Smart and Sustainable Built Environment

Value chain reconfiguration in office fit-outs for circular transition: a network-based analysis of collaboration

Mohsen Ahmadi, Tuba Kocaturk and Abid Hasan
School of Architecture and Built Environment, Deakin University, Geelong, Australia, and
Farzad Piadeh
Centre for Engineering Research, School of Physics, Engineering and Computer Science, University of Hertfordshire, Hatfield, UK

Received 16 May 2026
Revised 14 July 2026
27 August 2026
16 October 2026
Accepted 19 October 2026

Abstract

Purpose – Office fit-outs generate substantial material waste and embodied carbon due to frequent refurbishment cycles and fragmented value chain coordination. While circular economy strategies have increasingly been adopted, limited attention has been given to how collaboration dynamics and actor-network structures influence circular transition. This study investigates how relationships among actors shape the implementation of circular practices across the office fit-out value chain.

Design/methodology/approach – The study analyses 42 circular practices identified from 23 global office fit-out case studies. A life cycle-based value chain (LCVC) representation was developed by translating qualitative case evidence into relational data describing changes in actor roles, activities, interactions and material flows across lifecycle stages and integrated with social network analysis (SNA) to examine collaboration structures, actor centrality and bridging roles. Finally, a scenario-based sensitivity analysis was further conducted to evaluate how targeted network interventions influence coordination capacity.

Findings – Circular transition in office fit-outs is fundamentally a coordination challenge shaped by network structure rather than isolated initiatives. Users, including landlords and tenants, occupy dominant governance positions, while suppliers and interior designers play key operational roles. Exchange platforms emerge as critical bridging actors enabling material circulation across lifecycle stages, whereas waste contractors, strip-out contractors, fit-out contractors and government remain underutilised. The sensitivity analysis further shows that targeted cross-lifecycle connections, particularly those involving exchange platforms and manufacturers, generate the greatest improvements in network coordination while remaining achievable through existing industry mechanisms.

Originality/value – This study integrates lifecycle and value chain perspectives into a relational analytical approach for examining circular transition. By combining LCVC representation with SNA and sensitivity analysis, it identifies key leverage points and transferable strategies for strengthening collaboration and enabling more coordinated circular transitions in office fit-outs.

Keywords Actor-network, Circular economy, Collaboration structures, Office fit-out, Social network analysis, Value chain

Paper type Research article

1. Introduction

1.1 Background

Fit-out elements in buildings are generally grouped into three categories of: (1) finishes such as ceilings, flooring, wall covers, and interior glazing; (2) furniture, including desks, chairs, sofas, and shelving; and (3) fixtures such as casework, ceiling suspension systems, doors, and

© Mohsen Ahmadi, Tuba Kocaturk, Abid Hasan and Farzad Piadeh. Published by Emerald Publishing Limited. This article is published under the Creative Commons Attribution (CC BY 4.0) licence. Anyone may reproduce, distribute, translate and create derivative works of this article (for both commercial and non-commercial purposes), subject to full attribution to the original publication and authors. The full terms of this licence may be seen at http://creativecommons.org/licences/by/4.0/

Smart and Sustainable Built Environment
Emerald Publishing Limited
e-ISSN: 2046-6102
p-ISSN: 2046-6099
DOI 10.1108/SASBE-05-2026-0439

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

partition walls (Menzies and Tsolaki, 2016; Ahmadi *et al.*, 2025). These components substantially influence the construction sector's environmental footprint, especially in office buildings, comprising a large proportion of commercial floor space, where frequent refit–defit cycles and lease churns generate high volumes of waste and carbon emissions (Rucińska *et al.*, 2020; Ahmadi *et al.*, 2026). Office fit-outs are commonly replaced every 3–7 years (Treloar *et al.*, 1999; Forsythe and Wilkinson, 2015), producing approximately 63–70 kg/m^2 of waste per cycle, with most discarded materials ending up in landfills (Host, 2018; RESET, 2022). In Australia, 70–80% of fit-out waste is landfilled (Fini and Forsythe, 2020), whereas in the USA, 80% of discarded office furniture meets the same fate (EPA, 2024). The cumulative embodied carbon emissions from multiple fit-out cycles can even surpass those from the building's structure and substructure (CLF, 2019; Fini and Forsythe, 2020). This significant impact stems largely from the prevailing linear economic model within the fit-out value chain (Pieroni *et al.*, 2019; Pournaghshband *et al.*, 2026), where materials are extracted, manufactured, used, and then discarded (Eisenreich *et al.*, 2022; CIRCO, 2024).

The persistence of this linear model is reinforced by industry practices across the pre-use, use, and post-use stages. During pre-use, material choices often hinder reuse and recycling due to composite and non-recyclable components (Wang *et al.*, 2015). Most mass-produced furniture and fixtures lack modularity, limiting refurbishment opportunities (Fini and Forsythe, 2020). Adhesive-based assembly further prevents disassembly and component recovery (FTD, 2023). Manufacturers are rarely incentivised to design for deconstruction or to use recycled content (Hart *et al.*, 2019). In the use stage, short leasing cycles and aesthetic-driven updates encourage the premature replacement of functional products (Menzies and Tsolaki, 2016), while the absence of reuse standards and financial incentives discourages refurbishment (Hart *et al.*, 2019). In the post-use phase, disassembly challenges often lead demolition contractors to destroy rather than salvage workstations and furniture (Fini and Forsythe, 2020). Material recovery is further hindered by unreliable waste reporting, logistical constraints, and the high cost of labour and transport (Shooshtarian *et al.*, 2020; Zaman *et al.*, 2022; van der Lans *et al.*, 2023). Together, these barriers make landfill diversion economically unattractive.

A more sustainable alternative is adopting a circular economy (CE) across the fit-out value chain to enhance value retention throughout the life cycle (Kocaturk and Reza Hosseini, 2023). This approach optimises resource efficiency in the pre-use stage, extends product lifespans during use, and enables material recovery through reverse logistics after use (Konietzko *et al.*, 2020; EMF, 2021a, b). According to the 10R framework (Bocken *et al.*, 2016; Potting *et al.*, 2017; Arup, 2022), this can be delivered by three principles: (1) Narrowing the loop, through refusing unnecessary materials/products (R0), rethinking the intensity of asset use (R1), increasing efficiency in manufacturing or usage to reduce natural materials usage (R2), (2) Slowing the loop, through reusing discarded materials/products in their original function if they are in good condition (R3), repairing defective products (R4), refurbishing old products (R5), remanufacturing discarded products into new products of the same function (R6), and (3) Closing the loop through repurposing discarded materials/products for new functions (R7), recycling discarded materials (R8), and recovering energy from discarded materials (R9).

1.2 Literature review

While numerous frameworks and strategies have been proposed to advance the CE, their implementation remains uneven and fragmented in practice. This limitation can be understood across three interconnected levels of transition (Guzzo *et al.*, 2022). At the micro level, organisations increasingly adopt circular strategies through innovations in materials, design, and business models. At the macro level, governments and institutions introduce policies, regulations, fiscal incentives, and social adaptation to promote circularity. However, despite these advancements, the transition often stalls at the meso level, where the coordination of multiple interdependent actors is required (Kalmykova *et al.*, 2018).

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

In the context of office fit-outs, this meso-level challenge manifests as a coordination failure among key stakeholders across the value chain. Circular practices require aligned decision-making, shared responsibilities, and effective information exchange between actors such as landlords, designers, suppliers, contractors, and waste managers (Wilmot *et al.*, 2014; Rashidian *et al.*, 2026). Yet, existing industry structures are characterised by fragmented responsibilities, short-term contractual relationships, and weak collaboration mechanisms, which hinder the implementation of circular strategies (Hart *et al.*, 2019; Konietzko *et al.*, 2020). As a result, even when viable circular solutions exist at the micro level and are supported by macro-level policies, their large-scale adoption is constrained by the lack of coordinated actor networks (Guzzo *et al.*, 2022).

This coordination challenge is also reflected in existing studies of the office fit-out value chain, which consistently highlight fragmented implementation and weak collaboration among actors at the meso level. In the context of office fit-outs, for instance, Wilmot *et al.* (2014) outlined key industry players and their influence in decision-making but identified limited collaboration and unclear responsibilities, noting that designers often overlook end-of-life considerations in material selection. Similarly, Casas-Arredondo *et al.* (2018) examined the fit-out supply chain and revealed systemic issues such as the absence of material recovery pathways after tenancy and weak information exchange between designers and manufacturers. Fini and Forsythe (2020) further demonstrated how fragmented responsibilities across demolition contractors, waste contractors, and offsite facilities hinder effective material recovery and reuse. Together, these studies indicate that the core challenge lies not merely in identifying actors within the value chain, but in understanding how their interactions and relationships can be systematically restructured to enable coordinated circular practices (Jemal *et al.*, 2026).

Despite identifying the importance of collaboration and the fragmentation of actor relationships, existing studies have largely remained descriptive. They have not yet provided a systematic analytical procedure for translating circular fit-out practices into actor-network structures that can be quantitatively examined. Consequently, limited attention has been given to how changes in actors, activities, interactions, and material flows can be converted into relational data to identify central actors, bridging roles, structural gaps, and potential collaboration interventions.

These limitations point to the need for a relational perspective that can capture how interactions among actors shape the implementation of circular practices. In this regard, this study draws on insights from Actor-Network Theory (ANT), which conceptualises socio-technical systems as networks of interdependent actors whose relationships influence system-level outcomes (Hald and Spring, 2023). Originally developed within science and technology studies, ANT conceptualises social systems as networks of both human and non-human actors (Latour, 2005; Law, 1992), emphasising that outcomes emerge from interactions among heterogeneous elements. In this study, ANT is employed as a guiding lens rather than a fully developed analytical framework. Accordingly, ANT provides the conceptual perspective for understanding actor relationships, whereas the empirical analysis of those relationships is undertaken using SNA.

Accordingly, because the objective of this study is to examine collaboration and governance structures within the office fit-out value chain, the analysis concentrates on human and organisational entities as the primary decision-making actors at the meso level. Since decisions governing circular implementation are enacted through relationships among organisations and decision-makers and their contribution, this level of abstraction is the most appropriate for addressing the research question. Consequently, non-human elements, such as materials, technologies, and products, are treated as mediating components embedded within actor interactions rather than as independent analytical units.

To operationalise this relational perspective, the study integrates lifecycle and value chain thinking through the development of a LCVC representation. The LCVC structures the office fit-out lifecycle across three major phases: pre-use, use, and post-use inspired by Wilmot *et al.*

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

(2014) and Bocken *et al.* (2016), while capturing how actors, activities, interactions, and material flows evolve throughout these stages. In the pre-use stage, actors such as manufacturers, suppliers (producers and retailers), fit-out contractors, and interior designers contribute through manufacturing, assembly, retail, and installation. The extraction stage, while important, is excluded from this study as it is not specific to the building sector. During the use stage, users including occupiers, landlords or their representatives such as asset managers, engage in operation, maintenance, repair, and asset management. In the post-use stage, strip-out contractors, waste contractors, and waste facilities manage demolition, strip-out, and waste segregation (Wilmot *et al.*, 2014; Fini and Forsythe, 2020; Casas-Arredondo, 2021).

