Drivers for adopting reverse logistics in the construction industry: a qualitative study

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Abstract

Purpose – The purpose of this paper is to investigate and analyse the perceptions of South Australian construction practitioners on drivers affecting the implementation of reverse logistics (RL). In this context, RL is defined as the process of moving goods from their typical final destination for the purpose of capturing value or ensuring proper disposal.

Design/methodology/approach – Semi-structured interviews were conducted with eight practitioners to collect data and the interview transcripts were analysed using the NVivo (version 10) package. Cluster analysis was used to cross-validate the findings and provide an in-depth insight into the findings.

Findings – The findings indicate that most of the drivers identified in earlier research are relevant for the construction industry. In addition, the study identified some new drivers that are categorised as "targeted demands by an exclusive clientele". These drivers were found to be complementary to the economic, environmental and social drivers as previously conceptualised. In addition, a set of factors affecting the strength of drivers that had been overlooked in previous studies emanated from the interview analysis. These include the type of project and the attributes of clients, both of which strongly affect the drivers of RL implementation in construction.

Research limitations/implications – The major limitations are the relatively small size of the sample of interviewees and having interviewees from one geographic area with specific socio-economic characteristics.

Practical implications – The identified drivers and the clustering of RL themes could be used by practitioners as a "road map" for the development of appropriate solutions to successfully promote RL within the construction industry. Organisational energies could thus be channelled towards the drivers that need the most improvement.

Originality/value – The study contributes to this research sphere by employing cluster analysis to customise and contextualise the drivers that were previously identified. The study goes beyond the extant literature by discovering the prominent effects of these drivers on the impact of targeted demands by an exclusive clientele. This could be of great value in terms of creating avenues for future investigations on the topic.

Keywords Drivers, Reverse logistics, Construction industry, Cluster analysis,
Supply chain management (SCM), South Australia

Paper type Research paper

1. Introduction

The construction industry is notorious for consuming a large proportion of the world's natural resources and for generating a huge volume of waste (Gorgolewski, 2008). Closing the loop of the construction supply chain (CLSC) through embracing reverse logistics (RL) would reduce these detrimental environmental effects in tandem with boosting the efficiency of construction activities (Schultmann and Sunke, 2007a; Kibert, 2012). In this paper, CLSC is defined as "[…] the design, control, and operation of a system to maximize value creation over the entire life cycle of a product with dynamic recovery of value from different types and volumes of returns over time" (Govindan *et al.*, 2015, p. 603). In contrast, RL in the construction industry is defined by Nunes *et al.* (2009, p. 3717) as "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 goods to the productive cycle through reverse distribution channels, adding value of various types to them: economic, ecological, legal, logistical, corporate image, etc." The synergies between RL processes and a closed loop system are further described by Sakis (2012) as products first flow outbound to a customer (forward logistics): those same products then flow back inbound. In essence, RL is a precursor for establishing an efficient system for reusing, recycling and salvaging materials used in construction. This yields cost savings, improves the green image of companies and increases their profitability (Shakantu *et al.*, 2012; Chileshe *et al.*, 2015). Nevertheless, RL has not yet become commonplace in the construction industry and remains an "unexploited" area (Nunes *et al.*, 2009; Durmisevic and Yeang, 2009; Kibert, 2012).

As with any unconventional practice, widespread adoption of RL might not occur without the support of construction stakeholders (Nunes *et al.*, 2009). Stakeholders need to realise the benefits of adopting RL for it to become a well-established practice. Drivers within the construction environment are needed to make it visible to stakeholders. As highlighted by Bouzon *et al.* (2015, p. 14), "understanding the factors that influence the implementation of reverse supply chain systems is one of the first steps for companies to get interested in RL issues". Yet, the body of knowledge on RL in a construction context suffers from a lack of empirical evidence to support its widespread use (Agrawal *et al.*, 2015; Chileshe *et al.*, 2015). The drivers associated with the adoption of RL in construction remain an understudied area. The extant literature dealing with construction is mainly focused on unearthing barriers to adopting RL (Couto and Couto, 2010; Chileshe *et al.*, 2015). On the other hand, generic theories on RL developed outside the boundaries of construction might not necessarily be applicable to the industry. According to Riley and Clare-Brown (2001), managerial knowledge from other sectors becomes applicable to construction only after introducing considerable refinements to moderate the peculiarities of the industry. According to Vrijhoef and Koskela (2000, p. 177), attempts to modify construction supply chains should "[…] take into account the characteristics and the specific situation of construction". In view of this, investigating the potential drivers and envisaged benefits of adopting RL in construction becomes relevant and timely (Chinda, 2013; Jaillon and Poon, 2014; Agrawal *et al.*, 2015; Chileshe *et al.*, 2015).

In order to fill the above knowledge gap, this study explores the drivers that are relevant for implementing RL practices in construction. The findings of the study are expected to contribute to the field by enhancing the theoretical background on cradle-to-cradle principles in construction (van Dijk *et al.*, 2014). In terms of practical implications, the findings could raise the general awareness of RL among industry stakeholders. This will inform practitioners and policy makers about the areas that need close scrutiny and to which they should direct their energies.

2. Literature review

2.1 RL in construction

Supply chain management in construction has been defined by Love *et al.* (2004, p. 44) as "[…] the network of facilities and activities that provide customer and economic value to the functions of design development, contract management, service and material procurement, materials manufacture and delivery, and facilities management". Construction supply chains have always been treated differently to those in other industries due to their unique problems (Arantes *et al.*, 2015). This has been attributed to low productivity, their fragmented nature, the large amount of waste generated and unsatisfactory environmental performance (Vrijhoef and Koskela, 2000; Ofori, 2000). As a result, the need to modify current practices has been highlighted by many researchers (Love *et al.*, 2004; Arantes *et al.*, 2015). According to Ofori (2000, p. 201), "the increasing environmental consciousness and commitment of businesses, governments, groups and individuals has inspired the development of procurement and purchasing policies incorporating environmental requirements […]". In fact, in revising its supply chains, the construction industry has focused on reducing waste as a primary target (Dainty and Brooke, 2004).

