WP57 - Coordinating reverse logistics in construction: mechanisms to manage uncertainties for various disposition scenarios

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Abstract

Reverse logistics in construction deals with the movement of building products and materials from salvaged buildings to a new construction site. Demolition firms and contractors need to coordinate their inter-firm activities for disposition scenarios such as reuse, refurbishing, recycling or disposal. Through elaborating on information processing theory, this multiple case-study explores how their coordination mechanisms match uncertainties in different disposition scenarios. Three configurations of demolisher-contractor interorganizational relationships are uncovered: the 'disposer-controller' (successful for material recycling), the 'mover-reseller' (successful for modular component reuse) and the 'seller-speculator' (unsuccessful for element reuse) configuration. These insights contribute to information processing theory and may open up new possibilities to promote resource efficiency within the construction industry.

Keywords: *coordination; information processing; reverse logistics*

Introduction

The construction industry has begun implementing reverse logistics principles in response to increasing economic and environmental challenges. The construction and maintenance of the physical infrastructure accounts for more than half of the total global virgin resources consumed annually and for more than one third of the total global energy usage and associated emissions (Iacovidou & Purnell, 2016; Ness, Swift, Ranasinghe, Xing, & Soebarto, 2015). Construction and demolition (C&D) waste represents a major waste stream in the EU with only a small part of the materials being recovered (Kourmpanis et al., 2008). Increasing environmental awareness and regulations have stimulated the construction industry to revise its supply chains. While researchers, policy makers and practitioners initially primarily gave attention to reducing waste in forward supply chains, the reverse flow of supply chains, or reverse logistics, has more recently grown in importance (Agrawal, Singh, & Murtaza, 2015).

The adoption of reverse logistics entails redesigning and enhancing supply chains to efficiently manage the flow of consumed products or materials, and to direct them towards reuse, remanufacturing/refurbishing and recycling (Chileshe, Rameezdeen, & Hosseini, 2016). Govindan and Soleimani (2017) argue that the classic supply chain approach "does not feel any responsibility" for products at the end of their life-cycle; reverse logistics tries to account for that by guiding to the most environmentally friendly disposition scenario. It is often defined as "the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal" (Rogers & Tibben-Lembke, 1999). Reverse logistics in construction deals with the movement of products and materials from salvaged buildings to a new construction site (Hosseini, Rameezdeen, Chileshe, & Lehmann, 2015). The uptake of reverse logistics in the construction industry has nevertheless not kept pace with other industries.

For reverse logistics to become a well-established practice, the organizational factors that influence establishing an efficient reverse logistics network need to be understood (Chileshe et al., 2016; Schultmann & Sunke, 2007). Reuse of building parts depend on a supply of recovered items and a demand for these goods (Cooper & Gutowski, 2015). Demolition firms and contractors are the dominant companies for connecting supply and demand in this context, but there is little evidence of effective relationships between them. Construction with reclaimed materials is challenging, since sourcing typically requires individual searching and negotiation, the use of reclaimed parts increases project complexity and it may be necessary to recertify recovered building parts (Allwood, Ashby, Gutowski, & Worrell, 2011). In this context, a better understanding of the coordination mechanisms that demolition firms and contractors collaboratively deploy is urgently needed to achieve real transformations in the sector.

This paper therefore aims to uncover configurations of interorganizational relationships for reverse logistics. Through elaborating on information processing theory, we explore how coordination mechanisms match uncertainties in different disposition scenarios. The next section presents the theoretical points of departure of this study, after which three cases and the research methods are discussed. Based on that, we discusses three possible configurations of interorganizational relations. The paper concludes with a number of propositions on how these configurations can be used to successfully achieve different disposition scenarios.