The LCVC further incorporates the value hill concept (Bocken *et al.*, 2016), further supported by (CIRCO, 2024). The value hill provides a conceptual basis for understanding how the embedded value is added in the pre-use stage, maintained during the use stage, and managed at the end of use (EoU) or end of life (EoL) in the post-use stage; Throughout this study, the term "value" refers to this embedded value, encompassing the materials, energy, labour, and associated environmental resources invested throughout the lifecycle of office fit-out elements, rather than monetary value alone.

In this sense, the LCVC does not constitute a standalone theoretical framework, but rather an integrative analytical representation that combines lifecycle thinking, value chain analysis, and CE principles to support relational and network-based analysis. This integration enables a structured interpretation of value dynamics across the fit-out lifecycle and supports the analysis of how different practices influence the value chain.

1.3 Research aim and contribution

In response to the limited understanding of meso-level collaboration structures in circular office fit-out transitions, this study investigates how circular practices can be realised through the configuration of actor networks and collaboration structures across the office fit-out value chain. It aims to identify key actors, structural gaps, and leverage points within the network, as well as the interactions and governance mechanisms that facilitate circular transitions. Accordingly, the central research question guiding this study is: How do collaboration structures and actor-network reconfigurations shape the implementation of CE practices across the office fit-out value chain?

This study makes three key contributions to advancing CE research in the built environment, with a specific focus on office fit-outs: (1) It offers a conceptual contribution by integrating and extending existing value chain and lifecycle-based perspectives into a Life Cycle-Based Value Chain (LCVC) representation that captures how circular transitions reconfigure actor roles, interactions, and material flows across the office fit-out lifecycle; (2) It provides a methodological contribution by integrating LCVC visualisation with Social Network Analysis (SNA), enabling a systematic examination of collaboration patterns, actor centrality, and structural gaps within the value chain, and (3) It delivers a practical contribution by identifying key leverage points and underutilised actors within the network, and proposing targeted strategies to enhance collaboration and facilitate circular transitions in office fit-outs.

Therefore, the technical novelty of this study lies in operationalising circular value-chain reconfiguration as a measurable actor-network problem. Moving beyond the predominantly descriptive analyses reported in previous studies, the proposed framework translates LCVC-based qualitative case evidence into SNA-compatible relational data, enabling circular practices to be analysed not only as isolated strategies but also as structural changes in collaboration networks. This provides a systematic analytical procedure for identifying central actors, bridging roles, structural gaps, and high-impact collaboration interventions.

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

2. Methodology

A structured multi-stage methodological approach is adopted to combine case-based analysis, LCVC mapping, SNA, and scenario-based sensitivity analysis, as shown in Figure 1. These methods are applied sequentially to construct, analyse, and evaluate actor-network configurations within the office fit-out value chain. This approach is grounded in a perspective informed by Actor–Network Theory (ANT), which conceptualises circular transition as a process of actor-network reconfiguration, where changes in roles, interactions, and collaborations enable new forms of value creation (Hald and Spring, 2023). In this study, ANT is employed as a guiding lens rather than a fully developed analytical framework.

The process begins (Figure 1) with the identification of relevant case studies and the extraction of CE practices across the office fit-out value chain. These practices are then systematically structured and synthesised to develop the LCVC, capturing changes in actor roles, activities, interactions, and material flows across lifecycle stages. Building on this representation, SNA is applied to examine collaboration patterns, identify key actors, and reveal structural gaps within the network. Finally, a scenario-based sensitivity analysis is conducted to evaluate how potential changes in actor relationships influence coordination capacity and support circular transition.

2.1 Case study selection

The office fit-out sector is a rapidly evolving, practice-driven domain in which industry-led innovations often outpace the development of consolidated academic theory. As a result, many CE practices are documented primarily in industry reports, organisational case studies, and policy-related publications rather than in peer-reviewed literature. In such under-theorised contexts, drawing on diverse sources is essential to capture emerging real-world practices that remain underrepresented in academic discourse. Accordingly, a systematic review of secondary and grey literature is adopted to identify CE initiatives within the office fit-out sector.

To ensure broad coverage, a targeted keyword search was conducted using the Google search engine, applying the keywords [(“circular economy” OR “circularity”) AND (“fit out” OR “fit-out” OR “interior” OR “office” OR “building”)]. This initial search generated a wide pool of potential cases documented across sustainability platforms, organisational reports, and governmental or institutional sources. To ensure data reliability, only sources produced or

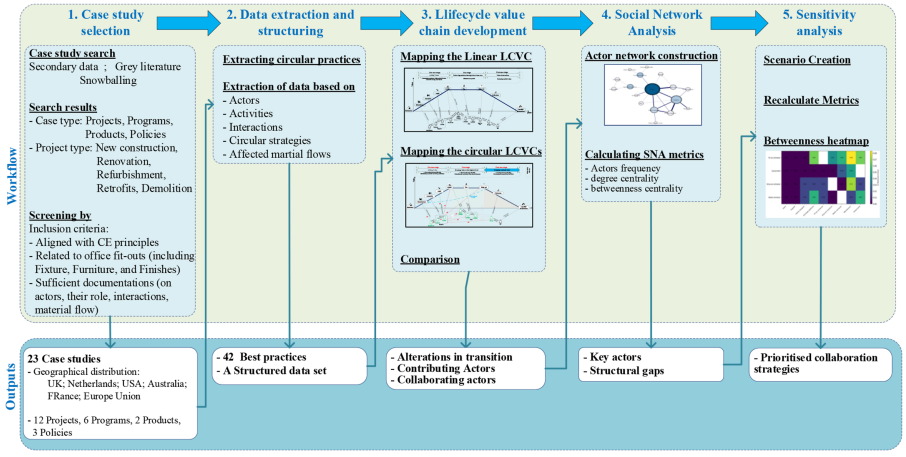


Figure 1. Research workflow proposed for the analysis of collaborating actor network for a circular fit-out sector

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

verified by reputable scientific, industrial, or institutional bodies such as the Green Building Council and the Circular Building Toolkits were retained.

The identified cases encompassed a range of types, including projects, programmes, products, and policies, and span diverse project contexts such as new construction, renovation, refurbishment, retrofit, and demolition. This breadth ensures comprehensive coverage of circular practices related to resource efficiency, material reuse, and waste reduction.

A snowballing-inspired approach was applied to complement the keyword-based search and enhance the dataset, inspired by Du and Costello (2025). Initial cases served as entry points to identify additional relevant sources via embedded references, hyperlinks, partner organisations, and related reports. This iterative process enabled the identification of additional initiatives not captured by keyword searches alone, which is particularly important when working with grey literature that lacks formal citation structures (Piadeh and Pournaghshband, 2026). A stopping criterion was applied to maintain transparency and methodological consistency. The search was discontinued after reviewing three consecutive result pages, each containing approximately 25 results, yielded no new relevant cases. This, together with the absence of emerging new patterns, was considered indicative of theoretical saturation (Markou *et al.*, 2025).

The identified cases were subsequently screened using three inclusion criteria: (1) The initiative had to be explicitly aligned with CE principles including narrowing, slowing, or closing resource loops, as defined by the Ellen MacArthur Foundation (EMF, 2021a, b); (2) The initiative needed to be directly related to office fit-out or interior refurbishment activities; and (3) Sufficient documentation had to be available to clearly identify the intervention, the actors involved, their roles and interactions, and the associated material flow implications. Cases that did not meet these criteria or lacked sufficient detail were excluded.

2.2 Data extraction and structuring

A systematic document analysis was conducted to extract and structure relevant data from each case study. The analysis focused on identifying circular practices, the actors involved, their roles within the value chain, and the nature of their interactions. Particular attention was given to how these practices influence material flows and lifecycle transitions within office fit-outs.

Each identified practice was treated as a discrete analytical unit to ensure consistent representation across cases. For each unit, data were extracted on: (1) the actors directly involved, (2) supporting or collaborating actors, (3) associated activities of actors, (4) their interactions, and (5) resulting changes in material flows and circular mechanisms. Transformations across these elements were then identified by determining whether each was added, removed, or reconfigured relative to the baseline linear LCVC.

To enhance analytical rigour, the extracted data were coded. Actors were classified according to their roles within the value chain (e.g. suppliers, designers, contractors, users), while interactions were categorised by their nature (e.g. contractual, collaborative, or supply-based relationships). Circular practices were further coded in relation to their underlying circular mechanisms, including 10R strategies, and to their associated value creation outcomes (narrowing, slowing, and closing resource loops) across different lifecycle stages (pre-use, use, and post-use). This coding process transformed qualitative case descriptions into structured relational data, forming the basis for subsequent LCVC mapping and network construction.

2.3 LCVC development

A cross-case comparative approach was employed to identify recurring patterns in actor roles, interactions, and value chain transformations across the dataset. Accordingly, inspired by Gomes Araújo and Lucko (2022), the cross-case comparison was conducted by treating each of the circular practices as an individual analytical unit and examining them using a consistent

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

analytical structure comprising actor roles, activities, interactions, and material-flow transformations. The resulting structures were then compared iteratively to identify recurring collaboration patterns and value-chain transformations across practices, consistent with the pattern-matching and cross-case synthesis approach recommended by Yin (2018). Therefore, the comparison sought to synthesise repeated configurations of actor participation, interaction structures, lifecycle transitions, and value-chain transformations while distinguishing them from case-specific characteristics.

These recurring patterns were subsequently abstracted into a generalised representation of the office fit-out value chain. It should be emphasised that the LCVC is not intended to model temporal sequence, the frequency of repeated loops, or dynamic system behaviour. Rather, it provides a structural representation of actor roles, activities, interactions, and material-flow transformations to support the analysis of circular transition within the office fit-out value chain.

Within this process, actor categories were not predefined *a priori*; instead, they emerged inductively from the comparative analysis of the documented circular practices. Actors were retained only when they performed an explicit role within a documented practice, ensuring that the constructed network represents observed collaborations rather than assumed relationships. Building on this generalised representation, and grounded in lifecycle thinking, the value hill perspective, ANT, and the findings of the cross-case comparative analysis, actor networks in LCVC were constructed. Each identified functional actor category was translated into nodes, while their activities were translated into functional linkages across lifecycle stages. Only explicitly documented contractual, regulatory, or collaborative relationships were represented as edges; inferred or indirect relationships were intentionally excluded. In this map, activities are represented as solid lines linking actors to particular lifecycle phases, while interactions are depicted as dotted lines connecting actors within the network (see Figure 2).

The resulting LCVC provides a structured visualisation of actors, activities, interactions, and material flows across the pre-use, use, and post-use stages of office fit-outs, forming the analytical basis for examining value chain configurations and transformations. To enable comparative analysis, each case study is mapped under two scenarios: (1) a linear value chain, which serves as the baseline for all cases; and (2) a circular value chain in each practice, which captures transformations introduced through circular practices, derived from the structured dataset developed in Step 2. The comparison between the circular LCVCs and the linear baseline reveals how circular interventions reconfigure value chain structures.

To clearly define the analytical scope of the LCVC, the lifecycle boundaries adopted in this study are summarised in Table 1. The table specifies the activities included within each lifecycle stage (pre-use, use, and post-use) and clarifies the analytical boundaries applied to the office fit-out value chain. These boundaries establish a consistent basis for mapping actors, activities, interactions, and material flows across the selected case studies.

