

Digital Marketplaces as Catalysts for Circular Economy in Construction: Exploring the Role of Modular Business Models

Saikarthik Vakkanthula¹, Atefeh Hesarbani², Soroush Abbaspour³, Amr S. Allam^{4,5}, Farzad Jalaei⁶, Arash Hosseini Gourabpasi⁷, and Mazdak Nik-Bakht⁸

Abstract

Question: The lack of profitability limits the adoption of deconstruction practices in the construction industry, largely due to inefficient secondary markets for recovered products. Although digital marketplaces (DMPs) can improve stakeholder connectivity and economic appeal, their uptake remains constrained by limited product diversity, fragmented operations, unreliable product information, and a lack of standardization. This results in continued reliance on virgin materials and limited recovery from end-of-life buildings.

Purpose: This study investigates how characteristics of salvaged products from the built environment influence combinations of business models (BMs) in DMPs to enable lean operational processes that support improved reverse supply chain logistics.

Research Method: A two-stage methodology was applied. First, the business characteristics of existing DMPs in construction were extracted by applying Osterwalder's Business Model Canvas (BMC) and aggregated as business model elements (BME) through morphological analysis. Second, these BME were mapped against building shearing layers using an interaction matrix informed by

¹ Graduate Student, Department of Building, Civil, and Environmental Engineering, Concordia University, Montreal, Quebec, Canada, saikarthik.vakkanthula@mail.concordia.ca

² Ph.D. Student, Department of Building, Civil, and Environmental Engineering, Concordia University, Montreal, Quebec, Canada, atefeh.hesarbani@mail.concordia.ca

³ Ph.D. Candidate, Department of Building, Civil, and Environmental Engineering, Concordia University, Montreal, Quebec, Canada, soroush.abbaspour@mail.concordia.ca

⁴ Ph.D. Candidate, Department of Building, Civil, and Environmental Engineering, Concordia University, Montreal, Quebec, Canada, amr.allam@mail.concordia.ca

⁵ Assistant Lecturer, Construction and Building Engineering Department, Arab Academy for Science, Technology and Maritime Transport, Alexandria, Egypt

⁶ Research Officer, Construction Research Center, National Research Council Canada, 1200 Montreal Rd., Ottawa, ON, Canada K1A 0R6, farzad.jalaei@nrc-cnrc.gc.ca

⁷ Research Officer, Construction Research Center, National Research Council Canada, 1200 Montreal Rd., Ottawa, ON, Canada K1A 0R6, Arash.HosseiniGourabpasi@nrc-cnrc.gc.ca

⁸ Associate Professor, Building, Civil & Environmental Engineering, and Founding Director, Concordia Digital Twins Hub, Gina Cody School of Engineering & Computer Science, Concordia University, Montreal, Quebec, Canada, mazdak.nikbakht@concordia.ca

product-specific reuse criteria and iterative brainstorming sessions.

Findings: Analysis of 29 DMPs resulted in 21 BMEs mapped across 5 building shearing layers. The interaction matrix shows that while some BM elements apply across all layers, others are strongly product-dependent, influenced by quality requirements, reuse feasibility, regulations, turnover time, and ease of disassembly. A single, standardized BM may constrain circular-lean objectives. However, DMPs in the construction industry have yet to implement tailored BMs that align with product-specific differences.

Limitations: The analysis is limited to digital marketplaces in Europe and North America and does not establish quantitative KPIs to evaluate the effectiveness of modular business model configurations. In addition, the interaction matrix requires empirical validation by industry experts.

Implications: The interaction matrix provides guidance to DMPs for configuring business models aligned with lean principles to support circular economy objectives.

Value for authors: The authors aim to demonstrate that the BMs function as operational processes in DMPs and should therefore be product-specific rather than uniformly applied across platforms.

Keywords: Circular Economy, Lean Digital Marketplaces, Lean Digital Platforms, Circular Business Models, Circularity

Paper type: Full Paper

Nomenclature

AEC	Architecture, Engineering, and Construction
B2B	Business-to-Business
BIM	Building Information Modelling
BM	Business Model
BMB	Business Model Blocks
BMC	Business Model Canvas
BME	Business Model Elements
CE	Circular Economy
CI	Construction Industry
DfD	Design for Disassembly
DMP	Digital Marketplace
DRMS	Digital Reuse Market Solutions
EoL	End-of-Life
KPI	Key Performance Indicator
P2P	Peer-to-Peer

Introduction & Background

The construction sector is a major consumer of natural resources, accounting for nearly half of global raw material usage, and is a significant contributor to landfills, with construction, renovation, and demolition waste representing more than 30% of the total solid waste (Luga et al., 2025; Mollaei et al., 2023). The construction industry follows a linear “take-make-dispose” model, leading to resource depletion and unsustainable production cycles (Yang et al., 2024). In contrast, the circular economy offers a

regenerative alternative prioritizing waste reduction, material reuse, and extended product lifecycles (Hossain et al., 2020). The transition from a linear to a circular economy is imperative but will bring about radical changes in the construction industry (A. S. Allam & Nik-Bakht, 2023a).

Recent efforts in Europe and North America have introduced guidelines, standards, and policies to promote circularity in construction (A. S. Allam & Nik-Bakht, 2024). However, in practice, economic viability concerns - including high initial investments, uncertain payback periods, and difficulties integrating into existing business models (BMs) - continue to discourage stakeholders and remain a primary barrier to CE adoption (A. Allam & Nik-Bakht, 2023b; Metinal & Gumusburun Ayalp, 2025). Demonstrating financial viability is therefore crucial for transitioning traditional BMs to circular BMs, as it provides the necessary justification for investment and strategic realignment (Guerra et al., 2021; Kanzari et al., 2022).

Beyond financial concerns, ineffective stakeholder communication and collaboration pose significant barriers to adopting circular economy practices (Banihashemi et al., 2024). Here, communication refers primarily to the exchange of business-related information such as the spatial availability of materials, transactions, and logistics, rather than technical information about the materials. At EoL, uncertainty persists related to the technical and factual characteristics of the recovered products, who potential buyers are, and how fair market value should be determined. This information gap contributes to low trust, limited collaboration, and reduced market activity (Byers et al., 2024). From a Lean Construction perspective, these challenges reflect systemic inefficiencies such as fragmented workflows, lack of early decision-making, and poor coordination across the value chain.

Digital marketplaces/platforms are key components of enabling a CE in various sectors and the construction industry is not an exception (Nik-Bakht et al., 2021). They offer a promising solution to address the challenges mentioned, by facilitating interaction among geographically dispersed stakeholders, as they widen the scope of industrial symbiosis processes and enable collaboration beyond local constraints (Silva et al., 2022). In doing so, they can improve resource efficiency, reduce costs, and establish transparent value networks that support circular economy business models. Their ability to connect stakeholders in a timely manner, streamline transactions, and provide data-driven insights position them as a vital tool in overcoming the economic and communication barriers, and it is the design of the DMP's operational processes that determines this ability.

Despite these potential benefits, adoption of DMPs in construction remains limited, particularly in Canada where such platforms remain relatively less mature and geographically fragmented compared to their counterparts in European countries (Aral et al., 2024; Byers et al., 2024). On the supply side, insufficient listings are driven by inadequate product information, storage costs, and uncertainty regarding sales timing (Çetin et al., 2022). On the demand side, negative perceptions of second-hand products persist due to unreliable information about quality, durability, remaining service life, and availability, compounded by a lack of standardization and warranties (Byers et al., 2024; Edwards, 2021). Together, these challenges, coupled with the fragmented and small regional scale of many platforms, have collectively stunted the growth of DMPs (Wuyts et al., 2023).

A fundamental contributor to these challenges lies in the inherent heterogeneity of the construction industry, where even a single-family home contains a vast array of materials and components. These components can be understood through the concept of building shearing layers, namely site, structure, skin, services, space plan, and stuff or moveable components, each characterized by distinct lifespans and renewal patterns,

which influence recovery and reuse (Brand, 1995; Davis et al., 2025; Gobbo et al., 2024). As a result, materials recovered at EoL follow distinct pathways, creating different market segments. To increase reuse and improve the profitability of deconstruction, DMPs must become sufficiently established and integrated into conventional supply chains (Walsh & Goodland, 2024).

The commercial viability and long-term success of any digital marketplace depend fundamentally on its underlying business model, that is, the logic of how value is created, delivered, and captured (Antai et al., 2025; Jovanovic et al., 2022). For platform owners, value is primarily generated through revenue streams such as subscription fees, transaction commissions, and service-based charges (Li et al., 2025), whereas for users, value manifests through efficient redistribution and smooth transaction processes for reusable components. Zott & Amit, (2024) conceptualize the business model of an organization as an activity system through which the value is created and realized. Under this framing, the BM is not static logic, but a design of how platform operates. However, research indicates that managers in construction industry neither properly understand the business model concept nor exploit similar value creation analyses in their business (Pekuri et al., 2013), suggesting that more customized approaches to designing and developing digital platforms therefore need to be adopted to address the specific contexts and requirements of the construction sector (Antai et al., 2025).

Accordingly, based on the premise that the BMs effectively constitute the operational processes of DMPs, this study investigates how deconstructed products and materials from the built environment, categorized through the building shearing layers framework, influence configurations of business models in DMPs and how this tailoring enables lean operations and supports circular economy objectives. The remainder of the paper is structured as follows. The next section presents a review of the literature on Lean and Circular Economy synergies, DMPs, and their business models. The subsequent sections describe the methods used in this study, followed by the results, discussion, limitations of the study, and finally, the conclusions.

Literature Review

This section reviews the existing literature and develops the foundation for the study across three interconnected areas. It first establishes the interactions between Lean and CE, then examines the DMPs placing them as bridging mechanisms for secondary material flows, and finally, reviews business models and presents the case for modular, product-specific configurations in construction industry.

Lean and Circular Economy

Lean and Circular Economy share an emphasis on optimization, waste elimination, and value creation, although from different systemic perspectives (Benachio et al., 2021; Nadeem et al., 2019). Lean primarily focuses on process efficiency through elimination of non-value-adding activities, creating flow, establishing pull, and pursuing continuous improvement. In contrast, CE extends value retention across multiple lifecycles through reuse, remanufacturing, and resource preservation (Johns et al., 2023; Nadeem et al., 2019). Rather than representing competing theories, studies suggest strong synergies. Benachio et al. (2021) identified 70 positive and 4 negative interactions, indicating an overall constructive relationship rather than a trade-off between the paradigms. Similarly, a review by El Hafiane et al. (2025) indicates that the integration of Lean and CE principles

enhances project performance across environmental, economic, operational, and social dimensions.