Theoretical framework

A starting point for reverse logistics in construction is that there are multiple disposition scenarios for a building and its constituents. Common disposition scenarios, or end-of-life-cycle options, are: reuse, remanufacturing/refurbishing, recycling and disposal (Agrawal et al., 2015; Allwood et al., 2011; Cheshire, 2016). These disposition scenarios essentially differ in the extent to which the original value of products is retained. Reuse is based on extending the life of a product without destruction, refurbishing is concerned with replacing older or damaged parts to restore its condition, and recycling is the process during which discarded parts are reprocessed into new materials for new products (Iacovidou & Purnell, 2016). If no material recovery is possible, disposal takes place. Despite theoretical prioritizations of disposition scenarios, the selection of one scenario for (part of) a building depends in practice on many factors such as market conditions and competitiveness, building and environmental regulations, awareness and prejudice and the extent to which a building was designed to be disassembled (Chileshe et al., 2016; Durmisevic, 2010; Hosseini et al., 2015; Iacovidou & Purnell, 2016).

Each disposition scenario requires coordination efforts between demolition firms and contractors. Key activities that need to be coordinated in reverse logistics include collecting, inspecting, sorting and further processing of products (Agrawal et al., 2015). Since buildings can be viewed as complex arrangements of many different building systems, components and elements, these activities need to be done systematically in order to recover the maximum amount of materials at the highest reuse value. In conventional demolition, however, buildings are torn down with heavy equipment (bulldozers, wrecking balls or explosives) and, as a result, the generated waste is mixed and recovery of materials is difficult (Kourmpanis et al., 2008). For material recovery to occur, demolition firms and contractors need to collaborate, communicate and share information. The latter is a focus of information processing theory (at the interorganizational level of analysis).

Information processing theory (IPT) views organizations as information processing systems facing uncertainty (Galbraith, 1973, 1974; Tushman & Nadler, 1978). Information processing refers to the gathering, interpreting, and synthesizing of information (Tushman & Nadler, 1978). Uncertainty, as the root cause of information processing, is defined as "the difference between the amount of information required to do the task and the amount of information already possessed by the organization" (Galbraith, 1973). Bensaou and Venkatraman (1995) distinguished between three major types of uncertainty in interorganizational relationships: environmental (arising through general environmental conditions), partnership (arising through partner behavior) and task (arising due to the specific required tasks) uncertainty. IPT posits that organizations need to respond to information processing needs by adopting at least one of the following four coordination mechanisms: creation of slack resources (lowering performance standards with buffers), creation of self-contained tasks (defining independent tasks with own resources), investment in vertical information systems (employing redundant information channels) or creation of lateral relations (employing selectively joint decision processes which cut across lines of authority) (Galbraith, 1973, 1974). These four coordination mechanisms either lower the need for information processing (first two) or increase the capacity for information processing (second two). Organizations will be more effective when there is a match between the information processing needs and the information processing capacity (Tushman & Nadler, 1978).

For the context of reverse logistics, significant insight is lacking about those (mis)matches in various disposition scenarios. Little is known about the coordination mechanisms that demolition firms and contractors adopt in response to the uncertainties they face in a project. That lack of knowledge on their interorganizational relationships currently hinders the transition to more sustainable (reverse) construction supply chains.

Table 1 Characteristics of the units of analysis per case

	1 – Faculty building	2 – Nursing home	3 – Psychiatric institute
Project type	Transformation	Deconstruction	Deconstruction
Focal disposition scenario	Material recycling	Modular component reuse	Element reuse
Size (floor area)	25,000 m^2	4,000 m^2	15,000 m^2
Location	Netherlands (East)	Netherlands (East)	Netherlands (South)
Construction year	1967	2001	1973

Research methodology

This research explores how coordination mechanisms for reverse logistics in construction match uncertainties in different disposition scenarios. The design of this research can best be described as exploratory theory elaboration. Theory elaboration involves the use of constructs from other theoretical perspectives, in this case information processing theory, to explain the phenomenon of interest (Ragin & Becker, 1992). It is exploratory, since that phenomenon of interest, reverse logistics, is still underrepresented in supply chain management research – particularly for the construction industry.