Figure 2a presents the baseline linear LCVC. In this configuration, value follows a typical linear trajectory. Value accumulates during the pre-use stage, driven by maximum virgin material usage, energy consumption, and labour inputs. During the use stage, value is maintained only temporarily due to relatively short service lifespans. In the post-use stage, value declines sharply as materials are discarded in landfills or incinerated at their EoU or EoL (Eisenreich *et al.*, 2022). This linear configuration results in a near-total loss of embedded value, including materials, energy, and labour.

On the other hand, to capture how circular practices reconfigure value dynamics across the lifecycle, circular LCVCs are developed for each case study based on extracted and systematically structured data from industrial practices. Unlike the unidirectional value decline observed in linear configurations, the circular scenario demonstrates how value is (1) enhanced in the pre-use stage through resource efficiency and reduced reliance on virgin inputs, (2) maintained at the highest level during the use stage by extending product lifespans, and (3) is kept and recovered in the post-use stage through circulating material at EoU and EoL (Bocken *et al.*, 2016; Konietzko *et al.*, 2020; EMF, 2021a, b).

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

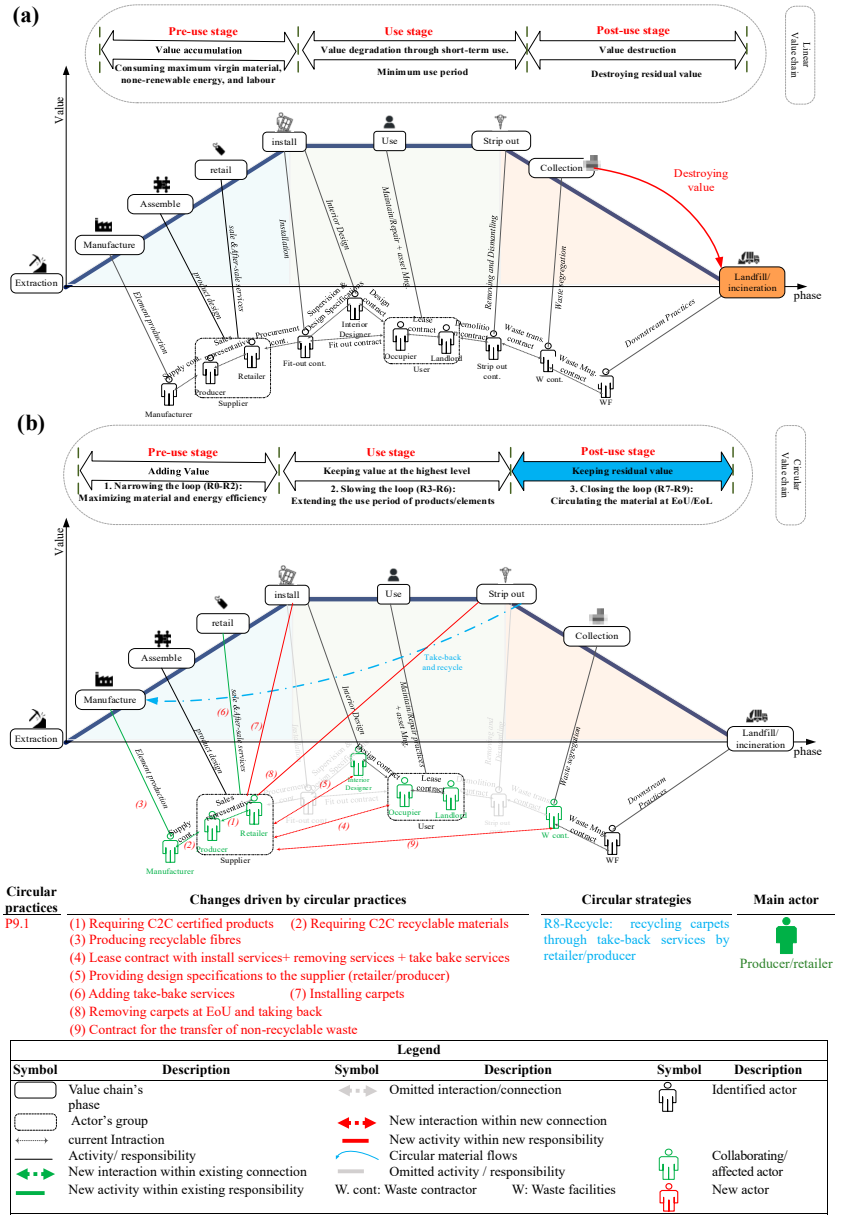


Figure 2. Actor Network of the LCVC in office fit-outs: (a) Linear LCVC as the baseline (raw data collected from Wilmot *et al.* (2014), Fini and Forsythe (2020), and Casas-Arredondo (2021)), (b) Circular LCVC for an illustrative practice. Source: Authors' own work

For clarity, circular practices are interpreted as interventions that transform baseline value chain configurations through three primary mechanisms (see Figure 2b showing an illustrative circular LCVC): the addition, removal, and reconfiguration of actors, activities, interactions, and material flows. These transformations in the value chain are visually represented as follows (1) coloured actors distinguishing main and collaborating roles; (2) coloured solid lines

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

Table 1. Scope and lifecycle boundaries adopted in the LCVC framework

Product's lifecycle stage	Included phases	Analytical boundary
Pre-use	manufacturing, assembly and production, retail, installation of office fit-out elements	Includes all activities directly associated with planning, producing, supplying, and installing office fit-out elements. Raw material extraction is excluded
Use	operation of office fit-out elements	Includes activities occurring during the operational life of office fit-out elements, covering product use, maintenance, repair, and life extension
Post -use	Strip-out and collection, waste management, and dispose	Includes end-of-use and end-of-life management of office fit-out elements, covering both conventional disposal pathways and circular resource recovery processes

indicating modified (green) or newly (red) introduced activities; (3) coloured dotted lines representing new (red) or modified current (green) interactions; (4) blue directional arrows illustrating changes in material flows. Where a circular practice simultaneously influences multiple lifecycle flows, multiple blue arrows are shown to represent these concurrent material-flow transformations. For example, a Furniture-as-a-Service practice may simultaneously reduce virgin material inflows by extending product service life while introducing a return flow for refurbishment and recirculation; and (5) Elements removed from the linear system are explicitly denoted as omitted components to indicate their exclusion. This provides a systematic visual depiction of how circular practices reconfigure value chain structures.

To enhance transparency, all shifts and changes in the circular LCVC, derived from the extracted data in Step 2, are explicitly presented using coloured annotations. Red annotations explain corresponding alterations in actors' activities, and interactions, while blue annotations represent CE strategies and changes in material flows. Together, these annotations enable traceability of the analytical process and support the reproducibility of the reported results.

Based on the comparative analysis of the linear and circular LCVCs, contributing and collaborating actors are systematically identified to support the construction of the social actor network in the subsequent stage. Contributing actors, represented as coloured nodes in the circular LCVCs, are those who directly influence the value chain through their activities or adapt to circular interventions by modifying existing actions, introducing new activities, or responding to changes initiated by other actors. In contrast, collaborating actors are engaged through relational linkages, supporting or enabling the transition via collaborative interactions. These relationships are visualised in the LCVCs through coloured dotted lines, indicating newly established or reconfigured interactions between actors. For instance, in Figure 2b, which illustrates a case utilising Furniture-as-a-Service (FaaS), the contributing actors include the manufacturer, supplier, waste contractor, users, and interior designer. Direct collaborative linkages are observed between actors, including the manufacturer and supplier, supplier and users, supplier and interior designer, and supplier and waste contractor.

Although developed for office fit-outs, the LCVC is intended as a transferable analytical representation rather than a project-specific template. Because it is structured around lifecycle stages, actor roles, activities, interactions, and material-flow transformations, it can be adapted to projects with different scales, procurement methods, and regulatory contexts by modifying the actor nodes, their activities, and interaction links while retaining the same lifecycle-based analytical logic.

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

2.4 Social network analysis

SNA is a methodological approach used to map and analyse relationships and interactions among actors within a network (Rawlings *et al.*, 2023). Originally rooted in sociology, anthropology, and mathematics, SNA was pioneered by Moreno (1934), who highlighted the importance of social ties and group structures. Unlike traditional approaches that focus on individual attributes, SNA examines how patterns of interaction shape collective behaviours and system outcomes (Mehra *et al.*, 2014).The approach assumes that actors are embedded within relational structures that influence their opportunities, constraints, and behaviours (Wasserman and Faust, 1994). Due to its capacity to capture complex interdependencies, SNA has increasingly been applied to innovation ecosystems and networked systems (Moslehian *et al.*, 2022), making it particularly suitable for analysing collaboration structures and circular transition within the office fit-out value chain.

In this study, the actor network is primarily composed of human and organisational actors, reflecting the meso-level focus on decision-making and coordination processes. While non-human elements such as materials, technologies, and products influence system outcomes, they are embedded within actor interactions and are not treated as independent analytical units (Hald and Spring, 2023), This analytical boundary ensures a focused examination of collaboration structures within the value chain.

2.4.1 Actor network construction. The social actor network is developed by identifying and analysing the roles of key actors, both contributing and collaborating, involved in the circular transition within each case study. This is achieved through the comparative analysis of the linear and circular LCVCs conducted in the previous stage. Within this framework, the network is defined by its analytical scope, which captures direct collaborative and operational interactions among actors. Accordingly, a link is established only where such interactions are explicitly observed. For instance, government influence is often exercised indirectly through regulations that require users (e.g. tenants, landlords, or their representatives) to ensure that their connected actors (such as suppliers, contractors, and designers) incorporate circular considerations in fit-out projects. In such cases, the network captures a direct link between government and users, while these mediated or indirect influences on other actors are not represented as separate network ties.

To ensure consistency and reliability while reducing subjectivity in network construction, all actor relationships were identified using a consistent coding protocol applied across the 42 circular practices. Only collaborations explicitly documented in the source material were translated into network ties, whereas inferred or indirect relationships were intentionally excluded. Consequently, the network was constructed entirely from observed collaborations rather than subjective assumptions.

Based on this analytical scope, the collaborating actor network is modelled using the Gephi version 0.10.1 (Product Version: 0.10.1 202301172018) (Bastian *et al.*, 2009). In this network, nodes represent actors, and edges denote collaborations. This representation enables the application of social network analysis metrics, such as degree and betweenness centrality, to examine coordination structures and identify bridging roles within the value chain.

2.4.2 Social network analysis metrics. SNA metrics, including actor frequency, degree centrality, and betweenness centrality, were subsequently employed to analyse network structure and actor positioning. Actor frequency measures the extent of participation of each actor across the dataset by counting their occurrences in different practices, thereby identifying the most consistently engaged actors (Landherr *et al.*, 2010).While frequency reflects presence, it does not capture relational importance; therefore, centrality measures were applied to assess actors' positions within the network. Accordingly, rather than assigning subjective weights to stakeholders, their relative importance emerged objectively from the topology of the observed collaboration network through standard SNA centrality measures.

Degree centrality, as shown in Equation (1), reflects the number of direct connections an actor has, indicating their level of interaction and immediate influence within the network (Bright *et al.*, 2015).

