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ReCreate

Reusing precast concrete for a circular economy

Mikko Sairanen

# Business Model Canvases for Precast Concrete Element Reuse

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|---|---|
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# Abstract

**This report presents business model canvases (BMCs) for precast concrete element reuse developed in the ReCreate project. The BMCs are a result of structured analyses of ReCreate's pilot projects' business models and value creation mechanisms. Their purpose is to provide profound understanding on how concrete reuse businesses are construed on system, company, and process levels. These insights can help companies and value chains to improve their business models, e.g., by identifying increased value creation potential and by understanding of potential cost-efficiency pitfalls to address.**

The ReCreate project (funded by European Union's Horizon 2020 under grant agreement no 958 200) studies the construction industry's possibilities to transition from virgin concrete production and aggregate recycling into reuse of precast elements. This could potentially reduce the product phase carbon footprint by more than 90%. However, the reuse of precast concrete elements is still only rarely seen as economically viable. This is due to, among other things, the perceived difficulty of deconstructing elements as intact, and it is also impacted by the high cost-effectiveness of business-as-usual virgin production processes. Therefore, one of ReCreate's main objectives is to demonstrate the value and profitability potential of the reuse model, as well as to develop scalable business models. The investigation is facilitated by the ReCreate consortium's four pilot projects in Finland, Sweden, Germany, and the Netherlands. Each of the pilots involve a leading company partner which carries out the practical implementation.

The current deliverable's objective is to provide business-relevant understanding for companies aspiring to engage in the reuse of precast concrete elements. The knowledge is structured in the levels of the whole value chain (system), individual company roles, and process stages, and it is presented in the form of BMCs. The analysis concludes that although element reuse entails multiple new high-value processes and thus creates attractive business for involved companies, labour costs from time-intensive deconstruction and component handling remain a major profitability barrier. To scale up reuse in the industry, the creation of new marketplaces for reuse elements by either existing or new value chain actors could play a key role. Lastly, companies can divide responsibilities in the reuse value chain in various ways, and vertical integration of different process stages from deconstruction to reuse has the potential to bring about business benefits regarding cost-efficiency and market creation.

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# 1. Introduction

For precast concrete element reuse to scale up and flourish as a profitable business, interested companies must access to high-quality knowledge on the business potential of these processes. This includes information on: (1) impactful value propositions - what are potential customers of element reuse looking for; (2) multidimensional value creation - what are the critical aspects to consider in designing and delivering element reuse; and (3) maximal value capture - how to turn the process profitable through cost optimization and revenue maximization.

The Business Model Canvas (BMC) is a widely used method to communicate and characterise the aforementioned critical business insights (Osterwalder et al. 2010). A business model describes the organizational and financial architecture of a business (Teece 2010). A BMC is its visual representation. It consists of nine building blocks, which are value propositions, key partners, key activities, key resources, customer relationships, channels, customer segments, cost structure, and revenue streams). BMCs can be applied to different levels of business operations. In this report's analysis regarding concrete reuse, they are used for describing the business models not only for different company profiles, but also for the element reuse value chain as a whole, as well as its for distinct process stages.

The BMCs to be presented were construed by investigating the ReCreate pilot projects in Finland and Germany (see Methodology). In these value chains, seven distinct company profiles were recognised: the construction firm, element refurbisher, structural engineer, architect, deconstruction firm, integrative solution provider, and building owner. A BMC will be presented for each of these profiles. Notably, the integrative solution provider was identified as a distinctive company profile. It is an actor that combines the execution of multiple process stages 'under one roof', leading to interesting business model implications. The presented company-level BMCs are not descriptions of ReCreate partner companies' business models. Instead, they seek to produce generalizable understanding of different business models along the element reuse value chain. Their purpose is to bring up important insights for different company profiles.

Regarding the process level, two types of process stages for element reuse were identified. The basic process stages include deconstruction, element refurbishment, planning of the new building, and reuse. The basic process stage business models significantly overlap the company-level business models and are thus covered within the company-level BMCs. Additional process stages include quality management, storage, and logistics. The additional process stages are less actor-specific, so they are covered with the help of dedicated BMCs. In addition, the analysis encompasses a system-level BMC which was construed to reflect how value is proposed, created, delivered, and captured in the value chain level by integrating the views of all investigated actors.

