examine whether digital transformation represents a critical determinant of knowledge creation over a specific time period. Furthermore, we collected data on employee perspectives on the

organisation's digital transformation and innovative behaviour. Future studies could collect and analyse data at the organisational level.

CRediT authorship contribution statement

Usama Awan: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Saqib Shamim:** Writing – review & editing, Writing – original draft, Conceptualization. **Mushfiqur Rahman:** Writing – review & editing, Writing – original draft. **Erhan Aydin:** Writing – review & editing, Writing – original draft.

Appendix
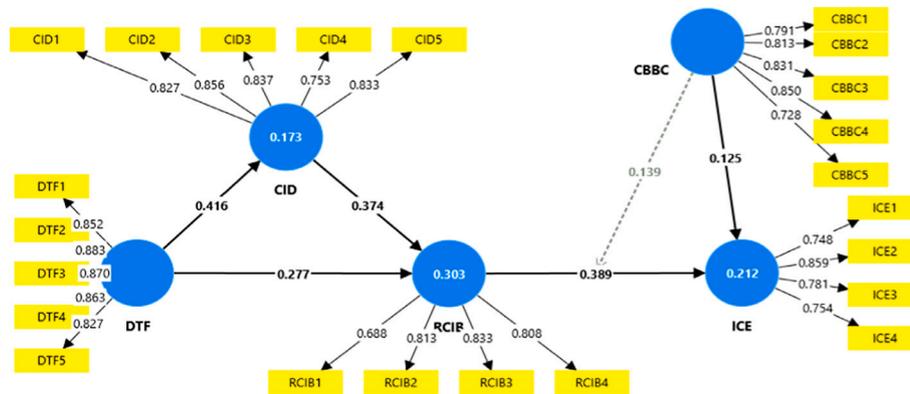
SEM diagram.
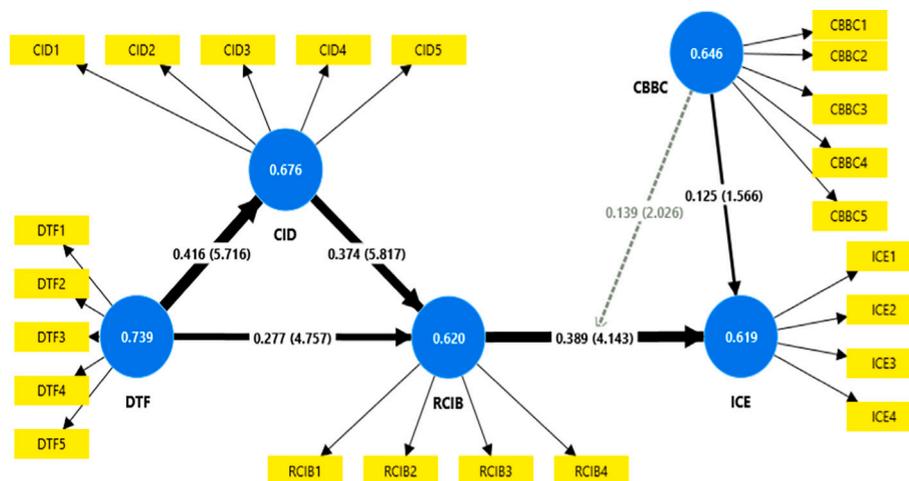
PLS-SEM structural model.

Data availability

Data will be made available on request.

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