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

$$C_D(i) = \frac{d_i}{n-1} \quad \text{Eq. (1)}$$

where $C_D(i)$ is the degree centrality of actor i, d_i is the number of direct connections of actor i, and n is the total number of actors in the network.

Betweenness centrality, as shown in Equation (2), also captures the extent to which an actor acts as a bridge between other actors by lying on the shortest paths connecting them, thus indicating their role in facilitating coordination and information flow (Das *et al.*, 2018).

$$C_B(i) = \sum_{j \neq k \neq i} \frac{\sigma_{jk}(i)}{\sigma_{jk}} \quad \text{Eq. (2)}$$

where $C_B(i)$ is the betweenness centrality of actor i, $sigma_{jk}$ is the total number of shortest paths between actors j and k, and $sigma_{jk}(i)$ is the number of those paths that pass through actor *i*.

Accordingly, higher degree centrality indicates greater collaboration potential through direct connections, whereas higher betweenness centrality reflects an actor's capacity to bridge otherwise disconnected parts of the network and facilitate coordination across lifecycle stages. These metrics were computed using the Gephi platform, enabling both visualisation and quantitative analysis of the actor networks (Valente *et al.*, 2008).

Both metrics were computed in Gephi using an undirected, unweighted binary adjacency matrix. A tie was assigned a value of one when a direct collaboration between two actors was documented in at least one circular practice, irrespective of how frequently that relationship occurred across the dataset. The frequency with which each relationship was identified was retained separately as an empirical edge attribute for visualisation.

2.4.3 Key actors and structural gaps. This step focuses on identifying the key actors, gaps in the network and collaboration. Actors with high frequency indicate strong involvement across multiple practices, suggesting they play a key role in various circular practices within the network. Their repeated presence highlights their influence, decision-making power, or essential contributions to CE processes (Landherr *et al.*, 2010). Actors with a high degree centrality are considered central to the flow of information or resources, making them key players in implementing circular practices. They facilitate numerous interactions, and their actions can influence the wider network. By prioritising these central actors, strategies can be devised to leverage their influence in promoting widespread circularity practices and ensuring a more seamless transition across the value chain (Das *et al.*, 2018). Conversely, actors with high betweenness centrality play a crucial role in connecting different parts of the network, helping facilitate communication and decision-making across otherwise disconnected groups (Valente *et al.*, 2008). Identifying these intermediaries can uncover potential points of influence where targeted interventions can amplify the impact of circular initiatives.

Additionally, this analysis highlights gaps in collaboration in areas where greater interaction among actors could raise centrality metrics and, consequently, strengthen the overall circularity of the value chain. By addressing these gaps, the network can utilise more effective collaborations to foster circularity across the value chain.

2.5 Scenario-based sensitivity analysis of potential network interventions

This step focuses on identifying opportunities to enhance collaboration within the circular office fit-out value chain through a scenario-based sensitivity analysis of potential network interventions. The analysis was designed to evaluate the effects of hypothetical collaboration interventions on network structure rather than to test the stability of the network under data uncertainty. It evaluates how introducing new relationships between weakly connected or disconnected actors influences network structure and coordination capacity. Rather than relying solely on predefined collaboration strategies, a set of feasible and functionally

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

meaningful connections was systematically identified based on the LCVCs to ensure analytical relevance and practical applicability.

To improve the transferability of the analysis, the sensitivity assessment was limited to generalisable actors broadly relevant across office fit-out value chains, including users, suppliers, interior designers, exchange platforms, fit-out contractors, strip-out contractors, waste contractors, manufacturers, and government. Case-specific actors, such as IT companies and co-occupiers in co-location models, were excluded, as their roles are tied to particular business model configurations and may not represent broader collaboration opportunities across different contexts.

Each underutilised actor, based on betweenness centrality, was then examined by systematically connecting the focal actor to each of the other possible actors one at a time. For each scenario, the modified network was constructed and the betweenness centrality of the focal actor was recalculated to assess how each potential connection alters its capacity to bridge otherwise disconnected parts of the network. Betweenness centrality is used here as the primary indicator of coordination capacity, as it captures the extent to which an actor occupies strategic positions along the shortest paths between other actors. Changes in betweenness centrality between the baseline and modified networks were used to quantify the impact of each intervention. While the analysis focuses on betweenness centrality, the same procedure can be applied to other network metrics, depending on the analytical objective. This scenario-based sensitivity analysis provides a systematic and evidence-based approach for identifying high-impact collaboration strategies, enabling the prioritisation of interventions that most effectively support the circular transition in office fit-outs.

Since some actors in the full network are specific to particular cases, such as IT companies and co-occupiers in co-location models or SPVs in service-based models, the sensitivity analysis was restricted to nine generalisable actors that are broadly relevant across office fit-out value chains in different contexts: users, suppliers, interior designers, exchange platforms, fit-out contractors, strip-out contractors, waste contractors, manufacturers, and government. This boundary improves the transferability of the analysis by ensuring that the tested interventions represent collaboration opportunities applicable beyond individual case-specific configurations.

2.5.1 Analytical scope and validity. An exploratory and interpretive analytical approach is adopted aimed at revealing patterns of actor-network configurations rather than testing predefined hypotheses. The combination of systematic case selection, structuring data, and cross-case comparison enhances analytical robustness by grounding findings in recurring empirical patterns rather than isolated observations. While the reliance on grey literature may introduce limitations related to data consistency and standardisation, these are mitigated through clearly defined inclusion criteria, systematic data extraction, and consistent coding procedures. This approach is particularly appropriate for investigating emerging and practice-driven domains such as circular economy implementation in office fit-outs, where real-world practices often precede theoretical development.

3. Results and discussion

3.1 Overview of circular practices and dataset

A total of 23 case studies were selected, representing diverse geographical contexts, including Australia, the United Kingdom, the Netherlands, the United States, France, and the broader European Union. Notably, all identified cases originated from developed economies. This likely reflects the comparatively greater maturity of circular economy policies, sustainability reporting frameworks, waste regulations, and supporting market infrastructures in these contexts, as well as the wider availability of documented industry-led circular initiatives and publicly accessible case studies.

Across these cases, 42 circular practices were identified, comprising 26 practices from 12 individual projects, 8 practices from 6 organisational programs, 5 practices from 3 policy

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

initiatives (e.g. government regulations and procurement frameworks), and 3 practices associated with 2 product-based solutions. Table B1 in Appendix B presents these practices, showing that some cases implemented a single initiative while others adopted multiple approaches. Likewise, while certain cases targeted specific fit-out elements, others addressed broader scopes. For instance, case 13, San Francisco's procurement policy, focused solely on carpets, whereas case 11, involving shared office spaces, influenced the consumption of all fit-out components.

For consistency, fit-outs are categorised into three groups following Forsythe (2017): Furniture (e.g. tables, chairs, storage), Fixtures (e.g. doors, walls, partitions), and Finishes (e.g. wall, ceiling, and floor coverings). Some practices in Table A1 are marked with "#" to denote potential strategies yet to be implemented but suggested in reports as opportunities to enhance circularity. For example, in case 2, limited time and space for dismantling removed products were identified as challenges. The report recommends offsite storage to provide adequate time and space for dismantling and upgrading materials, and this proposed practice is labelled with "#". These demand-oriented initiatives were included in the analysis alongside implemented initiatives to explore potential network mechanisms. Insights derived from both implemented and proposed initiatives informed the subsequent analysis, enabling a better understanding of current practices.

Following the identification of circular practices, data were systematically extracted from each practice, treated as discrete analytical units, including the actors involved (both directly and collaboratively), their activities, their interactions, and the associated changes in material flows resulting from the implementation of CE strategies. To enhance transparency, these data are explicitly represented in the circular LCVC visualisations provided in Appendix C for all practices. In these visualisations, red and blue annotations, together with coloured arrows and actor representations, illustrate the specific practices and the corresponding alterations in actors, activities, interactions, and material flows. This approach enables clear traceability of the analytical process and supports the reproducibility of the reported results.

3.2 LCVC representation of linear vs. circular value chains

Following the data extraction and structuring process, circular practices identified across the case studies were systematically translated into LCVC representations. For each case, data on actors, activities, interactions, and material flows were synthesised to construct both linear baseline configurations and their corresponding circular transformations. These LCVC maps serve as visual and analytical tools for examining how circular practices reconfigure value chain structures.

The transformed value chains resulting from circular practices were mapped across all 23 case studies, encompassing all identified practices, as shown in Figures C1 to C23 in Appendix C. These maps illustrate how each case departs from the conventional linear value chain through modifications in actors, activities, interactions, and material flows, by implementation of 10R strategies. To demonstrate these transformations, two representative cases are discussed in detail to clarify how circular LCVCs are visualised and interpreted.

Figure 3a illustrates a FaaS model introduced by the Australian company Living Edge in case 12 (see Figure C12 in Appendix C for a detailed visual). This leasing-based model enables customers to use furniture products while the supplier retains ownership and assumes full responsibility for maintenance, refurbishment, and end-of-use management. In this circular configuration, the supplier becomes the primary actor, with the FaaS model functioning as the enabler of circularity. The supplier directly influences other existing actors (shown in green), including occupants, interior designers, and waste contractors, by altering existing activities and interactions (indicated by green lines in Figure 3a) or by introducing entirely new ones (represented by red lines). This transformation also leads to the elimination of certain actors, such as fit-out and strip-out contractors, since the supplier assumes responsibility for both installation and end-of-use removal (new activities highlighted in red). These structural

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

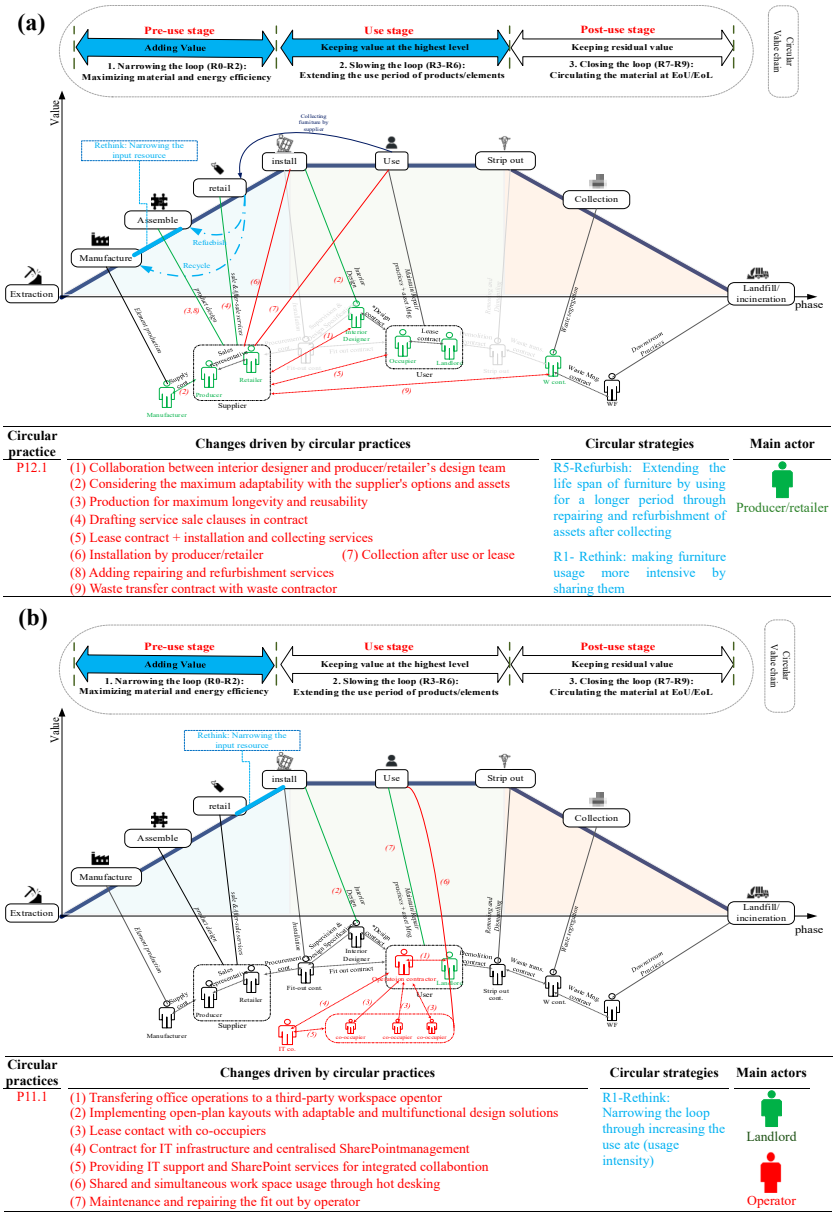


Figure 3. Circular LCVC examples: (a) Case 12: Living Edge Lifecycle program in Australia, and (b) Case 11: Co-location program in Australia. Source: Authors' own work