For this kind of research, a multiple case-study is a preferred method as it enables to gain in-depth insights into real-life events (Eisenhardt, 1989; Yin, 2009). We assumed that both uncertainties related to reverse logistics and corresponding coordination mechanisms would vary among different disposition scenarios. Three cases that we knew to be dealing with different disposition scenarios were therefore purposefully selected (theoretical sampling): (1) transformation of a faculty building, (2) deconstruction of a nursing home, and (3) deconstruction of a psychiatric institute (Table 1). The uncertainties and coordination mechanisms regarding reverse logistics are our primary units of analysis in these cases.

Data were collected from multiple sources to enable data triangulation. The most important type of data stems from interviews with knowledgeable practitioners in each case. Because reverse logistics is multidisciplinary and requires input from numerous functions, semistructured interviews were conducted with project leaders, demolishers and asset managers. The interviews were recorded, transcribed and sent to the interviewees for approval. For each of the projects, internal documents were collected, such as demolition schedules, tender and contract documents, technical drawings and project management plans. We also conducted multiple construction site visits to observe and photograph demolition and deconstruction activities. Additionally, access to an online database with recovered building products was obtained for one of the cases.

Data analysis involved the structuring of theoretical constructs and relations. For each case, we analyzed the transcripts, project documents and photographs from our site visits. We coded uncertainties related to reverse logistics using the distinction between environmental, partnership and task uncertainties proposed by Bensaou and Venkatraman (1995), albeit in a qualitative rather than quantitative manner. We also coded the four coordination mechanisms of Galbraith (1974) that were applied in these projects. After having mapped both the uncertainties and coordination mechanisms, we investigated the match between those two for each case.

Findings

This section organizes the findings per case. We discuss the uncertainties and the (resulting) coordination mechanisms for three different disposition scenarios.

Case 1: material recycling from the transformation of a faculty building

The first case deals with the transformation of a faculty building into a student housing complex, hotel and conference center. At the time of our study, the building was for that reason being stripped down to its main load-bearing structure that consists of a concrete skeleton with prefabricated concrete floors. This load-bearing structure is essentially the only building system that is being reused for the new student housing complex, hotel and conference center. All other building elements are being sorted per material type and then moved away from the site. Bricks and other cementitious materials are being crushed on site for future use as road foundation. Steel, iron, aluminum and other metals are recycled by a metal waste processor; timber, plastics, isolation and other materials by another waste processor.

Uncertainties. While there are some environmental uncertainties, partnership and task uncertainties regarding these material streams are low. All building products are treated as waste that will be recycled. The construction site is quite big and can be used easily for on-site storage of demolition waste. Information regarding the actual amount and type of materials and asbestos, needed to plan and execute the demolition works, were obtained during site visits and from drawings. The original construction drawings from the building were still present, but drawings from later additions and renovations have gone missing. The exact quantities “are and remain an educated guess” though since it would be too costly to map the exact number of installations, cable trays, ceiling tiles and so on (demolisher). Market prices of metals (that yield money) and most other materials (for which landfill costs need to be paid) vary per year since the demolition firm has annual contracts with several waste processors.

Mechanisms. The demolition firm stores building parts on the construction site until they are transported to a waste processor. As one of the first steps in the project, the demolition firm cleared the four elevator shafts of the former faculty building so that they could be used as construction chute. Demolishers collected the demolition waste and sorted it per material type in front of these elevator shafts. The sorted waste is then thrown into the shafts and, at the ground floor, pushed out of the building with a skid steer loader. Big piles with waste, sorted per material type, can be found outside. Asbestos is stored per floor in vacuum packages and will only be lifted out of the building once the façade is removed in order to minimize the chance that this toxic material escapes. Storage times differ per material type and their transportation is mostly efficiency-driven, which is determined by factors such as the needs of waste processors, their opening hours, the availability of empty trucks and possibilities for on-site storage in other projects. The planning of the demolition works is relatively tight (with little slack time), so that any delays can only be dealt with through scaling up in the number of people working on site.