This convergence is visible across the building lifecycle stages. In the design and construction stages of the building lifecycle both Lean and CE promote standardization, modularization, off-site construction, and the use of intelligent tools to reduce variability, improve production flow, and reliability (Benachio et al. 2021; El Hafiane et al. 2025). Integrating Lean principles with BIM during the design stage can improve deconstruction outcomes through transparency, by enabling selective dismantling, and securing recovery pathways before physical deconstruction takes place (Marzouk & Elmaraghy, 2021). At EoL stages, Lean-supported deconstruction research highlights the importance of early planning, systematic sequencing of activities, and process-oriented execution to reduce project duration, improve productivity, and enhance material salvaging (Hei et al. 2024). Using a Canadian case study, Boukherroub et al. (2024) demonstrated that embedding Lean principles into deconstruction processes strengthens information flows, stakeholder collaboration, and material reuse rates. Marzouk et al. (2019) mapped 16 core Lean principles to deconstruction activities and examined their interaction with BIM functionalities, demonstrating their potential to enhance deconstruction project performance. From a broader perspective, the literature positions Lean not as a substitute for CE, but as an operational enabler that enhances the implementation of CE practices.

Digital Marketplaces

Digital marketplaces in the construction industry are often discussed through the earlier “e-marketplace” stream, where multiple organizations, both sellers and buyers, communicate, collaborate, and perform commercial transactions through a common web platform (Alarcón et al., 2009; Schnonherr et al., 2007). Contemporary DMPs facilitating the sale of recovered materials in the CI form a subset of broader digital platforms and are commonly referred to as transaction platforms. Their main purpose is to facilitate transactions between different user groups and reduce transaction costs by enabling users to find each other easily and simplifying the transaction process (Antai et al., 2025; Evans & Gawer, 2016; Li et al., 2025). With increased digitization, the adoption of online platforms has gained momentum, owing to the advantages of sharing information about the materials available to facilitate a match between interested parties (Silva et al., 2022).

From a Lean Construction viewpoint, DMPs can be interpreted as coordination mechanisms that support pull-based material flows and reduce informational waste by aligning supply with actual demand (Marzouk et al., 2019), while lowering search and matching frictions. Alarcón et al. (2009) showed e-marketplaces directly support lean goals by cutting turnaround times, errors, and waste, directly contributing to a leaner procurement process in Chilean construction firms. Laine et al. (2017) demonstrated that platform ecosystems replace traditional gatekeepers, enabling pull-based value delivery, reducing transaction costs, and fostering standardized, continuous-flow production aligned with lean thinking.

However, empirical evidence suggests that this coordination potential remains largely unrealized in circular construction. (Sivers et al., 2022) identified 746 Digital Reuse Market Solutions (DRMS) across Europe and found that nearly 46% are dealers of reused building components, yet only 5.9% of all DRMS qualify as true digital marketplaces, indicating that most existing solutions remain transitional and largely offline. More recently, Sivers & Fivet, (2025) demonstrated through a seven-country market scan that the reuse market continues to behave as a series of ad-hoc, one-off trades rather than a predictable reverse supply chain, resulting in supply-demand misalignment. This generates a chicken-and-egg

problem: reuse can become mainstream only if a broader variety of materials is available for trade, yet such diversity increases only if reuse becomes mainstream (Çetin et al., 2022). These constraints point to the need for more structured platform configurations tailored to the construction context.

Business Models and Construction-Specific Tailoring

A business model describes how an organization creates, delivers, and captures value to its stakeholders (Antai et al., 2025; Jovanovic et al., 2022), although the value can mean different things for different stakeholders. Central to conceptualizing this value creation is the business model canvas developed by Osterwalder & Pigneur, (2010), a visual tool consisting of nine interlocking blocks, which include key activities (KA), key resources (KR), key partners (KP), value propositions (VP), customer relationships (CR), channels (CH), customer segments (CS), cost structure (CS), and revenue streams (RS), as listed and described in Table 1. Building on the activity system view introduced above (Zott & Amit, 2024), each BM block can be understood not merely as a descriptive category, but as a configurable operational unit within the overall value system.

The connection between lean thinking and business model design has been explored through Lean Startup Approaches which adapted lean thinking from manufacturing sector to entrepreneurial contexts, to theorize, test, and evaluate viability of business models of digital startup ventures through an efficient and structured process (Balocco et al., 2019; Zott & Amit, 2024). In project-based sectors, Kujala et al. (2010) argued that firms must tailor their business models to the unique requirements of individual solutions or projects rather than relying on a single firm-level business model. Extending this line of reasoning to the construction industry, Pekuri et al. (2013) suggested that business models in the construction industry should be studied and developed at the level of field of operation, as this would support the development of business models that better meet the needs of specific customers or market segments. Yet Lawanga et al. (2025) found in a systematic review that current practices in construction largely treat Lean and BM concepts in isolation, revealing a significant gap in understanding how the two can be cohesively merged to produce lean business models tailored to the construction context.

Within the CE context, BMs have proven highly relevant for DMPs. De Jong and Mellquist (2021) demonstrated that circular business models are essential enablers for online DMPs seeking to facilitate the redistribution and reuse of plastic materials. Within the built environment specifically, Bestul and Gruis (2024) identified six distinct business model types for circular building component reuse actors, namely upcyclers, component-specific suppliers, material resellers, reuse platforms, reuse consulting offices and deconstruction companies, each characterized by different value propositions, revenue streams, and operational roles in the circular reuse chain. At the same time, research suggests that circular business models are not universally applicable across sectors or product types. Charnley et al. (2022) investigated whether digital technologies can increase consumer acceptance of circular business models in second-hand fashion, and found that there is no one-size-fits-all business model, as consumer acceptance varies depending on the specific offerings that address consumer barriers and the type of circular offering presented i.e. resale, rental, swapping, or refurbishing. Collectively, these point toward the need for modular BM configurations adjusted to match the requirements of different product categories rather than rigid structure applied uniformly across an entire platform.

Table 1: The Blocks of the Osterwalder's BMC and Their Focus Areas

Block	Focus Areas
Customer Segments	Who are the most important users of the marketplace, and how is the offering tailored to each segment?
Value Proposition	What value does the marketplace deliver to its users—such as buyers, sellers, or both—and potentially to broader stakeholders like society and the environment?
Channels	Primary touchpoints through which users' access and interact with the marketplace
Customer Relationships	Types of relationships established with users throughout their journey (before, during, and after a transaction), including community engagement
Revenue Streams	Sources of revenue for each customer segment and the structure of payments
Key Resources	Essential resources required to operate, scale, and support the platform, including those related to channels and customer service
Key Activities	Core activities to deliver the value proposition, manage and maintain the platform, and grow the user base
Key partners	External parties and service providers the marketplace relies on for efficient operations
Cost structure	Major fixed and variable costs involved in delivering the value proposition and maintaining strategic functions

The reviewed scholarship converges on three limitations in current research. First, the business models of DMPs developed in other sectors may not directly translate to construction industry due to the sector's unique characteristics, including project-based fragmentation, localized operations, and the niche and discrete purpose of many existing platforms (Li et al., 2025; Riemensperger & Falk, 2020). Second, while Lean and CE have been shown to be complementary, their integration within business models in the construction industry remains largely unexplored (Lawanga et al., 2025). Third, limited attention has been given to how business model configurations should adapt to the heterogeneity of recovered materials in the built environment.

The building shearing layers framework (Brand, 1995) provides a basis for understanding this heterogeneity systematically. Products from different building layers fundamentally exhibit different characteristics in terms of turnover frequency, quality assurance requirements, regulatory compliance, ease of disassembly, and market demand patterns. Sivers & Fivet (2025) reported that standardized and widely used components show stable demand patterns compared to complex materials due to challenges in logistics and project factors. Components in structural layer, for example foundations, have long replacement cycles and lower reuse rates when compared to products in skin layer (Gobbo et al., 2024). These differences imply that the business model elements should vary systematically across product categories. A single, standardized BM applied monolithically across a DMP is therefore unlikely to simultaneously optimize for the quality certification demands of structural components and the accessibility needs of moveable components in stuff layer.

Methodology

A two-stage methodology, as shown in Figure 1, was adopted to explore how the types of deconstructed materials and components from the built environment influence the BMs of DMPs. For terminological clarity, business model blocks correspond to the nine building blocks of the Business Model Canvas, whereas elements denote the operational design features within each block that may be tailored or customized. In contrast, materials, components, and products refer to secondary resources recovered at the end-of-life of buildings.

In Stage 1, existing DMP BMs were investigated through four steps:

1. conducting targeted web searches using the keywords “reuse digital marketplaces”, “reuse online marketplaces”, and “circular economy digital marketplaces”;
2. screening identified DMPs to exclude those selling exclusively virgin or non-recovered components;
3. reviewing official websites and associated public communications (through various channels including social media accounts of shortlisted DMPs); and
4. extracting and analyzing each DMP’s business model using Osterwalder’s BMC (Osterwalder & Pigneur, 2010).

The study boundary of DMPs is limited to Europe, the USA, and Canada due to similarities in construction market mechanisms and the presence of established reuse initiatives. At the same time, these regions differ in the maturity of DMPs, with Europe generally more advanced and North America comparatively less developed. This variation allows the study to capture a broader range of marketplace characteristics within otherwise comparable construction contexts.

A systematic approach was applied to complete each block of the BMC by answering specific questions. For instance, under “value propositions” block, questions such as why customers pay, what value they get, what needs are satisfied, and how does this value proposition differ from competitors were addressed. Osterwalder’s BMC is widely used as a strategic tool to analyze and compare BMs, providing insights into how companies create, deliver, and capture value. Its comprehensiveness and ease of interpretation make it popular framework for adapting and developing industry-specific BMs in general (Jayakodi et al., 2024) and in construction specifically [Mazen & El-Diraby]. Given that the DMPs studied span multiple sectors, the traditional BMC was adopted to ensure consistency and comparability.

