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A qualitative examination of major barriers in implementation of reverse logistics within the South Australian construction sector

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Despite extensive research on the benefits of reverse logistics (RL), it has yet to become commonplace in the construction industry. Furthermore, the uptake and number of studies on RL remains very limited within the Australian context and particularly related to the construction industry. This paper is aimed at filling that knowledge gap by employing an exploratory approach to examine the critical barriers faced by South Australian construction organizations in implementing RL practices. Semi-structured interviews and a ranking approach facilitated the treatment of qualitative data through quantitative coding using cloud-based applications. The research identified 12 barriers to RL implementation, four of them very significant according to the responses of the interviewees: the regulatory environment, additional costs involved, lack of recognition in the construction supply chain, and extra effort required. The study also explored their inter-relationships through the Co-occurrence Index. The study proposes some remedial measures for RL implementation in South Australia based on the barriers identified.

Keywords: construction industry; reverse logistics; barriers; hierarchical clustering techniques; cloud-based applications; South Australia

Introduction

Reverse Logistics (RL) has generated interest in a wide range of organizations (Subramanian et al. 2014) due to its ability to enhance the competitiveness and efficiency of businesses (Abdulrahman et al. 2014). RL facilitates the adherence to environmental regulations and enhancement of the environmental image of organizations, as asserted by Griffith and Shen (2011). Hence, some investigators have claimed that its implementation is increasingly becoming a necessity for organizations (Bai & Sarkis 2013). The European Working Group on Reverse Logistics (REVLOG) defines RL as 'the process of planning, implementing and controlling backward flows of raw materials; in process inventory; packaging and finished goods; from a manufacturing, distribution or use point, to a point of recovery or point of proper disposal' (Brito & Dekker 2004, p. 5). Nunes et al. (2009, p. 3717) described RL in construction to be:

> how the area of business logistics plans, operates and controls the flow of logistics information corresponding to the return of post-sale and post-consumption of the goods to the productive cycle through reverse distribution channels, adding value of various types to them: economic, ecological, legal, logistical, corporate image, etc.

Implementing RL in construction can reduce the cost of projects (Chini & Bruening 2003; Sassi 2008). It lessens the detrimental effects on the environment (Schultmann & Sunke 2007b; Kibert 2012). Nonetheless, evidence demonstrates that RL is not widely adopted in the construction industry (Sinha et al. 2010; Shakantu & Emuze 2012). Given that the advantages of RL are obvious, such a lack of interest should be due to barriers preventing its adoption in the construction industry (Höglmeier et al. 2013). Against this backdrop, investigating the barriers to implementing RL and developing strategies to overcome them has become very important. Past studies have investigated barriers to implementing RL in different industries but only a few have looked at the construction context (Abdulrahman et al. 2014). In addition, existing studies have mainly used case studies which lack an industry-wide focus (González-Torre et al. 2010). As a result, generalization of the available findings to reflect the circumstances of the construction industry is not possible (Abdulrahman et al. 2014). As highlighted by Denhart (2010) and Dantata et al. (2005), barriers to adopting RL are 'area-specific' and are closely linked to the circumstances prevalent in a particular location (e.g. local labour costs). As the primary barrier of implementation is usually economic in nature, the detail varies considerably between locations (Nakajima & Russell 2014). Thus, studies using methods other than case studies covering an industry-wide perspective are very useful. In spite of that, to the best of authors' knowledge, no previous study on barriers to RL implementation has been conducted in the Australian context.

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Therefore, identifying the barriers to RL implementation in the Australian construction context has become relevant and necessary. It is a prerequisite for promoting RL in the Australian construction industry. In response to such a need, this study intends to unearth the major barriers to implementing RL in the South Australian construction industry. In addition to further to establishing the field in terms of theoretical contribution, the findings of the present study could be used as a 'road map' for the successful implementation of RL in South Australia.

Literature review

RL has been regarded as an important element in enhancing the efficacy of the supply chain in a wide range of industries by complementing the forward logistics system (Govindan et al. 2012). Redesigning the supply chain and deploying RL for construction has been recommended by many past researchers, particularly to ease the detrimental effects on the environment (Chini & Bruening 2003; Sassi 2004, 2008; Addis 2006a; Schultmann & Sunke 2007b; Aidonis et al. 2008; da Rocha & Sattler 2009; Razaz 2010; Kibert 2012; Shakantu & Emuze 2012). Nonetheless, there is consensus that RL has yet to become commonplace in the construction industry (Leigh & Patterson 2006; Schultmann & Sunke 2007a; Durmisevic & Yeang 2009; Kibert 2012). According to Nunes et al. (2009), it is an unexploited theme in many countries. In order to promote RL, the barriers to its implementation need to be well understood (Pirlet 2013; Ravi & Shankar 2005). The main barriers identified in past studies are summarized in Table 1.