The main contractor has completely outsourced the demolition works to the demolition firm. Those works consist of two main tasks that have their own resources (crew and equipment) and could be considered as self-contained tasks: stripping and asbestos removal. The asbestos crew typically requests the stripping crew to pre-demolish some obstacles to make the asbestos accessible. Areas in which the asbestos is located are then sealed off with duct tape, plastic film and negative air machines, after which the crew can remove the asbestos. This task is followed by performing the complete stripping work and, finally, the asbestos removal from window putty and the façade. The demolition firm only rents bigger cranes and some additional freight trucks for these tasks, but owns most of the necessary equipment itself.

The use of vertical information systems is fairly limited for the demolition works as it tend to rely heavily on experience and tacit knowledge. Transport movements (for all projects) are monitored with an ICT system that displays all trucks in real-time. The planning of the demolition works, which fits into the overall planning of the transformation project, was made with a simple scheduling system. This planning, containing rather abstract activities such as "stripping 9th [floor]" was revised once at the time of our study and would probably be revised once more (according to the project leader). There is no need for ICT systems for the on-site demolition work; as the demolisher puts it: "everything just needs to go out of the building." During some early site visits, the contractor had nevertheless taken some measurements to check whether the as-built situation corresponds with the available drawings. Additionally, the actual status of the concrete load-bearing structure was then photographed and stored (in order to avoid disputes on potential damages at the project hand-over).

The demolition works are primarily characterized by informal information sharing strategies. For the demolition firm, personal contact is the most important lateral relation. On-site demolishers get told what activities need to be done on a daily basis and do not (need to) have access to the project schedule. The stripping and the asbestos removal crews discuss any interdependent tasks on a regular and informal basis (e.g. during lunch breaks). An overall planner is responsible for planning all transport movements. The foremen have primarily telephonic contact with the planner as well as with other supply chain partners to order any cranes, trucks or other equipment. Representatives of the contractor and the demolition firm meet on a weekly basis to discuss the project progress and to solve any issues. The contractor furthermore holds daily safety inspections on the site.

Case 2: modular component reuse from the deconstruction of a nursing home

The second case deals with the deconstruction of a temporary nursing home. That building was originally built by a contractor that focuses on (among others) standardized, modular building components. The deconstruction of this building was awarded to the same company, which usually happens with the temporary buildings that this contractor makes. The nursing home had been stripped down until the load-bearing structure by a demolition firm working for the contractor. The entire structural system was then disassembled, transported to and stored at the contractor's headquarters. These components were there stored until they could be reused in a new construction project. The building's finishes (such as partitioning walls and doors) were further processed via waste processing firms since transporting, handling and storing them was not deemed profitable, their quality would deteriorate due to weather conditions and they are very taste-specific. This deconstruction project was completed at the time of our study.

Uncertainties. Partnership and task uncertainty were rather low in this project, while environmental uncertainty is higher. The contractor that was responsible for deconstructing the nursing home is the same company that originally built it. This firm still has detailed drawings, contract and project management documents from the building as it maintains an extensive archive from all previous projects. It has also been working with the same sizes for modular components for over thirty years. According to the firm's project leader, "everything that you don't see in a building" is standardized, such as foundation, floor, façade and roof components (but not building finishes). The contractor plans to reuse these components in a new construction project. Environmental uncertainty was slightly higher since no such project is available yet, but also because changed building regulations pose limitations on direct reuse – particularly for permanent buildings. The deconstruction tasks were (as usual) done by one specific demolition firm with which the contractor has a long-term relationship. Those deconstruction tasks were predictable due to the great extent of standardization of the building systems. Finally, the nursing home does not contain any asbestos since that was already prohibited at the time of construction.

Mechanisms. Recovered building components from the nursing home were stored at a warehouse at the contractor's headquarters. The demolition firm started removing all installations and finishes until only the load-bearing components, floors, walls and the façades remained. These components were then disassembled, sorted and packaged by the demolition firm upon transport to the contractor's warehouse. The façades were labelled per type according to a plan from the contractor. The contractor had handled the components in its warehouse, picking the packages from the truck and putting the components into storage. Façade components are at the time of our study stored for approximately one year, while the storage time for floors, walls and other building components is about half a year. When a new customer is found, the building components are inspected and – if necessary – repaired by the contractor. The components will then be transported from the warehouse to the new construction site in the same way as new supplies.