# 2. Methodology

As the idea of BMCs is to synthetize knowledge from a complex setting into an easily understandable written and visual form, a qualitative research approach was employed (Yin, 2018). To obtain in-depth understanding of companies' business models, the data for the study was mainly gathered through semi-structured interviews. Cross-pilot interview rounds with project partner companies were carried out from 2021 until early 2023. For the final analysis, data from a total of 13 interviews was utilized.

The analysis was carried out with the help of Atlas.ti 22 qualitative data analysis software. Data was coded according to sections of the BMC, value creation aspects, and related phenomena such as regulation or digitalization. Interpretative thematic analysis was carried out to develop the BMCs. To ensure the quality of the findings and prevent any confidential data from being published, all interviewed companies were given the opportunity to review and revise the BMCs.

# 3. Business Model Canvases

## 3. 1. System-level BMC

<table>
<tr>
<td rowspan="2">Key partners<br>Construction firms<br>New building owners<br>Element refurbishers<br>Structural engineers<br>Architects<br>Deconstruction firms<br>Logistics companies<br>Subcontractors and equipment suppliers<br>Cities and municipalities<br><br>One actor may assume multiple roles (e.g., deconstruction + refurbishment + construction)</td>
<td>Key activities<br>Deconstruction planning<br>Deconstruction<br>Quality inspection<br>Transportation<br>Element refurbishment<br>New building design<br>Reassembly<br>Permission management with public stakeholders</td>
<td rowspan="2">Value proposition<br>Reducing element-bound emissions by ~90% and whole new building embodied carbon footprint by 50-70%<br>Economic value still largely dependent on regulatory incentives, but will increase with process standardization<br>In some contexts, costs of energy-intensive concrete production may directly imply profitability of reuse<br>Reused elements are of high quality and could enable new types of architectural solutions carrying both immaterial and functional value<br>Opportunities for new product concepts, such as replicable circular low-carbon buildings</td>
<td>Customer relationships<br>Many new, highly collaborative customer relations (e.g., element refurbishers as customers of deconstructors) that network around the pre-existing relations</td>
<td rowspan="2">Customer segments<br>For construction firms: private and public building owners, e.g., housing providers<br><br>For deconstructors: Construction firms, element refurbishers, donor building owners<br><br>For element refurbishers: Construction companies<br><br>For structural engineers: Construction and deconstruction companies</td>
</tr>
<tr>
<td>Key resources<br>Suitable donor buildings<br>Functional logistics including temporary storage<br>Special deconstruction and quality management (condition investigation & refurbishment) equipment</td>
<td>Channels<br>Possibilities to create new marketplaces, e.g., an online store of reusable elements<br>The value chain may be fragmented, or a leading company may manage the marketing for several phases</td>
</tr>
<tr>
<td colspan="3">Cost structure<br>Added costs:<br>Cost bound to prolonged process duration (vs. use of virgin elements)<br>Additional labor costs: mainly in deconstruction, also in refurbishment & quality inspection<br>Cost of added logistics (manageable cost when planning is smart)<br>Special equipment costs<br>Saved costs:<br>No need for new element production/purchases<br>Future possibilities through taxational/policy-related cost savings (e.g., emissions trading)<br>Saved waste management costs</td>
<td colspan="3">Revenue streams<br>On sub-process level:<br>Increased value and price of various process phases, such as deconstruction, design and consultation services. Exact revenue flows depend on task division and ownership of the elements between use cycles.<br>On system level:<br>Building sales; some customers could be willing to pay extra for reused elements<br>Regulation likely to affect profitability in the future, e.g., through carbon-neutrality commitments or ETS</td>
</tr>
</table>

# 3. 2. Company-level BMCs

## 3.2.1. Deconstruction firm

*The BMC for deconstruction firms involves the following basic process stage: deconstruction.*