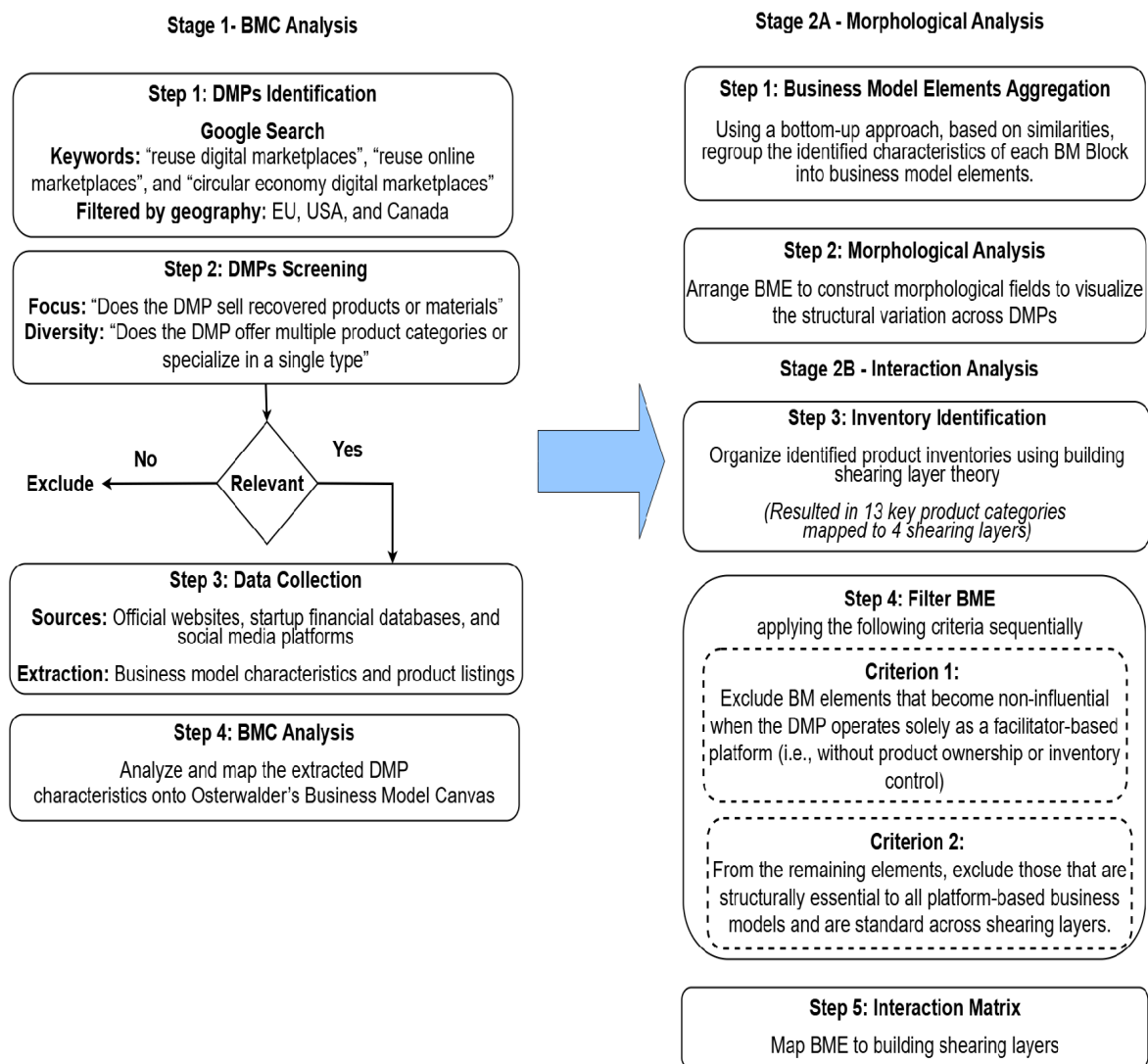


Figure 1: High-Level Methodology

The second stage was conducted sequentially in two sub-stages (Stages 2A and 2B). In Stage 2A, Morphological Analysis, the focus was on synthesizing the diverse business model characteristics of DMPs identified in Stage 1. Using a bottom-up approach, the main characteristics of each BM block were aggregated into BM elements based on similarity. The BM elements and their characteristics were then integrated using a morphological approach to present the overall 'Gestalt' of the identified BMCs (i.e., to visualize the full picture of the business models). This follows the approach proposed by Möller et al., (2022) for designing business model taxonomies.

In Stage 2B, the synergies between the identified BM elements and potential materials from the built environment were explored through a series of brainstorming sessions conducted by the authors, involving representatives of the industry, academia, and government sectors. First, BM elements that were either general in nature or invalid under a facilitator-only DMP assumption were filtered out to focus the interaction analysis. Under this assumption, DMP solely enables transactions by providing a platform for sellers and buyers or fulfills custom orders through matchmaking, and without offering any

deconstruction consulting services, or maintaining its own inventory. Next, potential materials emerging from deconstruction projects were identified using the shearing layer theory as the primary organizing framework, supported by insights from the review of DMPs in construction conducted in Stage 1. While shearing layers were originally proposed to describe building change dynamics (Brand, 1995), this study applies them as a proxy for reuse velocity, regulatory constraints, and market behavior. This framework enables systematic categorization of materials according to turnover rate, reuse feasibility, and compliance requirements, all of which influence marketplace operations.

Finally, an interaction matrix was constructed by mapping the retained BM configurable elements to the shearing layers in a building. Constructing such a matrix of principles, functionalities, or factors from two initiatives supporting the AEC industry is a proven method for exploring interactions between those initiatives (A. S. Allam & Nik-Bakht, 2024; Marzouk et al., 2019; Sacks et al., 2010).

Results

This section presents the Morphological and Interaction analyses conducted in this study. The morphological analysis outlines the BMs of DMPs, while the interaction analysis examines the synergies between materials or components, extracted from the built environment and the various BM Blocks and Elements.

Morphological Analysis

The results of morphological analysis, highlighting recurring and divergent business practices across DMPs, are presented in this section. Specifically, the analysis provides the following insights, each corresponding to a discrete step of morphological analysis and together providing a foundation for subsequent interaction analysis.

- Systematic identification and aggregation of the observed business model characteristics of DMPs into business model blocks and elements
- Quantitative assessment and examination of patterns of characteristics in these BM elements
- Identification and examination of interdependencies between the BM elements to understand how decisions made regarding one element influence how DMPs operate in other elements.

The initial search identified forty-nine DMPs specializing in selling second-hand materials across eight industries: construction, plastics, fashion, batteries, consumer electronics, furniture, classified advertising, and general (covering multiple industries). To ensure that the subsequent analysis focused on BMs relevant to the built environment, the identified DMPs were screened to include only platforms that list recovered building materials either exclusively or alongside other categories. This screening process resulted in narrowing down the sample to 29 DMPs, including 23 in construction, three (3) in classified advertising, one (1) in furniture, and two (2) categorized as general, covering multiple industries. The details of the selected 29 DMPs can be found in Appendix 1.

For the selected DMPs, business model information was extracted and analyzed using Osterwalder's BMC. In the initial step, the collected characteristics within each BMC block were aggregated and subsequently grouped into common elements based on observable similarities in the market segmentation, type of value provided, operational roles

performed, communication channels, revenue generation mechanisms, partner types, and core activities. This process resulted in a total of 31 BM elements, which together form the morphological fields presented in Table 2.

To illustrate the aggregation logic, within the “Customer Segments” block, users were grouped into two configurable elements based on whether they participate in marketplace transactions in an individual capacity or as commercial entities. These groupings were subsequently labeled as the “Individuals” and “Businesses”. Similarly, within the “Value Proposition” block, the observed benefits or unique propositions claimed by DMPs were grouped according to the primary type of value delivered, resulting in seven customizable elements (value sub-categories), i.e., (i) user-oriented as ‘Consumer’; (ii) monetary as ‘Financial’; (iii) deconstruction knowledge and support as ‘Technical’; (iv) sustainability-driven as ‘Environmental’; (v) exchange pathways as ‘Transaction’; (vi) expanded regional access as ‘Market’; and (vii) pricing-mechanism related as ‘Pricing’. This aggregation procedure was consistently applied across the remaining business blocks.

In the second step, within each business block the identified characteristics were normalized by dividing the number of occurrences of each characteristic by the total number of occurrences of all characteristics identified within the corresponding block. This normalization approach enables a direct comparison of the relative prominence of characteristics within and across business blocks and elements. Based on this normalized structure, the morphological analysis reveals two dominant patterns, i.e., convergence, where DMP practices align; or divergence, where DMPs adopt varying approaches across the same business model element.

Analysis of the morphological fields reveals that certain characteristics are widely adopted across DMPs, while others vary considerably. For instance, under the “Market” element of “Value Proposition” block, expanded geographical access is the dominant characteristic emphasized by DMPs. This indicates that market-related value creation is predominantly associated with increasing spatial reach for selling or sourcing recovered materials. Similarly, within the “Recurring” element of “Revenue Streams,” subscription and membership models dominate, suggesting that many DMPs prioritize predictable and stable income streams.

In contrast, other BM elements exhibit notable divergence, reflecting strategic differences among the analyzed DMPs. The “Pricing” element of the “Value Proposition” demonstrates this variability most clearly, with marketplaces adopting fixed, auction-based, and negotiation-based pricing systems. The co-existence of multiple pricing approaches suggests that DMPs adapt their strategies to improve product resale, reflecting an iterative, trial and error approach. Likewise, the Customer Segments block illustrates platforms supporting peer-to-peer (P2P), business-to-business (B2B), and hybrid models. This heterogeneity reflects the diverse customer base DMPs cater to, ranging from contractors and demolition firms supplying salvaged materials to architects, designers, and homeowners seeking sustainable building solutions.

The morphological analysis also indicates interdependencies between characteristics across different business model blocks. For example, the “technical” value propositions emphasizing consultation and technical support are closely associated with revenue generation from consultation or training fees under the service-based “Revenue Streams”. Similarly, when technical benefits emphasize curated product data recording sheets, they align with corresponding “Key Resources”, including skilled and experienced workforce, as well as with “Strategic Costs” related to research activities. Engagement-oriented customer relationships, such as community partnerships, are likewise associated with “Key Activities” focused on education and outreach.

The morphological analysis also reveals that a substantial share of DMPs operate under a reseller-oriented or hybrid model, in which marketplaces either source recovered materials, through donations, buy-back schemes, and deconstruction partnerships, or take ownership prior to resale. In such cases, managed inventory necessitates physical storage capacity, explaining the prevalence of warehouses, while the dominance of digital platforms as a key resource underscores their central role in cataloguing, pricing, visibility, and transaction coordination. Together, these observations suggest that construction DMPs occupy a continuum between digital brokerage and physical resale operations.