The contractor completely outsourced deconstruction tasks to one demolition firm. These tasks include stripping and then disassembling and transporting the reusable building components from the nursing home to the warehouse. The demolition firm has its own equipment for the deconstruction tasks and mainly worked with a fixed crew. The contractor has an own design department that designs new buildings with building components from its own product lines. If the firm gets awarded a new project, it would use as many products from stock as possible and – if necessary – purchase any additional new ones. However, for products for which new, tighter building regulations came into effect since their original manufacturing, like floors, the reuse potential is restricted. The project leader therefore "tends to favor new floors" over reused ones, particularly for new permanent (rather than temporary or semi-permanent) buildings.

There was little support of vertical information systems for the deconstruction tasks. The contractor shared its original drawings and other relevant project documents with the demolition firm. It requested that firm to label (only) all façade systems so it could keep track of where those systems came from and what their quality is (in a simple MS Excel sheet). For each type of building component, there are only a few standardized variants (with different sizes) available. No ICT system is used to monitor the exact quantities of each variant in stock. Designers or project planners that need such information may simply check and count in person. Project planning is furthermore largely based on previous experience with frequent use of rules of thumb (e.g. price per square meter).

The most important lateral relation in this project was direct contact between managers from the contractor and the demolition firm. Both companies are collaborating already for a long time, yet contracts are drafted per project. For planning the deconstruction project, telephonic contact between the companies is (usually) enough, since "[the demolition firm] already knows what he'll need to do" and it is "most of the times the same kind of work" (project leader). Inter-organizational contact during project execution was informal and limited to just one or few meetings since the project was relatively small and predictable. Both firms followed similar, informal communication strategies in their collaborations with waste processors.

Case 3: element reuse from the deconstruction of a psychiatric institute

The third case deals with the deconstruction of a psychiatric institute that became redundant. The demolition firm deconstructs (rather than demolishes) the building and tries to sell as many building elements as possible. The project supervisor (a company acting on behalf of the building owner) documented the complete inventory of the building in a material catalogue. Building elements that the demolition firm deems reusable (such as doors, cranes, railings and emergency exit signs) are being offered via a novel online 'marketplace for second-hand building materials' for which the project supervisor took the initiative. Any buyers need to pick up their purchases from the construction site and no warranty is given. Unsold building parts are being disposed via waste processors, yet cementitious materials will end up as road foundation. Since not enough sales were made, it was – at the time of our study – just decided to dispose already deconstructed building elements via traditional routes as well.

Uncertainties. Environmental and partnership uncertainty are rather high in this case; task uncertainty is mediocre. The largest uncertainty in this project is – by far – the lack of information regarding contractors interested in buying reused building elements. There is virtually no demand for recovered building elements since – as argued by the project leader – contractors and clients in the Netherlands (and in most other parts of the world) prefer new building products over used ones. The market for recovered building elements is underdeveloped with uncertain prices for reusable elements, but market prices for demolition waste have been fixed with year contracts between the demolition firm and a number of waste processors. There is relatively a lot of as-is information available (3D pictures, construction drawings and a material catalogue) because of the stocktaking efforts of the project supervisory firm. It is more difficult to estimate the amount of asbestos which is (only) located in the façade of the building. Deconstruction tasks require also more subtle and longer procedures than the (usual) demolition activities of the firm to prevent any damages to the building elements. The firm finally works with many unemployed young adults through a job creation program.

Mechanisms. The demolition firm has been deconstructing, sorting and storing building elements inside the building upon potential buyers. All reusable elements were sorted and stored inside the building, forming piles of ceiling tiles, doors, installations etc. These time-consuming tasks were very labor-intensive with little use of machinery to prevent building elements from being damaged (and becoming unsellable). The firm planned to earn back that extra investment through the sale of building elements, but admitted "that did not succeed." In a six month-period, just one trader in building materials had visited the building and actually purchased some elements. That slack time cannot be extended any longer, since the deconstruction work "needs to go on, I don't have time to wait" (project leader). Transporting and renting storage space in the hope of finding any contractors to sell elements to was considered too expensive and "not a core business."

