Circular transition

Changes and responsibilities in the Dutch stony material supply chain

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Circular transition: Changes and responsibilities in the Dutch stony material supply chain

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ABSTRACT

Recent literature has recognized the difficulty of implementing Circular Economy (CE) in supply chains. This has not yet led to a clear understanding of the reasons. This is critical to address, because the difficulty stalls the CE transition and suspends its benefits. Therefore, this paper investigates the reasons for the difficulty of implementing CE in supply chains. In so doing the Dutch stony materials supply chain is used as empirical case. Through a literature review, the role of changes and responsibilities in CE implementations inside the supply chain, has been gained. Based on these insights, a Social Network Analysis approach for capturing and analysing perceptions of supply chain actors on the CE changes was developed. The findings show that the diffusion of responsibility and differences of perceptions are underlying reasons of the difficulty to implement CE in supply chains. The main reasons for these two developments consists of: (1) Lack of incentives for the supply chain actors to make a change towards circularity; (3) Lack of mutual interests between supply chain actors; (2) High uncertainties and risks and (4) Clashes of perceptions on all levels in supply chains. It was found that the observed diffusion of responsibility was due to the individual pursuance of the changes that benefit individual business models and making parties responsible for these changes if they have the biggest impact on their business. As long as supply chains are voluntarily changing, this will stall the transition, some obligatory outside influence can refine the incentives to change.

1. Introduction

Circular economy (CE) is worldwide acknowledged as a way towards a sustainable future, especially in China (CCICED, 2008) and in Europe (European Commission, 2015; Ghisellini et al., 2016). Circularity promises the decoupling of economic growth from resource constraints and Earth's degradation (EMF, 2015). End of life materials and products should be re-used and reinserted in supply chains (Aminoff and Kettunen, 2016), thereby minimizing waste, lengthening product life span and creating more value (Di Maio and Rem, 2015).

Recent literature aims to understand the difficulty of implementing CE in supply chains to realize these promises (Zeng et al., 2017). Since the field of CE is developing, there is no widely accepted and comprehensive definition (Kirchherr et al., 2017; Adams et al., 2017; Murray et al., 2017). Unfortunately, this infancy leaves the delivery of the promises idle. So far, the definition by Kirchherr et al. (2017) is the most encompassing reference to understand the implementation of CE. Literature reviews have recognized the implementation difficulty by lengthy lists of barriers, challenges and strategies (Govindan and Hasanagic, 2018; Bressanelli et al., 2018; Kalmykova et al., 2018). However, these have not yet led to a clear understanding into the reasons why CE implementation in a systemic change appears so problematic (Kalmykova et al., 2018). In fact, there is no particular study addressing the difficulty for the CE changes in a supply chain by focusing on responsibility, importance and reasons of its supply chain actors.

This paper aims to fill this gap by answering the key question: *How do the perceived needed changes and responsibilities inside a supply chain relate to the formulation of the CE transition for that supply chain?* To answer this question the perception of supply chain actors is elicited in a real-time case where a supply chain is making a systemic change toward CE. A social network analysis is applied, because of its ability to map and trace the perceptions and reasons for the entire supply chain and between its supply chain actors. The perceptions are defined for this study as the views of supply chain actors regarding the most important changes and the regarded responsible party for each change. Party is defined as any entity that the actors have indicated as responsible for a change.

The study focuses on the systemic change toward a CE in the Dutch stony materials supply chain (SMSC). Since 2015, representatives of the

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Dutch SMSC have been struggling to formulate an agenda for needed changes and responsibilities. They have been negotiating these changes and responsibilities with the expectation to formulate a voluntary agreement, known as the 'Concrete Agreement'. A respective group from the SMSC and other parties finally signed this agreement in the summer of 2018, like demolition companies, contractors and government agencies. This study elicited data on the underlying perceptions and reasons for the lengthy struggle, in the period before the agreement was signed.

The most important contribution is the recognition of 'bilateral dependencies' phenomenon inside the SMSC. The paper flags this as the individual pursuance of the changes that benefit individual business models and making parties responsible for these changes if they have the biggest impact on their business. The bilateral dependencies partly explain why the CE implementation from a systemic point of view leads to a reactive change process. It can help to pinpoint incentives to advance the system change toward a CE by an obligatory outside party. Secondly, the case revealed the general tendency of actors to diffuse the responsibility for CE changes to other actors than themselves. Finally, the study of the SMSC contributes to literature about implementing CE in the construction sector.

