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Analysis of reverse logistics implementation practices by South Australian construction organisations

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Abstract

Purpose – A large number of benefits have been reported when reverse logistics (RL) is fully implemented in the construction industry. However, RL is yet to become common place in the construction sector, particularly in Australia. The particular sub-sector in which RL operates is small and weak and the remainder of the sector must embrace and accommodate it comfortably. Research is lacking on how to promoting RL in the construction industry. Very little has been done to identify the current practices that have the potential to promote RL industry-wide. The purpose of this paper is to identify the practices that work well in the sector, a strategy could be mapped out to promote RL to all stakeholders.

Design/methodology/approach – In order to fill the above gap, the present study used a mixed method approach to gather and evaluate current practices and their potential to promote RL in South Australia's construction industry. Practices that were identified using a comprehensive literature review were evaluated with a questionnaire survey and series of interviews involving construction professionals.

Findings – The findings are that practices facilitating deconstruction is the most important, followed by practices facilitating the use of salvaged materials in new construction to promote RL in South Australia. Awareness of deconstruction benefits, challenges and procedures at the organisation level and facilities and services at industry level were associated with RL implementation. Availability of salvaged materials in the market was found to influence its use in new construction and as a consequence its demand. Designing for reverse logistics is another practice that could facilitate deconstruction and the onus of its promotion lies mainly with the designers.

Research limitations/implications – This research was confined to one state in Australia. As such the generalisation to other states and other countries should be treated cautiously.

Practical implications – The findings of this study can help inform the industry and its stakeholders on areas that they need to concentrate more on to make the South Australian construction industry a fully RL integrated one. To that end the authors propose some recommendations arising from the findings reported here.



Originality/value – This study makes a contribution to the body of knowledge on reverse logistics within a previously unexplored South Australian context. In addition, the study provides valuable insights into the contribution of RL practices to the construction industry.

Keywords South Australia, Supply chain management, Construction industry, Reverse logistics, Practices, Mixed methodology

Paper type Research paper

1. Introduction

The construction industry is renowned globally as the largest producer and contributor of waste to landfill (Wang *et al.*, 2010). Against this backdrop, the strategies proposed to address this issue have been mostly geared towards improving supply chain management (SCM) by minimising waste and adding value by effective stewardship of information and refining logistics (Cheng *et al.*, 2010; Shin *et al.*, 2011). With reference to the practices proposed for refining SCM, implementing reverse logistics (RL) is regarded as a remedial measure that moderates the detrimental impacts of construction projects on the natural environment (Schultmann and Sunke, 2007b) and enables organisations to be more efficient and effective through the attainment of economic benefits and sustainable competitiveness (Agrawal *et al.*, 2015). Similarly, recent studies such as Okongwu *et al.* (2015) have provided empirical evidence for SCM practices impact on financial and non-financial performance. Conversely in other sectors such as automotive industries in China, Yu *et al.* (2014) established the relationship between three dimensions of integrated green SCM and multiple dimensions of operational performance. Nevertheless, RL has yet to become common place in the construction sector (Schultmann and Sunke, 2007a; Kibert, 2012; Nunes *et al.*, 2009). Despite anecdotal evidence suggesting local people in Australia have been using materials and components salvaged from old buildings, the uptake of RL is limited in the Australian construction industry. There is consequently a need to explore the ways of promoting RL in Australia. A review of the literature revealed an absence of studies examining the desirable practices of RL in Australia.

Driven by the need to fill this gap in the body of knowledge, this study aims to identify the practices that could promote the adoption of RL in the construction industry in South Australia. Uncovering these best practices would facilitate their promotion over others to establish a vibrant RL sub-sector. To fulfil this aim, the following section summarises a literature review on practices affecting RL implementation. This is followed by the justification of the methods used for data collection. Then the results of the study are presented with a discussion outlining implications for policy-makers, governments and practitioners.

2. Literature review

2.1 Theoretical framework

RL was defined by Fleischmann (2001, p. 6) as “the process of planning, implementing and controlling the efficient, effective inbound flow and storage of secondary goods and related information opposite to the traditional supply chain direction for the purpose of recovering value or proper disposal”. In construction, Nunes *et al.* (2009, p. 3717) described RL 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 the goods to the productive cycle through reverse distribution channels, adding value of various types to them: economic, ecological, legal, logistical,

corporate image, etc.". Drawing upon the definition of "practices" as provided by Wu *et al.* (2012, p. 123), the following interpretation of RL practices is made:

RL practices include specific procedures, organisational arrangements, protocols, techniques and other ways of implementing RL activities such as usage of salvaged materials or reduction of waste as part strategic objectives.

Drawing from the seminal work of Carter and Ellram (1998), a framework of factors affecting RL activities was developed and conceptualised as consisting of two groups: operational task environment; and macroenvironment. According to the framework, the operational task environment can be viewed in terms of following four sectors: input; regulatory; output; and competitive.

Furthermore, Carter and Ellram (1998, p. 84), identify different types of organisations within these four sectors, these being suppliers in the input sector, government agencies and non-profit organisations in the regulatory sector, buyers in the output sector and competitors in the competitive sector. Building on the Carter and Ellram (1998) framework, subsequent studies by Dowlatsahi (2000) and Knemeyer *et al.* (2002) included internal considerations and further classified the internal factors into strategic and operational.

Against this background the present study builds on the Carter and Ellram (1998) and Knemeyer *et al.* (2002) framework and maps the practices "external" to the operational task and macroenvironment; and "internal" to strategic and operational factors. The identification of practices promoting RL from the literature and subsequent discussions are based on the following three levels as illustrated in Figure 1:

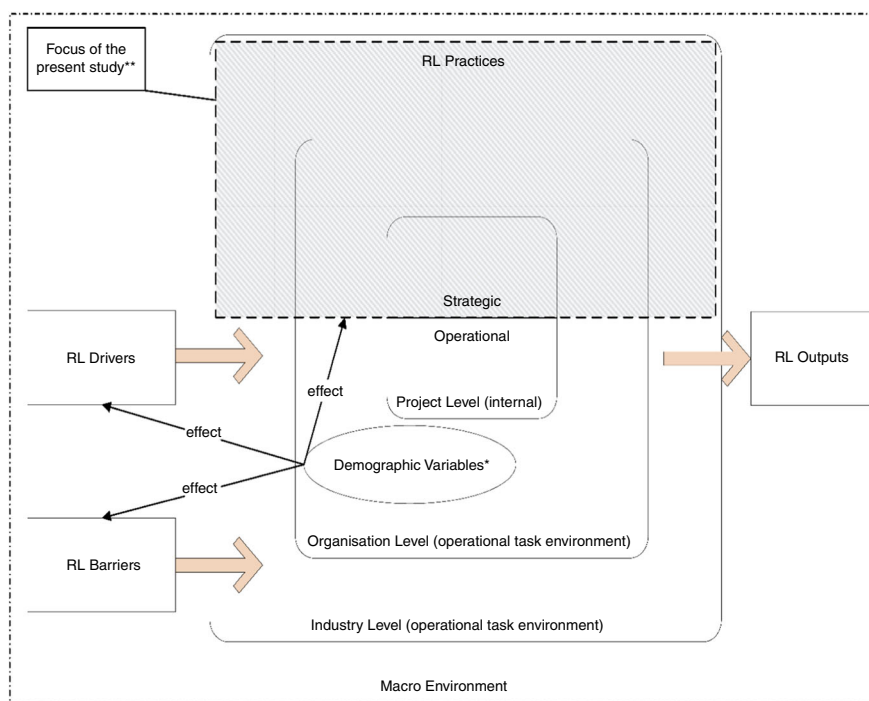
- (1) industry;
- (2) organisation; and
- (3) project.