<table>
<tr>
<td rowspan="2">Key partners<br>Construction firms and/or donor building owners<br>• As the customer<br>• Project specifications and planning<br><br>Structural engineers<br>• Technical consultancy in deconstruction planning<br><br>Logistics provider & element refurbisher<br>• Post-deconstruction actions</td>
<td>Key activities<br>Preparation, uncovering, opening, and/or cutting the fasteners (much care required, takes most of the time)<br>Attaching elements to the crane for lifting<br>Lifting and placing the elements on trucks be transported</td>
<td rowspan="2">Value proposition<br>Elements deconstructed according to the plan<br><br>Elements deconstructed intact, without damage</td>
<td>Customer relationships<br>Deconstruction often requires a little bit more joint planning with the customer</td>
<td rowspan="2">Customer segments<br>Construction firms (especially when construction firms use the elements in their own projects, see integrated service provider BMC)<br><br>Donor building owners, including cities and municipalities<br><br>If deconstructor owns the elements: element refurbishers</td>
</tr>
<tr>
<td>Key resources<br>Cranes<br>Equipment for uncovering the fasteners and detaching the element</td>
<td>Channels<br>If deconstructor owns the elements: direct sales to element refurbishers</td>
</tr>
<tr>
<td colspan="3">Cost structure<br>Element deconstruction takes significantly longer than demolition (around twice the time of normal demolition) and requires more manpower, hence making the cost increase significant<br>Some cost savings result from avoided waste management costs</td>
<td colspan="2">Revenue streams<br>Service fees; high costs taken into account in pricing<br>If deconstructor owns the elements: element sales</td>
</tr>
</table>

## 3.2.2. Element refurbisher

*The BMC for element refurbishers involves the following basic process stage: element refurbishment.*

<table>
<tr>
<td rowspan="2">Key partners<br>Structural engineers<br>• Quality assurance<br>• Deconstruction planning and element inventory<br><br>Construction firms<br>• Key customer<br><br>Deconstruction firm<br>• Supply of deconstructed elements<br><br>(Logistics providers)</td>
<td>Key activities<br>Refurbishment: coating, grouting, drilling fasteners, clean-up (similar to existing repairs of faulty elements)<br>Post refurbishment quality inspection (possibly also pre-inspection)</td>
<td rowspan="2">Value proposition<br>Reused elements with smaller environmental footprint but with normal quality and durability</td>
<td>Customer relationships<br>Leveraging refurbished elements in branding<br><br>Joint planning; same customer could sell and buy the products to/from the element refurbisher (cf. integrative solutions provider)</td>
<td rowspan="2">Customer segments<br>Same as with conventional business;<br><br>Construction companies, whose demand strongly guides the market</td>
</tr>
<tr>
<td>Key resources<br>Existing, extended and new production lines<br>-> extensions and new lines needed if volumes grow<br><br>Element data stored in documents and BIM models</td>
<td>Channels<br>Per se, no big changes compared to conventional business<br><br>Possibility to organise a secondary marketplace like an online store for refurbished elements</td>
</tr>
<tr>
<td colspan="3">Cost structure<br>Work costs: refurbishment process is not very expensive if well standardised and done in a production line instead of on-site, but normal element production is still clearly more cost-effective<br>Material costs: not very significant, fastener assemblies etc.<br><br>Depending on the ownership model: cost of incoming deconstructed elements (the seller may vary too)<br>Possible: Quality assurance costs, new work stage costs like planning of the refurbishment process</td>
<td colspan="2">Revenue streams<br>Refurbished element sales or service fees; added costs must be embedded<br><br>Refurbished elements can act as an additional product/source of revenue, which may even boost overall sales due to sustainability marketing and improved image<br><br>Environmental product declaration values, such as carbon footprint, could be dropped substantially, which could at some point lead to financial or market benefits -> regulative incentives or sanctions would increase profitability</td>
</tr>
</table>

## 3.2.3. Construction firm

*The BMC for construction firms involves the following basic process stages: deconstruction, new building design, and reuse.*