Section 2, reviews literature about the CE implementation in supply chains. Based on this input and the case material, the methodology is described for the empirical investigation in Section 3. In Section 4, the SNA analysis is reported for the SMSC. Section 5 discusses the significance of the SMSC case in correspondence to the relevant CE literature and concludes in Section 6.

2. Literature review

CE advocates that waste should be eliminated by closing material flows in the supply chain. This requires a systemic approach for supply chain actors to integrate their activities with the other actors, because actions of one actor can affect other actors (EMF, 2015). Hence, integration means that parties need to collaborate and communicate transparently to achieve their goals (EMF, 2015).

Because CE is still quite novel, its academic literature is still limited but is growing fast. Generally, there is a need for clarifying CE on all levels, which is pinpointed in the recent relevant literature (EMF and Granta Design, 2015; Elia et al., 2017; Ghisellini et al., 2016; Mendoza et al., 2017; Tisserant et al., 2017). Research needs to adopt a clear CE definition and guide the process of implementing (Di Maio et al., 2017; Nasir et al., 2017).

Academic literature seems to agree that implementation issues depend on the ambiguity in understanding CE (Kirchherr et al., 2017; Geisendorf and Pietrulla, 2018). This ambiguity of the term introduces different interpretations, effectively providing challenges (Preston, 2012; Cossu and Williams, 2015) and opportunities (Geisendorf and Pietrulla, 2018) to the implementation of CE. The challenges are magnified when the implementation is focused on the lower levels, i.e. the supply chain.

Supply chains are an increasingly important arena in the CE literature that requires more research on implementing CE (Homrich et al., 2018; Aminoff and Kettunen, 2016). It includes the material closed loops and new business models. Scholars underpin that supply chains require fundamental changes from its actors (Masi et al., 2017). However, the debate is still unsettled on the changes that supply chains are going to implement in order to transition toward CE, since it lacks a clear list of changes (Bressanelli et al., 2018). Therefore, one guiding question is:

What are the needed changes towards a CE in the Supply Chain?

Supply chain changes have mostly focused on integrating sustainability, i.e. green supply chain management (Cai and Wu, 2014). Some of its concepts seem useful to advance CE, particularly: complexity, transaction cost economics, agency and information (Liu et al., 2018).

In the CE field, Govindan and Hasanagic (2018) provides a state of the art literature review on supply chain changes. They concluded that there is no concrete study on the current state of drivers, barriers and practices in the field. They suggest that CE can be promoted by changes in the laws, policies, risk reduction measures and more strict governance.

The CE literature produced many case studies, which has delivered useful catalogues of possible needed changes. In this way, Diaz Lopez et al., 2019 map 143 cases of supply, demand and life cycle measures for CE. Sharma et al. (2019) identified challenges to implement CE in the diary food industry. They found poor governmental policies, lack of technology, lack of practical knowledge and awareness to hamper the implementation of CE. Kalmykova et al. (2018) created a CE strategies database and one CE implementation database based on implementation cases. They found CE implementations are mainly about products, materials and sectors. They also recognize that system changes are lacking.

Changes are also needed from individual companies in the supply chain. However, the CE literature seems to lack a systematic and holistic understanding of challenges that such companies face. As an exception, Bressanelli et al. (2018) noted that companies face several challenges when they are redesigning their supply chain. They identified 24 challenges to implement CE inside a company. This list revealed the multidisciplinary character of the needed changes to CE, like financial risks, brand image and the eco-efficient technologies. Bressanelli et al. (2018) concludes that companies who desire to implement CE should be prepared to face these challenges from direct and reverse flow of materials. This one of the first calls for more research on the responsibility of the supply chain actors.