Overall, the morphological analysis highlights both recurring business practices and variation among DMPs, reflecting the diversity of business practices. These findings indicate that DMPs are experimenting with different combinations of characteristics based on the types of reusable materials listed, targeted user segments, and operational roles. Importantly, the above insights motivate the need to examine how different materials emerging from deconstruction in built environment interact with business model combinations.

Interaction Analysis

This section presents the interaction analysis which builds on the preceding morphological analysis to examine how different salvaged materials influence BM configurations. While the morphological analysis identifies the breadth of business practices adopted by the DMPs, the interaction analysis seeks to explain, using an interaction matrix, how these practices should vary depending on the type of materials listed on the platform. This is achieved through an interaction matrix that explicitly links recovered construction products, categorized by building shearing layers, to BM elements.

The interaction analysis proceeds in three steps. First, the structure and scope of the interaction matrix are defined; second, the definition of alignment and the assessment criteria used to qualify the alignment is described; and third, the rationale behind the alignment is described.

Table 2: Business Model Canvas of Digital Marketplaces, based on Osterwalder Business Model Canvas (BMC)

BM Block	BM Elements	Characteristic				
Customer Segments	Individuals	Homeowners (12%)	DIY Enthusiasts (12%)		Renovators (6%)	
	Businesses	Contractors (20%)	Waste Processing Facilities (12%)	Manufacturers (10%)		Architects (9%) Marketplaces and Retailers (19%)
Value Proposition	Consumer	Reliability (3%)	Quality Products (11%)		Verified Participants (6%)	Easy-to-Use Platform (9%)
	Financial	Budget-Friendly Listings (6%)	Cash Rewards (1%)	Tax Credits (1%)	Material Warranties (1%)	
	Environmental	Reduced Waste (13%)	Increased Reuse (9%)		Carbon Emission Reductions (7%)	
	Technical	Consultation & Technical Support (7%)		Curated Product Data Recording Sheets (4%)		
	Transaction	Sourcing Requests (1%)		Salvage Requisition Services (1%)		
	Market	Expanded Geographical Access (18%)				
	Pricing	Fixed (1%)	Auction-Based (1%)		Negotiation (1%)	
Channels	Operational Roles	Facilitator (11%)	Reseller (8%)	Intermediary (7%)	Information Aggregator (2%)	
	Logistic Partnerships	Delivery (10%)	Buyer/ Seller Arrangement (8%)		Pick-up (1%)	
	Interaction	Physical (10%)		Online (9%)		
	Shopping	Online - Web platform (20%)		Physical (11%)	Online - Mobile Apps (3%)	
Customer Relationships	Support-Oriented	Automated Service (29%)		Personal Assistance (21%)		Self-Service (17%)
	Engagement-Oriented	Community Partnerships (29%)		Guides & Resources for Reuse (23%)		
Revenue Stream	Transaction-Based	Managed Inventory (23%)		Transaction and Commission (16%)		



Vakkanthula et al. (2026): Digital Marketplaces as Catalysts for Circular Economy in Construction: Exploring the Role of Modular Business Models

BM Block	BM Elements	Characteristic			
	Recurring	Subscription and Membership (19%)			
	Service-based	Consultation (16%)		Training (5%)	Logistics Services (4%)
	Funding and Grants	Government (5%)		Investor Equity (5%)	
	Marketing	Advertisement and Product Promotion (7%)			
	Key Resources	Digital	Digital Platform (37%)		Database of Service Providers (9%)
Physical		Warehouse (16%)			
Human		Customer Service Staff (18%)		Skilled and Experienced Workforce/Team (16%)	
Key Activities	Operational	Digital Platform Maintenance (28%)		Networking and Partnerships (8%)	
	Customer-Centric	Customer Support (25%)		Customer Engagement (12%)	Education and Outreach (8%)
	Strategic or Analytical	Sourcing of Managed Inventory (12%)		Marketplace Data Analytics (7%)	
Key Partners	Financial Partners	Payment Partners (19%)		Financial Institutions (3%)	
	Operational	Logistics Partners (22%)	Deconstruction Service Providers (19%)	Salvage Suppliers (7%)	Contractors and Facility Managers (3%)
	Environmental & Quality Assurance	Environmental Organizations (13%)		Educational institutions (11%)	Testing Service Providers (3%)
Cost Structure	Fixed Cost	Platform Development &Maintenance (27%)		Operational Costs (20%)	Staffing Costs (6%)
	Variable Cost	Marketing & Promotion (19%)		Logistics and Material (14%)	
	Strategic Cost	Customer Support Services (10%)		Research Activities (4%)	



Key: Numbers in brackets represent the percentage share of each characteristic relative to the total occurrences within the same business model block.



Structure and Scope of Interaction Matrix

The interaction matrix is structured to explicitly examine how product characteristics influence the suitability of specific business model features to maximize market reach and enable increased reuse. The rows of the interaction matrix represent selected blocks and elements of BMC, while the columns represent construction products guided by the shearing layers theory, the identified materials are organized according to their functional role and typical rate of change within buildings, see Table 3.

The BM elements used in the interaction matrix were derived from the preceding morphological analysis and reduced from the original set of 31 to 21. This reduction was undertaken to focus on those configurable elements, that are most likely to vary as a function of shearing layers. This was conducted through a sequential two-step evaluation. First, a BM element was considered non-influential if its presence or absence did not affect the operations of a DMP under a facilitator-only model. Accordingly, consulting service & technical support, service-based revenue streams, funding & grants, and physical resources, i.e., a warehouse, were excluded. Second, from the remaining BM elements, those that are invariant in nature and essential regardless of the shearing layer, such as environmental value proposition, human resources, operational activities, and fixed and variable costs were excluded.

Table 3: Building Shearing Layers and Associated Construction Materials, adapted from (Brand, 1995) and (TU Delft, 2019)

Shearing Layer	Description	Construction Materials
Site	The location in which the building is situated	No products are considered to originate from the Site (Shearing) layer
Structure	The foundation and load-bearing structural components	Structural wood, Steel Beams
Skin	The façade of the building and all the materials located in the exterior enclosure	Wood Sheathing, Stone, Brick
Services	Includes the services of the building	Mechanical, Plumbing, Electrical
Space plan	The interior layout of the building	Doors and windows
Stuff	The components within the building that are free to move.	Architectural wood products, Furniture, Ornamental & hardware products, Architectural finishing types, other than wood

Within this intermediary-only scope, retained BM elements were further refined where different characteristics represent fundamentally different practices. For example, under the "Consumer" element, characteristics including quality products and verified participants were assessed individually, and under the "Digital" element, data analytics tool and database of service providers were evaluated separately. In contrast, elements such as "Financial" and "Operational," were represented by a single dominant characteristic to avoid over-fragmentation. This does not imply that other characteristics within these elements are less important; rather, they are either inherent to the element (e.g., digital platform under the "Digital" element), outside the defined scope of marketplace model (e.g., consultation and technical support under "Technical Value Proposition" element), or may not yet be viable within the construction industry, where DMPs are still at a relatively nascent stage (e.g., cash rewards under the "Financial" element).

Alignment Rationale and Assessment Criteria

In the interaction matrix, Table 4, each cell indicates whether a given business model element or a characteristic is appropriate for enabling transactions of materials from a specific building shearing layer. A tick-mark denotes a possible alignment, while its absence indicates no alignment. Alignment was assessed based on material-specific reuse criteria: the existence of an established secondary market, quality requirements, compliance requirements, turnover time, original use of a material or component, probable trade volume, certainty of reuse, and ease of disassembly. Based on these criteria, a structured questionnaire was developed, see Appendix 2, and applied to each shearing layer. For each BM element-layer pairing, a “Yes” response indicated alignment, while a “No” response indicated non-alignment. The responses were grounded in the reviewed literature and refined through iterative evaluative judgement among the authors. This was done as reuse feasibility varies by component attributes (Arora et al., 2020). Alignment decisions were revisited multiple times to ensure consistency and reduce subjective bias. The matrix is intended to identify alignment tendencies rather than deterministic prescriptions. Nevertheless, broader expert validation through Delphi or focus group methods remains part of the future work.

Table 4: Interaction Matrix of Building Shearing Layers vs. Business Model Elements

BM Block	BM Element	Building Shearing Layers				
		Structure	Skin	Services	Space Plan	Stuff
Customer Segments	Individuals		✓		✓	✓
	Businesses	✓	✓	✓	✓	✓
Value Proposition	Consumer (Quality Products)	✓		✓		
	Consumer (Verified Participants)	✓	✓	✓	✓	✓
	Financial (Budget-Friendly Listings)	✓	✓	✓		✓
	Technical	✓	✓	✓	✓	
	Transaction	✓	✓	✓	✓	✓
	Market	✓	✓	✓		
	Pricing - Fixed	✓	✓	✓	✓	✓
	Pricing - Negotiation	✓	✓	✓		✓
	Pricing - Auction		✓		✓	✓
Channels	Operational Role - Facilitator	✓	✓	✓	✓	✓
	Operational Role - Intermediary	✓	✓	✓		
	Logistic Partnerships	✓	✓	✓	✓	✓
	Shopping - Physical Access			✓	✓	✓
	Shopping - Online Access	✓	✓	✓	✓	✓
Customer Relationships	Support-Oriented	✓	✓	✓		
	Engagement- Oriented	✓	✓		✓	✓
Revenue Stream	Transaction-based	✓	✓	✓		

BM Block	BM Element	Building Shearing Layers				
		Structure	Skin	Services	Space Plan	Stuff
	Recurring				✓	✓
	Marketing	✓	✓	✓		✓
Key Resources	Digital (Data Analytics Tool)	✓	✓	✓	✓	✓
	Digital (Database of Service Providers)	✓	✓	✓		
Key Activities	Strategic or Analytical	✓	✓	✓	✓	✓
Key Partners	Operational (Deconstruction Service Providers)	✓	✓	✓		
	Environmental & Quality Assurance	✓		✓		
Cost Structure	Strategic Cost	✓	✓	✓		

between BM elements and building shearing layers was assessed by examining how these criteria vary across layers, progressing from slowest-changing to fastest-changing layers.