<table>
<tr>
<td rowspan="2">Key partners<br>Structural engineers<br>• New building design<br>• Deconstruction planning<br>• Early quality inspections<br><br>Architects<br>• New building design<br><br>New building owners<br>Deconstruction firms<br>• Deconstruction planning<br><br>Element refurbishers<br>• New building planning<br>• Quality validation</td>
<td>Key activities<br>Giving specifications for building design<br>Construction with reused elements (Deconstruction commission and supervision)</td>
<td rowspan="2">Value proposition<br>In competitive tendering, it largely depends on the scoring set by the customer<br><br>On a general level, to provide a solution towards a company's internal and societal carbon neutrality<br><br>Non-mainstream, innovative sustainable solution<br><br>Demonstrating circular values: "Giving a new life to a building"<br><br>Recognition and anticipation of changing customer values</td>
<td>Customer relationships<br>No big changes compared to conventional business, close collaboration</td>
<td rowspan="2">Customer segments<br>Roughly the same as with conventional business;<br>• Public customers<br>• Private companies and organizations<br>• Homebuyers<br><br>Inside the segments, element reuse and similar concepts can bring about new customerships.<br>Publicly-owned buildings maybe most potential segment in the early phase.<br>Regarding flats, certain segments might be more receptive to reuse.</td>
</tr>
<tr>
<td>Key resources<br>Suitable target buildings (for both deconstruction and new building)<br><br>Use of own workforce common in the critical processes, such as element assembly</td>
<td>Channels<br>Same as with conventional business;<br><br>• Speculative building / development<br>• Customers through tendering</td>
</tr>
<tr>
<td colspan="3">Cost structure<br>Deconstruction is significantly slower and deconstruction cost thus higher than in demolition<br>Construction process and costs not affected much – except that extra care needed in moisture management, because reused elements take lots of time to dry if allowed to get wet (In theory, improved moisture management could also turn out to be a cost saving in the future)<br>If the new building planning relies on the availability of reused elements, the overall process can be clearly slower and schedule more uncertain which brings significant added costs<br>Additional work safety considerations can bring some extra costs (only if involved in deconstruction)</td>
<td colspan="2">Revenue streams<br>Awareness of market demand early on is valuable to ensure that the elements will contribute to sales in new buildings<br><br>Some customers possibly willing to pay a premium for building made with reused elements<br><br>Regulatory incentives needed (e.g., through ETS or carbon taxation)</td>
</tr>
</table>

## 3.2.4. Structural engineer

*The BMC for structural engineers involves the following basic process stages: deconstruction, new building design, and reuse.*

<table>
<tr>
<td rowspan="2">Key partners<br>Construction firm<br>• On the new building: planning and BIM-modelling<br><br>Deconstruction firm<br>• On the donor building: condition survey, selection of elements for deconstruction<br>• Technical planning work of deconstruction<br><br>Architects<br>• On the new building: planning and BIM modelling</td>
<td>Key activities<br>Determining information needs regarding the donor building to execute the deconstruction<br>Inventory BIM (for structural parts)<br>Defining what will be deconstructed<br>Quality inspections<br>Giving ideas in which purposes the elements could be reused<br>Planning the new building</td>
<td rowspan="2">Value proposition<br>In deconstruction: enabling efficient deconstruction planning and quality inspections<br><br>In new building construction: providing options for element reuse, carrying out structural design<br><br>On a general level: to support customers’ and industry’s transition with services for carbon-neutrality and resource conservation</td>
<td>Customer relationships<br>Highly interactive role during projects<br><br>Deeper collaboration with deconstructors (compared to when they carry out demolition)</td>
<td rowspan="2">Customer segments<br>Same as with conventional business;<br><br>Construction companies<br>Building owners<br><br>Additionally: Deconstructors<br><br>New skills and services enable contacting desired new customers from conventional segments</td>
</tr>
<tr>
<td>Key resources<br>Skills on pre-deconstruction auditing & structural condition investigation of donor building<br>Modelling software<br>Capabilities for early recognition of element characteristics, such as harmful substances, dimensions, mountings</td>
<td>Channels<br>Conventional channels: direct requests for quotation, public tendering</td>
</tr>
<tr>
<td colspan="3">Cost structure<br>Both in deconstruction planning and new building planning the design labour cost increases<br>All additional research processes add to the total cost – therefore it is important to recognise which information is necessary to have<br>Some measuring and analysis processes may prove to be too expensive, such as 3D laser scanning</td>
<td colspan="2">Revenue streams<br>Service fees; increased amount of design work taken into account in pricing<br><br>New kind of service concepts / packages can possibly be bundled</td>
</tr>
</table>

