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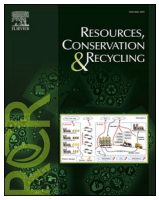

Overcoming barriers to circularity for internal ICT management in organizations: A change management approach

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ABSTRACT

Circularity-conscious management of information and communications technology (ICT) owned by organizations is important to achieving a circular economy. However, changes in organizational management toward circularity has been met with multiple challenges. This study uses 11 semi-structured interviews with on-the-ground ICT decision-makers in organizations to determine what barriers prevent the development and implementation of circularity-related changes in organizational ICT management. We identified 13 barriers relating to information and knowledge transfer, access to circular equipment, finances and contracts, and prioritization over circularity. Barrier-based interventions were further structured by Lewin's 3-step change management model – *unfreeze, change, refreeze* – highlighting the role of information access, relationships with contracted partners, and internal accountability and priority structures. These results bridge a currently underdeveloped link between circularity and management research as well as provide policy makers, researchers, and ICT managers insight on facilitating ICT's impactful role in society's transition to circularity.

Spotlights

- Increasing lifetime extension in internal organizational ICT management has high impact potential for the circular economy.
- Barriers to ICT circularity relate to information, equipment access, finances, contracts, and prioritization structures.
- This study works to bridge a disconnect between circularity research and organizational management research and practice.
- Increased ICT circularity prevents the significant environmental and social impacts of premature e-waste generation.
- The results support future research on incorporating practical strategies like change management in circularity literature.

1. Introduction

Public and private organizations are responsible for large amounts of information and communications technology (ICT) devices (e.g., a laptop for each employee that is commonly replaced after a few years). As a result, these organizations have the potential to affect the lifetime of many ICT devices, resulting in significant contributions to global and European Union (EU) goals toward the circular economy. Achieving these positive effects necessitates concerted efforts for organizational change. However, organizations face various internal and external challenges in changes toward circularity. Research on organizational challenges focuses largely on transitions to circular business models, where businesses shape the marketing of their outgoing products (e.g., Hina et al., 2022; Vermunt et al., 2019), but there is limited attention to circular transitions for organizations' inner workings. For large organizations in particular, internal decisions about procurement, use, maintenance, and end-of-use disposal of products used in their business activities can greatly affect organizations' performance in sustainability. Organizations, after all, are not only participating in the economy through their development and sale of products and services, but also through their purchase and use of products and services (Klein et al., 2020). Organizations can also typically exert more control over their own internal processes than external ones (Lozano 2013).

The exploration of internal organizational change in everyday practices is a valuable, but currently lacking, addition to the literature on organizational circular transitions. A notable exception is the procurement process, which accounts for most articles addressing internal organizational transitions to circularity (Klein et al., 2020; Xu et al., 2022; Alhola et al., 2019). However, procurement is only the first stage

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of shaping organizations' internal circularity. Organizations must also consider how they treat products they procured to make effectual organizational change.

Additionally, research on circular business models is largely generalized across products and industries even though category-specific barriers may exist (Hina et al., 2022). This provides opportunities for new studies to explore what industry and product-specific factors prevent and enable internal organizational change. Given the near ubiquitous use of ICT equipment in many organizations in conjunction with both upstream and downstream impacts of electronics, understanding ICT-specific barriers allows for high-impact change within organizations.

Our study uses interviews with on-the-ground ICT decision-makers in organizations to explore which factors influence decisions made about procurement, maintenance, repair, and disposal practices affecting lifetimes of equipment used by employees for daily business practices. We aim to determine what encourages critical organizational change toward circular internal ICT management (e.g., purchases, use practices, repair, reuse, end-of-use).

To further structure our recommendations for organizational action, we apply an adapted Lewin's classic three-stage change management model. In this model, successful organizational change can be structured through first 'unfreezing', preparing for change by upsetting current norms and practices and facilitating acceptance through awareness and communication, second, through 'changing', actively making changes to processes and structures, and lastly, through 'refreezing', solidifying changes and putting measures in place to ensure reinforcement and continuation (Burnes 2004). Organizational change management has been acknowledged as a key factor in successful sustainable business model innovation, but was also labeled as an under-researched area in business transitions to the circular economy (Santa-Maria et al., 2021). Utilizing change management for ICT management is limited in the literature, with the exception of studies that focus on new technology implementation and applications for ICT (e.g., Šuc et al., 2009; Nograšek 2011). Lewin's 3-step model allows us to build up from change management's classic foundations to explore a new application for change management models – internal organizational ICT management.

Due to the limited availability of ICT-specific, actionable information on what enables organizations to better incorporate circularity into internal ICT processes, we explore what causes organizations' difficulty transitioning to circular internal decision-making. In contrast to existing literature, we contribute to both circularity and change management literature by:

1. looking inward at processes for managing ICT equipment used daily to keep organizations afloat;
2. focusing on circularity for the high-impact category ICT;
3. linking circularity and change management literature by using known change management models to effectively shape processes for circular organizational change.

2. Background

2.1. Lifetime extension and the circular economy

Extending product lifetimes through repair, reuse and refurbishment is an important part of the transition to a circular economy (Korhonen et al., 2018; Geissdoerfer et al., 2017). These strategies delay the premature disposal of products, which results in material loss and degradation despite current collection and recycling processes (Islam et al., 2020). In particular, the prevention of electronic waste (e-waste) through greener procurement and lifetime extending strategies is of high importance. This is due to high greenhouse gas emissions and water consumption in the production of electrical and electronic equipment and use as well as its composition of valuable, difficult to obtain materials that often become hazardous to human and ecological health at extraction and disposal (Belkhir et al. 2018; Ahirwar and Tripathi 2021). Within the growing flows of e-waste, categories including ICT devices, e.g., computers, phones, and printers, accounted for over 20 % of e-waste generated globally in 2019. 'Professional IT' equipment such as servers and routers account for an additional portion of the 33 % attributed to the 'large equipment' category (Forti et al., 2020).Yet, despite the impact of ICT production and waste streams, ICT devices tend to suffer from end-of-use disposal much sooner than potential functional lifespans (Bakker and Schuit 2017).