Layer-wise Rationale of Interaction Alignment

The following discussion details how the alignments presented in Table 4 were established, using representative products from each building shearing layer. A summary of the criteria used to assess the alignment is presented in Figure 2.

Structure Layer

Products associated with the Structure layer, such as structural wood members, structural steel members, and other load-bearing components, are the slowest changing. Their reuse is subject to strict regulatory requirements and safety considerations, and the absence of formal grading or design recognition introduces higher uncertainty regarding reuse feasibility (Bob Falk, 2002; Falk et al., 2012). Additionally, reliable reuse of these materials requires establishing structural performance with sufficient confidence (Gorgolewski, 2008; Riuttala et al., 2024), although exceptions exist when structural components are reused in non-structural applications (Bob Falk, 2002).

Materials under the Structure layer typically move slowly, are traded less frequently, and are handled through specialized resale channels in bulk volumes (Bob Falk, 2002). Consequently, their alignment with marketplace strategies favor business customer segments, as quality control and guidance gaps make professional handling more suitable than individual participation on the seller side. Verified marketplace participants play a vital role in building a layer of trust, while providing intermediary services by DMPs enables more effective matchmaking. Reused steel members often require tighter spacing or larger member sizes to achieve equivalent structural performance (Gorgolewski, 2008). Consequently, pricing mechanisms for structural components are less suited to fixed pricing and instead benefit from negotiation-based approaches that can account for variability in condition, certification, and reuse context. Their long turnover time aligns with transaction-based revenue models, reduced or waived listing fees, and optional paid advertising packages to improve listing visibility.

Skin Layer

Materials in Skin layer such as siding, cladding, and exterior wall occupy an intermediate position between structural and non-structural products. While they often

retain reuse value but are subject to variability in dimensions, compatibility with existing building envelopes, and differences arising from building age and construction method. Moreover, these materials are usually required in bulk quantities to meet demand (Hulsbeek & Van Den Berg, 2022). As a result, Skin layer materials align with both individual and business sellers. The pricing strategies can accommodate fixed, auction-based, and negotiation-based approaches to allow buyers and sellers to account for condition, quantity and compatibility with the new structure. Their moderate turnover rates necessitate hybrid marketplace strategies, including intermediary operational roles managing negotiations, logistics, & transactions, and support-oriented relationships, offering tailored services such as fulfilling custom orders, product matchmaking, and technical support.

Services Layer

Products within the Service layer including plumbing fixtures, mechanical equipment, and electrical fixtures removed during renovation or deconstruction differ in their reuse pathways. These are often part of larger systems and reuse depends heavily on contextual installation conditions, removal complexity, compatibility constraints, and professional installation requirements. As reflected in the interaction matrix, Services-layer components align more strongly with business-oriented customer segments, verified participants, and intermediary operational roles, and less with individual sellers or self-service transactions. Low-level components such as light holders, lighting fixtures, and faucets represent exceptions due to their greater ease of disassembly and reuse, highlighting the need for granular assessment within this layer accounting for differences in use, size, and volume.

Space Plan Layer

Materials associated with the Space Plan layer, particularly doors and windows, exhibit greater ease of disassembly, lower technical risk, and strong secondary market presence (Gorgolewski, 2008; Przywara, 2025; Van Den Berg, 2024). These components are visually inspectable, widely standardized, and supported by readily available technical documentation. As reflected in the interaction matrix, the products under this layer support facilitator-based operational roles (Przywara, 2025), both individuals and businesses as sellers, and online-only shopping channels when verified marketplace participants are involved. Their relatively high listing frequency enables fixed or auction-based pricing under conditions of short turnover time and predictable demand. However, energy performance considerations, age-limits, and the socio-economic conditions may still influence reuse decisions (A. S. Allam & Nik-Bakht, 2025; Przywara, 2025; Sischarenco, 2025).

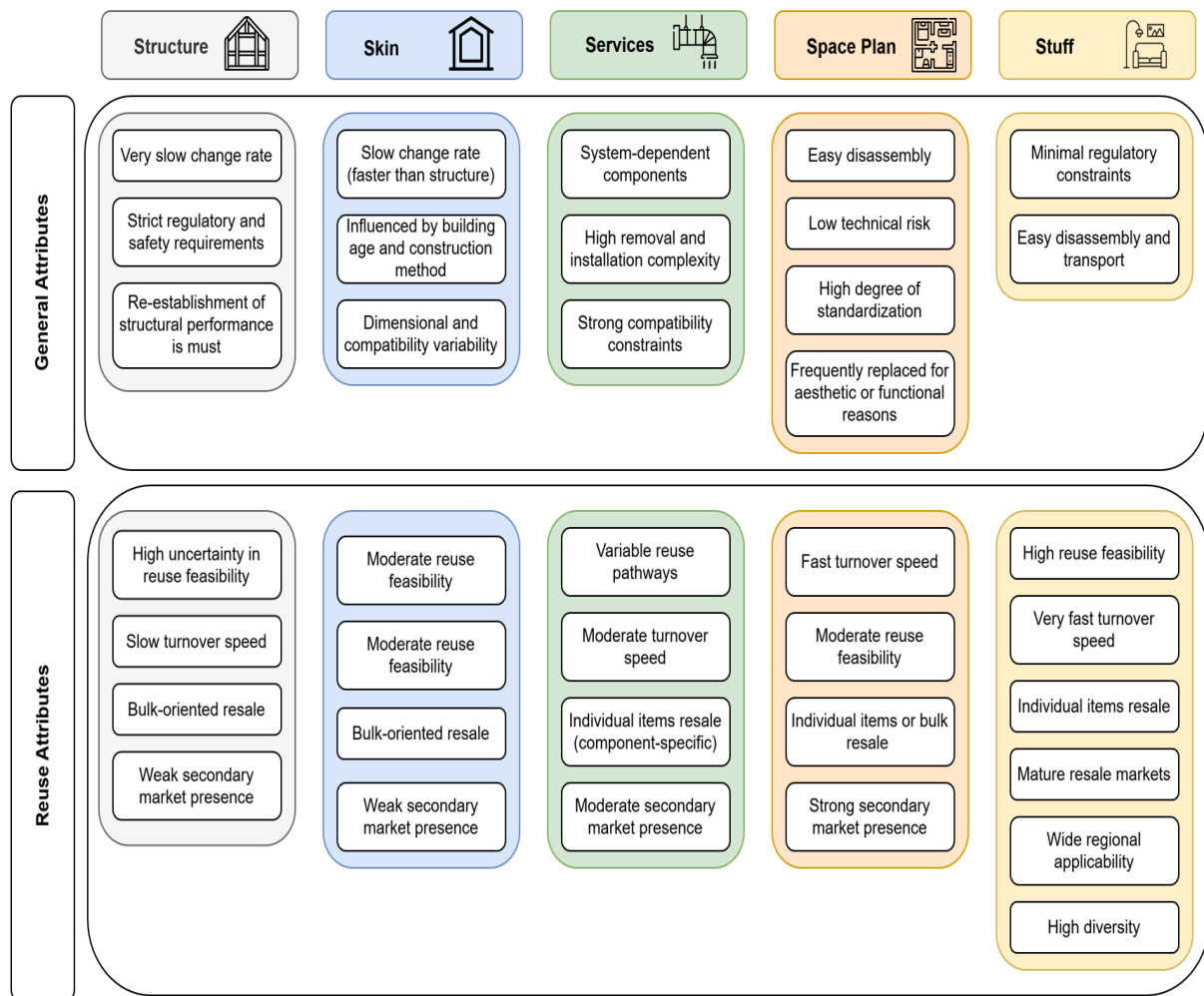


Figure 2. Attributes influencing alignment of shearing layers with BM Elements

Stuff

Products within the Stuff layer, such as furniture, ornamental hardware, and architectural finishes, exhibit the highest compatibility with simplified marketplace strategies, and represent the most reused items (Van Den Berg, 2024). These products are typically easy to disassemble, transport, reuse, face minimal regulatory barriers, and have more established resale markets. Their high listing volumes, short turnover time, and broad use across different regions can enable DMPs to implement fixed-price or auction-based pricing mechanisms and generate revenue through subscription or membership models aimed at frequent users. These characteristics also reflect strong alignment with individual customer segments, online-only access, and facilitator-based roles allowing platforms to function primarily as passive intermediaries between buyers and sellers.

Together, these observations demonstrate that alignment between building shearing layers, and business model characteristics is necessary to support effective reuse pathways, providing a basis for tailoring BMs of DMPs to materials or components emerging from deconstruction.

Discussion

The interaction matrix demonstrates that a single BM configuration cannot be universally applied across all materials comprising shearing layers within the construction industry. Instead, the analysis shows that specific BM elements align more strongly with certain shearing layers, reflecting inherent differences in reuse feasibility, regulatory constraints, turnover time, and market behavior. The proposed framework does not prescribe rigid configurations but identifies alignment tendencies to support decision-making. DMP operators may adapt configurations based on local market conditions, regulatory environments, and platform maturity.

When interpreted in light of existing secondary material exchange practices, the findings of this study help explain why many reuse marketplaces remain fragmented and largely confined to physical operations. Since this results in limiting their capacity to address the economic viability and logistical barriers associated with material reuse, the subject is worthy of further investigation. This pattern is reflected in several existing reuse organizations and marketplaces that primarily operate through localized physical outlets with limited digital inventory integration. For example, some reuse networks maintain extensive brick-and-mortar storefronts, such as Habitat for Humanity ReStore locations (Habitat for Humanity Canada, n.d.), while others operate at a localized scale and have limited or no digital presence with respect to their inventory, including initiatives such as The Reuse People (The ReUse People, n.d.), RÉCO market (RÉCO, n.d.), and Web-Recyc (Web-Recyc, n.d.). On the digital front, certain platforms facilitate the transfer of excess construction materials for free, such as the Minnesota Material Exchange (Minnesota Materials Exchange, n.d.) or function primarily as informational intermediaries, such as ReuseWood (ReuseWood.org, n.d.), rather than fully integrated, transaction-oriented digital marketplaces.

As a result, these platforms and marketplaces remain insufficiently integrated and digitally fragmented, and therefore fall short of supporting owners, developers, architects, and deconstruction and salvage companies to organically embed circularity practices into everyday work processes. Thereby, constraining widespread reuse of salvaged materials. From a Lean Construction perspective, this fragmentation reflects inefficiencies in information exchange, fragmented supply chain partnerships, limited transparency, and mismatches between marketplace value propositions and user expectations.