Fischer and Pascucci (2017) ask how requirements for transitioning to CE create a new organizational form in inter-firm collaborations, and how these forms stimulate the emergence of new institutions enhancing sustainability. They identify two pathways: the Status Quo arrangements (SQ-a) and the Product-as-Service arrangements (PAS-a). SQ-a implies changes in the form of formal rules, i.e. industry standards. PAS-a implies changes with a wider range, particularly with regards to ownership of actors in the supply chain (De Angelis et al., 2018). This indicated that next to responsibility, also the importance of the needed changes to CE should be better understood. It raises the question:

Who should be responsible to realize CE changes, and how important are these changes?

So far, the CE literature produced little empirical data on responsibility. Firstly, some sources recognize the government as an impactful player in CE (Govindan and Hasanagic, 2018), because it can share large amounts of resources and infrastructure (Cai and Wu, 2014), and it can apply oversight to the industry for controlling disruptive effects of some changes (Gaustad et al., 2018). Also the governance structure helps to align supply chains to system changes (Maaß and Grundmann, 2018).

Secondly, responsibility may come from CBMs of actors which drive circular supply chains (Geissdoerfer et al., 2018). On the upside, this may be because, businesses see competitive advantages amidst the changes coming from external pressures (Dubey et al., 2018). On the downside, required changes for implementing CE in supply chains will have radical implications for business models of actors and expose businesses to more risks, which might impede the change altogether (Masi et al., 2017). Businesses appear to navigate in a reactive mode of survival by asking new questions as a result of opportunities or challenges that happen during the implementation (Howard et al., 2018). This supports the idea that supply chain actors must be investigated for their perception of needed changes separately for the supply chain.

The importance of changes may vary to supply chain actors. In support of this, Diaz Lopez et al. (2019) found among 143 cases that a supply chain faces a mix of classes of barriers, making it complex to change. They find that no particular implementation measure or change could be attributed to a barrier class. This points out that the supply chain changes are situational and need to be clarified on a case-by-case

basis. Hence, a key question is:

What are possible clarifications for the responsibility and importance of CE changes?

One study might reveal an interesting clue. Genovese et al. (2017) found in two case studies that "the implementation of circular supply chains may be challenging from an economic point of view" (Genovese et al., 2017, p. 11). They point out that "bottom-up initiatives at a supply chain level might need to be incentivized through some form of top-down governmental support" (Genovese et al., 2017, p. 11), which points to the responsibility of the government to create reasons for proper responsible change agents within the supply chain. Another explanation could be the bottom-up behaviour of supply actors themselves. Bressanelli et al. (2018) state that the challenges for CE implementation are not yet clear, and that companies will likely learn them once getting to grips with the changes.

The current CE literature on implementation mainly involves reviews and large scale case comparisons. There appears no particular study that looks at the identification of the system changes for a supply chain towards a CE with explicit attention to the responsibility and importance of these changes from its particular actors. However, this is important in order to understand the reasons behind the difficulty of CE implementation.

3. Materials and methods

3.1. Case material

The SMSC services the construction sector, which is responsible for 50% of used raw materials, 40% of generated waste in the Netherlands (ABN AMRO and Circle Economy, 2015; The Ministry of Infrastructure and the Environment, 2016; BAM, and ARUP 2017).

Stony materials belong to the Construction and Demolition Waste (CDW), which is one of the major waste streams generated, with roughly 30% of all waste produced in the EU (European Commission, 2016) and 40% in the Netherlands (CBS, PBI, and Wageningen UR, 2017). In the Netherlands, CDW consists for 65% of various end-of-life stony materials (Mulders, 2013). Out of the stony materials, concrete proves the most promising, yet challenging material for CE. For example, concrete is one of the most frequently used construction material worldwide (Marinković et al., 2010). At the same time it has a monolithic structure which makes up-cycling or design for re-use of concrete challenging.

In the Netherlands, various supply chain actors organize the stony materials flow, i.e. concrete, masonry, gypsum and ceramics. The materials flow is determined by the trade and movement of these materials through two market places.