A very high cost of implementing RL was identified by about half of the previous studies and a deeper review shows that this is mainly associated with the high labour costs involved in deconstruction. This is exacerbated by a wrong perception among practitioners that RL is expensive compared to traditional demolition and disposal (Dantata et al. 2005). RL is only feasible if deconstruction is widely practised in the construction industry as opposed to traditional demolition (Sassi 2008; Hiete et al. 2011). Deconstruction and salvaging of materials will become easier if the building has been designed for it Designing for Disassembly (DfD) in the first instance. However, researchers have found that current design approaches do not consider deconstruction and as a result it is considered a major barrier that needs to be given very high consideration in RL implementation (Crowther 2009; Kibert 2012). The lack of mature and stable markets for sale of salvaged building materials is another important barrier identified by past researchers (Vaughan 2013; Earle et al. 2014). Similarly, the lack of facilities for deconstruction could pose a serious threat to RL implementation (Kuehlen et al. 2014). The

Table 1.   Major barriers to deconstruction identified in previous studies.

Barriers	References (2001−2014)																	No	%
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
High costs		✓	✓		✓	✓	✓	✓				✓			✓			8	47.05
Design of existing buildings	✓	✓		✓		✓	✓				✓			✓		✓		8	47.05
Long lifecycle of buildings			✓						✓	✓				✓				4	23.53
Wide diversity of returned products and materials			✓						✓									2	11.76
Contaminations and existence of hazardous substances			✓				✓		✓			✓	✓		✓	✓	✓	8	47.05
Lack of markets and infrastructures								✓	✓						✓	✓		4	23.53
Contractual arrangements of projects		✓		✓		✓	✓					✓			✓	✓	✓	8	47.05
Lack of awareness		✓		✓	✓		✓	✓							✓		✓	7	41.18
Lack of support from regulations				✓			✓	✓				✓	✓			✓		6	35.29
Complicated supply chain in the construction industry			✓	✓						✓				✓	✓			5	29.41
Cheap and easy landfilling															✓	✓	✓	3	17.64

Sources: 1 Crowther (2001); 2 Sassi (2004); 3 Schultmann and Sunke (2007b); 4 Addis (2006a); 5 Addis (2006b) 6 Gorgolewski (2008); 7 Chini and Bruening (2003); 8 Leigh and Patterson (2006); 9 Schultmann and Sunke (2007a);10 Guy et al. (2006); 11 Densley et al. (2012); 12 Srour et al. (2012); 13 Denhart (2010); 14 Kibert (2012); 15 Earle et al. (2014) 16 Kuehlen et al. (2014); 17 Guy (2014).

existing contractual practices are not favourable to RL implementation either − for example, tight schedules for the demolition of old buildings are the norm in construction (Sassi 2004; Kuehlen et al. 2014; Nakajima 2014).

Lack of awareness and recognition of the possible use of salvaged materials is also a barrier worth considerable attention from the policy-makers (Crowther 2002; Chini & Bruening 2003). In that regard, the need for recognition of RL in building codes, regulations and so on has frequently been highlighted by past researchers. Low disposal fees coupled with ease of disposal were highlighted by Smith et al. (2007) as an important barrier for promoting RL among builders and demolition sub-contractors. Many barriers to RL also stem from the idiosyncrasies of the construction supply chain. This include the impacts of the large number of parties involved in decisions on the fate of an existing building (Shakantu & Emuze 2012); the dominance of small and medium sized enterprises (SMEs) (Zou et al. 2005); the fragmented nature of the supply chain (Tennant & Fernie 2014); and the lack of cooperation among parties involved (Earle et al. 2014).

Research methodology

Taking into account that the RL concept is little understood in the construction context, this research is exploratory in nature. According to Creswell (2009), where the topic is new and key variables are unknown it is most appropriate to treat the question in a qualitative way. Reflecting the intricacies of the construction discipline, Amaratunga et al. (2002, p. 22) described the qualitative approach 'as the best strategy for discovery, exploring a new area and developing hypothesis'. Similarly, drawing from other disciplines and research areas such as e-business development, Fillis et al. (2004, p. 359), provided the same justification in using a qualitative approach due to the limited nature of research in that area. Some studies from the realms of RL have also provided support for utilization of the qualitative approach.