The demolition firm mainly focuses on the actual deconstruction activities that need to be done for the project. This basically concerns stripping of the building and removing the asbestos, for which it owns the necessary equipment itself. Since asbestos was only found in the façade, stripping of the interior could start immediately. The façade will be left untouched for as long as possible to keep providing shelter to the on-site personnel and to protect deconstructed elements. Employees that were trained in removing asbestos are assigned to do that but may also be assigned to stripping activities (yet not the other way around). Transportation of demolition waste is done by waste processing companies, who place a container in which waste is thrown and pick it up when it is full. The project supervisor hosts a new web shop for recovered building materials on which deconstructed building elements are offered for sale. The demolition firm has nevertheless little to do with this website – instead the project leader mainly tries to sell deconstructed elements via his personal relations.

The web shop is one of the few examples of a vertical information system in this project. Planning, monitoring and execution of the deconstruction tasks rely heavily on experience and tacit knowledge. Little is thereby documented by the demolition firm. The project supervisor, however, created a rich database of all materials inside the building (including quantities and quality assessments) based on their stocktaking activities. Pictures and other product-related data collected during those activities are used for the project supervisor's web shop. The demolition firm only determined sales prices of the products on sale.

Direct contact is the most important lateral relation in this project. The project supervisor and the demolition firm meet every other week to discuss the project progress, adjustments and risks. Apart from the new web shop, reusable building elements are primarily offered to a fixed partner that trades in new and used construction materials. The demolition firm and that partner primarily communicate through informal communication channels (i.e. by phone). For all other waste, the demolition firm works with a number of fixed waste processing partners as well. There is almost no contact with any other contractors (interested in) buying recovered building elements or materials.

Table 2 Interorganizational relationships and (mis)matches between information processing needs (resulting from uncertainties) and information processing capabilities (resulting from coordination mechanisms) in three cases

<table>
<tr><th colspan="2"></th><th>1 – Faculty building</th><th>2 – Nursing home</th><th>3 – Psychiatric institute</th></tr>
<tr><td colspan="2">Focal disposition scenario</td><td>Material recycling</td><td>Modular component reuse</td><td>Element reuse</td></tr>
<tr><td colspan="2">Demolisher-contractor configuration</td><td>disposer-controller</td><td>mover-reseller</td><td>seller-speculator</td></tr>
<tr><td>↓</td><td>Uncertainties
• Environmental
• Partnership
• Task</td><td>Low
• Mediocre
• Low
• Low</td><td>Mediocre
• High
• Low
• Low</td><td>High
• High
• High
• Mediocre</td></tr>
<tr><td>↓</td><td>Information processing needs</td><td>Low</td><td>Mediocre</td><td>High</td></tr>
<tr><td colspan="2">Match (↕)</td><td>Match</td><td>Match</td><td>Mismatch</td></tr>
<tr><td>↑</td><td>Information processing capabilities</td><td>Low</td><td>Mediocre</td><td>Low</td></tr>
<tr><td>↑</td><td>Coordination mechanisms
• Slack
• Self-contained tasks
• Vertical information systems
• Lateral relations</td><td>Minimal
• On-site storage upon transport to waste processor
• Stripping crew (demolisher); asbestos crew (demolisher)
• Minimal ICT
• Direct contact</td><td>Mediocre
• Warehouse storage upon reuse in new projects
• Disassembly crew (demolisher); Designers (contractor);
• Fairly limited ICT
• Direct contact</td><td>Minimal
• On-site storage upon potential buyers
• Disassembly crew (demolisher); Asbestos crew (demolisher)
• Experimental ICT
• Direct contact</td></tr>
</table>

Discussion

This study revealed how demolition firms and contractors deploy various coordination mechanisms in response to uncertainties in reverse logistics. We explored this under-represented area in supply chain management research through elaborating on information processing theory (Galbraith, 1973, 1974; Tushman & Nadler, 1978). For three purposefully selected cases with different disposition scenarios, uncertainties and resulting coordination mechanisms were presented in the previous section. As our scientific contributions, we here typify the uncovered interorganizational relationships in these cases and discuss the (mis)matches between information processing needs (resulting from uncertainties) and information processing capabilities (resulting from the coordination mechanisms deployed) (Table 2).