At a design level, designers of circular products should have two focuses (Den Hollander et al. 2017). The first focus is to prevent obsolescence, which can be described as a scenario where the user deems the product no longer useable or outdated (Mellal 2020). The second focus is to ensure the ability to recover obsolete products with the highest level of integrity for reuse and refurbishment. Physical durability of ICT products was generally not the main driver in the use discontinuation for ICT products (Zhilyaev et al., 2021). Obsolescence can occur for reasons beyond the device's ability to function well, including changes in aesthetic style, technological and economic advancements, style, and social reasons, e.g., norms and social pressure. Obsolescence can also be planned or forced by the manufacturer (Burns 2010; Mellal 2020). Behaviorally, the extent of and reasons for premature obsolescence can vary by economic status (e.g., high demand/value for second-hand consumer electronics in developing nations [McMahon et al., 2021]) and between business-to-consumer and business-to-business environments like the one studied in this article. ICT equipment faces particular problems with premature obsolescence and short product lifetimes, often ending up prematurely disposed of or stored indefinitely. (Bakker and Schuit 2017; Baldé et al., 2020; Zhilyaev et al., 2021).

The importance of circular economy principles is acknowledged by many world governments (Ogunmakinde 2019; European Commission 2020). The European Union legislation generalizes the circular economy as one that "involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible" to extend the product and material lifetimes.[1] EU legislation influencing resource efficiency, environmental impact, and support of the circular economy stretches throughout the life cycle of electrical and electronic products like ICT, with much currently contributing to the goals set out in the Circular Economy Action Plan[2] and the European Green Deal.[3] Toward the beginning of the lifecycle, the Ecodesign Directive sets standards for the design and manufacturing of energy-related products, seeking to decrease their environmental impacts. At purchase, the Energy Label Regulation ensures the provision of information to consumers about the energy efficiency and environmental performance. While energy use does not directly relate to circularity, it is tightly linked to broader sustainability goals. A 2022 proposal has introduced the next stage of these legislative pieces in the form of the Ecodesign for Sustainable Products Regulation.[4]

This proposal allows for a broadening of circularity and sustainability-related frameworks of requirements including product composition, durability and repairability, and recyclability. The new legislation also allows for requirements relating to the disclosure of product information in the form of a digital product passport. Digital product passports provide comprehensive and transparent information about a product's production history, lifecycle, environmental impact,

[1] https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits

[2] https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en

[3] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

[4] https://commission.europa.eu/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/sustainable-products/ecodesign-sustainable-products-regulation_en

and key characteristics, allowing purchasers make informed decisions. In the EU, batteries are likely to be one of the first product categories to be required to have a digital product passport, creating a pathway for more product types.[5]

Proposed 'right to repair' legislation aims to increase consumer access to repairs and repair-related resources and aims to obligate producers to design for repairability and to provide repair services beyond the initial warranty period, among other things. Electrical and electronic equipment such as washing machines, vacuums, phones, tablets, and laptops are a key product type in the movement toward a right to repair.[6] In the Netherlands, regulations such as future 'right to repair' legislation as well as other EU laws are followed through transposition into Dutch national law. Furthermore, the Dutch government also has the ambition to speed up the transition to a circular economy with the goal to become fully circular in 2050.[7] As part of this broader plan, there is a plan from 2023 to 2030 that also includes more repair and lifetime extension with the ambition to lower resource use with 50 %, including ICT equipment.[8]

At the end of the lifecycle, the WEEE Directive and its corresponding Dutch transposition legislates the end-of-life collection, treatment, and preparation for reuse or recycling.[9] In circular economy research, however, there is heavier focus on the 'outer loops' of waste management and recycling than the 'inner loops' of waste prevention, such as reuse, refurbishment and other lifetime extensions (Ghisellini et al., 2016). This imbalance leaves preventative solutions underexplored (Ghisellini et al., 2016). In practice, recycling processes can suffer from high energy consumption in addition to potential material or quality losses. Thus, recycling and other waste recovery strategies are suggested to be a lower priority than lifetime extension through repair, reuse, and refurbishment (Directive 2008/98/EC). Thus, we consider in this research a view of upstream processes for organizational ICT management prior to its surrender as waste.

2.2. Challenges for organizations in circular transitions

Business model focused literature addressing the transition to circularity in organizations commonly writes about barriers and distinguishes between internal and external ones. Studies characterize internal barriers as organizational, financial, technological, resource-related, collaboration-related, product design-related, and internal stakeholder-related. Similarly, external barriers include consumer barriers, legislative and economic barriers, supply chain barriers, and social, cultural, and environmental barriers (Cantú et al., 2021; Hina et al., 2022). Studies suggest that most barriers to circular business model innovation exist at the organizational level and that research on barriers for the public sector focuses largely on procurement-related processes (Guldmann and Huulgaard 2019; Klein et al., 2020). Focus on circular supply chain management has led to increased interest in procurement's crucial role in the economy's circular transition (Qazi and Appolloni 2022). Even so, the body of literature about circular procurement is described by a 2022 review as growing but scattered, with gaps in discussion caused by: focus on the broader circular supply chain with few mentions of procurement, focus on only public procurement, a limited discussion of barriers or enablers relating to circular procurement, and only macro level views of the market or technological aspects (Qazi and Appolloni 2022).

A review by Santa-Maria et al. (2021) classified organizational change management, organizational inertia, and systemic change as 'important' and 'under-researched' in circular business transition studies. Change management is a process used by businesses to develop organizational competencies and capabilities that considers organizational culture, leadership, strategy, learning, and alignment. It can be used as a tool to evaluate resources, processes, and values through a lens of organizational behavior and culture (Bertassini et al., 2021). Applying these change methods that consider the need for systemic change and incorporating human behavioral factors was proposed as "indispensable" to realize change management in circular economy transitions (Mauss et al., 2023). Despite this, there is a disconnect between organizational management and circularity literature. Our study fills this gap by linking change management to improving facilitation of the yet unstudied internal circular transition for ICT in organizations.