To meet the need for efficacy and the above environmental requirements, construction supply chains should be modified to "[…] facilitate the reuse, recycle, and recovery of component materials and parts" (Sundarakani *et al.*, 2014, p. 533). As stated by Dainty and Brooke (2004), this modification in the supply chain structure occurs only if clients establish alliances with suppliers and designers. These alliances should target reducing the level of waste generated during supply, design and construction (Dainty and Brooke, 2004). Construction supply chains should resemble natural mechanisms that use resources efficiently with minimal waste, with this commonly known as the closed loop supply chain (Sassi, 2004, 2008). To close the loop of a supply chain, Rogers and Tibben-Lembke (1998) suggested adopting RL through returning materials and related information from the consumption point back to the point of origin. In order to adopt RL, supply chains would be redesigned and enhanced to efficiently manage the flow of consumed products or materials, and to direct them towards reuse, remanufacturing and recycling. The advantages envisaged by adopting RL transcend the environmental aspects to include economic, social and strategic benefits (Autry, 2005): RL increases revenue to organisations (Daugherty *et al.*, 2002) and enhances the overall efficiency and productivity of the industry (Glenn Richey *et al.*, 2005). In addition, RL is "[…] a source of opportunity for companies to improve their visibility and profitability; and achieve lower costs across the supply chain […]" (Chileshe *et al.*, 2015, p. 180).

Nevertheless, the construction industry is far behind other sectors in establishing an efficient RL network linked to the traditional (forward) supply chain (Leigh and Patterson, 2006; Schultmann and Sunke, 2007b; Durmisevic and Yeang, 2009; Kibert, 2012; Chileshe *et al.*, 2015). The failure to harness the benefits of RL has been ascribed to the traditional and change-resistant environment dominating the sector and the fragmented nature of its supply chains (Dainty and Brooke, 2004). In addition, technical aspects such as the type of building materials and cost of disassembly of old buildings play a role in the under-performance of the sector in regard to RL (Nakajima and Russell, 2014). The large number of parties involved, the complexity and the temporary nature of projects make it harder for the sector to embrace RL (Arantes *et al.*, 2015). As indicated by Pan (2010, p. 79), the level of adoption of any unconventional method within the construction industry is contingent upon the possibility of such a method

improving the current situation, opening up new horizons and ensuring the reinforcement of compliance and enhancement of an organisation's profile. Bouzon *et al.* (2015) demonstrated how these visible drivers could play a pivotal role such as pushing organisations towards using RL practices.

2.2 Classification of RL drivers
To facilitate the development of an indexing system, thus enabling the retrieval and coding of interview data (Maclaran and Catterall, 2002), the RL drivers identified in the literature review were grouped into several categories. Shaik and Abdul-Kader (2012), in their study, grouped RL drivers into the following six categories: economic, product and technology, legislation, customer, industry and market, and corporate citizenship. Brito and Dekker (2004) and El korchi and Millet (2011) grouped RL drivers in three categories: economic, environmental and social. This section presents a summary of the drivers for RL adoption as identified in the literature using the latter classification.

Many economic drivers of RL have been reported in past studies (Addis, 2006b; Aidonis *et al.*, 2008; Hiete *et al.*, 2011). Cost savings due to less usage of virgin materials; reduced transportation and disposal costs; and revenue generated by the sale of salvaged materials were among the main economic drivers (Guy *et al.*, 2006; Leigh and Patterson, 2006; Laefer and Manke, 2008; Saghafi and Teshnizi, 2011; Hiete *et al.*, 2011). Implementing RL in construction could yield approximately 85 per cent of the materials used in a project through salvaging materials from old buildings destined for demolition (Endicott *et al.*, 2005). Similarly, Gorgolewski (2008) estimated the cost savings of a project as a result of using salvaged materials to be in the range of 30-50 per cent. Nevertheless, the initial cost of deconstruction would be approximately 21 per cent higher than that of traditional mechanical demolition. According to Guy and McLendon (2002), the revenue from reuse and resale of salvaged materials and the reduction of disposal cost would make construction 37 per cent cheaper.

The major environmental driver of RL implementation is the possibility of reversing the negative impacts of construction activities on the environment (Macozoma, 2002). Implementation of RL complies with environmental regulations and makes organisations self-compliant (Densley Tingley and Davison, 2012). It encourages the usage of less virgin raw materials in buildings and less energy for the transport of goods, and generates less waste (Denhart, 2010; Guy *et al.*, 2006; Thormark, 2000; Schultmann and Sunke, 2007a, b; Gorgolewski, 2008). In addition, RL diverts construction and demolition (C&D) waste from landfill so they can be more appropriately used (Bleek, 2013). A recent study by Bouzon *et al.* (2015) showed that the salience of environmental, social and regulatory drivers is on the rise; however, they are not yet considered important in countries with restricted regulations.

With regard to social drivers for RL, new jobs could potentially be created due to deconstruction. Local communities could become involved in the RL supply chain, also benefiting from improved health conditions due to less pollution (Addis, 2006a, b; Leigh and Patterson, 2006; Aidonis *et al.*, 2008; Shakantu *et al.*, 2008). Companies implementing RL practices would improve their image, a crucial point for the construction industry which currently suffers from a poor public image (Rameezdeen, 2007; Denhart, 2010). However, the motivation of companies to meet environmental requirements and enhance their green image largely rests on local circumstances and the social values prevalent in the community (Schultmann and Sunke, 2007b).

3. Research methodology

The study adopted a methodology appropriate to exploring the relevance of the known RL drivers while probing into new territory to look for construction-specific drivers. The steps involved in carrying out this study are captured in a framework illustrated in Figure 1.

3.1 Research design and conceptual framework

The peculiarities of the construction supply chain, which is quite unique from those other industries, demanded a qualitative research method (du Toit and Mouton, 2012). Furthermore, as this was a new topic within the construction industry, the choice of a qualitative method was supported, as argued by Amaratunga *et al.* (2002). This is further justified when considering the intention of this study which was to explore the RL drivers as perceived by stakeholders, thus entailing a rigorous exploration of their real-life needs and intentions. Therefore, as suggested by du Toit and Mouton (2012), interviews with stakeholders were used in this study: this is considered to be the most effective method for assessing the needs and aspirations of stakeholders in a natural context.