Given the above support for a qualitative approach, the aim of the present study is to attempt to view the barriers to RL from the perspective of stakeholders in South Australia using interviews. For inquiries drawing upon the viewpoints of construction practitioners, an interview survey is recommended by Fellows and Liu (2008). Similarly, Seidman (2006, p. 11) asserts that when a study aims at elucidating the subjective understanding of people, interviewing has proven to be 'the best avenue of inquiry'. Thus, collecting data through interviews was deemed the most effective method for the present study. This interview survey was conducted as part of a broader study looked at drivers, barriers and practices of RL implementation in South Australia. Only the questions related to barriers form the theme of this paper.

To analyse interview transcripts, the coding procedure recommended by Bazeley (2007) was used which involved three stages, as shown in Figure 1. Catterall (1996, p. 29) highlighted that coding is an ambiguous but significant first step in entry and analysis of qualitative data using computers. It involves the breaking down of data into segments and assigning a code or label to each (Catterall 1996). The second stage is associated with sorting nodes into a tree to reflect the structure. The main purpose of this stage is to facilitate conceptual clarity and early micro-analysis (Bazeley 2007).

To investigate the level of relative influence of barriers to RL, integration of qualitative data into quantitative coding was deployed as recommended by Bazeley (2006, 2009). Using such a strategy is an acceptable practice for qualitative data analysis known as 'value coding', where codes associated with passages of transcripts are linked to scales (Bernard & Ryan 2010, p. 87; Saldaña 2009, p. 89). Maclaran and Catterall (2002, p. 32) have shown that the linking of data will permit researchers to try out possible relationships among themes generating valuable insights on their associations. Hutchison et al. (2010, p. 297) further opine that the relationship nodes generated by NVivo help identify other concepts or processes which contribute to the identified relationships. In addition, use of computer packages will enhance the rigour of data analysis with greater speed (Bazeley 2013; Lewins & Silver 2007). According to Bazeley (2013), Dedoose is such a software package for ranking codes by assigning a weight. Dedoose is a cloud-based application developed by socio-cultural research consultants LLC and its version 5.0.9 was used for the data analysis in this study.

A 'purposive sampling' approach was used to select interviewees based in South Australia with sufficient experience in construction RL who represent all four task environments identified by Carter and Ellram (1998). According to Bazeley (2013), a purposive sample enables researchers to acquire sufficient knowledge to fulfil the objectives of the inquiry alongside comparing variations among respondents. Initially 26 potential experts were considered through companies' websites and professional networks and groups such as LinkedIn. Invitations were sent and eventually eight experts, as shown in Table 2, were selected in consideration of their willingness to contribute to the study. This approach is expected to improve the quality of collected data due to the strong intention of experts to add value to the study, as postulated by Simms and Rogers (2006). Each interview lasted approximately an hour, with a semi-structured guideline as the basis. Apart from one, all interviews were held in the interviewees' offices.

While eight interviews seems too small a sample, according to Mason (2010) and Bazeley (2013), saturation of data could occur with as few as six interviews based on the richness of data collected. Furthermore, as highlighted by Qu and Dumay (2011, p. 246), a semi-structured approach enables questioning to be guided by identified themes in a consistent and systematic manner while probes can be used to elicit more elaborate responses.
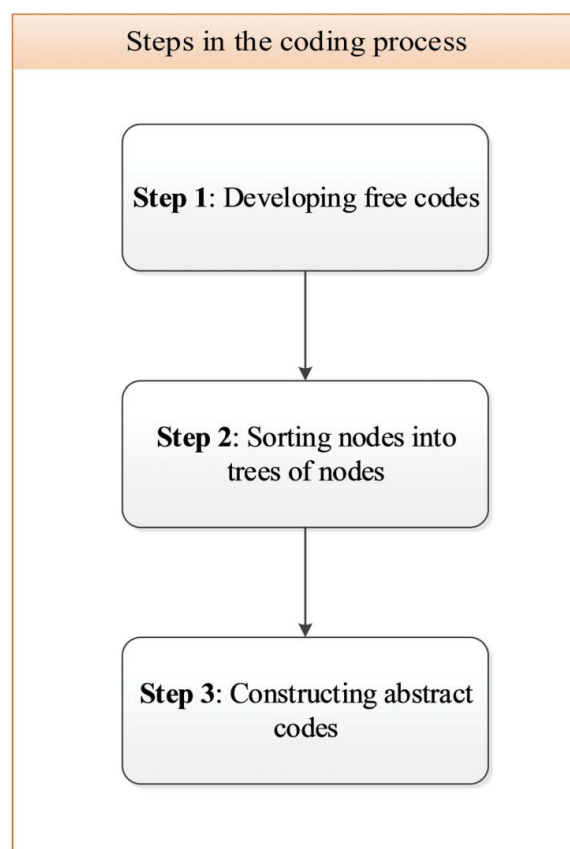
Figure 1.   Steps in the coding process.