changes enhance the implementation of CE strategies, particularly R5 (Refurbish), by extending product lifespans through repair and refurbishment, and R1 (Rethink), by promoting shared use and service-based consumption. The resulting material flows are represented by light blue lines on the map, illustrating how circular strategies reshape and redirect them.

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

Similarly, Figure 3b illustrates the Co-location program for shared flexible offices in case 11 (see Figure C11 in Appendix C for details). This model introduces new actors, including operators, co-occupiers, and IT service providers, into the baseline value chain (shown in red). The landlord and operations contractor act as main actors, influencing other existing ones (indicated in green) and generating both new (red lines) and modified (green lines) activities and interactions. Enabled by the co-location business model and IT technologies, these transformations result in a narrowing of the resource loop, depicted by the light blue lines in the visualisation.

Overall, based on the mapped value chain across all cases, changes driven by the adoption of circular practices can be categorised into the following types, with some instances may occur simultaneously: (1) Adding actors, e.g. the government becomes a new actor in case 13 within the value chain by its role in circular procurement policies through City San Francisco's green carpet policy in the USA (see Figure C13 in appendix C); (2) Omitting actors, e.g. strip-out contractors are removed, as the supplier takes on the responsibility for collecting carpets at EoU, taking them back and recycling them through the Desso Carpet Lease™ Program in the Netherlands (see Figure C9 in appendix C); (3) Reorganising the value chain, e.g. a clear reorganisation of the value chain, where a new arrangement and process are established among the landlord, operating company, co-occupiers, and an IT service company to provide shared services in the Hub Australia program (see Figure C11 in appendix C); (4) Adding activities, e.g. UK interior designers incorporate Raised Floor Access (RAF) into the design process, promoting repairability and extending product lifespan and adding an activity to design activities via case 4, White Collar Factory Project (see Figure C4 in appendix C); (5) Omitting activities, e.g. in case 2, practice 9 (Stockland Flight Centre project in Australia), traditional carpet installation by fit-out contractors is omitted, shifting installation to suppliers who use glue-free methods, facilitating easier collection at EoU (changed activity No 5 in Figure C2 in appendix C); (6) Adding interactions, e.g. a new consultation interaction forms between the interior design team and the supplier's design team to create modular, movable sliding partitions (added interaction No 2 for case 6, Sky Believe project, UK, shown in Figure C6 in appendix C); and (7) Omitting interactions, e.g. in case 12, the direct interaction between users and the waste contractor is removed, with the waste contract now handled between the supplier and waste contractor (Compare linear LCVC with circular LCVC in Figure C12 in appendix C).

Based on the circular LCVCs, all actors involved in these transitions, both contributing and collaborating, were systematically identified and analysed to construct the overall collaborating actor network. The structured datasets of actor connections, derived from the LCVCs and used for network construction, are provided in Table D1 (Appendix D). These datasets enable traceability of the coding process, support the reconstruction of the network in Gephi, and enhance the reproducibility of the reported results. Table C1 summarises these actors and their corresponding practices, coded as Pij. Contributing actors directly influence the value chain by performing or adapting activities, creating new interactions, or responding to initiatives led by others. For instance, in case 12, (see Figure 3a), which illustrates a case utilising FaaS, the contributing actors include the supplier, waste contractor, users, and interior designer. Collaborating actors, represented by dotted lines in the LCVCs, connect through cooperative relationships that support these transitions; for example, in this case, collaboration between the interior designer and the supplier, between the supplier and the users, and between the supplier and the waste contractor.

3.3 Social network structure and analysis

Figure 4 illustrates the frequency of actors within the value chain based on contributing actors from Table D1 (in Appendix D), highlighting their involvement in circular practices. Users (landlords and occupiers) appear most frequently (31 occurrences), reflecting their dominant influence in decisions related to material and design selection, space utilisation, lease agreements, and asset management. Suppliers (21 occurrences) and interior designers (20 occurrences) also play pivotal roles, with suppliers managing material flows and providing

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

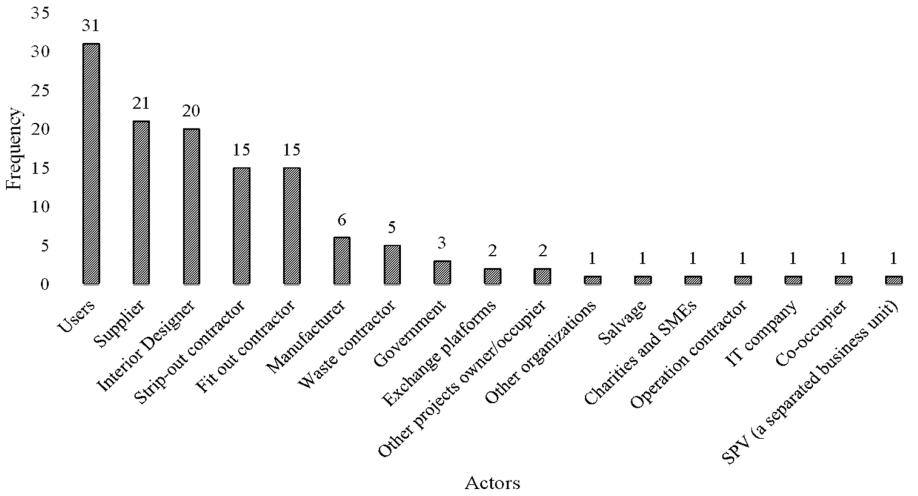


Figure 4. Frequency of various actors of the fit-out value chain involved in circular practices

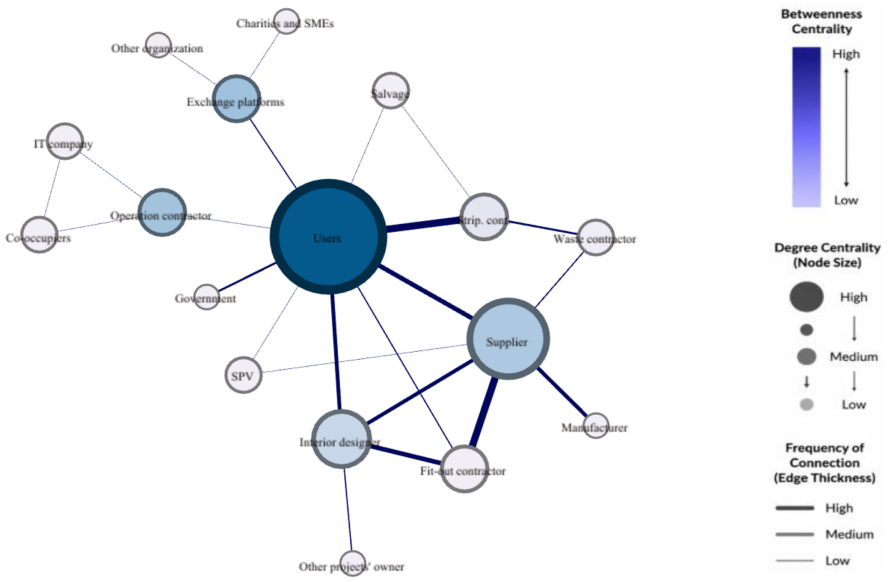
sustainable product specifications, while interior designers embed circular design principles through adaptive solutions and sustainable fit-out specifications. Fit-out and strip-out contractors each appear 15 times, underscoring their crucial roles in dismantling, refurbishing, and reinstalling materials to facilitate reuse, repurposing, and recycling. However, frequency alone does not reflect relational influence; therefore, centrality analysis is used to interpret how actors position themselves within the network and influence system-level outcomes.

The aggregated collaborating actor network comprises 17 nodes and 23 edges. It has a network density of 0.169, indicating that only 16.9% of all possible connections among the identified actors are existing. This relatively low density reflects limited overall connectivity across the value chain. Nevertheless, the network has an average clustering coefficient of 0.548, demonstrating a moderate tendency for actors to form locally interconnected groups, and an average path length of 2.419, indicating that any two actors are separated by approximately 2.42 connections on average. Together, these metrics characterise a network that is locally clustered but sparsely connected overall.

Figure 5 visualises the structure of this network, developed using Gephi, and the relative positions of its actors. In this network, nodes represent actors and edges denote collaborating relationships. Node size is proportional to degree centrality, reflecting the number of direct connections maintained by each actor; larger nodes therefore indicate higher levels of connectivity and involvement in collaborative activities. Node colour represents betweenness centrality, capturing the extent to which an actor functions as a bridge between others by occupying positions along the shortest paths within the network. Darker nodes thus indicate a stronger bridging role and a greater capacity to facilitate connections across otherwise disconnected actors. The frequency of direct collaborations between actors in circular practices is illustrated by edge thickness, with thicker edges representing more frequent interactions. This frequency attribute is used only for visualisation and does not influence the unweighted degree or betweenness centrality calculations. This distinction enables the network visualisation to communicate the relative frequency of documented collaborations while the centrality measures capture actors' structural positions without frequency-based or subjective weighting.

3.3.1 Centrality, power and governance in actor networks. While user group, including landlords, tenants, and their representatives such as asset managers, are the most frequently occurring actors, their significance extends beyond participation. As illustrated in Figure 5,

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026



Global network metrics
Total Nodes=17, Total Edges=23, Network density=0.169, average clustering coefficient= 0.547, and average path length=2.419

Figure 5. Collaborating actor network for all case studies

users connect multiple actor groups, including suppliers, designers, contractors, and policymakers, allowing them to coordinate material flows, align stakeholder decisions, and influence circular outcomes across the lifecycle. This structural positioning demonstrates that circular transition is not purely supply-driven, but is largely governed by demand-side control over network coordination and resource allocation.