The first two levels correspond to the "operational task" and "macro" environments, whereas the project-level practices refer to the "strategic" and "operational" factors.

As illustrated in Figure 1, only the practices at the strategic level are considered for this study (see Table I, project practices 1 through 7). The assumption and rationale for this approach is provided by Dowlatsahi's (2000, p. 150) study which identifies the need to consider strategic factors prior to operational factors. In Figure 1 the main practices are shown as a "nested model" within the broader theoretical framework. It should be noted that while Figure 1 illustrates the linkages between the main concepts (i.e. drivers, barriers, practices and outcomes) including the demographic variables of RL, the main focus of this study is to identify the best practices and their inter-relationships. A summary of studies associated with practices of RL is presented in Table I.

2.2 Industry practices

The conceptualisation of RL levels according to Figure 1 and the relevant "Industry" practices are influenced by both the external factors residing in the macroenvironment and the internal organisations within the industry. Examination of Table I shows that the seven industry practices ranged from availability of salvaged products, components and materials which in essence could be compared to the services offered by the "suppliers" as identified by Carter and Ellram (1998).



Notes: ^aDemographical variables include number of employees; sector, size, turnover, etc. associated with the organisation; ^bThe rest of the diagram represents future areas of investigation

Figure 1.
Overall conceptualisation of the theoretical framework

Similarly, “availability of deconstruction and dismantling service providers” could be equated to the “competitors” residing within the “competitive task environment” of Carter and Ellram (1998). The “regulatory” task environment which is normally associated with the “Government” and “Interest aggregators” would refer to industry practices 5 and 6 which are associated with the “regulatory and financial incentives” namely, in favour of deconstructing buildings (Table I IndPrac5) and “promoting use of salvaged materials in buildings” (Table I IndPrac6). According to Carter and Ellram’s (1998) propositions, the regulatory sector’s perceived influence on RL will be significantly greater than the output, input and competitive sectors. Subsequent studies of Kibert *et al.* (2000), Saghafi and Teshnizi (2011) and Huscroft *et al.* (2013) confirmed some of the stated propositions. For example, government support could take many forms including disincentives for disposal (Kibert *et al.*, 2000). In addition, support from the government would promote wider public acceptance of RL as a national goal (Saghafi and Teshnizi, 2011). Similarly, recent studies such as Huscroft *et al.* (2013) identified key issues faced by supply chain professionals when managing RL processes. They employed the Carter and Ellram (1998) framework and identified the following seven key issues that RL managers must deal with: customer support, top management support, communications, cost, formalization, timing of operations and environmental issues.

While the main focus of this sub-section is a discussion of “industry practices”, the seven key issues listed above are relevant to the different levels of practices as

No.	Practices	Previous studies ^a
OrgPrac1	Clear understanding of the benefits of deconstructing buildings	Crowther (2000), Sassi (2004, 2008), Addis (2006b), Guy <i>et al.</i> (2006), Razaz (2010), and Chileshe <i>et al.</i> (2015)
OrgPrac2	Awareness of deconstructing procedures	Greer (2004) and Schultmann and Sunke (2007a, b)
OrgPrac3	Understanding of challenges associated with deconstruction	Pulaski <i>et al.</i> (2003), Sassi (2004), Guy <i>et al.</i> (2006), Leigh and Patterson (2006), Gorgolewski (2008), Weil <i>et al.</i> (2006), Saghafi and Teshnizi (2011), and Kibert (2012)
OrgPrac4	Understanding of different aspects of reusing buildings	Greer (2004) and Schultmann and Sunke (2007a, b)
IndsPrac1	Availability of salvaged building products, components and materials	SA Government (2012)
IndsPrac2	Availability of deconstruction and dismantling service providers	SA Government (2012)
IndsPrac3	Existing demand for salvaged and used building products	Addis (2006a), Gorgolewski (2008), Hiete <i>et al.</i> (2011), and Agrawal <i>et al.</i> (2015)
IndsPrac4	Facilities to recover the used products after deconstruction	Schultmann and Sunke (2007a, b)
IndsPrac5 ^b	Regulatory and financial incentives in favour of deconstruction	Carter and Ellram (1998), Kibert <i>et al.</i> (2000), Saghafi and Teshnizi (2011), and Huscroft <i>et al.</i> (2013)
IndsPrac6 ^b	Regulatory and financial incentives for promoting use of salvaged materials	
IndsPrac7	Quality control compliance for used products	Tibben-Lembke and Rogers (2002), Sassi (2004), Dowlatshahi (2005), Nordby <i>et al.</i> (2009), Da Rocha and Sattler (2009), Kibert (2012), Densley <i>et al.</i> (2012), Aitkens and Harrison (2013), and Chileshe <i>et al.</i> (2015)
ProjPrac1	Deconstruction is implemented in our projects	Crowther (2001)
ProjPrac2	Utilisation of salvaged materials in new buildings	Chini and Bruening (2003) and Razaz (2010)
ProjPrac3	Reducing the amount of waste generation as part of strategic objectives	Genchev <i>et al.</i> (2011) and Zero Waste SA (2011)
ProjPrac4	Enhancing the green image as part of strategic objectives	Addis (2006b), Laefer and Manke (2008), Kralj and Markić (2008), and Fabbe-Costes <i>et al.</i> (2014)
ProjPrac5	Organisational support for using salvaged materials in new buildings	Carter and Ellram (1998), Dey <i>et al.</i> (2011) ^c , Genchev <i>et al.</i> (2011), and Huscroft <i>et al.</i> (2013)
ProjPrac6	Organisational support for deconstructing buildings	Carter and Ellram (1998), Dey <i>et al.</i> (2011) ^c , and Huscroft <i>et al.</i> (2013)
ProjPrac7	Organisational support for designing buildings based on designing for reserve logistics (DfRL) principles	Carter and Ellram (1998), Dey <i>et al.</i> (2011) ^c , and Huscroft <i>et al.</i> (2013)

Table I.