## 3.2.5. Architect

*The BMC for architects involves the following basic process stages: new building design and reuse.*

<table>
<tr>
<td rowspan="2">Key partners<br>Structural engineers<br>• In new building planning<br><br>Subcontractors<br>• For technical measurements and analysis</td>
<td>Key activities<br>Design and modelling of the new buildings<br><br>Inventory BIM (for structural parts)</td>
<td rowspan="2">Value proposition<br>Provision of optimal building designs for the reuse of elements, according to the needs of the commissioner<br><br>Potential to envision radically new building solutions for reused elements, using existing elements as basis for design</td>
<td>Customer relationships<br>If the traditional model stays, architect works according to customer specifications<br><br>If the model changes, architects could be more proactive solution creators</td>
<td rowspan="2">Customer segments<br>Construction companies, other private and public commissioners of buildings<br><br>In a broader sense: society</td>
</tr>
<tr>
<td>Key resources<br>Modelling software<br><br>Potentially some more technical knowledge needed as architects cannot choose technical specifications with same freedom as in conventional construction</td>
<td>Channels<br>No substantial changes to conventional business</td>
</tr>
<tr>
<td colspan="3">Cost structure<br>Increased need for subcontracting in order to obtain technical information<br>Possible that added costs occur from additional personnel or software</td>
<td colspan="2">Revenue streams<br>Service fees for design work and potentially for inventory BIM work</td>
</tr>
</table>

## 3.2.6. Integrative solution provider

*The BMC for integrative solution providers involves the following basic process stages: deconstruction, element refurbishment, new building design, and reuse.*

<table>
<tr>
<td rowspan="2">Key partners<br>Depending on integration scope; partners who provide the execution of remaining processes or consultation<br><br>Typically, at least structural engineers and architects<br><br>Building owners</td>
<td>Key activities<br>Vertically integrating deconstruction, element refurbishment, new building planning and reconstruction (+ possibly additional operations such as logistics)<br>Assessments of element a) demand b) offer in own projects</td>
<td rowspan="2">Value proposition<br>To conduct comprehensively sustainable business with flexible and circular internal operations<br><br>Offer unique know-how and efficiency to the customer by integrating deconstruction, refurbishment and reuse<br><br>A wider portfolio of offerings produces a competitive advantage</td>
<td>Customer relationships<br>No big changes compared to conventional construction; element reuse can be used as a selling argument depending on the customer</td>
<td rowspan="2">Customer segments<br>Same as with conventional construction<br><br>In a way, integrative solution provider also acts as its own customer in element reuse</td>
</tr>
<tr>
<td>Key resources<br>Broad capabilities to carry out various process stages<br>System-level planning of material flows<br>Efficient product data management</td>
<td>Channels<br>Same as with conventional construction; speculative development / building and tendering, although tenders do not yet say promote element reuse in any way</td>
</tr>
<tr>
<td colspan="3">Cost structure<br>Added costs depend on the technical difficulty (duration) of the deconstruction, refurbishment, and reuse processes, as well as the physical proximity of the sites where these activities are performed<br><br>Well-standardised internal integrated processes lower costs<br><br>Cost savings result from avoided waste management costs, and energy and material savings</td>
<td colspan="3">Revenue streams<br>Building/project sales or possibly building/apartment rental revenues, no new revenue streams compared to conventional construction<br><br>Depending on the project type, revenue and profit can be made from the individual processes also separately<br><br>Regulatory or subsidy-based incentives increase profitability</td>
</tr>
</table>