For the first case, material recycling is achieved through a demolisher-contractor configuration that we typify as a 'disposer-controller' relationship. The contractor responsible for transforming a faculty building completely outsourced the demolition tasks to a demolition firm and controls their tasks. That firm treats all building products (except the concrete load-bearing structure) as waste that needs to be disposed/recycled via one of its fixed waste processing partners. The low uncertainty arising from these predictable tasks with a guaranteed market for demolition waste poses low information processing needs. This matches with the low information processing capacity resulting from the combination of coordination mechanisms deployed: on-site storage of waste, division between stripping and asbestos removal tasks that need little interaction, minimal use of ICT systems and direct contact between representatives of the contractor and the demolisher.

For the second case, reuse of modular components is achieved through a demolisher-contractor configuration that we typify as a 'mover-reseller' relationship. The demolition firm tasked with deconstructing a nursing home primarily acted as a mover of disassembled modular building components to the contractor. The contractor originally constructed the building and will attempt to resell those components in new construction projects. The absence of a new project where the component can directly be transported to poses a high (environmental) uncertainty, whereas task and partnership uncertainties are low due to the fixed partnerships and the use of standardized components with routine disassembly tasks. This results in mediocre information processing needs. Those needs match with the mediocre information processing capabilities caused by the coordination mechanisms applied: long-term component storage at the contractor's warehouse, limited dependencies between the contractor's designers and the demolition firm's disassemblers, fairly limited ICT usage and mostly direct contact.

For the third case, reuse of building elements is not achieved through a demolisher-contractor configuration that we typify as a 'seller-speculator' relationship. The demolition firm disassembled a former psychiatric institute in the hope to sell as many building elements as possible. There were, however, almost no contractors (characterized as speculators) interested in buying any recovered elements – which led to high (environmental and partnership) uncertainties. It is also difficult to acquire certifications and warrantees for reusable building elements. These factors increase the need for high information processing capabilities, which were not achieved with the coordination mechanisms deployed. On-site storage time cannot be extended longer due to project deadlines and no off-site storage point is used, no self-contained tasks were set up for salesmanship, the demolisher made limited use of an experimental web shop of the project supervisor and instead relied mainly on personal and informal contact with potential contractors.

Even though it appears that there are multiple ways to establish effective interorganizational relationships for reverse logistics, we would like to emphasize here that there are major differences in the extent to which building products retain their value. In the first case, most building products are downcycled: they are treated as waste and get lower quality and functionality. In the second and third case (and in the first case concerning the concrete load-bearing structure), attempts are made to preserve the present value of building products.

Conclusion

This study uncovered three configurations of demolisher-contractor relationships for reverse logistics by elaborating on information processing theory. First, we posit that material recycling can be achieved through a 'disposer-controller' relationship in which the demolisher and contractor simultaneously deploy minimal coordination mechanisms in response to low uncertainties. Second, modular component reuse can be achieved through a 'mover-reseller' relationship in which the demolisher and the contractor apply more extensive coordination mechanisms to cope with mediocre uncertainties. Third, element reuse cannot be achieved through a 'seller-speculator' relationship in which the demolisher applies minimal coordination mechanisms to deal with high uncertainties.

These configurations provide new insight into the uncertainties and coordinating mechanisms at hand in reverse logistics. Our study contributes with multiple ways for how the supply of used building products can meet the demand for these goods. Due to the exploratory nature of our study, these contributions need to be interpreted as propositions – to be tested and refined in subsequent research. They provide a theoretical explanation for how information processing needs emerge and are dealt with in the context of reverse logistics at the interorganizational level of analysis. We hope that this opens up new possibilities to promote resource efficiency within the construction industry.

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