Table 2 ranks collaborating actors based on their degree and betweenness centrality values. Beyond structural positioning, these centrality measures reveal deeper dynamics of power and control within the network. Users exhibit both the highest degree centrality (0.56) and the highest betweenness centrality (0.75), indicating a dominant structural position. High degree centrality reflects their extensive direct connections to multiple actors, while their exceptionally high betweenness centrality indicates a strong bridging role, positioning them along the shortest paths that connect otherwise fragmented parts of the network. Therefore users function as a governance node, controlling key decision points related to procurement, leasing, and asset management.

Suppliers and interior designers also emerge as central actors, though their influence operates differently. According to Table 2, suppliers (degree = 0.38; betweenness = 0.20) and interior designers (degree = 0.25; betweenness = 0.13) maintain relatively high connectivity, indicating strong involvement in collaboration processes, while also performing secondary bridging roles within the network. Suppliers shape circular outcomes through control over material specifications, and lifecycle management, whereas interior designers influence upstream decisions by embedding circular principles into design strategies. Together, these actors form the core operational cluster of the network, where decision-making authority (by users) intersects with technical and implementation capacity (by suppliers and designers). This configuration highlights that effective circular transition depends on the alignment between governance power and operational capability, rather than the isolated influence of individual actors.

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

Table 2. Centrality degrees of identified actors

Actor	Description	Degree centrality	Betweenness centrality
Users	Building owners, tenants, occupiers, asset managers	0.56	0.75
Supplier	Product producers and retailers	0.38	0.20
Interior designer	Designers of interior fit-outs	0.25	0.13
Exchange platforms	Product resale and exchange platforms such as Globchain	0.19	0.24
Fit out contractor	Contractors delivering fit-out installation	0.19	0.00
Strip-out contractor	Contractors responsible for removing fit-outs and dismantling	0.19	0.04
Operation contractor	Workspace operators facilitating flexible asset and space management	0.19	0.23
Waste contractor	Waste collection and processing firms	0.13	0.01
Co-occupier	Shared-space users or tenants	0.13	0.00
IT company	IT service providers for hot desking and sharepoints	0.13	0.00
SPV[a]	A separate business unit or entity created to own fitout assets	0.13	0.00
Salvage	Salvage operators responsible for dismantling, sorting, and redirecting recovered products	0.13	0.00
Manufacturer	Material, and sub-element manufacturer	0.06	0.00
Charities and SMEs[b]	Reuse-oriented charities and small- and medium-sized enterprises	0.06	0.00
Government	Regulatory and policy authorities	0.06	0.00
Other projects owner	External project or building owners	0.06	0.00

Note(s): [a]SPV: Special Purpose Vehicle, a legal entity created by a parent company to isolate financial risk, manage specific assets, or facilitate complex transactions, [b]SME: small- and medium-sized enterprises

3.3.1.1 Bridging and integrative role. Exchange platforms emerge as key bridging actors within the network. As indicated in Table 2, they exhibit moderate degree centrality (0.19) but comparatively high betweenness centrality (0.24), highlighting a structural position that is less defined by the number of direct connections and more by their role in linking otherwise disconnected actors. This configuration indicates that their influence lies in enabling interactions across fragmented parts of the network rather than dominating through direct engagement.

From the perspective of the Structural Holes theory (Burt, 2003), actors that bridge gaps between otherwise disconnected groups, referred to as structural holes, gain access to diverse information and are able to mediate relationships across the network. Such positions enhance their capacity to influence coordination and enable the flow of resources between fragmented clusters. In this context, exchange platforms occupy these strategically advantageous positions. By bridging these structural holes, exchange platforms facilitate the flow of information, materials, and coordination across the value chain, linking actors that would otherwise remain weakly connected. As illustrated in Figure 5, exchange platforms connect users, charities, SMEs, and suppliers, enabling the circulation of resources beyond primary supply chains.

3.3.2 Structural gaps and underutilised actors. Despite the presence of central and bridging actors, several key actors remain underutilised or weakly connected within the network, despite their significant involvement in circular practices (as reflected by their high frequency). This misalignment limits their potential influence in driving circular initiatives. In particular, waste contractors, strip-out contractors, fit-out contractors, and the government show low centrality measures, indicating limited engagement and bridging roles in circular transitions.

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

Waste contractors exhibit low degree centrality (0.13) and minimal betweenness (0.01), suggesting poor connectivity and limited influence in linking actors. This weak role hinders effective material circulation. Strip-out contractors, who are crucial for material dismantling during office strip-outs, display a degree centrality of 0.19 and low betweenness (0.04), reflecting weak ties with exchange platforms, waste contractors, and fit-out contractors. Fit-out contractors also show low engagement, with a degree centrality of 0.19 and no bridging influence (betweenness = 0). Despite their key role in implementing circular design strategies, they remain weakly linked to interior designers, suppliers, and landlords, limiting their impact on circular procurement and installation.

The government exhibits low connectivity in the network (degree = 0.06; betweenness = 0), indicating a limited direct bridging role among actors in the analysed value chain. This reflects the analytical scope of the network, which captures direct collaborative interactions, whereas government influence is primarily exercised indirectly through regulatory frameworks and procurement policies. In practice, such policies are typically mediated through users or their representatives (such as asset managers), who are required to incorporate circular requirements into procurement decisions rather than through direct engagement with multiple actors. As a result, the government's systemic influence is not represented as a bridging position in the network.

4. Collaboration opportunities for addressing network gaps

To conduct the scenario-based sensitivity analysis, nine generalisable actors broadly relevant across office fit-out value chains across different contexts were selected: users, suppliers, interior designers, exchange platforms, fit-out contractors, strip-out contractors, waste contractors, manufacturers, and government. Within this general actor network, four underutilised actors were examined: government, waste contractors, strip-out contractors, and fit-out contractors. For each actor, eight scenarios were simulated by connecting the focal actor to each of the other general actors one at a time. This produced 32 intervention scenarios in total. For each scenario, the betweenness centrality of the focal actor, was recalculated to assess how each potential connection would affect the focal actor's capacity to bridge otherwise disconnected parts of the network.

Figure 6 presents a heatmap of betweenness centrality changes to demonstrate how each potential connection influences the bridging capacity of the four underutilised actors. The heatmap enables systematic identification of high-impact connections by highlighting scenarios that produce the greatest increases in betweenness centrality, thereby revealing which relationships most effectively enhance network integration.

The sensitivity analysis reveals (Figure 6) that the effectiveness of new collaborations is driven by consistent structural patterns rather than being actor-specific. First, connections to exchange platforms consistently generate the greatest improvements, particularly for use and post-use actors. Such collaborations could be facilitated by incorporating requirements for material recovery through exchange or second-hand markets into procurement specifications, demolition contracts, or strip-out agreements. The highest observed increase (+0.06) occurs when fit-out contractors are connected to exchange platforms, with similarly strong effects for waste contractors (+0.04). This indicates that secondary market actors play a critical role in bridging otherwise disconnected lifecycle stages, especially between use and post-use phases. This pattern is aligned with practices observed in cases such as Case 10 (Globechain), where linking fit-out contractors to exchange platforms facilitates circular transition by enabling the reuse of second-hand materials in new installations.

Second, connections to manufacturers produce moderate but consistently positive effects across multiple actors. Improvements of approximately +0.05 (in Figure 6) in the betweenness of strip out and fit-out contractors suggest that linking post-use and use actors to production systems enhances lifecycle integration, particularly by strengthening reverse logistics pathways. These connections could be facilitated through manufacturer take-back schemes,

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

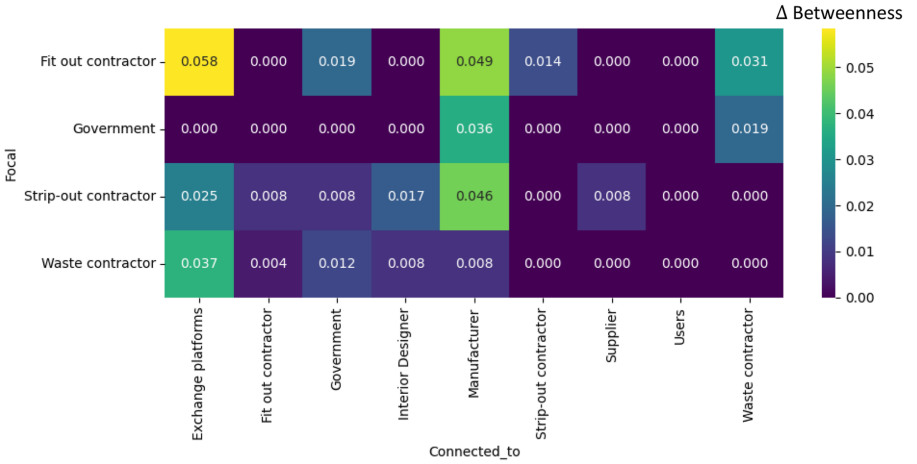


Figure 6. Sensitivity analysis of changes in betweenness centrality for underutilised actors

product stewardship arrangements, or upgrade business models (Ahmadi *et al.*, 2026) that support refurbishment and reverse logistics. However, these effects are comparable to those associated with exchange platforms, indicating that production-side integration alone is insufficient to drive system-wide coordination and it should be complemented by the development of secondary market mechanisms.

Third, the effectiveness of new collaborations depends critically on whether they bridge structurally distant parts of the network, rather than simply increasing the number of connections. Several scenarios yield negligible changes ($\leq$0.01 in Figure 6), particularly when linking actors that are already closely connected or occupy similar positions within the value chain. This demonstrates that network improvement is not driven by density, but by the strategic positioning of connections.

Finally, connections involving government actors generate only modest improvements (up to $+$0.036), reinforcing the interpretation that their influence is primarily indirect. Rather than acting as a central actor, government actors contribute to coordination through enabling conditions, such as policy and procurement frameworks, rather than through direct structural integration within the network. Overall, the results from the sensitivity analysis demonstrate that circular transition is driven by targeted network reconfiguration, indicating that improving circularity depends less on increasing collaboration broadly and more on strategically bridging key structural gaps across lifecycle stages.

5. Implications and contributions

From a theoretical perspective, the study refines the understanding of value chains in CE contexts by developing an integrative LCVC representation. Rather than proposing a new theoretical model, the LCVC operationalises and synthesises existing lifecycle thinking, value chain analysis, and CE principles into a coherent analytical structure. This representation enables the systematic examination of how circular practices reshape actor roles, interactions, and material flows across pre-use, use, and post-use stages. In doing so, it translates value chain transformations into an actor-network logic, providing a structured way to interpret coordination dynamics and relational dependencies within circular systems.

Methodologically, the study contributes by combining LCVC mapping with SNA to examine collaboration structures within the value chain. This integration enables both visual and quantitative analysis of actor interactions, allowing the identification of central actors,

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

bridging roles, and structural gaps. In particular, the application of scenario-based sensitivity analysis extends conventional SNA approaches by systematically evaluating how targeted network interventions influence coordination capacity. Although developed in the context of office fit-outs, the integrated analytical workflow is applicable to other construction value chains where circular transition depends on multi-actor coordination. While the specific network configurations, actor priorities, and intervention strategies will vary according to value chain characteristics and contextual conditions, the underlying procedure for translating qualitative evidence into measurable collaboration networks remains applicable across different project settings. This provides a scalable analytical workflow for assessing potential collaboration strategies and prioritising high-impact relationships in circular transitions.