The seminal study by Carter and Ellram (1998) presented a framework for RL which is regarded as the first comprehensive description of RL stakeholders. Carter and Ellram (1998) asserted that all activities of an organisation associated with RL are affected by "internal" and "external" factors. The importance of investigating the external factors was emphasised as "[…] a greater understanding of organisational behaviour can be gained by examining how organisations interact with their environment" (Carter and Ellram, 1998, p. 90). According to these authors, the four environmental forces influencing an organisation's RL activities could be classified as: customers; suppliers; competitors; and government agencies. Carter and Ellram (1998) subsequently developed a model of the environmental forces affecting RL activities and depicted the task environment in which organisations operated by dividing it into
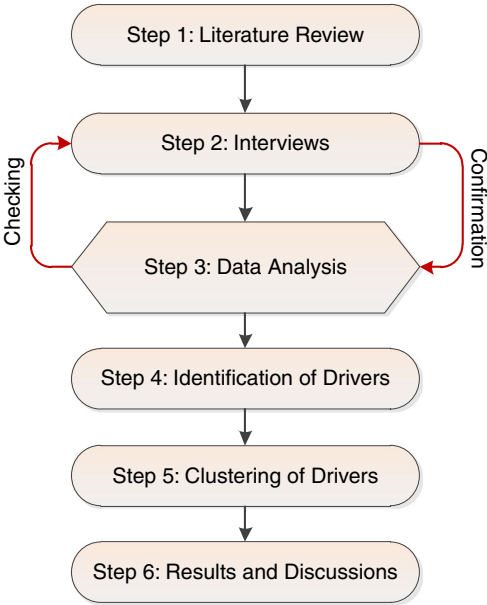
Figure 1.
Research framework

the following four sectors: input; regulatory; output; and competitive. Therefore, interviewees selected for the current study represented the above four segments of the RL stakeholder framework.

The interviewees were selected from the state of South Australia due to its leadership in C&D waste management in Australia (Zero Waste SA, 2012). South Australia is recognised internationally for its deployment of best global practices and for enforcing environmental legislative reforms (UN-HABITAT, 2010). Conducting this study within such a context is expected to provide a wealth of knowledge due to the state's maturity, history and experience in dealing with C&D waste. To identify interviewees in the four segments described above with adequate knowledge of and experience in RL, a "purposive sampling" approach was used. Purposive sampling enables researchers to meet the goals defined by the research aim in conjunction with controlling the level of variation among the interviewees (Bazeley, 2013).

A preliminary list of 23 organisations based in South Australia with experience and sufficient involvement in RL was identified. Sources such as the Yellow Pages; websites of leading demolition and salvaging companies; groups dedicated to salvaging construction materials; and social professional networks such as LinkedIn helped to identify these organisations. Eventually, senior-level representatives from eight organisations agreed to take part in the study. While eight interviews may seem a small sample, according to Mason (2010), the size of the sample in qualitative research becomes irrelevant due to the fact that the value of the study is based on the quality of data. The willingness of these eight interviewees to be involved in the study was one of the major reasons for recruiting them. According to Simms and Rogers (2006), implementing such an approach enhances the richness of data due to the commitment of the interviewees. The link between the interviewees' profiles and the role played by them in the RL subsector, as defined by Carter and Ellram (1998), is depicted in Table I.

The profile of the interviewees attests to the diversity of organisations contributing to this study in light of the various roles they play in the RL subsector. In addition, there is a fair representation of organisations associated with a range of construction activities comprising: monitoring and regulations (Interviewees C and F); salvaging (Interviewees A, B, D, E and F); recycling (Interviewees B, D, E and F); building (Interviewees B and H); and design (Interviewee G). It was contended that such a pool of experts would provide the breadth of knowledge and necessary expertise as well as a healthy variation to make meaningful comparisons as recommended by Ochieng and Price (2010).

3.2 Data collection, confirmation procedure and analysis

All interviews except one were conducted in the respondents' organisations and were arranged through a pre-notification phone call. Each interview lasted approximately one hour and was recorded with the consent of the interviewee. In order for the interviewees to stay focused on RL, the study adopted a semi-structured interview approach. As shown in Figure 1, the second and third steps involved an iterative process of "interviews" and "data analysis". Between these two steps, the procedures of "confirmation" and "checking" were undertaken. This procedure is similar to the "participation checks and validation" undertaken in the study by Ardichvili *et al.* (2003). The interview transcript was sent to each interviewee via e-mail to obtain their agreement to its correctness and their feedback. This process was intended as a verification stage to augment the reliability of the collected data.

Interviewee	Designation	Role of the company	Years of experience	Task environment[a]	Role[a]	Description
A	CEO and owner	Salvaging and demolition	25	Output	Buyer	Owns the largest salvage yard in Australia
B	Executive manager	Construction	15	Competitive	Competitor	Middle-sized construction company active in projects mostly for the South Australian government
C	Managing director	Consulting	20	Regulatory	Interest aggregator	Active in offering legal and environmental consultancy for construction companies
D	Executive manager	Salvaging, recycling and demolition	9	Output	Buyer	One of the leading salvaging businesses in South Australia
E	Marketing manager	Salvaging and recycling	21	Input	Suppliers	One of the largest recycling facilities in South Australia
F	Senior environment protection officer	Environmental regulation	na	Regulatory	Government agency	South Australia's primary environmental regulator
G	Architect	Designing	13(6)[b]	Input	Supplier	Middle-sized consulting and design company active in South Australia
H	Builder	Construction, renovation and refurbishment	15	Competitive	Competitor	

Table I.
Profile of interviewees and interviewees' profiles mapped to the Carter and Ellram (1998) framework[a]

Notes: [a]See Carter and Ellram (1998) for more details; [b]13 years overall and six years in South Australia

As suggested by Lewins and Silver (2007), qualitative studies should reflect on how decisions were made about the coding themes in analysing the interview transcripts. Recent studies such as that of Bazeley (2013) have recommended a process focusing on comparison, contrast and similarity against a theoretical foundation. This approach directed the current study to using "a priori codes" as recommended by Bazeley (2013, p. 170). Consequently, a set of codes based on the literature review was used as the theoretical foundation for demarcating codes from the interview transcripts. Implementing such a technique safeguards the link between the research questions and the data while producing fresh ideas (Bazeley, 2013). The list of a priori codes for this study was based on RL drivers as previously identified and discussed in the literature review section, with these further classified into the following three categories: environmental; economic; and social.