List of practices for RL and similar studies

Notes: ^aPrevious studies arranged in chronological order ;^bthe review of the literature for the two industry practices is combined due to the common denominator of “regulatory and financial incentives”; ^csupply chain logistics-related study

illustrated in Figure 1. However, the most relevant key issue out of the seven suggested by Huscroft *et al.* (2013, p. 319) is “environmental” where most managers felt that they had little control over environmental regulations. Interestingly, the “environmental” factor was ranked lowest. This review also identified specific studies such as Addis (2006a), Gorgolewski (2008) and Hiete *et al.* (2011) which focused on “demand” (see Table I IndPrac3).

The proposition that salvaged materials should be offered a “label” or “grading stamp” to ensure their quality and integrity is another important practice that affecting the use of salvaged materials (Tibben-Lembke and Rogers, 2002; Densley *et al.*, 2012). They proposed developing indices to evaluate the degree of compliance of buildings with respect to RL practices and label their “greenness”. Tibben-Lembke and Rogers (2002) highlighted the lack of information concerning salvaged materials as a factor affecting successful deployment of RL.

2.3 Organisation-level practices

Studies looking at organisation level were mainly concerned with: awareness of procedures, understanding of benefits, challenges, safety issues and the potential to reuse different materials. These belong to the operational task environment as illustrated in Figure 1 and are for the most part associated with either RL or deconstruction of a building compared with demolishing and how salvaged building materials are being reused. It is often argued that any implementation of formal “practices” is linked to the level of awareness, benefits and challenges. Some notable studies such as Guy *et al.* (2006) highlighted the following benefits of RL:

- (1) reduced nuisance during deconstruction compared to demolition;
- (2) less tools and equipment necessary for deconstruction;
- (3) increasing the longevity of buildings; and
- (4) reducing pollution and toxicity in the building removal process.

Similarly, Addis (2006b) and Razaz (2010) highlighted RL practices to make a building re-attractive as an investment property by increasing its value. Razaz (2010) identified lower maintenance costs being the main benefit. Lack of knowledge in the industry impedes deploying preferred strategies as illustrated by organisation practice 2 (Table I). According to Schultmann and Sunke (2007a) and Greer (2004), due to lack of knowledge, salvaged materials end up in down-cycling or recycling instead of reusing them which is a lower level sustainability objective. Understanding the challenges involved in deconstruction as opposed to demolition is the third organisational practice which includes; first, safety issues; and second, longer completion times. Guy *et al.* (2006) suggested that the level of usage of RL could be drastically reduced due to the influence of these factors. Likewise implementing RL in construction projects is fraught with challenges for designers (Gorgolewski, 2008). Some of these challenges cited in the literature relate to increased capital costs and a longer time taken to deliver projects (Guy *et al.*, 2006; Leigh and Patterson, 2006; Gorgolewski, 2008).

2.4 Project-level practices

As illustrated in Figure 1, RL practices at the “project level” include deconstruction (ProjPrac 1), utilisation of salvaged materials in new construction (ProjPrac 2), alignment of waste management practices with organisational strategic objectives

(ProjPrac 3 and 4) and top management support for RL activities (ProjPrac 5, 6, 7). The justification and importance of these “strategic” practices have been acknowledged in previous studies (Dowlatshahi, 2000; Knemeyer *et al.*, 2002; Fabbe-Costes *et al.*, 2014).

Carter and Ellram (1998), Genchev *et al.* (2011) and Huscroft *et al.* (2013) identified “top management support” as an important factor in implementing RL in an organisation. To contextualise some of the practices included within this sub-category (Table I), the following definition of “top management support” as provided by Huscroft *et al.* (2013, p. 309) could be highlighted:

[...] involves issues such as organisational buy-in, continuous improvement objectives, and management support via resources, commitment, etc.

Underpinning the organisational support for using salvaged materials in new construction, Genchev *et al.* (2011) highlight the need for formal processes. This, “formalisation” refers to the extent to which rules, procedures, instructions and communication are written (Genchev *et al.*, 2011, p. 246). Table I provides further evidence of the need for management commitment to be formally recognised, supported across a range of practices such as usage of salvaged materials in new construction; deconstruction and designing for RL (Carter and Ellram, 1998; Genchev *et al.*, 2011; Huscroft *et al.*, 2013).

An examination of Table I and Figure 1 further highlights the linkages across these three levels of practices. Some practices can also be related to more than one level such as “implementation of deconstruction” and “utilisation of salvaged materials” (ProjPrac 1 and ProjPrac 2, respectively) at project level which are strongly associated with a firm’s awareness and knowledge of deconstruction procedure (OrgPrac 2).

3. Research methods

3.1 Research approach

The study adopted a mixed method approach due to the numerous benefits associated with it (Creswell and Clark, 2007; Abowitz and Toole, 2010). First, it overcomes the limitations of the narrower focus of a single method. Second, it is a remedy for low-response rates normally associated with single methods. Third, enhanced validity and reliability of findings through multiple sources of data is guaranteed, and finally the possibility of triangulation of diverse observations makes it possible to arrive at a consensus outcome. In addition, a “mixed method” approach very well suit the aim of this study, which by its very nature is exploratory. The study used a questionnaire survey and a series of interviews as data collection tools described below.

3.2 Questionnaire survey

A questionnaire comprising four distinct sections was administered in the South Australian construction industry as follows:

- Section 1 encompassed general demographics of the study sample, which acted as “control variables” for the study as illustrated in the theoretical framework (Figure 1);
- Section 2 comprised three sub-sections in order to capture the respondents’ perception of the importance of prevailing construction practices that could support RL at three levels in South Australia (i.e. industry, organisation and project);

- Section 3 captures the drivers of RL in South Australia; and
- Section 4 captures the barriers of RL in South Australia.

The results reported in this paper are related to the first two sections of the questionnaire. It is beyond the scope of this paper to report on the other two sections of the research project. The second section consisted mainly of practices identified through the literature review described above.

The sampling frame for the study comprised randomly selected professionals (as the unit of analysis) representing builders, designers, subcontractors, demolishers and salvaging companies. Builders were registered with either the Civil Contractors Federation of South Australia or Master Builders Association of South Australia. Professionals working for design and management companies belonging to the Australian Institute of Building, Australian Institute of Project Management and Australian Institute of Architects were contacted to be a part of the study. A snowball sampling method was used to recruit respondents from subcontractors, demolishers and salvaging companies. The rationale for adopting “snowballing” technique is provided by Burns *et al.* (2008) which makes it possible to explore the existing “bonds” and “links” that exist between the initial sample and others in the target population. It also facilitates the identification of groups that are not easy to be identified.