Results

Analysis of transcripts resulted in applying 529 codes, with interviewee perceptions emerging from the data that highlighted the barriers to implementing RL in South Australia. Twelve barriers were unearthed from these codes, as given in Table 3. It captures the outcome of weighting and the number of times each barrier was referred to by the interviewees. According to the principles of qualitative data analysis, concepts that are considered important are repeated more frequently within interview transcripts, as opined by Bazeley (2007). Examination of Table 3 shows that the frequency count of the 12 barriers ranged from 4 (lack of information sharing) to 89 (regulatory environment). Out of the 12, four barriers, namely the regulatory environment, additional costs involved, lack of recognition in the construction supply chain, and the extra effort involved were clearly the most significant according to the frequency counts. Therefore, the following sections will elaborate on these four barriers, followed by a brief explanation of the remaining eight.

Table 2.   Profile of interviewees.

No.	Interviewee	Designation	Nature of business[†]	Years of experience in RL field
1	A	Manager and owner	Demolition/salvage	25
2	B	Executive manager	Construction	15
3	C	Managing director	Consulting	20
4	D	Executive manager	Demolition/salvage	9
5	E	Marketing manager	Recycling	21
6	F	SEPO[*]	Regulatory	N/A
7	G	Architect	Design	13
8	H	Builder	Construction	15

Notes: [*]SEPO = Senior Environment Protection Officer; [†]Nature of businesses aligns with RL activities as described by Carter and Ellram (1998).

Table 3. Descriptive statistics for the level of importance of RL barriers.

Rank[*]	Major barriers	Count	Min	Max	Mean	Median
1	*Regulatory* environment	89	1	10	6.5	7
2	Additional *costs* involved	58	1	10	7.7	8
3	Lack of *recognition* in construction supply chain	44	2	8	5.7	6
4	Extra *effort* involved	42	1	9	5.8	6.5
5	Financial *risks* associated with RL	30	1	10	4.8	4.5
6	*Contractual* obligations	25	2	10	6.8	8
7	Lack of attention to *design* for RL	22	1	8	6	6.5
8	Lack of *support* from consumers	21	1	9	6.2	7
9	*WHS* risks associated with RL	15	2	9	6.5	7
10	Lack of *facilities* and technology	7	1	8	6	7
11	*Resistance* to change	5	1	9	5.2	6
12	Lack of *information* sharing	4	5	8	6.5	6.5

Note: [*]Ranking arranged in the order of the number of counts.

Regulatory environment

Bureaucratic red tape for deconstruction approvals and use of salvaged materials in new construction were highlighted by the interviewees as preventing the widespread practice of RL in South Australia. Interviewee C argued that 'regulations should be amended to make it easy for people who want to use salvaged materials and prevent disposing them in landfills'. He added 'too many regulations without much positive impact only make life harder for people intending to use salvaged materials'. This seemingly unsupportive role of the government was highlighted by interviewee A, who is manager of a salvaging company: 'endless red tape enforced by the government hinder our work'. As observed by interviewee C, 'storage of salvaged materials from buildings is an issue since environmental regulations regard anything without immediate use as waste and ask to remove it from the site immediately'. The above observation was reaffirmed by interviewee A declaring that on-site sorting of materials is no longer possible due to strict environmental and health and safety regulations. It stresses the necessity of easing the regulatory requirements associated with RL. In particular, as opined by interviewee C, 'environmental regulations should be modified to differentiate between storage of waste and a depot of salvaged materials'. The decisive role of bureaucratic barriers was highlighted by Zhai et al. (2014) in a study on adopting sustainable construction.