Several BM elements identified in the interaction analysis directly support Lean principles. Enabling participation by verified users enhances transparency and allows stakeholders to make informed decisions. Ensuring that technical information is consistently available, verified, and validated against user expectations aligns with the Lean principle of “building quality at the source”. Together, these BM elements reduce uncertainty and variability. Offering separate pricing mechanisms and shopping channels based on shearing layers further enables users to evaluate available options, while aggregating listings from multiple marketplaces at the national level strengthens the overall value proposition of extended geographical reach and improves confidence among end users.

Technological enablers play a central role in supporting Lean objectives. The development and integration of data analytics tools that allow users to estimate selling prices based on information completeness, material condition, and historical pricing can significantly reduce transaction friction. Complementing these with a database of qualified deconstruction, quality testing, and logistics service providers adds significant value for the marketplace participants. Together, these capabilities support the Lean principle of enhancing value delivery through appropriate use of technology (Marzouk et al., 2019).

In addition, BM configurations that enable transaction value through sourcing requests and salvage requisition services support a shift from a traditional push-based recovery model to a pull-based approach driven by downstream demand. Customer relationships that emphasize both support-oriented and engagement-oriented interactions, together with intermediary operational roles for fulfilling custom orders, reinforce Lean principles of collaboration and shared responsibility. Strategic partnerships with environmental and quality testing providers, deconstruction service providers, and logistics partners reflect the Lean view of partners as extensions of the value stream, forming an integrated value stream.

The interaction matrix further indicates that a subset of BM elements, that align consistently across all shearing layers, play a critical role in enhancing marketplace reputation and building trust. These include business-oriented customer segments, verified marketplace participants, technical documentation, logistics partnerships, and digital analytical resources. Given the prevailing skepticism toward reused construction materials (Riuttala et al., 2024), prioritizing these BM elements is essential for the success of DMPs. From a Lean deconstruction perspective, strengthening these elements supports reliable information flow and quality assurance at the source, thereby enhancing consumer value and fostering marketplace relationships. In contrast, BM elements that exhibit product-specific alignment, such as pricing mechanisms and revenue generation streams, can be shaped to balance market penetration with steady financial stability while accommodating variability across different shearing layers.

Continuous improvement is a core Lean principle, and DMPs in the construction industry can experiment by adopting best practices from other industries. These may include offering cost incentives to encourage sellers who consistently meet quality standards and provide accurate or near-accurate information, thereby promoting the reuse of salvaged construction materials. Additional strategies include partnering with building insurance providers to offer warranties for reused materials (Bougrain, 2023; Cycle-Up, n.d.), aggregating listings from other marketplaces within the same country to improve market reach and establishing affiliate programs with other DMPs to create revenue-sharing opportunities when successful transactions occur.

Given that construction industry DMPs remain at an early stage of development, particularly in North America, and that no proven, time-tested business model that guarantees success has been established, it is imperative that marketplaces continuously innovate and explore alternative BM elements to remain competitive.

Limitations

This study has three main limitations. Firstly, majority of identified DMPs operate within a single country or a limited geographic region, particularly within the construction industry. While this localized focus aligns with CE principles, such as minimizing transportation distances and closing local material loops, it also points to differences in regional market maturity. In regions such as Europe, where reuse and circularity frameworks, regulatory structures, and cross-border cooperation are relatively well established among geographically proximate regions/countries, DMPs may be better positioned to scale their operations beyond national boundaries. By contrast, in less mature markets such as the USA and Canada, where regulations remain fragmented across states and provinces, DMPs may operate in more localized and fragmented contexts, characterized by limited diversity in listings and weaker secondary supply chains. As a result, the expansion of DMPs operations across national or provincial boundaries could introduce new challenges and opportunities that were not captured in this study.

Secondly, while the study identifies and aligns BM Elements with different shearing layers, it does not establish quantitative key performance indicators (KPIs) to assess the effectiveness of implementing proposed BM configurations. In the absence of such KPIs, it is not possible to assess whether the suggested configurations translate into improvements in process efficiency, economic viability, marketplace activity, reuse rates, and process duration.

Thirdly, the interaction matrix was developed through iterative brainstorming sessions among the authors, rather than a formal focus group. Although maintaining a cross-disciplinary among participants who (i) have expertise that span circular construction, business model innovation, and digital technologies; and (ii) represent various stakeholders' perspective (including academia, industry, and government), external validation remains necessary. Future studies should incorporate expert focus groups and obtain feedback from industry stakeholders to strengthen the robustness and applicability of the findings.

Conclusion

This study investigates DMPs operating in the material and product reuse space of four sectors (i.e., construction, classified advertising, furniture, and general serving multiple industries), with the objective of understanding their BMs. Most importantly, it identifies the alignment between BM elements (i.e., attributes) and the diverse product categories in construction, using building shearing layer theory as an organizing framework. An exploratory and conceptual approach was taken, aiming to identify alignment patterns between product categories and business model configurations. The findings indicate that the characteristics of BM elements vary significantly, underpinning the wide range of mechanisms DMPs employ to maintain competitive advantage. Through the interaction matrix, this study underscores the areas of concord and discord between shearing layers and BM elements, revealing that current DMPs in construction do not yet implement BMs tailored to shearing layer-specific requirements.

The study makes three primary contributions to research and practice. First, it reconceptualizes digital marketplace business models as operational coordination mechanisms that influence reverse supply chain performance rather than merely revenue structures. Second, it demonstrates that the heterogeneity of building components necessitates modular and product-specific business model configurations, challenging the prevailing assumption that platform models can be uniformly applied across reuse markets. Third, by applying Lean Construction principles with CE objectives, the study provides a process-oriented framework explaining how tailored marketplace configurations can reduce uncertainty, improve trust, and enable pull-based material flows. Together, these contributions advance understanding of how digital marketplaces can function as systemic enablers of circularity in the construction industry.

From a process-oriented perspective, the findings suggest that adopting product-specific BM configurations has the potential to reduce variability in workflows, decrease uncertainty in EoL processes, and improve coordination across the value chain. In turn, such improvements may support higher adoption of DMPs by users, greater diversity of listings, and more effective materials reuse. In this context, the identified synergies provide valuable guidance for both existing and new DMPs to refine marketplace operations in ways that better align with recovered materials from the built environment. While the theoretical implementation of these synergies suggests potential improvements in effectiveness of DMPs in the construction industry, their widespread adoption and long-term profitability warrant further research. Accordingly, DMPs would benefit from

developing a deeper understanding of the stakeholder needs and experimenting with proven strategies from other industries that improve alignment between recovered materials and marketplace operations. Based on the findings of this qualitative study, establishing quantitative KPIs and testing performance outcomes of construction DMPs in various markets will be an important next phase of the study.

Acknowledgement

- This study has been supported by the Construction Sector Digitalization and Productivity (CSDP) program under the project “A1-026366 - Digital Twins for Smart Decarbonization of the Built Environment Meeting Circular Economy Criteria”. The authors would like to extend their sincere gratitude to all the stakeholders who participated in this research and contributed to the findings presented in this paper.
- During the preparation of this work, the author(s) used ChatGPT to improve the language flow and readability of some paragraphs in the manuscript. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

References

- Alarcón, L. F., Maturana, S., & Schonherr, I. (2009). Impact of Using an E-Marketplace in the Construction Supply Process: Lessons from a Case Study. *Journal of Management in Engineering*, 25(4), 214-220. [https://doi.org/10.1061/\(ASCE\)0742-597X\(2009\)25:4\(214\)](https://doi.org/10.1061/(ASCE)0742-597X(2009)25:4(214))
- Allam, A., & Nik-Bakht, M. (2023a). *Barriers to circularity in construction: An analysis of experts' perspectives*. 2023 European Conference on Computing in Construction and the 40th International CIB W78 Conference. <https://doi.org/10.35490/EC3.2023.234>
- Allam, A. S., & Nik-Bakht, M. (2023b). From demolition to deconstruction of the built environment: A synthesis of the literature. *Journal of Building Engineering*, 64, 105679. <https://doi.org/10.1016/j.jobbe.2022.105679>
- Allam, A. S., & Nik-Bakht, M. (2024). Supporting circularity in construction with performance-based deconstruction. *Sustainable Production and Consumption*, 45, 1-14. <https://doi.org/10.1016/j.spc.2023.12.021>
- Allam, A. S., & Nik-Bakht, M. (2025, July 14). Knowledge Graph-Based Customer-Centric Deconstruction Assessment Model. *Proceedings of the 2025 European Conference on Computing in Construction*. 2025 European Conference on Computing in Construction and CIB W78 Conference on IT in Construction, Porto, Portugal.
- Antai, I., Lenka, S., & Achtenhagen, L. (2025). Digital platforms and the construction supply chain: Trends and emerging themes in extant AEC research. *Construction Management and Economics*, 43(2), 113-129. <https://doi.org/10.1080/01446193.2024.2396592>
- Aral, D., Kayaçetin, N. C., & Durmuş Arsan, Z. (2024). Circular economy in the built environment: A systematic literature review on the role of digital technologies across regional contexts. *IOP Conference Series: Earth and Environmental Science*, 1363(1), 012005. <https://doi.org/10.1088/1755-1315/1363/1/012005>
- Arora, M., Raspall, F., Cheah, L., & Silva, A. (2020). Buildings and the circular economy: Estimating urban mining, recovery and reuse potential of building components.