3. Methods

This qualitative study uses semi-structured interviews to gain insights on barriers (and enablers) that organizations face when transitioning to circular strategies for internal ICT management. Interviews conducted with 'on-the-ground' decision-makers explore ICT management from procurement through use, maintenance, and repair, to end-of-use when the equipment is sent for refurbishment, recycling, or other disposal.

3.1. Interview participant selection

Purposive sampling allowed for identification and recruitment of organizational employees in decision-making roles for procurement, maintenance, repair, and disposal of ICT products, e.g., laptops and data servers. Recruitment of initial participants was conducted from partnering organizations in the Circular Resource Planning for IT (RePlanIT) project. RePlanIT is a Dutch national project seeking to develop tools that will support organizational ICT decision-makers to know the circular impact of their ICT-related decisions and to utilize this knowledge to improve their organization's circularity. The project consists of several types of private and public organizations (both large and SME) working on the development of the tool, scientific researchers working to uncover the underlying principles of the tool in terms of needed data to steer decision making, and multiple organizations serving as end-users of the tool. Further snowball sampling was used to identify additional employees in important, connected roles at the same, affiliated, or similar organizations.

3.2. Interviews

A total of 11 semi-structured, on average 40-minute interviews across five large ($\geq$500 employees[10]) Dutch organizations with designated ICT departments were conducted with ICT management decision-makers from different functional backgrounds (e.g., procurement and contract managers, department leadership positions, etc.). Semi-structured interviews offer versatility and the ability for interviewees to flexibly expand on questions based on their real-world experiences (Galletta 2013; Lahane et al., 2021). Table 1 details interviewed participants. Duration varied based on proximity to ICT lifecycle stages.

The interview guide (Appendix A) asked interviewees to discuss procurement, use, maintenance, repair, refurbishment, and end-of-life decisions and what affects these decisions about ICT circularity within

[5] https://www.europarl.europa.eu/news/en/press-room/20221205IPR60614/batteries-deal-on-new-eu-rules-for-design-production-and-waste-treatment

[6] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1794

[7] https://www.government.nl/topics/circular-economy/circular-dutch-economy-by-2050#:~:text=2050A%20waste%2Dfree%20economy,hardly%20any%20waste%20is%20produced.

[8] https://www.rijksoverheid.nl/documenten/beleidsnotas/2023/02/03/nationaal-programma-circulaire-economie-2023-2030

[9] https://environment.ec.europa.eu/topics/waste-and-recycling/waste-electrical-and-electronic-equipment-weee_en

[10] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Enterprise_size

Table 1
Basic profile of interviewed participants.

Participant	Interviewee role involvement			Type of organization
	Procurement	Use Stage	End of Use	
1	x	x		Local Government
2	*			Private Telecommunications Corporation
3	x	x	x	National Government
4	x	x	x	National Government
5	x	x		National Government
6	x			Public University
7	*			Local Government
8	x	x		Local Government
9	x			Local Government
10	x	x	x	Private Financial Institution
11	*			National Government

* Asterisks indicate an upper management role rather than a technical role.

the organization. Interviewees were also asked to describe motivations for, decision making processes, successes, and failures of previous ICT circularity initiatives. Attention was paid that different ICT-specific issues found in literature on circular transitions were discussed, such as company policies and strategies, finances, lack of resources, supply chain concerns, collaboration, and legislative barriers. We also chose to discuss barriers creating, initiating, and executing ideas and initiatives for circularity in ICT. While enablers were also discussed, they generally represented the mirror-image of the barriers. Interviewees were provided with standardized informed consent documents prior to participation. Transcripts were anonymized and not shared in their raw, unanalyzed form.

3.3. Analysis

Interviews were conducted through video conferencing, which alleviated Covid-19-related concerns and facilitated recording and transcription. Interviews were subsequently coded using Atlas.ti. To avoid exclusion of important themes that may not be present in the current literature, interviews were coded inductively. Due to its flexibility, which allows for more effective exploration of ICT management as a novel topic, and its suitability to inductively code qualitative research, thematic analysis was utilized to identify patterns and commonalities in the interview transcripts (Braun and Clarke 2006). Thematic analysis has been used in change management for other fields, such as on leadership behavior and sustainability in educational institutions (Aldulaimi and Abdeldayem 2020), but not yet for circular management of ICT.

Following Braun and Clarke's (2006) steps for thematic analysis, initial 102 codes were determined in the unit of sentences, and subsequently reviewed for accuracy and to merge duplicate and/or similar codes. The resulting codes, which were reviewed and adjusted among the authors to improve reliability in the analysis, were then grouped by commonality into preliminary themes. The preliminary themes (i.e., barriers, enablers, drivers, internal processes, etc.) were then considered in relation to the research questions, thereby narrowing the themes (barriers, enablers, drivers). In cross-checking for accuracy and redundancy, a significant overlap was found between barriers and enablers, with enablers often boiling down to the mirror opposite of a listed barrier. Accordingly, we decided to combine these codes and focus solely on barriers as current practice suggests that barriers are more prominent for the (lacking) transition to a CE. Next, another iterative theming process was conducted within the barriers, first considering and grouping by commonalities, and subsequently considering Lewin's 3-step model – *unfreeze, change, refreeze*. Through discussion within the research team, barriers were further consolidated within the four resulting themes and themes were placed within the step of the Lewin's model for which they are most impactful.

Tables 3-6 in the following sections detail the final categorization of 13 barriers grouped into four themes within the subsections of each change management step. Additional information on the codes and their relation to themes can be found in Appendix B. Drivers were not separated into the three steps because drivers existed more on a general level and were therefore not specifically linked to one of the three steps. The data collection was deemed to have reached saturation with these 11 interviews given that no new barriers emerged in the final four interviews.