The absence of codes or standard guidelines to support sustainable construction was identified by Zainul-Abidin (2008) as a major barrier to adopting sustainable practices. Likewise, interviewees raised the challenges faced by salvaging businesses to comply with building codes and design guidelines enforced in South Australia. According to interviewees C and E, the government has only approved the use of recycled aggregates for road pavements. According to interviewee A, even though the government should be the main consumer of salvaged materials, its own technical requirements prevent it from using them. Interviewee D highlighted the unreasonably strict technical requirements of the government: 'there is opposition from government for use of recycled materials in their projects'. According to interviewees A and C, potential consumers such as government shy away from using salvaged materials to comply with technical requirements. Interviewees C and G argued that the requirements of the Building Code of Australia (BCA) is a major barrier in using salvaged materials in buildings because testing to show compliance is very expensive. Interviewee C made this clear by saying that 'if testing was made compulsory for signing off documents, there would be no one to pay for it'. According to interviewee C, 'In some city councils like […], one cannot even build a fence using salvaged materials let alone a building. It acts as a major barrier for using such materials'. Past research also observed similar barriers in other countries. According to Dowlatshahi (2005), salvaged materials are compared with technical requirements developed for virgin materials in order to take into account consumers' rights and satisfaction. Lack of standards, codes and guidelines for salvaged materials prevent building inspectors accepting them as appropriate for new construction (Sassi 2008; Nordby et al. 2009; Denhart 2010; Razaz 2010). Lack of protocols to systematize and regulate reuse procedures hinders the development of RL in Canada and the USA (Chini & Buck 2014; Earle et al. 2014). As highlighted by Addis (2006b) and Leigh and Patterson (2006), apart from national codes, local technical requirements also could pose a barrier to RL.

Regulations allowing easy disposal of debris in landfills adversely affect RL implementation according to Leigh and Patterson (2006), Sassi (2008) and Chini and Buck (2014). Low landfill levies are considered to be the main culprit according to Hao *et al.* (2011) and Storey and Pedersen Zari (2003), who highlighted that 'tipping rates need to align with the true cost of disposal' (p. 14). Landfills in South Australia are managed by the private sector or city councils but the government has the leverage to decide the landfill levy. According to interviewees F and B, at the prevailing rates RL would not be

economically viable compared to disposal at landfills. Interviewee D further highlighted that the decision depends on the distance to landfill. RL becomes economically viable only if the landfill is far away from the demolition site. According to interviewees C and D, 'increasing the landfill levy will not resolve the issue as it could lead to illegal dumping'.

Lack of consultation and communication between regulatory agencies was another barrier observed in past studies (Abdulrahman et al. 2014, p. 464). This turned out to be the case in the South Australian construction industry as well. According to interviewee C, 'regulatory bodies act in isolation oblivious to the real situation and issues in other fields'. He added that 'no one has ever considered these issues from a multidisciplinary perspective'. These sentiments were further supported by interviewees C and D, who expressed their dissatisfaction with different approaches followed by regulatory agencies in South Australia. The above findings were consistent with Sassi's (2004) observation that inconsistency between environment and health and safety regulations makes contractors reluctant to resort to recovery and reuse practices. Another facet of lack of consistency in regulations was highlighted by interviewee E claiming that regulations support only recycling of materials. This reflects the lack of a holistic approach in South Australia, where recycling is supported but reuse is overlooked by its regulatory bodies.

Additional costs and effort involved

Interviewees were of the view that additional costs associated with the RL process to have the most detrimental impact on its implementation. Interviewees G, B and A referred to high labour and transportation costs in South Australia, which make RL more expensive than mechanical demolition and disposal. Interviewee C highlighted that 'initial costs of RL are huge'. According to Lau and Wang (2009) and González-Torre et al. (2010), high costs associated with RL could act as a significant barrier in its implementation. In countries with high labour costs RL will be expensive compared to mechanical demolition and disposal (Denhart 2010). Expanding further on the cost implications of RL, interviewee A observed that construction practitioners will implement RL only if it is cost effective. Likewise, interviewee B highlighted that 'we want value for money through any new investments'. Interviewee G argued that builders are in the market for profit, and interviewee B iterated that they should remain competitive. This barrier was termed as 'competitive pressure' by Shaharudin et al. (2015, p. 7). Other past studies also highlighted similar observations that managers of construction companies will implement RL as long as they are assured of the gains (Schultmann & Sunke 2007b). According to Smith et al. (2007, p. 12) business managers will only implement RL if you 'show them the savings', as is the case for any other sustainability practice in construction projects (Zainul-Abidin 2008).

On the other side of the financial equation, interviewees revealed that prices of salvaged materials are often higher than those of new materials in South Australia. For example, interviewee A observed that 'prices of salvaged materials in some cases are higher than that of virgin ones'. Likewise, interviewee D postulated that 'the price competition with virgin materials is very marginal'. This brought to light the dominance of an unsupportive business environment for RL in South Australian. Further commenting on that, interviewee G suggested that 'to increase demand for salvaged materials, you have to make it available and cheaper'. The statements by other interviewees supported this view. According to interviewee H, 'the barrier facing the salvaged materials market is its cost. I believe if the cost issues could be resolved people would go for salvaged materials instead of virgin materials'. Similar to what is observed in South Australia, Earle et al. (2014) in Canada and Bohne and Wærner (2014) in Norway reported that virgin building materials are often cheaper than salvaged materials. Customers will shy away from purchasing salvaged materials because they are sold at the same or higher prices but without guarantees of their quality (Bohne & Wærner 2014; Shaharudin et al. 2015). According to Dowlatshahi (2005) and Shaharudin et al. (2015), salvaged materials should be sold at a lower price in order to attract consumers.