## 3.2.7. New building owner

*The BMC for new building owner involves the following basic process stages: reuse.*

<table>
<tr>
<td rowspan="2">Key partners<br>Construction firm (who can also be the building owner themselves, at least initially, before sales to final buyer)<br><br>Architects<br><br>Structural engineers</td>
<td>Key activities<br>Setting reuse specifications in building design</td>
<td rowspan="2">Value proposition<br>Towards own customers (tenants or final buyers):<br><br>Safe, high-quality buildings which have lower CO2 footprint and have consumed less resources in the making<br><br>Towards other stakeholders:<br><br>Especially publicly-owned buyers demonstrate sustainability progress to public stakeholders, such as cities or steering committees</td>
<td>Customer relationships<br>No big changes compared to conventional business</td>
<td rowspan="2">Customer segments<br>Consumers or private/public organizations who can either be tenants or buy the whole building or units within it</td>
</tr>
<tr>
<td>Key resources<br>Knowledge of the possibilities and benefits of concrete element reuse</td>
<td>Channels<br>No big changes compared to conventional business</td>
</tr>
<tr>
<td colspan="3">Cost structure<br>Price of construction<br>After sales: building maintenance costs which are affected e.g., by building performance</td>
<td colspan="2">Revenue streams<br>Rent from tenants or resales (whole building or units within it)</td>
</tr>
</table>

# 3. 3. Additional process -level BMCs

## 3.3.1. Quality management

<table>
<tr>
<td rowspan="2">Key partners<br>Quality management can be conducted in part by structural engineers, deconstruction firms, element refurbisher, construction firm, and external subcontractors, depending on process phase and procedure difficulty<br><br>Combinations exist; for example structural engineer may define measurement needs and an external contractor may carry out the measurements</td>
<td>Key activities<br>Checking for harmful substances (qualified surveyors, often structural engineers)<br>Checking for structural integrity (qualified surveyors, often structural engineers)<br><br>Pre-deconstruction, post-deconstruction, and post-refurbishment checks</td>
<td rowspan="2">Value proposition<br>Process guarantees that the elements are as good as new and can be bought and reused without worry</td>
<td>Customer relationships<br>Value chain-wide communication on the quality management to ensure optimal timing of activities and to avoid double work<br><br>Ensuring element data flow between value chain actors is crucial</td>
<td rowspan="2">Customer segments<br>Generally, the following actor in the value chain and ultimately new building owner can be considered customers</td>
</tr>
<tr>
<td>Key resources<br>Non-destructive structural condition investigation tools and destructive material sampling tools to carry out the investigation<br>Knowledge of needed and appropriate measures for each stage, e.g., from relevant standards</td>
<td>Channels<br>Typically executed by value chain collaborators, some activities could potentially be bought as a service</td>
</tr>
<tr>
<td colspan="3">Cost structure<br>If quality management steps are carried out too late (e.g., harmful substances found after deconstruction), severe extra costs and value destruction can occur<br><br>Extensive checking and use of advanced tech leads to high unnecessary costs</td>
<td colspan="3">Revenue streams<br>Quality management services embedded in the service prices of the actor who conducts them</td>
</tr>
</table>

## 3.3.2. Storage

<table>
<tr>
<td rowspan="2">Key partners<br>Most often involved in the storage stage are some of the following:<br><br>Deconstruction firm<br>Element refurbisher<br>Logistics provider<br>Construction company</td>
<td>Key activities<br>Taking the elements in<br>Storing the elements in appropriate conditions<br>Possibly conducting some quality validation during storage<br>Transporting the elements out</td>
<td rowspan="2">Value proposition<br>Maintaining the state of the elements, avoiding any damage</td>
<td>Customer relationships<br>Careful communication on the value of the elements with value chain collaborators and personnel to avoid mishandling that destroys value</td>
<td rowspan="2">Customer segments<br>Customers of the storage stage can be considered the actors who own the elements and who pay for the storage (same actor or two different ones) – these are most often deconstructor, element refurbisher, or construction firm</td>
</tr>
<tr>
<td>Key resources<br>Sufficient space<br>Required conditions, protection from moisture<br>Lifting tools (cranes) on-site<br>Racks/stands for elements</td>
<td>Channels<br>Can be bought as an external service or be sourced internally from value chain collaborators</td>
</tr>
<tr>
<td colspan="3">Cost structure<br>Cost accumulates from the combination of: storage space, storage time, (storage location or other factors)</td>
<td colspan="2">Revenue streams<br>Other value chain collaborators may pay a direct fee for storage service for its provider, or it can be embedded into the project price</td>
</tr>
</table>