4. Results & discussion

The following sections present and discuss the results of our interview analysis. Section 4.1 addresses the drivers, initiatives, and processes for circularity in the organizations and Section 4.2 addresses the themed barriers at the points in which they are most influential to the change management process, with each category of theme placed within a step of the 3-step process – *unfreeze (4.2.1), change (4.2.2), refreeze (4.2.3)*.

4.1. Existing circularity drivers

We found that organizations are interested in transitioning their internal processes toward circularity for reasons such as public image, costs, environmental impact, and compliance with legislation (see Table 2).

Additionally, all organizations had or were attempting incremental changes for sustainability and circularity, e.g., improved circular procurement criteria, experimenting with extended lifecycle management periods, 'green' ICT reporting, and reducing ICT-related energy consumption. However, interviewees expressed difficulty expanding incremental changes to achieve ambitious (but sometimes vaguely defined) future sustainability and circularity goals like carbon neutrality.

4.2. The 3-step model and barriers to circularity in organizational ICT management

The following subsections place the identified themes and their subsequent barriers into the structure of the 3-step change management model – *unfreeze, change, refreeze* – aligning each to the stage in which the themed barriers have the most impact.

4.2.1. Unfreeze

Lack of knowledge and awareness-related barriers about circularity in internal ICT practices were reported to have an impact at all employee levels. Increasing awareness and knowledge of 1) why change is important and 2) how change is achievable is a crucial factor in the first

Table 2
Drivers and motivators for organizational adoption of circularity in ICT.

Driver/Motivator	Illustrative quote
Public image	"It's good for our promotion, our name." (P3)
Cost savings	" Interestingly, extending the life of equipment in [type of organization] is driven more by the austerity tasks at hand than the sustainability aspects." (P8)
Environmental impacts	"We are a large organization, so already you can make a big impact just by reducing your own footprint." (P7)
Legislative requirements	"There is legislation coming… to prove what you've done regarding sustainability criteria." (P6)
Stakeholder pressure	"Investors ask us where we are on sustainability, so the score is becoming more and more important to attract the right finance instruments." (P7)
Talent attraction and retention	[Employees] "find it really important to work at a company that… is working a lot on sustainability, so they identify with it and it's also a way to retain and attract talent." (P2)
Personal employee interest	"Many of these kinds of initiatives… really happen because of an intrinsic motivation of an employee." (P9)

step of the change model, unfreezing. Awareness of circularity in organizational ICT management can change cultural norms and behaviors within organizations. For example, interviewees reported that device users sometimes have device preferences outside of the necessary specifications for their work including wanting new, aesthetically pleasing devices, and devices of a familiar brand or model. Users also were said to perceive personal ownership of devices, resulting in the push for preferences.

P9: "People see a laptop as their own device… which actually [it] isn't. It is the device of [the organization]…"

Such preferences can shorten equipment lifetimes (increasing device turnover rates) and limit circularity of new equipment (increasing purchases of overpowered devices). Top leadership communicating circularity's importance in choosing ICT devices could play a critical role in changing these behaviors.

Knowledge and awareness based barriers (see Table 3), including lack of technical knowledge and sharing of knowledge, also play a key part in circular transitions (Tura et al., 2019; Jabbour et al., 2019). However, the complexity of ICT's composition and impact proves particularly challenging for interviewed decision-makers. This is exacerbated by a lack of transparency as information about the ICT equipment moves down the pipeline from manufacture to use (types of information requested by interviewed ICT managers: Appendix C). Furthermore, organizations find it difficult to implement often vague ideas for circular improvements into concrete actions because the available information, measurements, and shifting standards complicate assessments of true impacts.

The lack of information provision was also prominent from the ongoing circular initiatives at the participating organizations. Six of the interviewees, representing four organizations, discussed initiatives to ask for or require more information related to circular ICT from suppliers, including use of eco-standards and energy labels, and the use of recycled materials in order to alleviate challenges relating to limited knowledge and ability to discern impacts.

4.2.2. Change

Step two, effecting actual change in the internal ICT management circular transition involves active changing how organizations procure equipment, what they procure, how long equipment stays in use, and the amount of lifetime extending activities, such as repair, reuse, and refurbishment. These necessary changes are hindered by a number of barriers relating to the ICT supply chain, feasibility of lifetime extending activities (see Table 4), and those associated with financial budgets, contracts for software and hardware support, and data security (see Table 5).

Lifecycle management periods (LCMs), which help organizations monitor assets in an efficient and cheaper way, were a cornerstone of ICT management in interviewed organizations. LCM also helps organizations to anticipate costs and plan budgets.

P4: "At the beginning of the year management has to say, ok, this is what you see coming. We have to price these systems and we expect this is the price for their lifecycle management."

However, LCM periods shorter than the practical lifespan of ICT devices are common and often result in well-functioning and suitable equipment going for end-of-life treatment. The length of these periods is shaped heavily by expected lifetimes of available equipment, contracted durations of software support from suppliers, and access to services like repair and refurbishment. What criteria should be included in circular procurement and how it is different from sustainable and green procurement is a developing concept (Kristensen et al., 2021; Xu et al., 2022). At a later stage, in cases where refurbishment is offered through original contracts, the process for ICT can be expensive, slow, and may only be available for devices that are still under warranty (Revellio and Hansen 2023). We found that both time and the types of devices available from refurbishers limit the organization's willingness to procure

Table 4
Equipment and access-related barriers to circular ICT management impacting the 'change' step.