From a practical perspective, the findings highlight that circular transition is not driven by isolated practices, but by the configuration and reconfiguration of actor networks. The analysis identifies key leverage points, including the central role of users in coordinating decisions, the bridging function of exchange platforms in enabling secondary material flows, and the underutilised potential of actors such as waste contractors, fit-out contractors, and government bodies. The results further demonstrate that improving circularity depends less on increasing collaboration broadly and more on strategically strengthening connections that bridge structural gaps across lifecycle stages. These insights provide actionable guidance for industry stakeholders and policymakers to design targeted interventions that enhance coordination, enable material circulation, and support more effective circular implementation in office fit-outs.

6. Limitations and future directions

Despite the contributions of this study, several limitations should be acknowledged. First, the office fit-out sector is a rapidly evolving and practice-driven domain, where industry-led innovations often outpace the development of consolidated academic theory. Consequently, many CE practices are documented primarily in grey literature rather than peer-reviewed sources. While these sources provide valuable insights into emerging practices, their use may introduce potential biases, including variations in reporting quality and detail, publication bias towards successful initiatives, and the predominance of case studies from developed countries. To minimise these limitations, this study adopted predefined inclusion criteria, systematic data extraction procedures, and a consistent coding protocol to ensure transparency and comparability across cases. Nevertheless, variations in the quality and completeness of the available documentation may have influenced the comprehensiveness of the dataset. Despite these limitations, this approach remains appropriate for capturing emerging practices in an under-theorised and dynamic field.

Besides, the study is based on a dataset comprising 42 circular practices derived from 23 case studies, representing the maximum number of relevant and sufficiently documented cases identified through the systematic search and screening process. Although these cases were selected to reflect diverse geographical and organisational contexts, the relatively limited sample size and case-based nature of the analysis may constrain the generalisability of the findings. The results should therefore be interpreted as indicative of recurring patterns and structural tendencies within the office fit-out value chain, rather than as statistically representative conclusions. Future research could strengthen the robustness and contextual relevance of these findings by incorporating primary data collection methods, such as interviews and surveys, to validate the identified patterns and capture stakeholder perspectives across different organisational and regulatory contexts.

Although this study examines the role of network dynamics and structural mechanisms in enabling the implementation of CE practices in office fit-outs, these processes are inherently influenced by macro-level contextual factors that extend beyond the analysed network structure. Factors such as regulatory environments, market conditions, organisational culture, and economic incentives can significantly shape how circular practices are adopted and

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

operationalised across the value chain. As a result, the findings may not fully capture the variability of circular transition processes across different contexts. Future research should therefore adopt complementary approaches to examine these contextual factors influences in parallel, enabling a more systematic understanding of how these conditions interact with network structures to facilitate or constrain the adoption of CE practices.

Finally, this study adopts an exploratory and interpretive analytical approach aimed at revealing patterns of actor-network configurations rather than testing predefined hypotheses. However, the combination of systematic case selection, structuring data, and cross-case comparison enhances analytical robustness by grounding findings in recurring empirical patterns rather than isolated observations. Furthermore, while the network analysis identifies potential improvements in collaboration structures and coordination capacity, it does not quantitatively assess the resulting material-flow or environmental outcomes. Therefore, changes in network centrality should not be interpreted as direct evidence of improved circularity performance. Future research could integrate network analysis with material-flow and environmental assessments to examine whether structural improvements translate into measurable circular outcomes.

7. Conclusion

The present study examined how collaborative structures and actor-network configurations shape the implementation of CE practices within the office fit-out value chain. Drawing on a dataset of 42 circular practices identified across 23 case studies, the research provides an empirically grounded analysis of how circular transition is realised through the reorganisation of actor roles, interactions, and material flows across lifecycle stages. By integrating lifecycle-based value chain mapping with social network analysis, the study offers a structured approach to understanding coordination mechanisms within circular systems.

The findings demonstrate that circular transition in office fit-outs is fundamentally a coordination challenge at the meso level. While circular strategies and policies are increasingly available, their effective implementation depends on how actors interact within the value chain. The analysis shows that office fit out users, including landlords, tenants and their representatives (e.g. asset managers) occupy the most dominant structural positions within the network, functioning as the primary coordinators of decision-making and resource allocation. Owing to this governance position, they are uniquely positioned to initiate circular transition by embedding circular requirements into design briefs, procurement processes, leasing arrangements, and asset management practices. In doing so, they can cascade circular requirements throughout the value chain, influencing suppliers, interior designers, contractors, and other downstream actors, thereby driving the reconfiguration of value-chain relationships toward circular implementation.

This governance role is reinforced by the dominant network positions of suppliers and interior designers, which emerge as the second and third most central actors in the collaboration network. Their high connectivity and secondary bridging roles enable them to translate users' strategic decisions into practical implementation by influencing material specification, lifecycle management, and the integration of circular principles into design. Exchange platforms complement this governance structure through their distinctive bridging role within the network. Their comparatively high betweenness centrality enables them to connect otherwise fragmented actors, facilitating information exchange, material circulation, and coordination across lifecycle stages. The sensitivity analysis further highlights their strategic importance, showing that strengthening links with exchange platforms consistently produces the greatest improvements in the network integration of underutilised actors, particularly fit-out and waste contractors.

In contrast, actors such as waste contractors, strip-out contractors, fit-out contractors, and government bodies remain underutilised, with limited structural influence despite their operational importance.

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

Their limited connectivity constrains material recovery, reverse logistics, and cross-lifecycle coordination, reducing the effectiveness of circular implementation. The findings suggest that greater circularity depends on strategically strengthening the integration of contractors within the network, while governments can more effectively support transition through enabling policy and procurement frameworks that influence collaboration indirectly rather than acting as direct coordinating actors.

The sensitivity analysis further reveals that the effectiveness of collaboration strategies is structurally dependent rather than uniform across actors. Targeted connections, particularly those linking post-use and use stage actors (such as fit-out contractors, strip-out contractors, and waste contractors) with exchange platforms and manufacturers, enhance coordination capacity by bridging gaps between lifecycle stages. Importantly, these prioritised connections are not intended to represent entirely new organisational structures but can largely be established through existing industry mechanisms, such as manufacturer take-back schemes, product stewardship arrangements, and procurement requirements into project delivery, that incorporate material recovery through exchange and second-hand markets.

However, the observed improvements remain moderate, indicating that circular transition is achieved through the accumulation of strategically positioned interventions rather than through a single dominant change. For instance, connections to manufacturers yields consistent but moderate improvements in the betweenness centrality of strip-out and fit-out contractors, reflecting enhanced integration between post-use and production stages through strengthened reverse logistics pathways. Nevertheless, these effects are similar to those associated with exchange platforms, suggesting that production-side integration alone is insufficient to drive system-wide coordination and must be complemented by the development of secondary market mechanisms.

The study demonstrates that achieving circularity in office fit-outs requires a shift from isolated implementation of circular practices toward the deliberate reconfiguration of actor networks. Improving circularity depends less on increasing collaboration broadly and more on strategically strengthening connections that bridge structural gaps across lifecycle stages. By providing an integrated analytical approach and empirically grounded insights into collaboration structures, this research offers both theoretical grounding and practical direction for enabling coordinated circular transitions in the built environment.

Future research should extend this work by incorporating primary data and examining how contextual factors, such as policy environments and market conditions, interact with network structures to shape circular outcomes. Although the collaboration mechanisms identified in this study are transferable because they focus on actor relationships rather than country-specific practices, their effectiveness is likely to vary across different regulatory and institutional contexts. Comparative studies across diverse geographical settings would therefore provide valuable insights into how these network interventions can be adapted to support circular transitions under different governance, market, and policy conditions.

Data and code availability statement

The data supporting this study are secondary sources drawn from publicly available industry reports, case studies, and grey literature, listed in Appendix B. The structured dataset derived from these sources, comprising the 42 coded circular practices, the linear and circular LCVC representations for all 23 case studies, and the actor-relational data used to construct the social network, is provided in Appendices B-D of this article. Appendix A contains the notation list and abbreviations used throughout the manuscript. No new primary data were collected. All appendices are available in this online repository on Zenodo (https://doi.org/10.5281/zenodo.21310504). The network metrics, including degree and betweenness centrality, were computed using Gephi version 0.10.1 (Product Version: 0.10.1 202301172018), an open-source network analysis platform; no custom code was developed for this study.

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

AI disclosure

Also, Authors confirm that ChatGPT coupling with Grammarly was used only for language editing and proofreading. These tools were not used to generate research data, conduct the analysis, interpret the findings or formulate the study's conclusions.

Acknowledgments

This research forms part of a broader PhD research project approved by the Deakin University Human Research Ethics Committee (Approval No. 2025/HE001050). The authors acknowledge that this paper does not appear to involve primary research with human participants or animals.

Supplementary material

The supplementary material for this article can be found online.

References

Ahmadi, M., Pournaghshband, A., Piadeh, F. and Hosseini, R. (2025), "Circularity-based embodied carbon performance in building design", *Journal of Cleaner Production*, Vol. 518, 145909, doi: 10.1016/j.jclepro.2025.145909.

Ahmadi, M., Kocaturk, T., Piadeh, F., Hassan, A. and Hosseini, R. (2026), "Transforming office fit-outs: a circular approach to redefining value chains, design strategies, and business models", *Engineering, Construction and Architectural Management*, Vol. 33 No. 15, pp. 617-652, doi: 10.1108/ECAM-05-2025-0742.

Arup (2022), "Circular fit-out in retail stores: circular design principles", available at: www.Arup.com (accessed 15 February 2026).

Bastian, M., Heymann, S. and Jacomy, M. (2009), "Gephi: an open source software for exploring and manipulating networks", *Proceedings of the International AAAI Conference on Web and Social Media*, Vol. 3 No. 1, pp. 361-362, doi: 10.1609/icwsm.v3i1.13937.

Bocken, N.M.P., De Pauw, I., Bakker, C. and Van Der Grinten, B. (2016), "Product design and business model strategies for a circular economy", *Journal of Industrial and Production Engineering*, Vol. 33 No. 5, pp. 308-320, doi: 10.1080/21681015.2016.1172124.

Bright, D.A., Greenhill, C., Reynolds, M., Ritter, A. and Morselli, C. (2015), "The use of actor-level attributes and centrality measures to identify key actors: a case study of an Australian drug trafficking network", *Journal of Contemporary Criminal Justice*, Vol. 31 No. 3, pp. 262-278, doi: 10.1177/104398621455337.

Burt, R.S. (2003), "The social structure of competition", in *Networks in the Knowledge Economy*, Oxford University Press, New York, NY, Vol. 13 No. 2, pp. 57-91.

Casas-Arredondo, M. (2021), *Circular Economy and Office Fit-Out: An Analysis for Office Fitout Processes Based on Material Flows (PhD Thesis)*, University College London.

Casas-Arredondo, M., Croxford, B. and Domenech, T. (2018), "Material and decision flows in non-domestic building fit-outs", *Journal of Cleaner Production*, Vol. 204, pp. 916-925, doi: 10.1016/j.jclepro.2018.08.328.