Analysis was conducted using NVivo (version 10) software which enhances the rigour of qualitative data analysis (Lewins and Silver, 2007; Bazeley, 2013). As asserted by Bazeley and Jackson (2013), to reveal concepts embedded in qualitative data, "it is incumbent upon investigators to extract the taxonomy of the emanated concepts and map out the patterns of associations. In the absence of such categorisation and illustration of associations, the true nature of discovered concepts remains undiscovered" (Bazeley and Jackson, 2013). To analyse the interview transcripts, the current study followed the approach used by Dransfield *et al.* (2004). This process involved two steps: first, coding and categorisation of the interview transcripts into different parent codes; and, second, running word frequency tests in that same order.

The rationale for this two-staged approach (Dransfield *et al.*, 2004) was as follows: first, running a word frequency analysis on coded segments of interview transcripts associated with parent codes would unearth the underlying context behind the enunciations of interviewees; and, second, according to Ryan and Bernard (2003), using the frequency of words or the number repetitions is the most efficient method to discover concepts and themes embedded in texts.

The fifth step in Figure 1 (cluster analysis) linked the discovered hierarchy to the established theoretical concepts as well as validating the emergent hierarchy. This was termed by Gibbs (2002) as "pattern matching" in qualitative studies as it entails a comparison between the patterns found in the data with patterns prescribed in the literature. According to Gibbs (2002, p. 158) "[…] a strong support is given to the validity of results when two patterns coincide". Cluster analysis is a method that can provide researchers with "cross-validation" to identify a reliable structure for their data (Uprichard, 2009). The term "cluster analysis" refers to a branch of an exploratory and descriptive statistical technique that sorts cases "[…] into groups of similar cases, whereby the cases within each cluster are more like than those outside the cluster" (Uprichard, 2009, p. 133). The software package, NVivo 10, is capable of performing cluster analysis to visualise patterns by grouping sources or nodes that share similar words or similar attribute value, or are that are coded similarly (Bazeley and Jackson, 2013).

Given the multi-researcher nature of this study, the codes emerging from the interviews were based on consensus opinion. The protocol for confirming the codes identified in all levels followed the procedure for coding as described by Ardichvili *et al.* (2003). That is, two researchers were in charge of defining the codes emerging from the interview transcripts. The codes and categories created by each individual researcher were discussed in meetings between the coders. These meetings resulted in re-analysis of some parts, recoding of some sections and changing the titles selected for a number of codes. Codes in each level were regarded as finalised once consensus was reached on the title of the code, the categories and the concepts emerging from the analysis of each segment of the text. As a result of two researchers performing the coding process and having the "confirmation" and "checking" processes with the interviewees, the outputs generated from this study remained very reliable.

4. Results and discussion
4.1 Analysis of interview transcripts
According to Bazeley and Richards (2000), ideas generated through the analysis of interview transcripts should have "a logical organisation". As shown in Figure 2, the logical organisation of the generated ideas formed a tree of codes with three different levels. The overarching diamond shape represents the source or the RL drivers. This is the top-level node or, as termed by Bazeley and Richards (2000), the "coat hanger" which is the starting point for the ordering of ideas. The second level represents the "grouping nodes" or "parent nodes" that conceptually classify nodes into groups. The four parent nodes in Figure 2 are labelled: "social drivers"; "economic drivers"; "targeted demands by an inclusive clientele drivers"; and "environmental drivers". The relationship lines link the "parent nodes" with nodes defined as "children". A new category of RL drivers (overlooked in the literature) emerged which is labelled as "targeted demands by an exclusive clientele". Table II summarises the frequency of coding references for themes based on the Carter and Ellram (1998) framework.

"Economic drivers" followed by "environment" were the RL drivers to which interviewees most frequently referred, thus reflecting the relative importance of
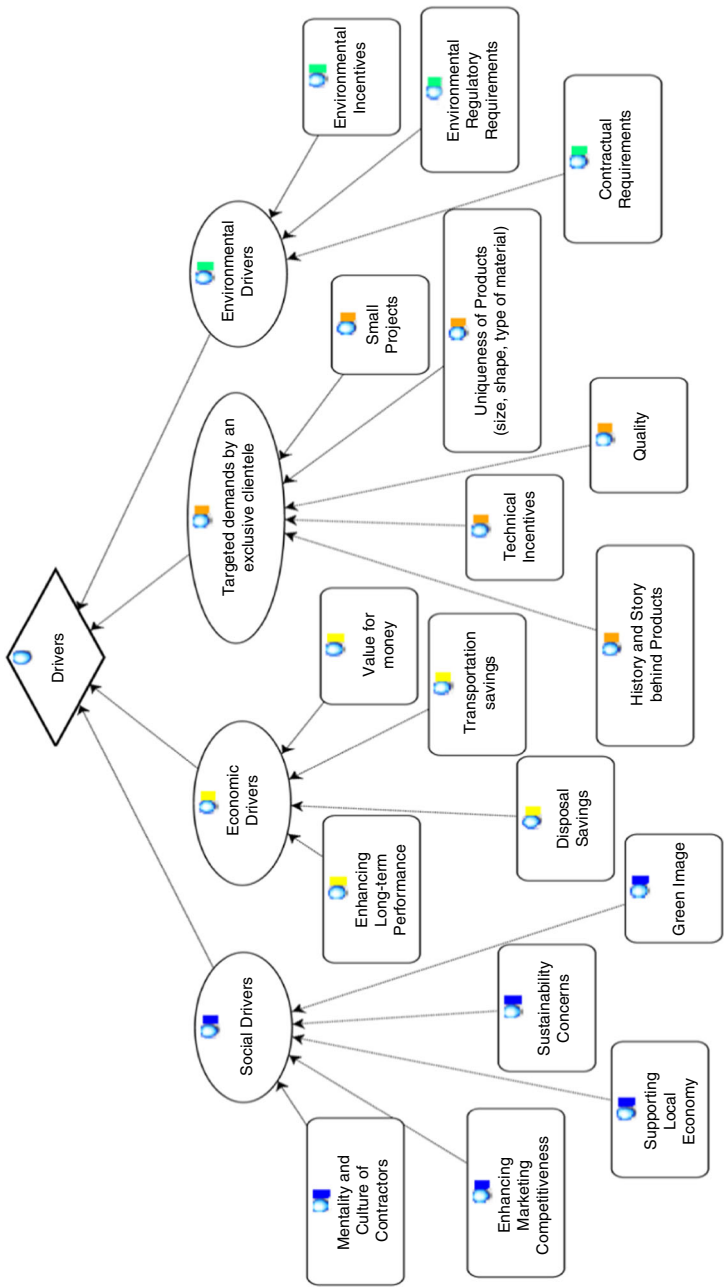
Figure 2.
Nodes similarity
diagram and
clustering of
responses according
to drivers based on
the interviews
(NVivo output)

such drivers. Table II shows that a buyer tends to refer more to economic drivers and less to social drivers. A supplier and interest aggregator are also concerned with economic drivers while competitors have generally treated all four categories relatively equally. The results are discussed in the following subsections.