	Access to circular ICT devices and spare parts	Limitations to incorporating refurbishment	Repair-related costs and limitations
Description	Organizations must be able to obtain specific devices and components to transition to circular ICT. Changing circumstances like supply chain issues (e.g., chip shortages) limit availability. It can also be difficult to obtain spare parts for repair or to store these parts in bulk.	The availability of refurbished equipment at the needed time is low (dependent on incoming equipment, what is already in stock, and processing time). There are also limited (or no) support contracts for refurbished equipment.	Effects on whether or not a device will be repaired include time to conduct the repair, need for specified tools, and weighing costs against current values of devices. When costs are considered too high, repair is not done.
Illustrative quotes	p.1: "You have different kinds of versions… it is very difficult to change one version for another one, so that kind of reuse is very difficult…"	p.3: "It took six months to get one laptop back. It's not doable for us."	p. 3: "We ask always can it be repaired in 15 min? Half an hour is longer… If we cannot open it fast enough it is not, for us, interesting anymore."

Table 3
Information-related barriers for circular ICT impacting the 'unfreeze' step.

	Lack of awareness	Lack of knowledge	Limitations in information flows	Difficulty assessing true impacts
Description	Organizational decision makers lack awareness of circularity's importance and benefits, which is necessary to effectively initiate circular activities within organizations.	Limited understanding of how to incorporate circularity and how circularity and existing processes fit together results in fewer, less effective circular initiatives.	Both producers and user organizations have information that would benefit circularity but have difficulty passing information to each other through bridging stakeholders.	Lack of previous baseline measurements, difficulty tracking measurements over large equipment quantities, frequently changing eco-standards, and potential misrepresentation of actual circular impacts of services (greenwashing) contribute to confusion over what decision will have the biggest positive impact on the environment, society, and organizational finances.
Illustrative quotes	P7: "Once you start being aware and start seeing the benefits… decisions are more easily made."	P1: "…we were asking ICT personnel to come [up] with things because they are experts, of course, technical experts, but they didn't come up with any solutions or ideas."	P1: "There needs to be more discussion between end users and producers [to] know what we really want at this moment. We want sustainable hardware… how can they help us with that?"	P6: "It was actually never measured before and after so that you could see whether you could save money."

Table 5
Financial and contract related barriers to circular transition of internal ICT management impacting the 'change' step.

	Financial barriers to circular ICT	Limited supplier interest in lifetime extension	Limits to existing or available contracts	Concerns for data security
Description	Existing budgets not considering circularity, potential higher initial costs of circular equipment, and costs of extending support contracts affect decisions to purchase longer lifetime equipment or extend lifetimes of existing equipment.	Lifetime extension is often not considered to be in suppliers' interest, limiting the availability and participation of suppliers in ICT lifetime extension.	Circularity may not be incorporated into existing or on-offer contracts. These contracts have limited service-period lengths, after which equipment would be unsupported.	There is often hesitancy about the completeness of data wiping, leading to non-circular activities like shredding hard disks. Older equipment may have outdated software or hardware compliance, risking data security.
Illustrative quotes	P6: "If you look at lifetime extension… then I think it's about money, and if it's expensive to extend contracts then that's a problem."	P11: "[suppliers'] interest is mainly to sell new devices and they're not particularly keen on offering you a device that could be used longer than they probably hoped for."	P4: "After [the contract] they want to get rid of all that old service, so they make the support very expensive."	P5: [after the contract period] "firmware is not being supported or updated by the brand. You can have security problems with that."

Table 6
Prioritization and accountability-related barriers to circular ICT impacting the 'refreeze' step.

	Low priority of circularity in ICT	Lack of accountability and initiative
Description	Basic needs, changing circumstances (e.g., Covid-19-related switches to laptops), energy costs, low-cost equipment that meets performance goals, standardized orders, and existing sustainability initiatives often have greater priority than ICT circularity.	Lack of a dedicated position or person to take accountability for circular choices and a lack of support or requirement from upper management to make circular decisions results in less action. Even when the importance of circularity for the organization is acknowledged, actions are not taken.
Illustrative quotes	P2: "Circularity also competes with sustainability goals that are more mature, like energy saving." P5: "I already have 200 of this, why should I buy one or two different?"	P8: "In terms of sustainability, once again we have really political objectives, but there is actually no internal mechanism that enforces anything afterwards."

refurbished ICT devices. In addition to the financial costs, time is also a decision-making factor for repairs, with increases in time resulting in decreasing willingness to repair.

The use of refurbished ICT devices was varied across the organizations. Four interviewees representing three organizations between them reported some participation in reuse or refurbishment of ICT equipment like laptops and data servers. Among these:

- one refurbishes and reuses half of what is returned to them from being used for technical applications in the field,
- one uses refurbished laptops for what was referred to as "swap stock," where refurbished laptops are given out to those who have a broken laptop and the broken laptop is repaired/refurbished (if possible) and handed to the next person whose laptop is broken,
  - this could alleviate one barrier to repair by speeding up the time that an employee can return to work,
- and one organization's individual departments organize their own laptop reuse, with some reusing laptops for replacements or new employees within the device's life cycle management periods, while others do not.

Of those who do not currently participate in reuse, interviewees from one organization reported a successful refurbishment initiative with small ICT accessories and that they would like to expand this for mobile phones and laptops. The remaining organization reported that a previous refurbishment initiative was not successful due to very slow and infrequent return of refurbished laptops from the supplier. All organizations have an agreed partner for end-of-use management of their ICT equipment that refurbishes (e.g., for charitable organizations) and/or recycles end-of-use equipment. Also at end-of-use, several interviewees discussed the use of data erasure software (e.g., Blancco) as an initiative to increase confidence in data destruction without the physical destruction of hard disks.

Extending LCM periods to be more in line with actual lifetime potentials of ICT equipment is an essential step in improving circularity in internal ICT management. Internally, change will involve proactively applying the information made accessible in the unfreeze step to: more accurately predict practical lifetimes of ICT devices, purchase devices with longer expected lifetimes, and increase equipment lifetimes through maintenance and repair. Financial information over time is especially helpful for these decisions, such as cost savings for lifetime extension versus initial costs of long-lifetime equipment,. Perhaps most challenging for organizational ICT decision-makers is the amount of external influence on these processes. Large-scale ICT purchases include contracts dictating what services will be provided (e.g., software support, warranty repairs, etc.) and for how long. During the duration of the contract, opportunities for changes are limited and, after the contract, loss of support often creates concerns for data security on top of functional issues. Facing outward into what is within the control of the organization, a successful transition will also constitute a change in relationships with external partners (e.g., suppliers and service providers) and the demand for circularity organizations create in their new contract tenders.