A total of 539 questionnaires were distributed using two modes of administration. A postal survey was used to administer 260 questionnaires to the builders and the RL community, while 286 questionnaires were sent via e-mail to designers and managers. A total of 49 completed questionnaires were returned as follows: 23 via e-mail and 26 via post and this generated an overall response rate of 9.09 per cent. While this number might be considered small when compared to the overall population of construction professionals within the sample, in relation to previous studies such as Yong and Mustaffa (2012) it seems adequate, and further complimented by the interview data. As highlighted by Yong and Mustaffa (2012, p. 547), if high-quality survey data could be obtainable from smaller samples drawn using well-developed selection criteria, meaningful findings can still be generated.

3.3 Interviews

Interviews were used to supplement the questionnaire survey and to obtain in-depth views from the RL community in South Australia. A semi-structured interview approach was used with a list of questions aimed at capturing the practices that could promote RL (the Appendix). The interviewees were also free to raise and discuss any issues not listed covering general areas of forward logistics, RL and waste management practices. Interviewees were selected on the basis that they represented a range of stakeholders identified in Carter and Ellram (1998). These included: suppliers, competitors, government agencies and non-profit organisations. The profile of interviewees is presented in Table II. This led to a sample size of six experts who were keen to express their opinions about the research topic. As highlighted by 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 interview data were coded, scored and statistically analysed using the Nvivo (version 10) software. As suggested by Ardichvili *et al.* (2003) the first drafts of the transcripts were sent to the interviewees for their comments. This process, known as the “validation and confirmation procedure” was very useful for generating unbiased outcomes.

Table II.

Descriptions of the organisations involved in the semi-structured interviews and linked with the Carter and Ellram (1998) framework

Interviewee	Task environment (TE) and role		Position and experience (individual*/organisation)
	Task environment	Role	
Interviewee A	Output	Buyer	Marketing manager (established since 1993)
Interviewee B	Competitive	Competitor	Managing director (*20 years' experience)
Interviewee C	Regulatory	Interest aggregator	Executive manager (Operational since 2005)
Interviewee D	Output	Buyer	CEO and owner (25 years in business)
Interviewee E	Input	Suppliers	Executive manager (*15 years' experience)
Interviewee F	Regulatory	Government agencies	Senior environment protection officer

Notes: A, organisation owning the largest salvage yard in Australia; B, medium-sized construction company active in projects for the South Australian (SA) Government; C, provider of legal services to SA construction companies; D, leading salvaging organisation in South Australia; E, largest recycling facility in South Australia particularly in recycling concrete and production of recycled aggregates; and F, South Australia's primary environmental regulator (Environmental Protection Authority (EPA)); *Refers to the individual's length of experience within the construction industry and note 'service' within a particular organisation

Source: Reference to Carter and Ellram (1998) framework

4. Findings

For the sake of brevity and to avoid duplication, the results of the questionnaire survey are presented together with the qualitative findings from the interviews. It is contended that combining the results of quantitative and qualitative provides a more in-depth understanding and enhances confidence in the representativeness of the research findings as argued by Creswell and Clark (2007).

4.1 Demographics and reliability

The respondents to the questionnaire survey comprised 27 executives (56 per cent), nine project managers (18 per cent), five other senior managers (10 per cent), three site engineers (6 per cent) and five field superintendents (10 per cent). Of these, 28 had more than 20 years' experience (57 per cent), 15 of them with 11-20 years (31 per cent), three with 5-10 years (6 per cent) and three with less than five years (6 per cent). In total, 15 respondents belonged to builders (31 per cent), 11 subcontractors (22 per cent) and the remaining 23 designers, managers and RL operators (47 per cent). As suggested by da Rocha and Sattler (2009), the major players involved in the RL process should be drawn from the following groupings: demolition and deconstruction service providers; contractors; C&D waste providers; designers; salvage items suppliers; and clients. The profile of respondents generally confirms the da Rocha and Sattler (2009) requirements and based on experience their opinions could be considered credible.

Table III shows the measure of reliability and average correlation of the sub-instruments of the three practice levels as well as the composite practice of RL instrument incorporating all 18 variables. The appropriate and acceptable value for $\alpha = 0.7$ was based on literature by Nunnally (1978) which provides justification for applying Cronbach's technique for measurement of reliability. The results of reliability analysis tests are included in Table III which includes the Cronbach α based on the standardised items and F -statistic from ANOVA.

As illustrated in Table III, the Cronbach values of the sub-instruments and composite practices were greater than 0.7, thus conforming the high reliability of the

results obtained (Nunnally, 1978). Inspection of the standardised item α 's including the F -statistics drew similar results. Pallant (2005), however, recommends inspection of the "corrected item-total correlations". While these results are not tabulated in this study, the following values were obtained for the sub-instruments: first, it ranged from 0.484 to 0.653 for the project-level sub-instrument; second, 0.649 to 0.746 for the organisation sub-instrument; and third, 0.256 to 0.649 for the industry instrument. The only notable exception was the low value (< 0.3) for the industry practice 3 (0.256). However, as the overall Cronbach α was greater than 0.7, there was no need to delete any of the variables within this sub-instrument (Pallant, 2005, p. 92).

4.2 Ranking of industry RL practices

Table IV shows the mean agreement responses for the seven industry associated RL practices.

As illustrated, the mean agreement scores ranged from 3.796 to 2.792. Based on the agreement scores, availability of salvaged materials was the highest ranked industry-level RL practice pointing to the crucial role of suppliers within the operational task environment. The availability of deconstruction and dismantling service providers was also ranked high by the respondents which highlight the role of competitors in the operational task environment. The higher rankings given to these industry practices are hardly surprising. According to a report by SA Government (2012), the major masonry materials recovered in SA are based on the source and location of the recovery facility. Remarkably, the practice of "existing demand for salvaged and used building providers" was ranked by the respondents to be medium.

No.	RL practices composite and sub-instrument	No. of items	Cronbach α	Cronbach α based on SI	$F(p)^a$
1.	Composite practices ^b	18	0.875	0.879	16.569 (0.000)
2.	Project level	7	0.810	0.818	8.580 (0.000)
3.	Organisation	4	0.872	0.874	3.192 (0.026)
4.	Industry	7	0.804	0.816	23.535 (0.000)

Notes: SI, standardised items. ^athe values in parentheses are the significance based on the ANOVA output; ^bthe composite practices instrument is the aggregate of the three sub-instruments, namely, project level; organisation; and industry (see Figure 1). Where $p \leq 0.05$, the model or sub-instrument is significant and $p \geq 0.05$, not significant

Table III.
Summary of
reliability statistics
for the RL practices
sub-instrument

Industry practices	Mean score	SD	R
Availability of salvaged building products, components and materials	3.796	0.735	1
Availability of deconstruction and dismantling service providers	3.714	0.707	2
Existing demand for salvaged and used building products	3.571	0.890	4
Facilities to recover the used products after deconstruction	3.694	0.713	3
Regulatory and financial incentives in favour of deconstruction	2.792	1.031	6
Regulatory and financial incentives for promoting use of salvaged material	2.729	1.001	7
Quality control compliance for used products	2.857	0.913	5

Note: R , ranking of practices based on the mean score

Table IV.
Ranking of industry
practices desirable
for RL
implementation

Furthermore, the “regulatory and financial incentives in favour of deconstruction”, and the “regulatory and financial incentives for promoting the use of salvaged materials” were the least ranked practices showing less importance of regulatory entities within the operational task environment.