- Resources, Conservation and Recycling*, 154, 104581.
<https://doi.org/10.1016/j.resconrec.2019.104581>
- Balocco, R., Cavallo, A., Ghezzi, A., & Berbegal-Mirabent, J. (2019). Lean business models change process in digital entrepreneurship. *Business Process Management Journal*, 25(7), 1520-1542. <https://doi.org/10.1108/BPMJ-07-2018-0194>
- Banihashemi, S., Meskin, S., Sheikhhoshkar, M., Mohandes, S. R., Hajirasouli, A., & LeNguyen, K. (2024). Circular economy in construction: The digital transformation perspective. *Cleaner Engineering and Technology*, 18, 100715.
<https://doi.org/10.1016/j.clet.2023.100715>
- Benachio, G. L. F., Freitas, M. D. C. D., & Tavares, S. F. (2021). Interactions between Lean Construction Principles and Circular Economy Practices for the Construction Industry. *Journal of Construction Engineering and Management*, 147(7), 04021068.
[https://doi.org/10.1061/\(ASCE\)CO.1943-7862.0002082](https://doi.org/10.1061/(ASCE)CO.1943-7862.0002082)
- Bestul, B., & Gruis, V. (2024). Six Business Model Types for Circular Building Component Reuse Actors. *Sustainability*, 16(13), 5425. <https://doi.org/10.3390/su16135425>
- Bob Falk. (2002). Wood-Framed Building Deconstruction A Source of Lumber for Construction? *FOREST PRODUCTS JOURNAL*, 52(3).
- Bougrain, F. (2023). *Prospective report on reuse and insurance—EN*. Interreg North-West Europe FCRBE. <https://vb.nweurope.eu/fcrbe>
- Brand, S. (1995). *How Buildings Learn: What Happens After They're Built*. Penguin.
- Byers, B. S., Raghu, D., Olumo, A., De Wolf, C., & Haas, C. (2024). From research to practice: A review on technologies for addressing the information gap for building material reuse in circular construction. *Sustainable Production and Consumption*, 45, 177-191. <https://doi.org/10.1016/j.spc.2023.12.017>
- Çetin, S., Gruis, V., & Straub, A. (2022). Digitalization for a circular economy in the building industry: Multiple-case study of Dutch social housing organizations. *Resources, Conservation & Recycling Advances*, 15, 200110.
<https://doi.org/10.1016/j.rcradv.2022.200110>
- Charnley, F., Knecht, F., Muenkel, H., Pletosu, D., Rickard, V., Sambonet, C., Schneider, M., & Zhang, C. (2022). Can Digital Technologies Increase Consumer Acceptance of Circular Business Models? The Case of Second Hand Fashion. *Sustainability*, 14(8), 4589. <https://doi.org/10.3390/su14084589>
- Cycle-Up. (n.d.). *Cycle Up—Plateforme de réemploi et de matériaux de récupération*. Retrieved January 24, 2026, from <https://www.cycle-up.fr/www.cycle-up.fr/home>
- Davis, A., Quintana-Gallardo, A., Martí Audi, N., & Guillén Guillamón, I. (2025). The impact of lifespan assumptions in LCA: Comparing the replacement of building parts versus building layers—A housing case study. *Energy and Buildings*, 326, 115050.
<https://doi.org/10.1016/j.enbuild.2024.115050>
- De Jong, A. M., & Mellquist, A.-C. (2021). The Potential of Plastic Reuse for Manufacturing: A Case Study into Circular Business Models for an On-Line Marketplace. *Sustainability*, 13(4), 2007. <https://doi.org/10.3390/su13042007>
- Edwards, M. (2021). *What's at risk with reuse?* UKGBC. Retrieved February 26, 2026 from <https://ukgbc.org/news/whats-at-risk-with-reuse/>
- Evans, P. C., & Gawer, A. (2016). *The Rise of the Platform Enterprise: A Global Survey*. The Center for Global Enterprise.
- Falk, R. H., Cramer, S., & Evans, J. (2012). Framing Lumber from Building Removal: How Do We best Utilize this Untapped Structural Resource? *Forest Products Journal*, 62(7-8), 492-499. <https://doi.org/10.13073/0015-7473-62.7.492>

- Gobbo, É., Nia, E. M., Straub, A., & Stephan, A. (2024). Exploring the effective reuse rate of materials and elements in the construction sector. *Journal of Building Engineering*, 98, 111344. <https://doi.org/10.1016/j.jobe.2024.111344>
- Gorgolewski, M. (2008). Designing with reused building components: Some challenges. *Building Research & Information*, 36(2), 175-188. <https://doi.org/10.1080/09613210701559499>
- Guerra, B. C., Shahi, S., Mollaei, A., Skaf, N., Weber, O., Leite, F., & Haas, C. (2021). Circular economy applications in the construction industry: A global scan of trends and opportunities. *Journal of Cleaner Production*, 324, 129125. <https://doi.org/10.1016/j.jclepro.2021.129125>
- Habitat for Humanity Canada. (n.d.). *Habitat for Humanity Canada | Home*. Habitat for Humanity Canada. Retrieved February 26, 2026, from <https://habitat.ca/en/>
- Hossain, Md. U., Ng, S. T., Antwi-Afari, P., & Amor, B. (2020). Circular economy and the construction industry: Existing trends, challenges and prospective framework for sustainable construction. *Renewable and Sustainable Energy Reviews*, 130, 109948. <https://doi.org/10.1016/j.rser.2020.109948>
- Hulsbeek, L., & Van Den Berg, M. (2022, September 5). *Evaluating Reuse Conditions During a Circular Demolition Project: An Ethnographic Study*. ARCOM 2022, Glasgow, UK.
- Jayakodi, S., Senaratne, S., & Perera, S. (2024). Circular Economy Business Model in the Construction Industry: A Systematic Review. *Buildings*, 14(2), 379. <https://doi.org/10.3390/buildings14020379>
- Johns, N. G. O., Talebi, S., Shelbourn, M., Roberts, C., & Kagioglou, M. (2023). *The Circu-Lean Revolution: A Review of the Synergies Between Lean and the Circular Economy*. 540-559. <https://doi.org/10.24928/2023/0242>
- Jovanovic, M., Sjödin, D., & Parida, V. (2022). Co-evolution of platform architecture, platform services, and platform governance: Expanding the platform value of industrial digital platforms. *Technovation*, 118, 102218. <https://doi.org/10.1016/j.technovation.2020.102218>
- Kanzari, A., Rasmussen, J., Nehler, H., & Ingelsson, F. (2022). How financial performance is addressed in light of the transition to circular business models—A systematic literature review. *Journal of Cleaner Production*, 376, 134134. <https://doi.org/10.1016/j.jclepro.2022.134134>
- Kujala, S., Artto, K., Aaltonen, P., & Turkulainen, V. (2010). Business models in project-based firms - Towards a typology of solution-specific business models. *International Journal of Project Management*, 28(2), 96-106. <https://doi.org/10.1016/j.ijproman.2009.08.008>
- Laine, E., Alhava, O., Peltokorpi, A., & Seppänen, O. (2017). *Platform Ecosystems: Unlocking the Subcontractors' Business Model Opportunities*. 177-184. <https://doi.org/10.24928/2017/0325>
- Lawanga, P. W. A. H., Sandanayake, Y. G., Ranadewa, K. A. T. O., & Department of Building Economics, University of Moratuwa, Sri Lanka. (2025). Lean integrated business model for construction: A systematic review on current practices and future directions. In K. G. A. S. Waidyasekara, H. S. Jayasena, P. L. I. Wimalaratne, & G. A. Tennakoon (Eds.), *13th World Construction Symposium—2025* (pp. 959-972). Department of Building Economics. <https://doi.org/10.31705/WCS.2025.72>
- Li, Y., Maxwell, D. W., & Moehler, R. (2025). Facilitating platform-based business model innovation in construction start-ups: A dynamic capability perspective. *Construction Management and Economics*, 43(10), 864-881. <https://doi.org/10.1080/01446193.2025.2528795>

- Luga, E., Mustafaraj, E., Corradi, M., & Daijko, M. (2025). Recycled Red Brick Masonry Demolition Waste as a Sustainable Cement Replacement Alternative: A DoE-Based Approach. *Journal of Building Engineering*, 100(111787).
<https://doi.org/10.1016/j.jobe.2025.111787>
- Marzouk, M., & Elmaraghy, A. (2021). Design for Deconstruction Using Integrated Lean Principles and BIM Approach. *Sustainability*, 13(14), 7856.
<https://doi.org/10.3390/su13147856>
- Marzouk, M., Elmaraghy, A., & Voordijk, H. (2019). Lean Deconstruction Approach for Buildings Demolition Processes using BIM. *Lean Construction Journal*, 147-173.
- Metinal, Y. B., & Gumusburun Ayalp, G. (2025). Uncovering Barriers to Circular Construction: A Global Scientometric Review and Future Research Agenda. *Sustainability*, 17(4), 1381. <https://doi.org/10.3390/su17041381>
- Minnesota Materials Exchange. (n.d.). *Minnesota Materials Exchange*. Retrieved February 26, 2026, from <https://mnexchange.org/#/>
- Mollaei, A., Byers, B., Christovan, C., Olumo, A., De Wolf, C., Bachmann, C., & Haas, C. (2023). "A global perspective on building material recovery incorporating the impact of regional factors." *Journal of Cleaner Production*, 429, 139525.
<https://doi.org/10.1016/j.jclepro.2023.139525>
- Möller, F., Stachon, M., Azkan, C., Schoormann, T., & Otto, B. (2022). Designing business model taxonomies - synthesis and guidance from information systems research. *Electronic Markets*, 32(2), 701-726. <https://doi.org/10.1007/s12525-021-00507-x>
- Nadeem, S. P., Garza-Reyes, J. A., Anosike, A. I., & Kumar, V. (2019, March 5). Coalescing the Lean and Circular Economy. *Proceedings of the International Conference on Industrial Engineering and Operations Management*.
- Nik-Bakht, M., An, C., Ouf, M., Hafeez, G., Dziedzic, R., Han, S. H., Nasiri, F., Eicker, U., Hammad, A., & Moselhi, O. (2021, November 2). *Value Stream Mapping of Project Lifecycle Data for Circular Construction*. 38th International Symposium on Automation and Robotics in Construction. <https://doi.org/10.22260/ISARC2021/0139>
- Osterwalder, A., & Pigneur, Y. (2010). *Business model generation: A handbook for visionaries, game changers, and challengers*. Wiley&Sons.
- Pekuri, A., Pekuri, L., & Haapasalo, H. (2013). The role of business models in Finnish construction companies. *Construction Economics and Building*, 13(3), 13-23.
<https://doi.org/10.5130/AJCEB.v13i3.3402>
- Przywara, A. (2025). Wartime circularity: Adapting buildings, salvaging materials, and designing supply chains for Ukraine. *Urban Research & Practice*, 1-18.
<https://doi.org/10.1080/17535069.2025.2571101>
- RÉCO. (n.d.). *Votre spécialiste du réemploi des matériaux de la construction*. RÉCO. Retrieved February 26, 2026, from <https://recocentre.ca/>
- ReuseWood.org. (n.d.). *ReuseWood*. Retrieved February 26, 2026, from <https://reusewood.org/>
- Riemensperger, F., & Falk, S. (2020). How to capture the B2B platform opportunity. *Electronic Markets*, 30(1), 61-63. <https://doi.org/10.1007/s12525-019-00390-7>
- Riuttala, M., Harala, L., Aarikka-Stenroos, L., & Huuhka, S. (2024). How building component reuse creates economic value - Identifying value capture determinants from a case study. *Journal of Cleaner Production*, 443, 141112.
<https://doi.org/10.1016/j.jclepro.2024.141112>
- Sacks, R., Koskela, L., Dave, B. A., & Owen, R. (2010). Interaction of Lean and Building Information Modeling in Construction. *Journal of Construction Engineering and Management*, 136(9), 968-980.
[https://doi.org/10.1061/\(ASCE\)CO.1943-7862.0000203](https://doi.org/10.1061/(ASCE)CO.1943-7862.0000203)