> *P2 "It's very important to collaborate with suppliers for them to also become climate neutral in our value chain."*

Given the complexity of stakeholder influence on circularity, collaboration between stakeholders is important in circular transitions (Ghisellini et al., 2016). To increase supplier interest in providing more circular options, interviewees expressed interest in collaboration between similar types of organizations (i.e., agreements between large public or private institutions) to communicate collectively that there is demand for circularity in tenders, through which organizations let suppliers know what they want to procure.

4.2.3. Refreeze

Step 3 involves a shift in agreed upon priorities of organizations and incorporating accountability for circular ICT management. To solidify changes made in the second step, interviewees suggested two pathways. First, to shape and reinforce that improving circularity in ICT

management is prioritized in the re-shifted new culture of the organization. Secondly, accountability for this new priority should be incorporated in appropriate ways at all employee levels. While leadership roles play an important part in moving initiatives forward, a sense of ownership in circular improvement can encourage ideas, initiative, and follow through at any level.

P2: "You just have to more and more convince people that it's part of their role… part of their DNA as well."

P10: "If you set something up and it works, it gives you a good feeling… so they grow and think 'I can come up with another idea'…"

Accountability was also suggested to be supported by reporting of measurable progress toward circular goals. One interviewee noted the reporting of energy savings and later reporting of rates of recycling and reuse to be existing and successful initiatives to improve sustainability. Through both required and voluntary reporting, organizations and their employees can not only provide transparency about their internal operations and confirm compliance with local requirements, but can also increase a feeling of accomplishment and share their success stories.

P6: "it would help us a lot to be challenged… we need to somehow share what we have accomplished."

5. General discussion

This study identifies challenges in the transition to circularity for the internal management of ICT in large organizations. While previous research has explored business model innovation for circularity in products they develop and put on the market, little attention has been shown to the management of ICT equipment owned by large organizations. We expand the current literature focuses on business model innovation (Hina et al., 2022) and outer loop circularity (e.g., recycling) (Ghisellini et al., 2016) to the barriers faced by organizational ICT managers making decisions for circularity within the daily use of their own organization's devices. We also add to the limited existing research on internal organizational management for circularity (Klein et al., 2020; Xu et al., 2022; Alhola et al., 2019; Kristensen et al., 2021) by offering insights on internal ICT decision-making both at and after the point of procurement. This study's identification of barriers for ICT's transition to circularity has important implications in several contexts. Broadly, circular management of the IT equipment used by organizations is an important contributor to meeting national, regional, and global sustainability and circularity goals. Our study confirms that some categories of barriers found in other product categories for previous research on circular business model innovation (e.g. the business-to-consumer sale of coffee, apparel, furniture) can apply to internal management of ICT as well, in particular barriers related to internal organization, finances, resource (including knowledge) availability, internal and external collaboration, product design, and the supply chain (Cantú et al., 2021; Hina et al., 2022). Alternately, we found that legislative, social, and cultural (external culture) barriers in other product categories may serve more to facilitate ICT transitions for the circular economy. For example, our results show that socio-cultural drivers such as circularity being good for their public image and keeping stakeholders and employees happy as well as legislation helping to drive circular improvements. Hereby, we extend the relevance of the barriers found by previous circular business model literature to the context of ICT.

Our research presents both theoretical and practical implications. In order to effectively encourage and legislate circularity, policymakers must be able to identify where challenges arise in compliance or continuous improvement on circularity metrics. Supported by our results, policymakers could, for example, focus on supply chain information pathways. This is in line with the current legislative exploration of digital product passports for product categories like ICT in the EU. Furthermore, the expansion of change management into research on ICT management facilitates a needed connection between circularity research and management literature. The understandings gained in both of these research fields will be necessary in bridging the disconnect between research and practice in organizational management. Our results support ICT management and on-the-ground decision-makers to lay out the important foundations for success in improving circularity in their daily practices, including a focus on top management involvement, improved dissemination of information, prioritizing circularity, and methods for accountability. Moving forward, these results provide stakeholders in policymaking, circularity research, and managerial domains with steps to move internal management of ICT forward in their circular transitions.

5.1. Recommendations

These insights create a baseline to facilitate organizational change toward more circular management of ICT by using the 3-step change management model to view ICT management through an organizational behavior and culture lens (Bertassini et al., 2021). From this baseline we recommend initial steps toward implementation of these three change management stages, which open the door to the following stages. First, *unfreezing* the process for organizational change to internal circular ICT management revealed two main needs for organizational managers to consider:

- an increase in awareness of the importance of ICT circularity across employment roles, leading to a subsequent shift in cultural and behavioral norms within the organization.
- an increase in not only device information available to decision makers, but also in the interpretability of that information.

Increasing organizational awareness in an issue contributes to a better understanding of the strategy of the organization, a sense of common group struggles and the need for change, and an appreciation for the variety of roles throughout the whole organization (Arena 2004). The call for various awareness campaigns is also supported in the literature as a means to increase social participation and inclusion (Hina et al., 2022).

To increase knowledge availability, establishing baseline measurements and the use of tools such as digital product passports and circularity scorecards would allow for development of, and access to, metrics necessary to discern how ICT decision-makers can make the most effective impact on circularity in their own organizations. In particular, the implementation of digital product passports, which are intended to allow open information about a device to be collected, shared, and traced, would help to overcome the barrier of missing transparency between the production and use stage. These methods for transparent and easy to digest access to information support awareness throughout the organization, breaking down internal barriers around lack of awareness and knowledge (Adisorn et al., 2021).