It is also notable that the fourth ranked practice contradicts as the previous studies by Addis (2006a), Gorgolewski (2008) and Hiete *et al.* (2011). Hiete *et al.* (2011) found that the supply is less than demand in the salvaged building materials market. Consequently, it is prudent to buy desired salvaged materials once they show up in the market (Gorgolewski, 2008). Planning to acquire these materials early in the project life cycle may mitigate this risk. However, according to Addis (2006a), locking up capital as well as warehousing cost could pose a problem with early procurement. A probable reason for the conflicting results is that the supply of salvaged materials in South Australia is deemed to mature with established facilities and the high barrier imposed on new entrants.

The major consumer of recycled materials in South Australia is the road industry and it utilises around 800,000 tons of output annually. It is facilitated by a very positive and progressive specification required by the Transport SA (specification 2000/02428) which permits utilisation of reused materials to the same level as virgin materials. The following comment by a marketing manager (i.e. a buyer within the theoretical framework) affirms the existing demand for salvaged products (Industry Practice 3) (Interviewee A):

[...] Number of customers is increasing. [...] Customers are people who do small alterations to their homes, house builders, architects, contractors etc. [...] Definitely, the domestic sector is very huge compared to the commercial sector, both as customers and providers of salvaged materials [...]

The above comment was further reinforced by a supplier (Interviewee E) who acknowledged that the market was booming with more competitors entering it.

Despite ranked 5th with a mean score of 2.875, the practice of “Quality control compliance for salvaged products” needs to be highlighted due to the importance attached to quality of these materials. Studies such as Kibert (2012) and Nordby *et al.* (2009) highlighted the inability of providing buyers with certificates of quality. However, some interviewees have acknowledged this problem, and suggested some measures be put in place to improve this practice. (Interviewee D) (i.e. buyer in the framework) observed:

We test the aggregates for asbestos. There are some chemical tests done.

This observation was made despite the reservation with the quality of salvaged products. With reference to the materials used in road construction, Interviewee D further highlighted the problems associated with quality:

There is also a bit of quality issue with recycled products. For example, bitumen mixed with tiny wood particles can have a mushroom effect on the surface of a road [...] Some tradesmen don't like concrete made out of re-cycled aggregate. [...] It sets quickly but compacts better. Maybe because of cement in those aggregates.

Despite a higher ranking given for this practice, some interviewees expressed serious reservations about the storage of extracted materials, subsequently highlighting the role played by the environmental regulator. An executive manager (Interviewee C) of

one firm offering legal services to SA construction companies made the following comment (obviously obtained from his client):

[...] Storage of extracted materials from buildings is an issue since the Environment Protection Authority (EPA) regards anything without immediate use as waste and asks to remove it from the site [...]

The above comments suggests that despite the efforts made at integrating and reusing salvaged products from a RL perspective, the issue of quality remains a major impediment to RL adoption. This is not only confined to the South Australian construction industry. For example, in Brazil a study conducted by da Rocha and Sattler (2009) that identified the major factors influencing reuse of building components established that the variability or inconsistency in quality hindered their popularity in a major way.

Despite the shortcomings associated with quality, there are also suggestions a buyer's age also influences the preference for salvaged materials. The older customers (baby boomers) as stated by (Interviewee A) (a buyer) liked salvaged products due to some intrinsic value found in them. He justified the reasoning as "they use it for holiday homes, dinner tables for restaurants etc.". In contrast, according to Interviewee F (regulatory) "young people are not in favour of using salvaged products". The lack of incentives was also highlighted by the same interviewee with the following observation: "There is no incentive for people who want to keep the materials in the stream". However, despite the contradictory views of Interviewees A and F, the need for good relationships among the stakeholders was highlighted by Interviewee A:

[...] I have very good informal partnerships with contractors and architects. The demolition contractor calls whenever he feels there is potential for salvaging [...] It is not only Adelaide, we have most of our customers from the countryside.

The least ranked industry practices, "regulatory and financial incentives in favour of deconstruction" and "regulatory and financial incentives for promoting use of salvaged materials in buildings" (sixth and seventh, respectively) contradict the studies by Carter and Ellram (1998), Kibert *et al.* (2000), Smith *et al.* (2007), Saghaei and Teshnizi (2011) and Huscroft *et al.* (2013). As shown in Table I, the level of support from the government for RL is important for its promotion in regional areas. However, some contrasting views on lack of incentives were noted by interviewees. For example, the executive manager of a leading salvaging business in South Australia (Interviewee D) highlighted the lack of support, and preferential treatment for certain sectors of the industry in his following comment:

However, there is no support for technology enhancement. A government agency gives funding and support only to their board members and doesn't support the entire industry.

The above comment was further followed up with reference to recycled products as follows:

There is no incentive for use of re-cycled products [...] (Executive Manager, Interviewee D)

Similarly, Interviewee C noted the negative impact of regulations in that "regulations should be amended to make it easy for people who want to use salvaged materials". Interviewee E remarked that some items like large concrete components are banned from landfills and as a result end up in recycling facilities. On the other hand, some

interviewees did extol the role of government. Another executive manager of a medium-sized construction company (Interviewee B) made the following observation:

Government recently promoted using environmental measures by including them within contractual conditions and bidding documents.

The contrasting views between Interviewees D and B could be attributed to some bias as Interviewee B was active in projects for the South Australian Government. However, the client base for Interviewee D consisted of non-governmental agencies where the government's reluctance to use salvaged materials for its projects became evident in recent times. The low ranking of this practice is further compounded by the fact that in Australia matters concerning the environment are not directly legislated by the federal government and falls under the jurisdiction of state or territorial governments (WCS Market Intelligence, 2007).

4.3 Ranking of organisational RL practices

Table V shows the mean agreement responses for the four organisational practices for RL implementation.