RL need extra effort from the stakeholders concerned and that often acts as a barrier, as highlighted in previous studies by Leigh and Patterson (2006) and Srour et al. (2012). Interviewees A, B, C, E and G observed that sorting and shipment of salvaged materials is a labour-intensive activity. This gets worse when practitioners encounter contaminated and hazardous materials, which require specific procedures and licensed contractors to deal with them. Interviewee H highlighted another facet of extra effort for RL by observing that 'Most of the time we can find what we look for in a salvage yard. However, if you need a specific size or material it is challenging and you may have to visit many salvage yards to find what you want. A virgin material is quite the opposite'.

Lack of recognition in construction supply chain

Interviewees were very clear that the lack of recognition for RL in the existing construction supply chain is another major barrier that hinders its development. The blame is on all stakeholders but some segments got disproportionately higher blame for not taking account of RL practices. For example, interviewee E, commenting on designers not accommodating RL, observed that 'designers usually copy and paste specifications from earlier designs'. Interviewee C said that the priority of designers is to safeguard themselves and they would not take any risks by using salvaged materials. According to

interviewee G, environmental protection is the lowest priority for designers as they usually tend to focus on fitting their designs within the client's budget.

Interviewee C highlighted that 'builders are reluctant to use salvaged materials in new construction', which is a barrier highlighted by many previous studies such as Chini and Bruening (2003), Sassi (2008), Denhart (2010) and Razaz (2010). Furthermore, interviewee C commented that builders do not regard the use of salvaged materials as a beneficial alternative and usually show no commitment to RL practices. As far as the demolishers are concerned, interviewee C argued that 'they do not care about the outcome but just want to complete the job quickly'. Interviewee G reinforced that point: 'builders do not care about demolition. They select the cheapest quote from demolition sub-contractors'. Interviewee G further added that 'construction practitioners often mentally fixed to a pre-defined budget and time. Environmental concerns are very rarely considered'. It is inferred that RL as a practice associated with sustainability faces the issue termed by Zainul-Abidin (2008) as 'circle of blame'. A circle of blame among construction practitioners refers to the reluctance to adopt sustainability practices and waiting for others in the construction supply chain to make their move (Zainul-Abidin 2008).

Other barriers

Financial risks associated with RL were perceived by interviewees to be a challenge to overcome, mainly in two aspects: first the risks and benefits of deconstruction versus disposal is obscure to stakeholders, and second the liabilities associated with using non-tested salvaged materials are hard to predict. Interviewees highlighted the contractual obligations and the resultant pressure to demolish buildings as another barrier to RL implementation. For example, interviewee A maintained that 'salvaging could not take place in such strict timelines and the whole building goes to landfill'. Designers' lack of attention to RL during the design stage of the project is considered to be another barrier by the interviewees. In addition, some universal barriers to RL have roots in consumers' preferences, tastes and negative perceptions about the quality of salvaged building materials. For example, interviewee C explained this issue by stating that 'even if someone is willing to take the risks and use salvaged materials, the stigma attached to using old materials will prevent him from doing so'.

Implementing RL is fraught with health and safety risks. Such risks represent the possibilities of encountering contaminated and hazardous substances during deconstruction as well as accidents. Such risks were acknowledged by the interviewees and highlighted the possibility of encountering asbestos in old buildings. Lack of infrastructure was also highlighted by interviewees as a barrier to fully implementing RL practices in South Australia. Resistance to change was also perceived as a barrier by some interviewees. While this barrier might be viewed as less important by the interviewees, it is pertinent to stress that any innovation within the construction context faces resistance to change (Zhai *et al.* 2014). Reverse logistics is no exception. To highlight this point, interviewee E made reference to the designers' resistance to changing traditional design and specifications by stating, 'they resist against changing of specs and still use the traditional construction methods repeatedly'. It came to light from interviews that no systematic exchange of information is available on RL markets in South Australia.

Discussion

This exploratory analysis provided 12 barriers perceived by stakeholders for implementing RL in the South Australian construction industry with environmental regulations being the most prominent, as is observed by Zhai et al. (2014) in China. This is followed by additional costs involved, lack of recognition in the construction supply chain, and the extra effort involved as the next three important barriers. Table 4 shows the distribution of interview codes for these four barriers based on the

Table 4. Distribution of top ranked interview codes among operational task environments.