## 3.3.3. Logistics

<table>
<tr>
<td rowspan="2">Key partners<br>Can be conducted either by value chain collaborators or by an external provider<br><br>Key partners around the logistics stage are construction company, deconstruction firm, and element refurbisher</td>
<td>Key activities<br>Collection logistics: Transporting the elements to be refurbished<br><br>Processing logistics: Possible transportations of elements between the storage and refurbishment facility<br><br>Redistribution logistics: Transporting the refurbished elements to new construction sites</td>
<td rowspan="2">Value proposition<br>Efficient and fast transportation<br><br>Maintaining the state of the elements, avoiding any damage</td>
<td>Customer relationships<br>Careful communication on the value of the elements with logistics provider and personnel to avoid mishandling that destroys value</td>
<td rowspan="2">Customer segments<br>Primary customers for collection logistics are construction firm, deconstruction firm, and element refurbisher<br><br>Primary customers for redistribution logistics are construction firm and element refurbisher</td>
</tr>
<tr>
<td>Key resources<br>Appropriate vehicle fleet to transport heavy concrete elements<br><br>Capabilities to transport elements with varying specifications<br><br>Lifting capabilities possibly required</td>
<td>Channels<br>Can be bought as an external service or be sourced internally from value chain collaborators</td>
</tr>
<tr>
<td colspan="3">Cost structure<br>Costs directly depend on the proximity of the deconstruction site(s), temporary storage, refurbishment, and reuse site(s)</td>
<td colspan="2">Revenue streams<br>Other value chain collaborators may pay a direct fee for storage service for its provider, or it can be embedded into the project price</td>
</tr>
</table>

# 4. Conclusion

All in all, the BMCs demonstrate significant business potential of precast concrete element reuse for all actors of the value chain, but they also point out issues, which can still hinder profitability and large-scale viability. Regarding the former, element reuse significantly increases the value of many process stages, such as deconstruction, element refurbishment, and design work, which indicates positive employment effects and allows involved companies to charge higher prices for their services. In addition, environmental sustainability might enable increases in building price-per-square-meter in some contexts.

On the other hand, element reuse leads to significantly higher labour costs due to work-intensive deconstruction and refurbishment processes. Currently, the production of virgin concrete elements is commonly so cheap that it can be hard for companies to justify the costs of the process required to execute element reuse. Even though element reuse also brings about some cost savings, such as reduced waste management costs, the development of regulatory incentives and obligations would be important to guarantee the cost-competitiveness of the reuse process against virgin production.

It is worth highlighting that according to the analysis, scaling up concrete element reuse would perhaps require, or at least greatly benefit from, the creation of new marketplaces for reusable elements. Some type of catalogue of elements available for reuse was widely suggested. This could be implemented either by a company new to the value chain or assumed by one of the existing players. In the latter case, element refurbisher would probably be the most natural actor to establish this second-hand marketplace, as the sales of refurbished elements would serve as an extension to their conventional business.

The identified company profiles as well as the BCMs themselves also demonstrate that companies may organise responsibilities in the value chain in various ways to implement concrete element reuse. Most importantly, it is possible for a company with suitable capabilities to vertically integrate much of the value chain (see the BMC of the integrated solution provider). The analysis shows that such vertical integration may lower costs through internal process optimisation, improved flow of production data and other information, and absence of tricky technological or market interfaces. Additionally, if the same company is involved in both deconstruction and reuse, they are in a good position to balance deconstruction projects with reuse market demand, thus minimising the risk of generating waste and facing extra costs due to the delay of the reuse stage.

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