Based on the mean scores, organisations' clear understanding of the benefits of deconstructing was the highest ranked practice. This finding is also consistent with RL literature regarding the associated benefits (Crowther, 2001; Addis, 2006b; Guy *et al.*, 2006; Sassi, 2008; Razaz, 2010; Chileshe *et al.*, 2015). For instance, the study by Sassi (2008) identified cost savings due to less use of virgin materials; and less pollution on soil, water and air to be the main benefits of RL. Despite the low ranking of "Awareness of deconstructing procedures" the mean score is higher than the cut-off point of 3.5. These observations tended to be similar among the interviewees, in particular the buyer who acknowledged the role played by the demolition subcontractors. For example, Interviewee A observed that "the process [of deconstruction] starts with the demolition sub-contractor (DSC) getting the job from the owner or the main contractor. The DSC calls us [the buyer] and let us carry out an inspection. We salvage anything that could be reused, mainly timber and all other things that could be used". Interviewee A further emphasised the point and acknowledges the fact that: "we stopped ripping the roof [...]".

Understanding challenges associated with deconstruction was the second ranked organisational RL practice. While none of the interviewees commented on this practice, the support of it is very evident in the literature such as Crowther (2001), Crowther (2009), Saghafi and Teshnizi (2011) and Kibert (2012). Saghafi and Teshnizi (2011) highlight this practice and observed that disassembling a building not designed for deconstruction might not result in recovering sufficient materials with acceptable quality. More literature supporting the relevance of this practice can be found in Crowther (2009) who acknowledges that the current practices in which buildings are not designed to be deconstructed do constitute the main hurdle that stops construction

Table V.
Ranking of
organisational
practices desirable
for RL
implementation

Organisational practices	Mean score	SD	Rank
Clear understanding of the benefits of deconstructing buildings	4.061	0.8269	1
Awareness of the deconstructing procedures	3.750	0.8873	4
Understanding of the challenges associated with deconstruction	4.020	0.7497	2
Understanding of the different aspects of reusing buildings	3.898	0.8477	3

firms from adopting RL. “Understanding of different aspects of reusing buildings” ranked 3rd with a reasonable level of agreement among the respondents.

The implications of the above findings suggest that design for reverse logistics’ (DfRL) is an important practice that could affect RL implementation and hence it is the responsibility of designers.

Analysis of RL
implementation
practices

4.4 Ranking of project-level RL practices

Table VI presents the ranking of project-level RL practices which belong to the category of “internal” according to Figure 1.

The mean agreement responses to the seven project-level practices ranged from 3.204 to 4.082 (Table VI) and the standard deviation 0.676-1.060. “Reducing the amount of waste generation as part of strategic objectives”, was ranked highest followed by “enhancing the green image as part of strategic objectives”. Much literature supports this finding, for example, Addis (2006a), Kralj and Markič (2008), Laefer and Manke (2008), and Fabbe-Costes *et al.* (2014). In particular, Kralj and Markič (2008) found that achieving sustainability objectives such as reducing the levels of pollution are clear benefits of adopting RL practices. Interviewee B supports this finding and highlights the changes within the tendering process in which prospective bidders are expected to demonstrate sustainability best practices in their submissions. According to Interviewee B; “In a recent tender, the Department of Environment Water and Natural Resources had a very important forward thinking strategy. They requested all bidders to fill out a table with innovative ideas on sustainability and included in the evaluation”. This finding is significant as it demonstrates the acknowledgement that the practice of RL is associated with project-based stakeholders’ environmental responsibilities.

Support from top management has been identified as an important element of RL according to Huscroft *et al.* (2013). The three practices related to organisational support, namely, DfRL, deconstructing buildings instead of mechanical demolition and the use of salvaged materials in new construction were ranked medium. This finding was complimented by some interviewees, for example, Interviewee B who observed that “the top management set the policies and leadership of sustainable practices and innovation in the workplace, as well as the work culture of the company [...]”.

The actual utilisation of salvaged materials in new buildings and deconstruction were the least ranked project-level practices (sixth and seventh, respectively). This was rather surprising, considering the respondents’ higher ranking of the two organisation-level RL practices of “clear understanding of the benefits of deconstructing building” and “understanding of challenges associated with this process”. This finding also contradicts the literature review, which identified numerous benefits of deconstruction

Project-level practice	Mean score	SD	Rank
Deconstruction is implemented in our projects	3.510	0.893	6
Utilisation of salvaged materials in new buildings	3.204	1.060	7
Reducing the amount of waste generation as part of strategic objectives	4.082	0.886	1
Enhancing the green image as part of strategic objectives	3.837	0.746	2
Organisational support for using salvaged materials in new buildings	3.776	0.848	5
Organisational support for deconstructing buildings	3.776	0.743	4
Organisational support for designing buildings based on DfRL principles	3.796	0.676	3

Table VI.
Ranking of project-
level practices
desirable for RL
implementation

such as facilitating relocation, reuse and changing the function of buildings (Crowther, 2001). The quantitative findings are supported by one interviewee who placed the blame on the reluctance of clients. Interviewee D observed “we can’t use recycled products in buildings particularly in government projects”. The same interviewee praised the private sector and asserted that they were more willing to accept salvaged materials in new construction. The overriding concerns with the government appeared to stem from the health and safety of the building’s occupier. Interviewee D explained that the government’s main concern was health issues of occupants particularly with regard to the lack of quality control. For example, even a tiny amount of asbestos in one of the recycled materials could have grave consequences. On the contrary, according to Interviewee D the Department of Planning Transport and Infrastructure accepted recycled materials mainly for road projects. Though the discussion within this section is related to “project practices”, it is closely linked to industry-level practices of “quality control compliance for used products”. Interviewee D has indicated having undertaken chemical testing on recycled materials.

The implications emerging from the findings indicate that in order to improve the level of utilisation of salvaged materials in new buildings, there is a fundamental requirement to adopt industry-wide RL practices. It is important to educate contractors on the benefits of deconstruction and designers on DfRL best practices (Chini and Bruening, 2003). Crowther (2001) offers a practical solution for DfRL in that use of building layers with different life expectancies so that they could be easily isolated during deconstruction.

4.5 Correlation analysis

Tables VII-IX show the correlations and coefficients of determinations among variables for the three levels of practices as obtained from the questionnaire survey. As shown in Table VII, 16 out of 21 correlations were significant at the industry level with “availability of deconstruction and dismantling service providers” and “facilities to recover the used products after deconstruction” to be showing strong positive correlations. This highlights the need for a fully fledged RL sub-sector to reinforce RL implementation in South Australia. An interesting negative correlation between “existing demand for salvaged materials” and “quality control compliance for salvaged materials” is also noteworthy. This implies that quality control compliance will certainly affect demand for salvaged materials. This finding is consistent with previous studies by Dowlatshahi (2005) and da Rocha and Sattler (2009) and reinforces the opinions of interviewees.