4.1.1 *Economic drivers.* The majority of interviewees acknowledged the role of economic factors in driving RL practices. Running a word frequency query analysis on passages related to economic drivers showed that the most repeated words were landfill, salvaged materials, cost, demolition, budget and estimation. This mirrored the general concerns expressed by interviewees indicating that the existing landfill levy is not enough to make recycling and salvaging cost effective. Furthermore, interviewees agreed that any marginal gains could be diminished due to the uncertainties with ascertaining the net gains from deconstruction, with this a factor that could further contribute to sending demolition waste to landfills. This observation was similar to that of Huscroft *et al.* (2013) who found, in relation to RL, that uncertainty is a suppressor of cost-based drivers. Any potential cost savings from RL could be diminished by the unexpected consumption of resources while the RL process is in motion.

A matrix coding query revealed that the frequency of references to savings in waste disposal and gains in terms of value for money was well above comparison to long-term gains and transport savings. This showed that immediate and tangible economic gains of RL are much more important for construction practitioners against potential long-term benefits as highlighted by Interviewee C:

> A contractor evaluates the cost of sending waste to landfills. However, they cannot estimate the gain achievable from deconstruction of buildings and the extracted salvaged items. As a result, they have no estimation of the outcome and this might prevent them from selecting deconstruction.

The estimates provided by the interviewees regarding the landfill levy varied between $6,000 and $7,000 for disposal of a typical South Australian single-storey house. General consensus among the interviewees indicated that rising landfill costs in Australia makes deconstruction a viable alternative as reported by the Environment Protection Authority (EPA) in New South Wales (Environment Protection Authority NSW, 2010). However, interviewees were in agreement that this only applies to waste disposal. All interviewees observed that there is no gain in terms of cost savings for a builder between the use of virgin and recycled materials. Interviewees considered that

Role[a]	Economic drivers Frequency	%	Environmental drivers Frequency	%	Social drivers Frequency	%	Targeted demands by an exclusive clientele Frequency	%
Buyer	149	60.57	44	17.89	9	3.66	44	17.88
Competitor	225	38.86	85	14.68	118	20.38	151	26.08
Government agency	60	44.44	60	44.44	0	0	15	11.12
Interest aggregator	119	95.97	0	0	5	4.03	0	0
Supplier	95	61.29	28	18.06	24	15.48	8	5.17

Notes: [a]According to the Carter and Ellram (1998) framework, the external drivers affecting the implementation of RL are nested within the task environment which is divided into the following four sectors: input, regulatory, output and competitive. Within these sectors exists the following corresponding types of organisations: suppliers, government (interest aggregator), buyers and competitors

Table II.
Percentage of themes
coded against the
role of interviewees

salvaged items were not cheaper. According to Interviewee H: "There is no glaring difference in terms of price between salvaged items and virgin ones albeit in some cases virgin items are cheaper". Therefore, cost differences between virgin and salvaged materials could not be regarded as an effective driver as also observed by Nakajima and Russell (2014). This underlines the role of government in providing financial incentives to make salvaged materials more competitive in the market. Nevertheless, it became apparent that RL is operational only within small private sector projects and is not viable for projects which have the government as an influential stakeholder. Interviewees agreed that RL is not considered as an option due to various issues when the government is involved. The same trend was observed in the USA by Guy (2014, p. 147) who noted "the majority of deconstruction project clients are private homeowners".

The main reasons for the above observations became clear when interview transcripts were analysed in detail. Demolition contractors avoid high-profile projects that have big players due to the involvement of unions and safety inspectors. In addition, high-profile projects are not suitable for RL due to the tight scheduling of such projects; the zero tolerance policy for safety; and risks to quality. There is enormous pressure on builder and demolisher to remove old buildings and to clear the site for construction in the shortest possible time due to contractual obligations. Safety or quality risks are not entertained in such projects and that rules out the potential for using salvaged materials. A number of interviewees pointed to the government as being an inhibitor rather than a driver of RL. For example, Interviewee A stated:

> Government as a client is not helping the industry. Government wants the old building to be demolished very quickly; as a result, salvaging will not materialise. For example, a hospital was abandoned for five years but gave just one month for demolition. Salvaging could not take place in this kind of strict timeline. The entire building went into landfill with mechanical demolition. No incentives (tax or any other) from government for salvaging. There is more red tape and government hinders our work. The main obstacle is the government.

The above comments and observations suggests that while economic drivers were considered to be highly influential, there were concerns that the landfill levy is not sufficient to make recycling/reuse cost effective. In addition, the cost differential between salvaged and virgin materials is so low that the cost of transportation becomes a critical factor for decision makers.

4.1.2 Environmental drivers. Word frequency query of the interview transcripts showed that the interviewees referred very often to regulations, licence and government. This highlighted the role of environmental regulations as an important driver for RL; yet the interviewees raised concerns that overly strict regulations could act as a double-edged sword and become a hurdle. Interviewees agreed that there is a dire need for amending current regulations in order to promote RL on construction projects. The insight provided by Interviewee F who works for South Australia's primary environmental regulator indicated that some attempts have been made to amend the Environmental Protection Act. This has also been reflected in recent publications in which the importance of reusing materials to manage waste generation has been emphasised (Zero Waste SA, 2012). The link between environmental regulations and economic drivers of RL was highlighted by the interviewees who called for incentives from the government. Interviewees also highlighted the necessity of integrating different sets of regulations as a first step in promoting RL in construction projects. Interviewee C urged the regulatory bodies to be properly coordinated "There

is a disconnection between EPA and other regulatory bodies involved in the construction industry. Each regulatory body only considers its own purview and ignores others".