Second, the process for procuring ICT equipment should be shaped to consider both initial and improving circularity in its necessary criteria for new contracts, thus avoiding a cycle of required stagnation based on contracts set for a number of years. The *change* step will require:

- an application of the new information made accessible in the first step to change internal processes for procurement, maintenance, repair, and disposal.
- changes to their relationships and contract tenders with outward facing stakeholders.
- adjustments to product demands and procurement criteria, e.g., access to more repairable or otherwise longer lifetime devices and contracts.

Strong communication of circularity as a goal between the procurer and the supplier, as well as the potential for agreements between similar procuring organizations can facilitate the willingness of stakeholders to incorporate circularity in contracts. The information found in the aforementioned digital product passports would be of critical use in developing such circularity criteria. While our study focuses on multiple stages of the organizational ICT lifecycle, we further confirm the perception of establishing green procurement criteria being "new and difficult," and based on the competences of the individual developing them (Kristensen et al., 2021). Providing this information also enables decision-makers to select equipment and contracts that enable longevity, for example, by providing access to repair for a long period of time and allowing for the extension of lifecycle management periods.

Lastly, the *refreeze* step will require reinforcing new priorities for circularity in the management of internal organizational ICT and a structure of accountability to ensure that improvement is continuous and to solidify a shift in company culture toward circularity. Our recommendations constitute a means to support changes in the five aspects of organizational culture important to circular cultural shift laid out by Bertassini et al. (2021) – values, mindsets, behaviors, capabilities, and competences. On top of the previous recommendations regarding knowledge building and application, our results suggest the value of reporting, both voluntary and legislative, and the designation of specific roles accountable for circularity within the organization to strengthen these aspects of a necessary redefinition of an organization's culture when it comes to circularity.

5.2. Limitations and future work

While sometimes considered simplified, 3-step 'unfreeze, change, refreeze' model provides an enduringly solid foundation for development of modern case-specific change management (Cummings et al., 2016; Rosenbaum et al., 2018). Similar models, such as Kottler's 8-step model, are commonly used in fields where change management research is already well-developed. Due to change management's novelty in internal ICT management literature, we chose the 3-step foundational model to identify both the broad and specific barriers to circular transition on which future studies can build. Exploring and comparing the potential additional insights of multiple change management models is an interesting avenue for future studies.

We operated within the scope of internal ICT management from the procurement process to the organization's relinquishing of the device at end-of-use. Due to the presence of ICT departments that consolidate management of ICT-related decisions, our interviewees were selected from large organizations with more than 500 employees. Analyzing circular ICT transitions in large organizations examines higher-impact decisions and allows for clearer identification of decision making chains. However, future research on small and medium enterprises may reveal additional barriers to circular ICT transitions. Furthermore, we spoke with employees in direct decision making roles for ICT. However, further influences on decision making are likely to be identified in adjacent roles, for example, the pressure reported by decision makers from the product users, and the importance of supplier contracts. A future research focus should zoom out into the influence of adjacent stakeholders in the lifetime of the ICT equipment.

6. Conclusions

Organizations regularly face challenges transitioning to circularity. This paper identifies those challenges for internal organizational management of ICT equipment and presents a way forward through the well-established process of change management. Comparatively, our analysis is distinct from existing literature in several ways, contributing a unique view of: ICT specific transitions, internal ICT decision-making within the boundary of procurement to equipment forfeiture, and the use of Lewin's change management model to create actionable steps toward improved circularity. Our unique focus on ICT within the boundary of the user organization's internal equipment management provides insight on barriers relating to the availability and transfer of information, access to circular equipment, finances and contracts, and the limited prioritization of circularity.

CRediT authorship contribution statement

Kathleen McMahon: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ruth Mugge:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization, Methodology. **Erik Jan Hultink:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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Appendix A – Interview Guide

The following text comprises the guide or protocol used in our semi-structured interviews with ICT decision-makers in organizations.

Interview Introduction

- What is your role in the organization?
- How is the (procurement/maintenance/repair/etc.) department or team structured?
- What process for decision making about laptops and data servers does the team follow?
- What would you say is your level of knowledge about circularity (defined as…)

Decision-making processes in sustainable initiatives

- Are there any sustainability/circularity initiatives or policies in place in your department/process? (e.g., eco-standards, energy efficiency, repair, any software based, experience cooperating with external partners, etc.) ?

- Please tell me about these (initiatives). Where did they come from? Who brought it up, and why?
- Do best to ask the following per initiative:
  - How was the initiative received?
  - To what extent is it implemented now?
  - What are seen as the benefits/motivations of the initiatives for the organization and for your team/department? In the case of no existing initiatives, what (e.g., environmental, moral, social, financial, including cost saving or supports/incentives, compliance initiatives/mandatory for legal reasons etc.)? (continue to ask for each barrier in detail)
  - What has served as facilitators to implementing the circular initiatives we discussed (each) or future initiatives? (e.g., cost saving, external support, etc.)? (increasing competitiveness not important for public bodies so not included) *In other words: what makes it easier to make circular decisions?*

- What would you say has served, or you anticipate serving, as barriers to implementing circular practices? (e.g., cost, lack of expertise, lack of materials, etc.) (e.g., investment of money, time, resources, new training/skills, resistance to change/reluctance among end users, performance of repaired/refurbished equipment, etc.)

In other words: what makes it harder to make circular decisions?

Questions specific to procurement decision makers:

- What is the procedure for procuring new products or services (laptops and data servers)?
- What are the selection criteria used in public bids (or in general for a company like KPN) for laptops and data servers?
- Are selection criteria shared across public bodies?
- Are eco-standards included in current selection criteria? (if so, when and how was this decision made?) *Fits into the general question about circular/sustainable initiatives above.*
- Does the organization procure any refurbished equipment (or is the procurement team involved in discussions about avoiding new procurement by having contracts to refurbish its own equipment?)
- Does the organization reuse laptops? (e.g., when an employee leaves, etc.)
- What types of information/data would support your team in making circular decisions about IT equipment?
- How would the implementation of the RePlanIT tool best facilitate these decisions?