For the first market place, demolition companies (DCs), demolish constructions and structures at their end-of-life. Demolished materials are then put up for sale. Recycling Companies (RCs) are on the receiving end. In the most unfavourable situation, the DCs will pay the RCs to take the stony materials. DCs are inclined to do this because they want to discard the stony materials due to the landfill ban in the Netherlands and because the stony materials are relatively cheap. DCs don't lose money over this, since they're mostly paid by a client who ordered the demolition. In the most favourable circumstance, RCs will take the stony materials for free. They will do so only if the materials have a certain level of cleanliness and composition that makes recycling easier. So, DCs have various options of sorting or pre-treating the materials in order to attain a more favourable deal with RCs. Therefore, the first market place determines how demolishers conduct the demolition and the way that they will sort and treat the CDW materials. A shortage of demolished materials in this market also determines the amounts of CDW materials that are imported or exported.

Before the RCs can supply the stony materials to the second market place, they need to ensure that these are sorted and further processed. Concrete Producers (CPs) are on the receiving end of this market, and are typically looking for raw materials from which they can produce concrete for the construction industry. The CPs can choose to use secondary or primary raw materials. This implies that Primary Aggregate Producers (PAPs) are competing with the RCs for market share. The market determines the level of sorting and treatment applied by the RCs. Stony materials can either be offered as rubble, as separate materials, or as a combination of both. Furthermore, RCs can apply different treatment processes depending on the required level of cleanliness and quality by the CPs.

The key actors in these two markets are DCs, RCs, PAPs and CPs. Although the cooperation is very limited, the SMSC was inspired by the nationwide program to achieve 100% circularity in 2050 (Rijkswaterstaat and National Institute for Public Health and the Environment, 2015). They voluntarily started a negotiation and implementation of CE via the so-called 'Concrete Agreement'. The negotiations commenced in 2015, but since then they struggled to agree on changes (MVO Nederland, 2016). After several negotiation rounds, several attempts were made by all of the actors to sign a draft version. On the one hand, these attempts were not successful in covering the full SMSC (MVO Nederland, 2016). On the other hand, a great hype had originated around CE such that the urgency kept on bringing parties back for renegotiation. The agreement was finally signed by enough parties in the summer of 2018.

3.2. Research methodology

To investigate the main research question a few key concepts and methods must be clarified. Key concepts are changes, important changes and responsibility. The changes towards circularity must be clear from the SMSC branches that negotiated the Concrete Agreement. Important changes are defined as changes that the SMSC actors need for changing to CE. Responsibilities are assigned to parties that need to act on changes.

Approaches to elicit and analyse the perceptions from multiple actors are plentiful, like mental mapping, social network analysis and even serious gaming or system. Mental mapping as an approach to derive the social cognition from a group (Allard-Poesi, 1998; Ginsberg, 1990), or individual maps (Schraven et al., 2015). These approaches are useful for data of multiple dimensions, which is not needed in this study. Another approach could be serious games or system dynamics (Barlas, 1996; Tsolakis and Srai, 2018), but these depend on a repeatable behaviour of actors, which is challenging in a real-life case study about changes, responsibilities and underlying reasons.

Social network analysis (SNA) is particularly useful for this study. Firstly, SNA studies networks as systems that consist of a set of interrelated actors (Scott, 2017). An actor is a discrete social unit (like an individual or company), who does not necessarily have the ability to act (Scott, 2017). SNA can map a set or sets of actors and the relations defined on them (Wasserman and Faust, 1994). In this way, SNA can map the expected responsible parties to each needed change.

Secondly, SNA allows for the systematic dissection of the data that represents the system, like at branch level or company level. It enables network measurements for sets of actors (Wasserman and Faust, 1994). These measurements help to investigate each relation in the supply chain to explain observed importance and responsibilities of changes per party.

The overall research design is provided in Fig. 1. It consists of guiding questions (see section 1), methodological steps and expected results. The methodology contains three steps. First, a list of needed changes for SMSC is collected. Second, the relative importance and responsible parties according to actors at the company-level are measured. Finally, the observed patterns are explained. The following sections will explain the methodological choices for each step.