- Schnonherr, I., Alarcon, L. F., & Maturana, S. (2007, July). Quantifying the benefits of using e-marketplace in construction companies. *Proceedings IGLC*. 15th International Group for Lean Construction.
- Silva, M. G., Carvalho, T. S. de, Castagna, A. G., Strauhs, F. do R., & Piekarski, C. M. (2022). The role of online platforms to enable the process of industrial symbiosis: An analysis of tools available in the market. *Cleaner Production Letters*, 3, 100021. <https://doi.org/10.1016/j.clpl.2022.100021>
- Sischarenco, E. (2025). Recycling or reusing? An ethnographic study of the demolition industry in Northern Italy. *Urban Research & Practice*, 1-17. <https://doi.org/10.1080/17535069.2025.2494996>
- Sivers, M., & Fivet, C. (2025). Reuse Market Dynamics: Unlocking Building-Component Reuse in European Construction. *IOP Conference Series: Earth and Environmental Science*, 1554(1), 012019. <https://doi.org/10.1088/1755-1315/1554/1/012019>
- Sivers, M., Fröhlich, M., & Fivet, C. (2022). Circular economy digital market solutions for reuse in the European construction sector. *IOP Conference Series: Earth and Environmental Science*, 1078(1), 012121. <https://doi.org/10.1088/1755-1315/1078/1/012121>
- The ReUse People. (n.d.). *The ReUse People*. <https://Thereusepeople.Org/>. Retrieved February 26, 2026, from <https://thereusepeople.org/>
- Van Den Berg, M. (2024). Digital Technology Use Cases for Deconstruction and Reverse Logistics. In C. De Wolf, S. Çetin, & N. M. P. Bocken (Eds.), *A Circular Built Environment in the Digital Age* (pp. 197-212). Springer International Publishing. https://doi.org/10.1007/978-3-031-39675-5_11
- Walsh, K., & Goodland, H. (2024). *The Circular Built Environment in Canada: A Review of the Current State, Gaps and Opportunities*. Circular Economy Leadership Canada (CELC) and CSA Group. <https://www.csagroup.org/wp-content/uploads/CSA-Group-Research-The-Circular-Built-Environment-in-Canada-A-Review-of-the-Current-State-Gaps-and-Opportunities.pdf>
- Web-Recyc. (n.d.). *WEB-RECYC*. Web-Recyc. Retrieved February 26, 2026, from <https://web-recyc.com/en/>
- Wuyts, W., Liu, Y., Huang, X., & Huang, L. (2023). *Evaluating existing digital platforms enabling the reuse of reclaimed building materials and components for circularity*. 60-66. Scopus. <https://doi.org/10.1201/9781003354222-8>
- Yang, Y., Zheng, B., Luk, C., Yuen, K., & Chan, A. (2024). Towards a sustainable circular economy: Understanding the environmental credits and loads of reusing modular building components from a multi-use cycle perspective. *Sustainable Production and Consumption*, 46, 543-558. <https://doi.org/10.1016/j.spc.2024.02.027>
- Zott, C., & Amit, R. (2024). Business Models and Lean Startup. *Journal of Management*, 50(8), 3183-3201. <https://doi.org/10.1177/01492063241228245>

Appendix 1

List of 29 Digital Marketplaces Investigated for Morphological Analysis

S. No.	Name of Digital Marketplace	Website URL	Country	Industry
1	IKEA Preowned	https://www.ikea.com/ca/en/circular/second-hand/	International	Furniture
2	Facebook Marketplace	https://www.facebook.com/marketplace/	International	Classified Advertising
3	Rheaply	https://rheaply.com/public/	United States of America	Classified Advertising
4	Preloved	https://www.preloved.co.uk/	United Kingdom	Classified Advertising
5	Safi	https://www.safi.co/	United Kingdom	General Recyclables
6	BaleBid	https://www.balebid.com/	United Kingdom	General Recyclables
7	Salvoweb	https://www.salvoweb.com/	United Kingdom	Construction
8	Material Reuse Portal	https://materialreuseportal.com/	United Kingdom	Construction
9	OPALIS	https://opal.is.eu/en	Belgium	Construction
10	Rotor Deconstruction	https://rotordc.com/	Belgium	Construction
11	BatiTerre	https://www.batiterre.be/contact	Belgium	Construction
12	Atelier Circuler - Materialenbank Leuven	https://www.ateliercirculer.be/materialenbank-leuven/	Belgium	Construction
13	Cornermat	https://www.cornermat.be/	Belgium	Construction
14	JK-GENBRUGSCENTER	https://jk-genbrugscenter.dk/	Denmark	Construction
15	Genbyg	https://genbyg.dk/	Denmark	Construction
16	Matériuum	https://materium.ch/	Switzerland	Construction
17	Caprionis	https://www.caprionis.com/	France	Construction
18	BACKACIA	https://backacia.com/collections/all	France	Construction
19	Gebruikte Bouwmaterialen B.V.	https://gebruiktebouwmaterialen.com/	Netherlands	Construction
20	Restado	https://restado.de/	Germany	Construction
21	Use Again	https://www.useagain.ch/de/	Switzerland	Construction
22	Loopfront	https://loopfront.app/no/marketplace/public	Norway	Construction
23	Centrum för cirkulärt byggande (CCBuild)	https://ccbuild.se/marknadsplats	Sweden	Construction

Vakkanthula et al. (2026): Digital Marketplaces as Catalysts for Circular Economy in Construction:
Exploring the Role of Modular Business Models

S. No.	Name of Digital Marketplace	Website URL	Country	Industry
24	Offloadit	https://offloadit.com/	United States of America	Construction
25	The Reuse People	https://thereusepeople.org/	United States of America	Construction
26	The Loading Dock	https://loadingdock.org/	United States of America	Construction
27	Ouroboros Deconstruction	https://www.ouroborosdecon.com	Canada	Construction
28	Green Salvaged Materials	https://greensalvagedmaterials.com/	Canada	Construction
29	Historic House Salvage	https://www.historichouse.ca/	Canada	Construction

Appendix 2

Questionnaire used for Assessing the Alignment with Building Shearing layers

No.	BM Element	Question
1	Individuals	Should individuals be enabled as primary actors for recovery and trade of materials in this layer?
2	Businesses	Should businesses be targeted as primary actors for recovery and trade of materials in this layer?
3	Consumer (Quality Products)	Is reuse of products in this layer constrained by regulatory standards such that the DMP should set quality requirements for listings to enable reuse?
4	Consumer (Verified Participants)	Will restricting transactions to verified participants increase trust and therefore improve reuse rates for this layer?
5	Financial (Budget-Friendly Listings)	Are listing volumes in this layer limited, such that reduced or flexible listing fees should be applied to stimulate listing diversity in this layer?
6	Technical	Will providing standardized technical data sheets increase perceived reliability and reuse likelihood for products in this layer?
7	Transaction	Would allowing sourcing requests prior to deconstruction reduce uncertainty and improve reuse outcomes for this layer compared to existing practices?
8	Market	Would aggregating listings across platforms significantly improve market reach and improve reuse for this layer?
9	Pricing - Fixed	Should fixed pricing be applied as the base pricing mechanism for this layer?
10	Pricing - Negotiation	Are products in this layer traded in bulk quantities or subject to variable valuation, such that negotiated pricing should be provided as an option for this layer, in addition to fixed pricing?
11	Pricing - Auction	Are products in this layer high-demand and fast-moving, such that auction-based pricing should be provided as an option for this layer?
12	Operational Role - Facilitator	Can this layer be effectively supported through a facilitator-only role?
13	Operational Role - Intermediary	Do marketplace participants require assistance in fulfilling custom orders or matchmaking, such that the DMP should provide intermediary coordination services for this layer, in addition to being a facilitator? Note: If the answer is “Yes”, Support-Oriented and Database of Service Providers automatically apply.
14	Logistic Partnerships	Do products in this layer involve logistical complexity or bulk handling that would benefit from partnerships with logistics providers?
15	Shopping - Physical Access	Is physical inspection necessary for buyers to reliably assess the quality of products in this layer, beyond what digital information alone can provide?
16	Shopping - Online Access	Can products in this layer be reliably assessed by buyers through digital information without physical inspection?
17	Support-Oriented	Does this layer lack a mature secondary market, such that the DMP should adopt a support-oriented role to facilitate transactions?
18	Engagement- Oriented	Should awareness-building or demonstration activities be implemented to stimulate demand in this layer?

Vakkanthula et al. (2026): Digital Marketplaces as Catalysts for Circular Economy in Construction:
Exploring the Role of Modular Business Models

No.	BM Element	Question
19	Transaction-based	Does this layer generate sufficient transaction frequency and value density to justify commission-based revenue?
20	Recurring	Are participants in this layer likely to engage repeatedly enough to justify membership or subscription-based pricing?
21	Marketing	Should paid promotional options be offered for this layer as an additional revenue source?
22	Digital (Data Analytics Tool)	Should the DMP maintain a data analytics tool for this layer that provides platform users with insights such as estimated sale time based on information completeness, and average listing versus sale price?
23	Digital (Database of Service Providers)	Should the DMP maintain a curated database of organizations providing services such as deconstruction and quality testing for this layer?
24	Strategic or Analytical	Does this layer require long-term strategic investment to stimulate supply or demand?
25	Operational (Deconstruction Service Providers)	Should formal partnerships with deconstruction contractors be established for this layer?
26	Environmental & Quality Assurance	Should partnerships with environmental or quality verification providers be integrated for this layer?
27	Strategic Cost	Does this layer require strategic investment by the DMP to enhance its competitive position and strengthen its value proposition?