The above comments suggest that the interviewees associated the government mainly with barriers due to bureaucracy and the lack of incentives. Nevertheless, a number of interviewees remained positive on the role of government. Thus, it could be inferred that regulations and government should play a vital role in promoting RL within the construction industry. The possibility of carrying out on-site sorting emerged as a driver from the interview transcripts. Six of the eight interviewees stressed the importance of on-site sorting as a critical driver in facilitating the adoption of RL. Interviewees B, E and F contended that on-site sorting is possible in South Australia while Interviewee A observed that on-site sorting is not viable any more due to stricter safety regulations and environmental codes. Interviewee C went on to imply that on-site sorting in South Australia could lead to fines because, according to state regulations, this is regarded as dumping of waste.

4.1.3 Social drivers. Social drivers were accepted as supportive of the economic and environmental drivers but, by themselves, were not deemed very significant by the interviewees. However, transcripts revealed that the interviewees were well aware of the pivotal role of culture, values and the society's environmental expectations as influential drivers of RL. As stated by Interviewee B: "They [customers] are aware about the expectations of the industry with regard to sustainability". This is also partly driven by the organisation's desire to address environmental concerns as noted by the interviewees. Similar observations from the manufacturing industry were reported by Bouzon *et al.* (2015) who indicated that the pressure from society termed as "corporate citizenship" encompasses a set of values and principles that drives organisations towards RL practices.

It came to light that these drivers are moderated by the stigma attached to the use of salvaged materials in new construction which still prevails among clients and designers. The clients' ages and levels of income were found to be influencing this stigma. As an example, Interviewee C stated that the "mostly young practitioners in the building industry are not in favour of using salvaged materials". Interviewee A highlighted that "baby boomers like salvaged materials due to some intrinsic value they find in these materials".

4.1.4 Targeted demands by an exclusive clientele. The main RL drivers identified in this category comprised the demand arising from small building alterations and renovations; superior quality of salvaged materials; sentimental value attached to very old materials; and uniqueness of these products due to size, shape, type of material, etc. As stated by the interviewees, some high-quality materials are no longer available in the market. For example, old timber from the USA or Africa is no longer imported to Australia. The superior quality of salvaged materials as a driver was acknowledged by Addis (2006b) and Guy *et al.* (2006). To underpin this, Interviewee H regarded quality as one of the main driving forces for customers who were looking for materials for structural use. Some customers purchase salvaged materials for "the history and sentimental value" attached to it. A similar driver was observed by da Rocha and Sattler (2009) who indicated that such customers care for the historical value of salvaged items. Furthermore, unique sizes, shapes, textures or types of material bring customers in search of salvaged materials. In this context, interviewees pointed out the emerging and increasingly popular trend of rustic appearance used in decorating restaurants, pubs and retail stores in South Australia. Addis (2006a) noted that salvaged materials are found in sizes, lengths and types that are no longer available in the market.

4.2 Results of cluster analysis

Cluster analysis provides an in-depth insight into the underlying nature of the drivers that emanate from interview transcripts in addition to cross-validating the findings. Literature shows that cluster analysis technique have been applied in supply chain management-related studies (Humphries *et al.*, 2007; Kannan and Tan, 2010). As asserted by Bazeley (2002), conducting a cluster analysis based on the similarities of patterning of sources is specifically useful in reviewing results. The results are commonly displayed as a dendrogram with the points (moving left to right) in which the codes are united manifesting the distance. In NVivo, dendrograms are based on "[…] Average Linkage (between groups), based on squared Euclidean distances calculated from similarities in the frequency […]" (Bazeley, 2002, p. 236). In addition to the "average" linkage, other approaches include the single, complete, ward and geometry (Abonyi and Feil, 2007, cited in Duarte *et al.*, 2012). The outcome of the exercise in the current study provided a dendogram based on agglomerative hierarchical clustering from which three clusters emerged as shown in Figure 3. According to Xu and Wunsch (2008, p. 487), agglomerative hierarchical clustering is commonly used in practice and provides the opportunity to visualise the results.

Each code in NVivo can be associated with a large number of attributes and each attribute can have different attribute types which creates a profile for each code. Linking codes to different attribute types enables researchers to compare the different classifications of codes as asserted by Gibbs (2002). This ability of NVivo was deployed in this study by linking the items of the clusters (as illustrated in Figure 3) to the three clusters that emerged from the analysis. The number of references to codes within each cluster was calculated: based on the percentages, a relative importance ranking was developed as shown in Table III.

The above analysis was based on the premise that important concepts are repeated more frequently within interview transcripts (Bazeley and Jackson, 2013). Thus, the number of references to each item provides a means of identifying the relative importance of concepts coded in the interview transcripts. The following sections briefly explore each cluster and its link to the main drivers identified in the study.

4.2.1 Cluster 1 – performance and competitiveness. The drivers within Cluster 1 could be interpreted as those promoting competitiveness and long-term performance of a business when it implements RL principles. As illustrated in Figure 3, Cluster 1 comprises the following four constructs: mentality and culture of contractors; enhancing marketing competitiveness; contractual requirements; and enhancing long-term performance. An examination of Figure 2 and Table III further illustrates that these constructs were drawn from social drivers (31 per cent), economic drivers (18 per cent) and environmental drivers (51 per cent). Table IV shows the similarity index computed by using Jaccard's coefficient for the variables in Cluster 1.