3.2.1. Step 1: Content analysis to identify list of needed changes

Senior branch representatives of the DCs, RCs, PAPs and CPs are key

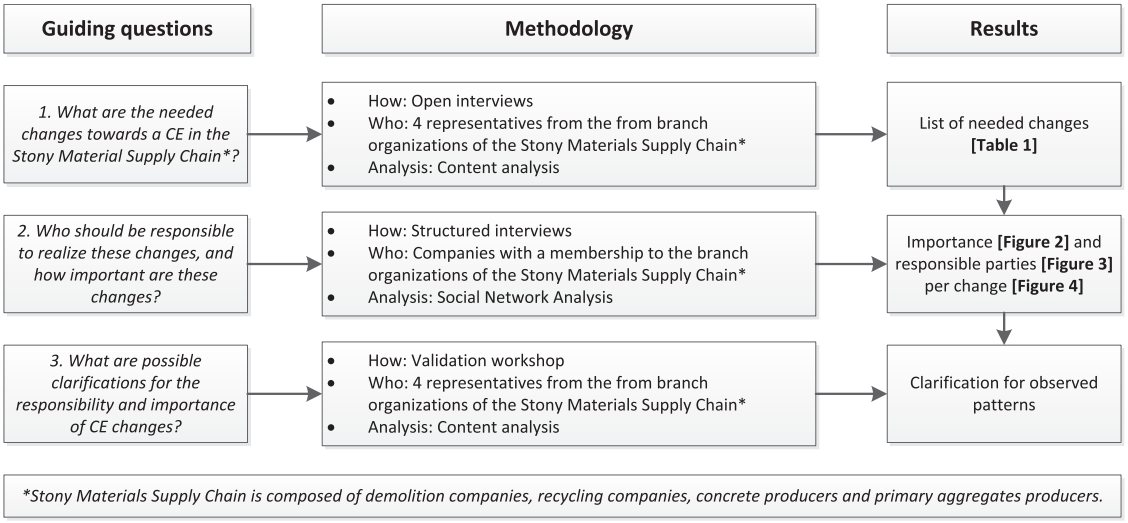

Fig. 1. Research design.

sources for the changes in the SMSC, because they aware of the circular developments in their branch and know the needed changes of their members. They also played an active role in the negotiations of the Concrete Agreement giving them a clear view on the agenda for needed changes.

During the interviews, the respondents were asked open questions to extract the most relevant changes. Open questions help more details about changes to surface during the interviews. This was particularly useful, because representatives could elaborate on specific stakes for their members. An interview protocol provided a general guideline to keep the interview on topic without discouraging further elaborations before it was clear what was meant with an answer (Cohen and Crabtree, 2006). The latter created a level playing field for all interviewees (Turner and Daniel, 2010).

The interview protocol should enquire the needed changes at various levels. Firstly, it should capture data at the supply chain level, because the Concrete Agreement is only valid if the SMSC supports it. Secondly, it should allow data from each branch level, because representatives have deep insight into their own branch's proposals. Finally, the questions should elicit criteria for change, before changes-as-actions. This helps the respondents to think of the instrumental role that these changes have to achieving CE. Hence the protocol had three parts: profiling questions for the branches, criteria and needed changes for the supply chain and the branch respectively.

The interviews were fully transcribed and subjected to finely grained content analysis to extract needed changes. Duplicates were removed from the obtained list. The identification of the list proved straightforward. The list of forty changes is provided in Table 1 (section 4).

3.2.2. Step 2: Social network analysis for importance and responsibility

This step indicates the relative importance and responsibility of the changes from step 1. This requires a judgement of the impact and action-ability of these changes. This does not lie with the branch organization itself, but with its members. If CE is to be implemented through the Concrete Agreement, then the branch members are the ones that feel the implications of the agreement and act as agents for the actual implementation. Therefore, the data is collected at the company level.

Since some branch organizations represent over two hundred member companies, enquiring the full population would be infeasible and irrelevant. Therefore a critical case sampling strategy is used, a form of purposive sampling, with direct input from the branch organizations acting as representatives of their members. Next, it was noted that PAPs has considerably fewer members (i.e. seven) than the DCs, RCs and CPs branches (i.e. above fifty). Therefore, it was determined that the sample should reflect this balance with a lower representation of PAPs. In addition, branch representatives indicated that only a handful of companies would be useful, because these were actively involved in the CE implementation. Upon further consultation, it was clearly not useful to include other companies. The quality of responses and willingness to answer questions would be poor for members who chose to not involve themselves in the Concrete Agreement. This resulted in four active companies from the DC, RC and CP branches, and two companies from the PAP branch.