As far as organisation level is concerned, all six correlations were found to be significant. Correlation between “awareness of deconstructing procedures” and “understanding of different aspects of reusing buildings” was the strongest suggesting the need for employees to be aware of the benefits as well as procedure to be followed in deconstruction. This confirms that the strength of the relationships among the firms was excellent and the variance shared between the practices was equally good and ranged from 32.05 to 48.02. In general, these results indicate that each practice within this category was important and contributed to the overall “organisational RL practice”.

As shown Table IX, 17 out of 21 correlations were significant at $p < 0.01$ and $p < 0.05$ levels. The highest positive correlation was found between “organisational support for deconstructing buildings” and “organisational support for designing buildings based on DfRL principles”. These results provide evidence for the importance of organisational support for RL implementation as identified by Huscroft *et al.* (2013)

Analysis of RL implementation practices

	Coefficient of determination (r^2) or amount of variance						
	IndsPrac1	IndsPrac2	IndsPrac3	IndsPrac4	IndsPrac5	IndsPrac6	IndsPrac7
IndsPrac1	1.000	41.86	16.40	56.55	10.96	7.02	7.08
IndsPrac2	<i>0.647**</i>	1.000	10.96	59.75	19.20	9.18	8.41
IndsPrac3	<i>0.405**</i>	<i>0.331*</i>	1.000	14.44	2.31	2.13	1.06
IndsPrac4	<i>0.752**</i>	<i>0.773**</i>	<i>0.380**</i>	1.000	14.21	8.70	6.30
IndsPrac5	<i>0.331*</i>	<i>0.437**</i>	0.152	<i>0.377**</i>	1.000	49.56	30.14
IndsPrac6	0.265	<i>0.303*</i>	0.146	<i>0.295*</i>	<i>0.704**</i>	1.000	38.69
IndsPrac7	0.266	<i>0.290*</i>	-0.103	0.251	<i>0.549**</i>	<i>0.622**</i>	1.000

Pearson correlations between industry practices

Notes: The values in italic and starred are significant at appropriate levels. **, *Significant at the 0.01 (two-tailed1) and 0.05 (two-tailed1) levels, respectively. For detailed explanation of industry practices, see Table I

Table VII.
Inter-item correlation of the industry practices

	Coefficient of determination (r^2) or amount of variance			
	OrgPrac1	OrgPrac2	OrgPrac3	OrgPrac4
OrgPrac1	1.000	<i>32.15</i>	<i>32.38</i>	<i>36.48</i>
OrgPrac2	0.567**	1.000	<i>45.83</i>	<i>48.02</i>
OrgPrac3	0.569**	0.677**	1.000	<i>47.88</i>
OrgPrac4	0.604**	0.693**	0.692**	1.000

Pearson correlations among the organisation practices

Notes: **Correlation is significant at the 0.10 (two-tailed); the values in italics are for the 'Coefficient of Determination'. This is the value of the correlation (in bold) squared, and it provides the proportion of variance accounted for by the relationship; the values in bold and starred are significant at appropriate levels; for detailed explanation of the organisational practices, see Table I

Table VIII.
Inter-item correlation of the organisation practices

	Coefficient of determination (r^2) or amount of variance						
	ProjPrac1	ProjPrac2	ProjPrac3	ProjPrac4	ProjPrac5	ProjPrac6	ProjPrac7
ProjPrac1	1.000	40.45	8.53	3.06	22.00	10.50	6.92
ProjPrac2	<i>0.636*</i>	1.000	4.41	3.61	5.62	13.32	12.18
ProjPrac3	<i>0.292*</i>	0.210	1.000	38.44	27.46	9.80	11.63
ProjPrac4	<i>0.175</i>	0.190	<i>0.620**</i>	1.000	36.00	14.67	9.24
ProjPrac5	<i>0.469**</i>	0.237	<i>0.524**</i>	<i>0.600**</i>	1.000	23.04	15.29
ProjPrac6	<i>0.324*</i>	<i>0.365*</i>	<i>0.313*</i>	<i>0.383*</i>	<i>0.480*</i>	1.000	54.17
ProjPrac7	<i>0.263*</i>	<i>0.349*</i>	<i>0.341*</i>	<i>0.304*</i>	<i>0.391**</i>	<i>0.736**</i>	1.000

Pearson correlations between firm and organisation practices

Notes: $n = 49$. The values in italic and starred are significant at appropriate levels. **, *Significant at the 0.01 (two-tailed1) and 0.05 (two-tailed1) levels, respectively. For detailed explanation of the project-level practices, see Table I

Table IX.
Inter-item correlation of the project-level practices

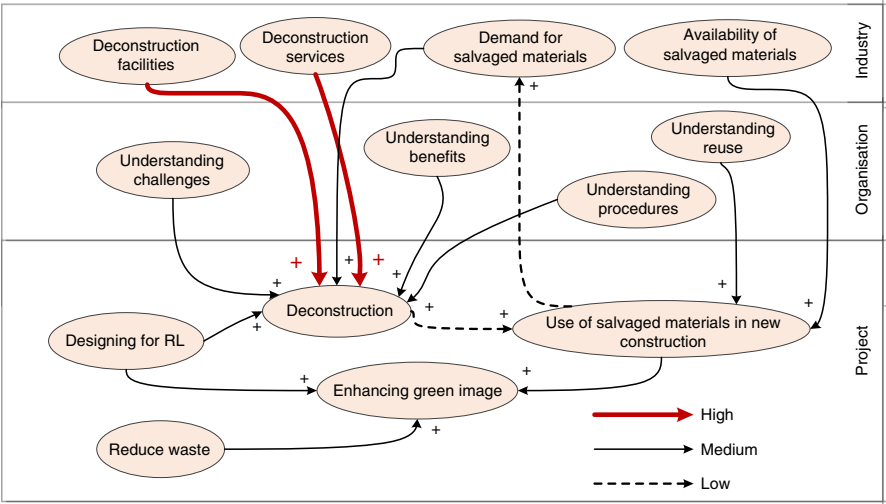
and Carter and Ellram (1998). A cursory examination of the coefficient of determination for the two practices further reinforces this stronger relationship. Despite evidence from literature on the benefits of RL, a weaker relationship was emerged between "utilisation of salvaged materials in new buildings" and "enhancing the green image as part of strategic objectives".