Major barriers	Frequency of codes on task environment				
	Input	Output	Competitive	Regulatory	Total
Regulatory environment	16	31	5	37	89
Additional *costs* involved	16	13	12	17	58
Lack of *recognition* in construction supply chain	19	8	4	13	44
Extra *effort* involved	8	12	6	16	42

Notes:* Where 'Input' sector has interviewees E and G; Output = interviewees A and D; Competitive = interviewees B and H; and Regulatory = interviewees C and F.

Table 5.   Co-occurrence of codes in interview transcript passages.

					RL barriers codes							
	A	B	C	D	E	F	G	H	I	J	K	L
A = Contractual obligations	–	9	8	7	1	16	6			2		12
B = Additional costs involved	9	–	25	13	5	29	5	1	1	3		9
C = Extra effort involved	8	25	–	16	10	27	4	1	3			7
D = Financial risks associated with RL	7	13	16	–	7	24	4			4	2	11
E = Health and safety risks associated with RL	1	5	10	7	–	11	1		1			3
F = Regulatory environment	16	29	27	24	11	–	14		5	9	3	21
G = Lack of attention to design for RL	6	5	4	4	1	14	–	1		5	2	13
H = Lack of information sharing		1	1				1	–				
I = Lack of facilities and technology		1	3		1	5			–		1	1
J = Lack of support from consumers	2	3		4		9	5		–		1	15
K = Resistance to change				2		3	2		1	1	–	4
L = Lack of recognition in construction supply chain	12	9	7	11	3	21	13		1	15	4	–

Note: The darker and lighter shaded cells highlight the highest and medium levels of co-occurrence respectively between cases.

operational task environments of the Carter and Ellram (1998) framework. According to the framework, the operational task environment of RL comprises input, output, competitive and regulatory, and the interviewees of this study represented all four task environments (see Table 2). Accordingly, the regulatory environment as a barrier was highlighted mainly by the regulatory and output task environments. While the concerns of the former are quite legitimate, the latter's concern is mainly due the impact of regulations on deconstruction, on-site sorting, storage and transportation of salvaged materials. Similarly, additional costs as a barrier were very strongly highlighted by the regulatory and input task environments. It shows that cost is a major concern for the users of salvage materials rather than the providers. For the providers the cost could easily be passed on to the users, whereas the users who are at the end of the supply chain will have no alternative but to absorb it. Lack of recognition for RL in the construction supply chain is strongly felt by the input task environment compared to the other three. As users of RL outputs, the input task environment faces a number of major challenges as highlighted under the results subsection, such as lack of quality, designers' lack of concern etc. Therefore, the input task environment's concern with the lack of recognition is quite understandable. The extra effort involved in RL is strongly felt by the regulatory and output task environments as the additional work is predominantly being shouldered by the demolition sub-contractors and salvaging companies in getting the salvaged materials to the market on time and within budget. Overall, these differing concerns are very useful for RL promoters and are considered very seriously in our recommendations for overcoming RL barriers listed at the end of the discussion section.

The study also analysed the inter-relationships among the barriers as they are very useful in assessing the effectiveness of potential remedial measures. In order to unravel the associations, we strategically reassembled the data emerging from the interview transcripts and investigated the co-occurrences of these codes (Saldaña 2009; Bazeley 2013). Bazeley (2007, p. 100) recommended acquiring such an understanding by detecting the patterns of association between codes that interviewees have frequently used together. The result of the reassembled data using Dedoose is summarized in Table 5. Based on the Co-occurrence Index (C-Index) (Hubbell & Garcia 1991; McDonald 2015; Rasmus et al. 2014), many strong associations were detected, as shown in Table 6.

Table 6.   Major Co-occurrence Indices of RL barriers.