CIRCO (2024), "Creating business through circular design", available at: www.circonl.nl (accessed 1 October 2025).

CLF (2019), "LCA for low carbon construction: life cycle assessment of tenant improvement in commercial office buildings", available at: http://www.carbonleadershipforum.org/ (accessed 1 March 2026).

Das, K., Samanta, S. and Pal, M. (2018), "Study on centrality measures in social networks: a survey", *Social Network Analysis and Mining*, Vol. 8, pp. 1-11, doi: 10.1007/s13278-018-0493-2.

Du, X. and Costello, K.L. (2025), "Information snowballing: information practices in the context of sustainable food practices", *Journal of Documentation*, Vol. 81 No. 2, pp. 469-490, doi: 10.1108/jd-08-2024-0200.

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

Eisenreich, A., Füller, J., Stuchtey, M. and Gimenez-Jimenez, D. (2022), "Toward a circular value chain: impact of the circular economy on a company's value chain processes", *Journal of Cleaner Production*, Vol. 378, 134375, doi: 10.1108/JD-08-2024-0200.

Ellen Macarthur Foundation (EMF) (2021a), "Completing the picture: how the circular economy tackles climate change", available at: www.ellenmacarthurfoundation.org (accessed 20 February 2025).

Ellen MacArthur foundation (EMF) (2021b), "Bringing office furniture full circle: Ahrend", available at: www.ellenmacarthurfoundation.org (accessed 1 November 2025).

Environmental Protection Agency (EPA) (2024), "Durable goods: product-specific data", available at: www.epa.gov (accessed 25 October 2025).

Fini, A.A.F. and Forsythe, P. (2020), "Barriers to reusing and recycling office fit-out: an exploratory analysis of demolition processes and product features", *Construction Economics and Building*, Vol. 20 No. 4, pp. 42-62, doi: 10.3316/informit.576485516383902.

Forsythe, P. (2017), "Quantifying the recurring nature of fitout to assist LCA studies in office buildings", *International Journal of Building Pathology and Adaptation*, Vol. 35 No. 3, pp. 233-246, doi: 10.1108/IJBPA-04-2017-0020.

Forsythe, P. and Wilkinson, S. (2015), "Measuring office fit-out changes to determine recurring embodied energy in building life cycle assessment", *Facilities*, Vol. 33 Nos 3/4, pp. 262-274, doi: 10.1108/F-08-2013-0065.

Forward Thinking Design (FTD) (2023), "Fit-out diversion report for Stockland de-fit", available at: www.ftdcircular.com (accessed 20 October 2025).

Gomes Araújo, L. and Lucko, G. (2022), "Best practices for case studies in construction engineering and management research", *Journal of Construction Engineering and Management*, Vol. 148 No. 8, 04022062, doi: 10.1061/(ASCE)CO.1943-7862.0002312.

Guzzo, D., Pigosso, D.C.A., Videira, N. and Mascarenhas, J. (2022), "A system dynamics-based framework for examining circular economy transitions", *Journal of Cleaner Production*, Vol. 333, 129933, doi: 10.1016/j.jclepro.2021.129933.

Hald, K.S. and Spring, M. (2023), "Actor–network theory: a novel approach to supply chain management theory development", *Journal of Supply Chain Management*, Vol. 59 No. 2, pp. 87-105, doi: 10.1111/jscm.12296.

Hart, J., Adams, K., Giesekam, J., Tingley, D.D. and Pomponi, F. (2019), "Barriers and drivers in a circular economy: the case of the built environment", *Procedia Cirp*, Vol. 80, pp. 619-624, doi: 10.1016/j.procir.2018.12.015.

Host, K. (2018), "Strip out waste guidelines", available at: www.betterbuildingspartnership.com.au (accessed 20 January 2026).

Jemal, K.M., Aibinu, A. and Oraee, M. (2026), "State of circular business models and product service system in construction research: a bibliometric-qualitative review", *Smart and Sustainable Built Environment*, pp. 1-25, doi: 10.1108/SASBE-07-2025-0431.

Kalmykova, Y., Sadagopan, M. and Rosado, L. (2018), "Circular economy–from review of theories and practices to development of implementation tools", *Resources, Conservation and Recycling*, Vol. 135, pp. 190-201, doi: 10.1016/j.resconrec.2017.10.034.

Kocaturk, T. and Reza Hosseini, M. (2023), "Towards a circular transition of the built environment: systemic and transdisciplinary models, methods and perspectives", *Building Research and Information*. doi: 10.1080/09613218.2022.2155377.

Konietzko, J., Bocken, N. and Hultink, E.J. (2020), "Circular ecosystem innovation: an initial set of principles", *Journal of Cleaner Production*, Vol. 253, 119942, doi: 10.1016/j.jclepro.2019.119942.

Landherr, A., Friedl, B. and Heidemann, J. (2010), "A critical review of centrality measures in social networks", *Business and Information Systems Engineering*, Vol. 2 No. 6, pp. 371-385, doi: 10.1007/s12599-010-0127-3.

Latour, B. (2005), *Reassembling the Social: An Introduction to Actor-Network-Theory*, Oxford University Press, ISBN: 9780199256044.

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

Law, J. (1992), "Notes on the theory of the actor-network: ordering, strategy, and heterogeneity", *Systems Practice*, Vol. 5 No. 4, pp. 379-393, doi: 10.1007/BF01059830.

Markou, I., Sinnott, D. and Thomas, K. (2025), "Current methodologies of creating material passports: a systematic literature review", *Case Studies in Construction Materials*, Vol. 22, e04267, doi: 10.1016/j.cscm.2025.e04267.

Mehra, A., Borgatti, S.P., Soltis, S., Floyd, T., Halgin, D.S., Ofem, B. and Lopez-Kidwell, V. (2014), "Imaginary worlds: using visual network scales to capture perceptions of social networks", *Contemporary Perspectives on Organizational Social Networks*, Vol. 40, pp. 315-336, doi: 10.1108/S0733-558X(2014)0000040016.

Menzies, G.F. and Tsolaki, T. (2016), "Think outside the box: 'Churn' and the environmental impact of office fit-out retrofit", *CIBSE Technical Symposium 2016*, Chartered Institution of Building Services Engineers.

Moreno, J.L. (1934), "Who shall survive? A new approach to the problem of human interrelations", *Nervous and Mental Disease Publishing*.

Moslehian, A.S., Kocaturk, T., Andrews, F. and Tucker, R. (2022), "The nature of innovation in hospital building design: a mixed grounded theory study", *Construction Innovation*, Vol. 23 No. 4, pp. 792-814, doi: 10.1108/CI-12-2021-0236.

Piadeh, F. and Pournaghshband, A. (2026), "Application of Artificial Intelligence in circularity assessment of building waste materials: a comprehensive review of recent advances and future directions", *Circular Economy and Sustainability*, Vol. 6 No. 2, p. 152, doi: 10.1007/s43615-026-00893-4.

Pieroni, M.P.P., McAloone, T.C. and Pigosso, D.C.A. (2019), "Business model innovation for circular economy and sustainability: a review of approaches", *Journal of Cleaner Production*, Vol. 215, pp. 198-216, doi: 10.1016/j.jclepro.2019.01.036.

Potting, J., Hekkert, M.P., Worrell, E. and Hanemaaijer, A. (2017), "Circular economy: measuring innovation in the product chain", *Planbureau Voor de Leefomgeving*, PBL publishers, No. 2544, available at: http://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2016-circular-economy-measuring-innovation-in-product-chains-2544.pdf (accessed 20 April 2026).

Pournaghshband, A., Piadeh, F., Ahmadi, M. and Sahaf, A. (2026), "Modular multi-domain AI framework for sustainable optimisation of design material quantity", *Environmental Impact Assessment Review*, Vol. 121, 108582, doi: 10.1016/j.eiar.2026.108582.

Rashidian, S., Hossain, S.K., Volz, K., Teo, M. and Rose, T.M. (2026), "Digital pathways to circularity: stakeholder engagement across the construction lifecycle in the era of construction 4.0", *Smart and Sustainable Built Environment*, pp. 1-29, doi: 10.1108/SASBE-09-2025-0565.

Rawlings, C.M., Smith, J.A., Moody, J. and McFarland, D.A. (2023), *Network Analysis: Integrating Social Network Theory, Method, and Application with R*, Cambridge University Press, ISBN: 978-1-61190-0.

RESET (2022), "Embodied carbon and circularity in office interiors: Part 2", available at: https://www.resetbuild.com (accessed 5 February 2026).

Rucińska, J., Komerska, A. and Kwiatkowski, J. (2020), "Preliminary study on the GWP benchmark of office buildings in Poland using the LCA approach", *Energies*, Vol. 13 No. 13, p. 3298, doi: 10.3390/en13133298.

Shooshtarian, S., Caldera, S., Maqsood, T. and Ryley, T. (2020), "Using recycled construction and demolition waste products: a review of stakeholders' perceptions, decisions, and motivations", *Recycling*, Vol. 5 No. 4, p. 31, doi: 10.3390/recycling5040031.

Treloar, G.J., McCoubrie, A., Love, P.E.D. and Iyer-Raniga, U. (1999), "Embodied energy analysis of fixtures, fittings and furniture in office buildings", *Facilities*, Vol. 17 No. 11, pp. 403-410, doi: 10.1108/02632779910291877.

Valente, T.W., Coronges, K., Lakon, C. and Costenbader, E. (2008), "How correlated are network centrality measures?", *Connections*, Vol. 28 No. 1, p. 16.

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026

Van der Lans, P.A., Jensen, C.A. and Oraee, M. (2023), "Overcoming head contractor barriers to sustainable waste management solutions in the Australian construction industry", *Buildings*, Vol. 13 No. 9, p. 2211, doi: 10.3390/buildings13092211.

Wang, J., Li, Z. and Tam, V.W.Y. (2015), "Identifying best design strategies for construction waste minimization", *Journal of Cleaner Production*, Vol. 92, pp. 237-247, doi: 10.1016/j.jclepro.2014.12.076.

Wasserman, S. and Faust, K. (1994), *Social Network Analysis: Methods and Applications*, Cambridge University Press.

Wilmot, K., McGee, C. and Milne, G. (2014), *Market Research: Tenancy Fitout Material Procurement Attitudes and Practices*, Report Prepared by the Institute for Sustainable Futures, University of Technology, Sydney, available at: http://hdl.handle.net/10453/30468

Yin, R.K. (2018), *Case Study Research and Applications*, Vol. 6, Sage, Thousand Oaks, CA.

Zaman, A., Maqsood, T., Shooshtarian, S., Wong, P.S.P., Ryley, T., Caldera, S., Khalfan, M. and Yang, R.J. (2022), *Creation and Stimulation of End-markets for Construction and Demolition Waste in Australia*, Sustainable Built Environment National Research Centre (SBEnrc).

Corresponding author
Mohsen Ahmadi can be contacted at: s222345972@deakin.edu.au

For instructions on how to order reprints of this article, please visit our website:
www.emeraldgrouppublishing.com/licensing/reprints.htm
Or contact us for further details: **permissions@emeraldinsight.com**

Downloaded from www.emerald.com/sasbe/article-pdf/doi/10.1108/SASBE-05-2026-0439/11966070/sasbe-05-2026-0439en.pdf by University of Hertfordshire user on 18 November 2026