Notwithstanding the association, Jaccard's coefficient of similarities shows the least similarity between "mentality and culture of contractors" and the remaining three constructs. This finding is supported by Figure 3 which shows how much further this construct is from the rest. The similarity index between pairs of the remaining three constructs was "most similar" with a Jaccard's coefficient of 1. Cluster 1 acknowledges the presence of "environmental" drivers to be closely linked to "social" drivers. This observation resonates with the contention of Brito and Dekker (2004) that paying attention to a firm's environmental outlook should be among the key contributors to competitiveness in leading companies.
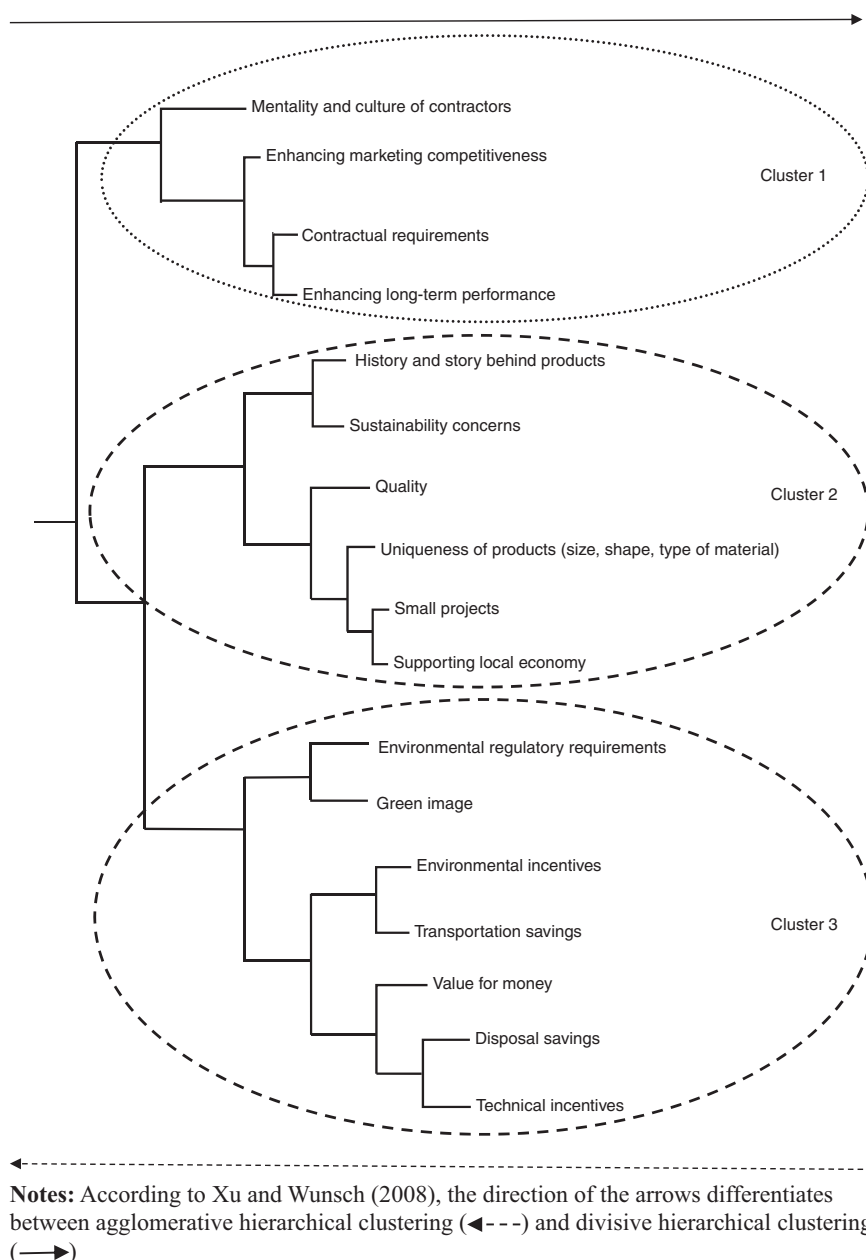
Notes: According to Xu and Wunsch (2008), the direction of the arrows differentiates
between agglomerative hierarchical clustering (◄- - -) and divisive hierarchical clustering
(⟶)

Figure 3.
Clustering of RL
drivers (constructs)
according to
Jaccard's coefficient
of similarity

4.2.2 Cluster 2 – local market. As shown in Table III, Cluster 2 turned out to be mainly
(i.e. 66 per cent) comprised of those drivers relevant to the local market as a result of the
niche created by the unique and quality recycled products that are considered to be
rare. Emergence of this cluster reaffirms the existence of the category titled "targeted

demands by an exclusive clientele". As illustrated in Figure 3, Cluster 2 comprises six constructs with four drawn from the "targeted demand by an exclusive clientele" category and the remainder from the "social" category. This cluster is referred to by Guy *et al.* (2006, p. 197) as the "aesthetic appeal of historic components". Similarly, Smith *et al.* (2007) stated that the appreciation for old materials creates markets for salvaged items which, in turn, promotes the deconstruction of buildings. In addition, small-scale builders in need of few items source their goods from salvage yards (Addis, 2006a). Presumably, in such cases, purchasing salvaged materials in limited volumes might be more cost effective as opposed to buying virgin materials that might not be available in small quantities. This kind of reuse is termed by Gorgolewski (2008, p. 178) as "component reuse". The rest of Cluster 2 (i.e. 34 per cent) was representative of social drivers. Table V shows the similarity index computed by Jaccard's coefficient for the constructs in Cluster 2 which ranged from 0.25 to 1.00.

Table III.
Matrix percentage and percentage of words coded from the clusters according to the RL drivers

Category of RL drivers	Cluster 1		Cluster 2		Cluster 3	
	Frequency	%	Frequency	%	Frequency	%
Economic	18	18.37	0	0	619	69.63
Environmental	50	51.02	0	0	167	18.79
Social	30	30.61	82	34.02	44	4.95
Targeted demands by an exclusive clientele	0	0	159	65.98	59	6.64
Total	98	100.0	241	100.0	889	100.0

Note: See Figure 3 for the individual composition of the constructs by clusters

Table IV.
Weighted Jaccard's similarity coefficient for selected pairing of items in Cluster 1

Construct[a]	1	2	3	4
1	–	1.000	0	1.000
2		–	0	1.000
3			–	0
4				–

Notes: [a]Labelling of the constructs within Cluster 1 is as follows: 1 = mentality and culture of contractors; 2 = enhancing marketing competitiveness; 3 = contractual requirements; and 4 = enhancing long-term performance; Jaccard's coefficient where 0 = least similar and 1 = most similar

Table V.
Weighted Jaccard's similarity coefficient for selected pairing of items in Cluster 2

Construct	1	2	3	4	5	6
1	–	0.750	0.667	0.333	0.333	0.333
2		–	0.500	0.250	0.250	0.250
3			–	0.500	0.500	0.500
4				–	1.000	1.000
5					–	1.000
6						–

Notes: Labelling of the constructs within Cluster 2 is as follows: 1 = history and story behind products; 2 = sustainability concerns; 3 = quality; 4 = uniqueness of products (size, shape, type of materials); 5 = small projects; and 6 = supporting local economy. Jaccard's coefficient where 0 = least similar and 1 = most similar

The pairing of "uniqueness of salvaged products" with "small projects" and "supporting local economy" was found to be most similar in addition to the link between "small projects" and "supporting local economy". This finding is further supported by the dendogram in Figure 3 which clearly highlight the closeness of these three constructs.