Figure 2.
Practices affecting
RL implementation
in South Australia

5. Discussion

The study looked at practices that could instil RL in South Australia. Practices at project, organisational and industry levels were ranked by respondents with further evidence provided by interviewees. Reducing waste generation was considered to be very important at project level while understanding of benefits of deconstruction and challenges associated with deconstruction were considered very important at organisation level. None of the practices were ranked very important for the industry level. Regulatory and financial incentives coupled with quality compliance at the industry level were rejected by respondents as least important with a mean value less than 2.9. The message is very clear that strategic practices which reinforce responsible behaviour were valued more important than mere financial or regulatory incentives. All other practices were ranked having medium importance ranging between 3 and 4 of mean value. There were six project level, two organisation level and four industry-level practices ranked medium. These 12 coupled with the three very important practices could be used to map out a strategy to install RL as a vibrant sub-sector in South Australia. As shown in Figure 2 these practices could impact on each other and form a monolithic force that could lift current RL activities to a higher level establishing it as a formidable sub-sector. The positive relationships among practices are denoted by a + sign in the diagram with thicknesses of the lines indicating their strength.

At project level it is important to undertake deconstruction instead of mechanical demolition at the end of life of a structure. Understanding of benefits, challenges and procedures at organisation level is very important for its success as top management support is needed for any formidable change within an organisation. Reduction of waste with an enhanced green image that produces financial benefits could be looked at positively by the top management. Deconstruction will not progress very far unless the industry as whole can provide these services with facilities in place for its smooth operation. Deconstruction – to be an effective method of removing old



structures – needs to be incorporated at the design stage. Consequently, the concept of DfRL becomes a responsibility of every designer.

Another important project-level practice identified by respondents is that of willingness to use salvaged materials in new construction. While deconstruction is linked to usage; demand and availability of salvaged materials in the market will also reinforce the practice and will become an industry custom with time. At organisation level, understanding the potential of re-use of buildings needs to be well instilled in every employee so that it becomes a norm rather than an exception. Despite the awareness regarding availability of salvaged materials within the South Australian context (see Table IV); there still remain some issues associated with quality control and compliance. This concern is evidenced by the low ranking (Table IV) assigned to this industry practice and inherently low levels of usage of salvaged materials in new buildings including the limited implementation of deconstruction at the project level (see Table VI). Introducing a state-wide quality labelling could be recommended as a viable practice to adopt.

The results also point to the need for effective management of quantity of salvaged materials, potential collection points, recovery options, markets and demand among the construction industry stakeholders. This brings to light the need for managing, sharing and exchange of knowledge on RL benefits and processes if the practices are to be sustained. It is apparent that the implementation of RL practices will be strongly affected by the prevailing conditions within the operational competitive environment. Capturing and sharing of knowledge will be of benefit to all concerned and would improve the overall RL uptake. Further research to explore the role of competitive forces will add valuable knowledge while research on capturing and sharing of knowledge is also recommended. Designers also have an equal responsibility in addressing the low levels of usage of salvaged materials in new construction. The major implication is that there is a need to design buildings with the intention of maximising the use of salvaged materials.

6. Conclusions

Through a questionnaire survey and a series of interviews, this study has established some very important practices that could help promote RL in South Australia's construction industry. Through a comprehensive literature review, 18 current practices were identified as having the potential to promote RL in construction. Based on the seminal work of Carter and Ellram (1998), these practices were divided into three levels, specifically, industry, organisation and project. Out of 539 questionnaires sent to professionals working in construction organisations that represent the input, regulatory, output and competitive task environments of RL, 49 usable questionnaires were returned with a response rate of approximately 9 per cent. Six interviews with experts working in the RL sub-sector were considered a supplementary data source which is very in-depth and exploratory in nature. The combined quantitative and qualitative data were very useful for identifying practices that have the potential to promote RL in South Australia.

The findings conclude that practices facilitating deconstruction is the most important followed by practices facilitating the use of salvaged materials in new construction. Practices that reinforce responsible behaviour in the sustainability sphere are more valued than financial and regulatory incentives. Awareness of deconstruction

benefits, challenges and procedures at organisation level and the facilities and services at industry level were found to be associated with RL implementation. Availability of salvaged materials in the market was found to influence its use in new construction and as consequence its demand. Thus, the market mechanism seems to follow a cycle. At the industry level, services of salvaging companies, collection points, sales outlets and information on availability are some of the factors that need close scrutiny. DfRL is another practice that could facilitate deconstruction and make RL viable in the construction industry. It is the responsibility of designers that DfRL is promoted among clients and industry stakeholders who could see a benefit in the long run for its implementation.

In view of the Carter and Ellram (1998) framework, the findings confirm the crucial role and significance of external forces such as the regulatory sector, competition among stakeholders, and the demand for outputs influencing RL implementation. The findings also highlight the impact of macroenvironment on RL implementation. This study provides further evidence of the links between two terms of reference in the environment, namely, the segment involving customers and competitors. The major finding from the correlation analysis was the existence of some strong positive and negative correlations between the industry practices. There was a positive correlation between “availability of deconstruction and dismantling service providers” and “facilities for deconstruction” at the industry level and “organisational support for deconstructing buildings” and “organisational support for designing buildings based on DfRL principles”. This shows the importance of industry-level service provision and organisation (top management) support for RL implementation in South Australia. The negative correlation between “quality control compliance for salvaged materials” and “demand” is a very interesting observation. The apparent implication of this negative correlation suggests that the quality of salvaged materials will affect its use in new construction. Consequently some measures to overcome these quality issues need further investigation and attention by industry stakeholders, and most probably the state government.

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Appendix. List of interviewee questions

Questions related to the reverse logistics (RL) practices

- (1) Describe the practices that are followed after extracting materials and products from old buildings.
- (2) Which parties are involved in reusing building materials in SA? How would you describe the availability of service providers for salvaged materials in SA?
- (3) Who are your main customers for salvaged materials?

Questions related to the barriers to implementing RL

- (1) What are the main policies and regulations which impede the process for reusing the extracted materials and components?
- (2) What challenges do you encounter when recovering and selling the salvaged materials in the market?
- (3) How do you verify the quality and integrity of salvaged materials available in the market?

Questions related to the drivers for implementing RL

- (1) What legislation and regulations mainly promote reusing the extracted materials and components?
- (2) How do you evaluate the price of recovered items in comparison to virgin ones?
- (3) how do you evaluate the costs associated with sending waste to landfills in South Australia?
- (4) How do you describe the perception of the community in SA about using salvaged materials and components?
- (5) Based on your professional experiences what could be done by each one of the main stakeholders (government, designers, builders and property owners) to promote RL in SA?

Questions related to the future usage and conditions for adopting RL

- (1) How do you describe the perceptions of different players (designers, suppliers, subcontractors, builders) towards using salvaged materials?
- (2) What is the perception in the construction industry towards using salvaged materials?

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- (3) Under current conditions in SA, how do you think the reuse of salvaged materials is going to evolve?

Questions related to the need and adoption of RL

- (1) Do you envisage having a closed loop reverse logistics practice in SA in the near future?
- (2) Do you see a need for collection centres for reused materials and does RL practice need to be integrated to that?

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