Questions specific to maintenance and/or repair decision makers:

- What is the process for scheduled maintenance of laptops and data servers?
- When unscheduled, how is it decided that a laptop or data server is repaired?
- What are the most common maintenance areas or issues with laptops and data servers?
- Is repair a common solution to equipment problems at the organization?
- What could prevent the choice to repair items (as opposed to dispose of them)? What could make that easier?
- What types of information/data would support your team in making circular decisions about IT equipment? (anticipating maintenance, determining necessary repair, etc.)
- How best would the implementation of the RePlanIT tool facilitate these decisions?

Questions specific to those making decisions about sending equipment for disposal or refurbishment:

- Who decides when a laptop or data server becomes 'waste'?
- Under what conditions is a piece of equipment considered end of life/end of use?
- Are there procedures for reuse? What could prevent the reuse of equipment?
- Where is equipment sent at end of life/end of use? (WEEE takeback contracts with producers, compliance scheme pick up/drop off, contracts with reuse charities, sold to refurbishers, etc.)
- What types of information/data would support your team in making circular decisions about IT equipment? What information would help determine if something is reusable or not (not = becomes actual waste)?
- How best would the implementation of the RePlanIT tool facilitate these decisions?

Appendix B – List of resulting codes, themes, and subthemes

Code	Subtheme	Theme
1. Upper management not aware of the importance of ICT circularity	Lack of awareness	Information-related barriers - *'unfreeze'*
2. Compartmentalized spread of awareness information about ICT circularity		
3. General lack of awareness across roles of the importance of ICT circularity		
4. Lack of education for circularity awareness of the importance of ICT circularity		
5. Lack of user knowledge of how to apply circularity to ICT	Lack of knowledge	Information-related barriers - *'unfreeze'*
6. Lack management knowledge of how to apply circularity to ICT		
7. Limited combined knowledge of both sustainability/circularity and ICT purchasing needs		
8. Lack of knowledge on how to translate ideas into action for circular ICT initiatives		
9. Distributor blocking sustainability/circularity information for ICT equipment	Limitations in information flows	Information-related barriers - *'unfreeze'*
10. Need for more ability for discussion about ICT device information between end users and producers		
11. Difficult to discern 'greenwashing' from true impacts	Difficulty assessing true impacts	Information-related barriers - *'unfreeze'*

(*continued on next page*)

(*continued*)

Code	Subtheme	Theme
12. Difficult to track history across many ICT devices		
13. Difficulty knowing which ICT decision makes the best circular impact		
14. Frequently evolving recommendations and eco-standards for ICT equipment		
15. Lack of previous ICT baseline circularity measurements for comparison		
16. Difficult to obtain circular ICT hardware	Access to circular ICT devices and spare parts	Equipment and access-related barriers - *'change'*
17. Needing storage space for spare ICT parts		
18. Difficult to interchange parts between similar but not identical ICT devices		
19. No/limited contractual support for refurbished ICT equipment	Limitations to incorporating refurbishment	Equipment and access-related barriers - *'change'*
20. Time for refurbishment of ICT equipment not fast enough		
21. Need for high quantities of the same ICT devices not met with refurbishment		
22. Repair price exceeding ICT device value	Repair-related costs and limitations	Equipment and access-related barriers - *'change'*
23. Lack of repairability in available ICT devices		
24. Repair time for ICT devices often too long to be financially balanced		
25. Higher initial cost of circular designed ICT equipment	Financial barriers to circular ICT	Financial and contract related barriers - *'change'*
26. High cost of extending contracts with ICT suppliers		
27. Previously planned budgets did not account for ICT circularity		
28. Lifetime extension of ICT not in suppliers' business model	Limited supplier interest in lifetime extension	Financial and contract related barriers - *'change'*
29. Changes to ICT contracts not in the interest of the supplier		
30. Pushback by suppliers to buy new ICT devices		
31. Sometimes limited control over procurement criteria in ICT tender processes	Limits to existing or available contracts	Financial and contract related barriers - *'change'*
32. Support for ICT devices is within limited time frames in existing contracts		
33. Limited to what circularity criteria is in available ICT contracts for circularity		
34. Limited by who the contractor has a supply chain relationship with		
35. Hesitancy/doubt about the completeness of data wiping leading to hard disk shredding	Concerns for data security	Financial and contract related barriers - *'change'*
36. ICT devices with limited time security compliance		
37. Software security support limited by contracts		
38. Prioritizing needs for capacity considering data growth	Low priority of circularity in ICT	Prioritization and accountability-related barriers - *'refreeze'*
39. Prioritizing wants and needs for upgrades/advanced ICT technology		
40. Prioritizing speed/turn around when obtaining ICT equipment		
41. Prioritizing the need for large amounts of identical/conforming ICT equipment		
42. Prioritizing non-ICT related projects		
43. Prioritizing existing/mature sustainability initiatives over new ICT-related circularity initiatives		
44. No role dedicated solely to ICT circularity	Lack of accountability and initiative	Prioritization and accountability-related barriers - *'refreeze'*
45. Lack of requirements from upper management to engage in circularity		
46. No internal mechanism for the enforcement of ideas		
47. Internal and external political influence on how much circularity is prioritized		
48. Lack of enthusiasm to pick up and initiate developed ideas		

Appendix C – Product information types

The following list represents the type of information interviewed ICT decision-makers in organizations state would like to see in a tool such as a product passport to facilitate more circular decision-making in their internal ICT management.

Types of Circular ICT Device Information Requested by Interviewed ICT Decision-Makers
• Realistic and accurate expected product lifetimes
• Energy consumption in production
• Energy consumption in the use phase
• Recycled material content
• Accurate recyclability of the device and components including actual returns with current technology)
• Repair and performance history (device tracking)
• Information on financial costs and trade-offs of equipment with a high circularity standard
• A comparative assessment of circular impact of different choices and devices

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