4.2.3 Cluster 3 – environmental externalities. Cluster 3 mainly consists of incentives and penalties related to environmental externalities as shown in Table III. Around 70 per cent of Cluster 3 was reflected in economic drivers while 19 per cent were environmental drivers. An examination of Figure 3 shows that this cluster comprised seven constructs with three drawn from "economic" drivers followed by two from the "environment". Table VI presents the weighted Jaccard's similarity coefficients for these seven constructs with none of the pairs achieving the category "most similar".

The financial ramifications of environmental regulations have acted as drivers of RL in many industries (Carter and Ellram, 1998; Laefer and Manke, 2008; Hosseini *et al.*, 2015) including construction (Addis, 2006b). As prescribed by Densley Tingley and Davison (2012) and Yeheyis *et al.* (2013), regulators could develop indices to evaluate the degree of compliance of a design with respect to RL practices. Government provision of incentives and the easing of regulations that impact on on-site sorting were highlighted in the interview results. Incentives provided in Germany (Kuehlen *et al.*, 2014) and New Zealand (Storey and Pedersen, 2014) are examples in this regard. In addition to environmental regulations, economic drivers can play a major role in promoting RL in South Australia but low landfill levies do not create an encouraging economic climate for this practice. As illustrated in Figure 3, a fine balance will be required between considerations for "disposal savings and technical incentives" and "environmental incentives and transportation savings". This will require closer cooperation with suppliers and government regulatory bodies, given their levels of prominence within this cluster.

5. Conclusions
The interviews conducted with RL stakeholders in the construction industry endorsed most of the previously identified drivers as being relevant for the construction context. In addition, the study brought to light a new category of drivers that are labelled together as "targeted demands by an exclusive clientele". These drivers were found to be complementary to the economic, environmental and social drivers as previously conceptualised. In addition, a set of factors affecting the strength of RL drivers

Construct	1	2	3	4	5	6	7
1	–	0.333	0.250	0.333	0.286	0.167	0.400
2		–	0.250	0.333	0.286	0.167	0.167
3			–	0.667	0.250	0.600	0.600
4				–	0.286	0.400	0.400
5					–	0.500	0.500
6						–	0.667
7							–

Notes: Labelling of the constructs within Cluster 3 is as follows: 1 = environmental regulatory requirements; 2 = green image; 3 = environmental incentives; 4 = transportation savings; 5 = value for money; 6 = disposal savings; and 7 = technical incentives; Jaccard's coefficient where 0 = least similar and 1 = most similar

Table VI.
Weighted Jaccard's
similarity coefficient
for selected pairing
of items in Cluster 3

emanated from the current study, highlighting the salience of considering the type of project and the attributes of stakeholders in association with the different drivers.

The clustering of interview results helped identify and highlight critical variables that control RL in several ways. The role of social responsibility and for companies to have a green image is of particular interest as these are looked upon as avenues to gain long-term competitiveness and financial gains in the market. In light of the findings, any attempt to encourage RL, especially in the context of the construction industry needs to carefully consider the following aspects as they form the recommendations of this study:

- Review of landfill levies in order to provide an economic climate for RL implementation.
- Easing of regulations affecting on-site sorting and waste depots.
- Revision of government standard specifications and tendering conditions to encourage the use of salvaged materials.
- Encouraging changes in attitude to eradicate the stigma attached to the use of salvaged materials among clients and designers. This might encourage and persuade the public and society at large regarding the acceptance of using salvaged materials.
- Considering RL at the planning stages of construction projects. This includes factoring in the requirement for flexible scheduling between "demolishing" and "salvaging" stages of the project life cycle. In addition, on-site sorting and provision for adequate space in site layout plans must be considered.
- Sharing of knowledge among stakeholders.

For researchers, these findings provide further avenues for investigating the interactive effects among RL drivers using additional empirical research and quantitative modelling techniques. In particular, given the conflicting concerns raised by the interviewees on the role of regulation, one of the possible avenues examining the impact of government regulations on RL implementation can be found in strategic management literature and theories. Based on the implications drawn, the findings of this study have the potential to influence policy and thus to increase the likelihood of RL adoption by practitioners and policy makers.

6. Limitations of the study
While the study makes several contributions to supply chain management and RL theory and practice, some limitations should be noted. The major limitations point to the relatively small size of the sample of interviewees and having interviewees from one geographic area with specific socio-economic characteristics. Despite such restrictions, in light of there being only a few published empirical investigations on RL in the construction industry, this study provides a foundation for further investigation of this important research area. Moreover, only external drivers were investigated in the current study in view of the considerations explained in detail in the methodology section. As opined by Hazen *et al.* (2012), market conditions and customer-related behaviours represent an important component of RL adoption. These are bound to differ across various countries and cultural borders. As such, these limitations and inherent assumptions based on the South Australian context should be considered before generalising the results to other countries with different market conditions.

The results and interpretation of Jaccard's coefficient (Tables IV-VI) should be treated with caution as studies such as Niwattanakul *et al.* (2013) have highlighted some weaknesses of Jaccard's similarity coefficient when measuring the similarity of certain words. One such limitation is linked to the limited ability of handling associations between low-frequency and high-frequency words (He, 1999). Further studies in RL should employ techniques such as social network analysis to determine the centrality (or degree of closeness) to measure the internal strength and density of a cluster (Ronda-Pupo and Martins, 2012, p. 171). This information would further enable the development of a "strategic diagram" to ensure that the constructs, as illustrated in Figure 3, are effectively mapped within appropriate quadrants, thus opening avenues for a discourse on the extent of development of the relevant clusters.

More inquiries are required in the form of case studies to provide evidence on how the various drivers identified above will affect the business model of existing players in the RL network. Specifically, the impact of landfill levies on RL could be investigated using an optimisation model. This study, including the literature review and the interviews, was limited to practitioners dealing with waste only arising from demolition and deconstruction. However, waste generated during the construction phase has great potential to join the RL cycle. This offers another prolific ground for future research targeting the mechanisms of promoting the reuse of materials regarded as "construction leftovers" in new construction. Finally, the current study is nested upon the Carter and Ellram (1998) study and has rightly mapped the profile of the interviewees to the advocated RL task environment and associated four environmental forces. However, it was beyond this study's scope to further explore the interactive effect of these four forces as well as the dyadic and exchange dynamics among the various stakeholders. Future studies should explore the commercial exchange dynamic within the RL concept.

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