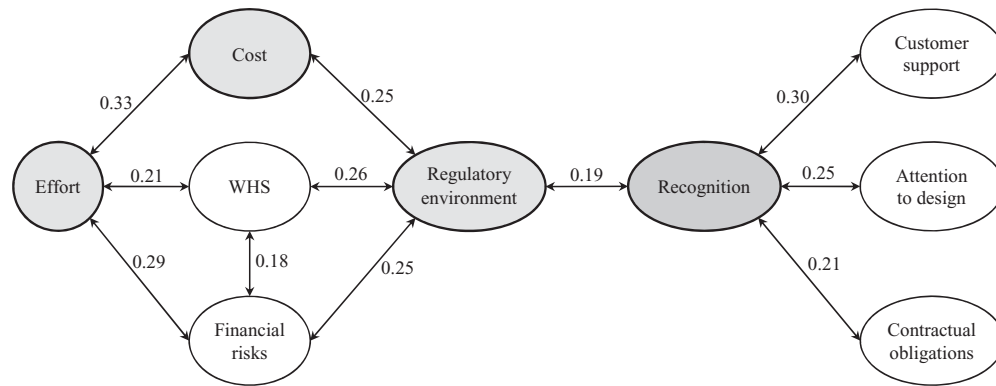| Rank	Barriers	Co-occurrence Index
1	Cost and effort	0.33
2	Recognition and support	0.30
3	Effort and risks	0.29
4	Regulations and WHS	0.26
5	Regulations and risks	0.25
6	Regulations and cost	0.25
7	Recognition and design	0.25
8	Effort and WHS	0.21
9	Recognition and contractual	0.21
10	Regulations and recognition	0.19
11	Risks and WHS	0.18

Figure 2.   Major associations between RL barriers (based on C-Indices).

The strongest of the associations is found between extra effort and cost of RL followed by recognition and customer support, both recording a C-Index of over 0.30. The concern that RL requires extra effort and as a result incurs additional costs is a well-founded association that needs serious attention from RL promoters. Similarly, lack of recognition for RL is strongly associated with the lack of customer support, lack of attention by designers, contractual practices and information sharing. Extra effort also found to co-occur with financial and workplace health and safety (WHS) risks with C-Indices of 0.29 and 0.21, respectively. The barriers that co-occur highly with regulatory environment are the WHS risks, financial risks and cost. In a nutshell, the co-occurrences show a very clear pattern, gravitating around a few barriers which are critical in making RL implementation a success in the South Australian context. These links are portrayed in Figure 2. It illustrates the major themes that could shape RL implementation while highlighting the two groupings that emerged, namely 'recognition' and 'regulations'. Similarly, under regulations, the centrality of 'workplace health and safety' is another noteworthy observation.

Based on the above discussion, solutions to overcome the 12 barriers identified in the study need to be strategically located around the three "nodes" identified above due to their ability to penetrate across many barriers. Also promoting RL within the construction context will not materialize without taking into consideration the intentions of main stakeholders represented by the operational task environments discussed above. As a result, six broad remedial measures for overcoming barriers to RL in the South Australian construction context are suggested as follows:

(1) The specifications and building codes should include requirements for systematic and regulated reuse of building materials and products.
(2) EPA regulations should be amended to differentiate between waste and a depot of salvaged materials in order to facilitate on-site sorting.
(3) The government should consider incentives and tax concessions to builders who practise RL.
(4) Issuance of advanced deconstruction permits.
(5) Regulating and organizing markets for salvaged construction materials through sharing of information.
(6) Enhancing cooperation and consistency between WHS and environmental regulations to make sure safety as well as environmental requirements are properly considered during the entire RL process.

Conclusions

This paper presents the results of a qualitative study on barriers to implementing RL within the South Australian construction industry. The purpose of this research is to identify them through an exploratory approach using interviews with RL stakeholders. The findings from the descriptive statistics such as the count, minimum, maximum, mean and median values generated from transcribing interview data highlighted 12 barriers to implementing RL in South Australia. Among them, the regulatory environment, additional costs involved, lack of recognition in the construction supply chain, and extra effort involved were considered to be the main barriers. While environmental regulations became an overarching barrier for all RL stakeholders, the importance of the other three main barriers differed significantly. The input task environment was mainly concerned about the lack of recognition as a barrier while the output task environment saw environmental regulations and extra effort as more relevant. Understandably, the competitive task environment was more concerned with extra costs involved while the regulatory task environment was very vocal on the regulatory environment. Based on the

Co-occurrence Index, many strong associations between barriers were also detected. Recognition, regulations and workplace health and safety concerns were found to be more connected to other barriers, making them more suitable candidates for remedial measures.

Thus, six remedial measures were proposed in order to overcome barriers to RL implementation in South Australia. While these six may be the most immediate and effective measures according to the results, other measures targeting the 12 barriers should not be discounted. As such, the findings of the study provide fertile ground for further research in defining the most effective operational procedures to adopt for these six remedies and further investigate others based on the barriers reported. While the study makes several contributions, an important limitation in relation to the context of South Australia and the construction industry should be noted as a caution to its generalization to other countries or industries. Future studies should be extended to other industries such as manufacturing and services within the South Australian context while the construction-related theme could be extended to other regions of Australia.

Disclosure statement

No potential conflict of interest was reported by the authors.

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