A closed and structured interview protocol is used to capture the importance and the assignment of the responsible parties per change. The vineyard technique proved useful to make intangible concepts or constructs tangible on cards for interviewees. Respondents were asked to select and rank a top ten changes out of forty changes, where 1 means the most important and 10 the least important. Respondents were asked who should be responsible for all the forty changes.

The obtained data was separately analysed for the relative importance and the assignment of the responsible parties per change. For relative importance, one indicator counts the importance by the number of times respondents selected it. The higher the number that a card is selected the higher the relative importance. Another indicator is the ranking of importance that each company assigned to each change in the position from 1 to 10. This captures which change is regarded more important to one particular company than another. The results of the two measures are plotted in Fig. 2 (see Section 4).

The assignment of responsible parties to each change is measured by the number of times (on average) actors per branch and the supply chain overall assign the same party as responsible to a change. The responsibility is interpreted at a broad level, by looking at the occurrences of all changes taken together in Fig. 3, and by looking at the co-occurrences for each assigned responsible party paired with its specific change through SNA in Fig. 4. SNA can include two types of variables (De Nooy et al., 2018), which in this case is the combination of parties (i.e. actors) and their responsibility to each change. This is made possible by the 2-mode affiliation network that consists of one set of actors and another set of events or attributes (Borgatti and Halgin, 2011). Thereby the network shows that Actor X is responsible for change Y.

3.2.3. Step 3: Clarification for observed patterns

The validation and clarification requires knowledgeable input for interpreting data at the level of the supply chain. For this reason, representatives of the branch organizations were chosen as the proper source. On the point of validity, the branch representatives could accept

Table 1
Needed changes mentioned by branch representatives.

#	Code for needed change	Indicated by	#	Code for needed change	Indicated by
1	New ways of appraising value	[CP; DC; RC; PAP]	21	Pre demolition audit	[DC]
2	Formulating circular economy	[CP; RC; PAP]	22	New role of demolition companies	[DC]
3	Real cost of transport	[CP; DC; PAP]	23	New recycling technologies	[RC]
4	Integration of the supply chain	[CP; RC; PAP]	24	Fully transparent process	[RC]
5	Raising awareness	[CP; RC]	25	Adequate pricing for demolition companies	[DC; RC]
6	Conducting research across the supply chain	[CP]	26	Law on circular economy	[RC]
7	Geographical distribution	[CP]	27	Circular business models	[RC]
8	Standardization of products	[CP]	28	Aligning theory, perceptions and reality	[PAP]
9	Ladder of Lansink	[CP]	29	Knowledge about circular economy	[PAP]
10	Reuse /recycling in the life cycle assessment	[CP]	30	Relieving political pressure	[PAP]
11	New value indicators	[CP]	31	Gap between the secondary and needed materials	[PAP]
12	Tool for best treatment	[CP]	32	Not reusing and recycling at any cost	[PAP]
13	Roads as material banks	[CP]	33	Quality of rubble without concrete	[PAP]
14	Different quality requirements	[CP]	34	No to “dirty” aggregates	[PAP]
15	Planning and designing for future	[CP]	35	No laws stimulating import of secondary materials	[PAP]
16	Designing for reassembly	[CP]	36	Optimum aggregate mix – taking everything into account	[PAP]
17	Modular constructions	[CP]	37	Allowing enough time for best choice	[PAP]
18	Separation at the source	[DC]	38	Urban mine database	[PAP]
19	Separation at the source and minimum amount of recycling in procurement procedure	[DC]	39	Material passports	[PAP]
20	More time, space and money	[DC]	40	Build for product level reuse	[PAP]

CP = Concrete Producers.
DC = Demolition Companies.
RC = Recycling Companies.
PAP = Primary Aggregate Producers.

or reject the observed patterns. With regards to clarification, they could provide additional and more in-depth explanation for their reasons.

A workshop was organized which all the branch representatives attended. Before the data was shown, the representatives were trained to read network graphs. All representatives were invited to one workshop, because this allowed them to validate and clarify the observed patterns collectively, both at the branch and supply chain level. All comments were recorded and transcribed.

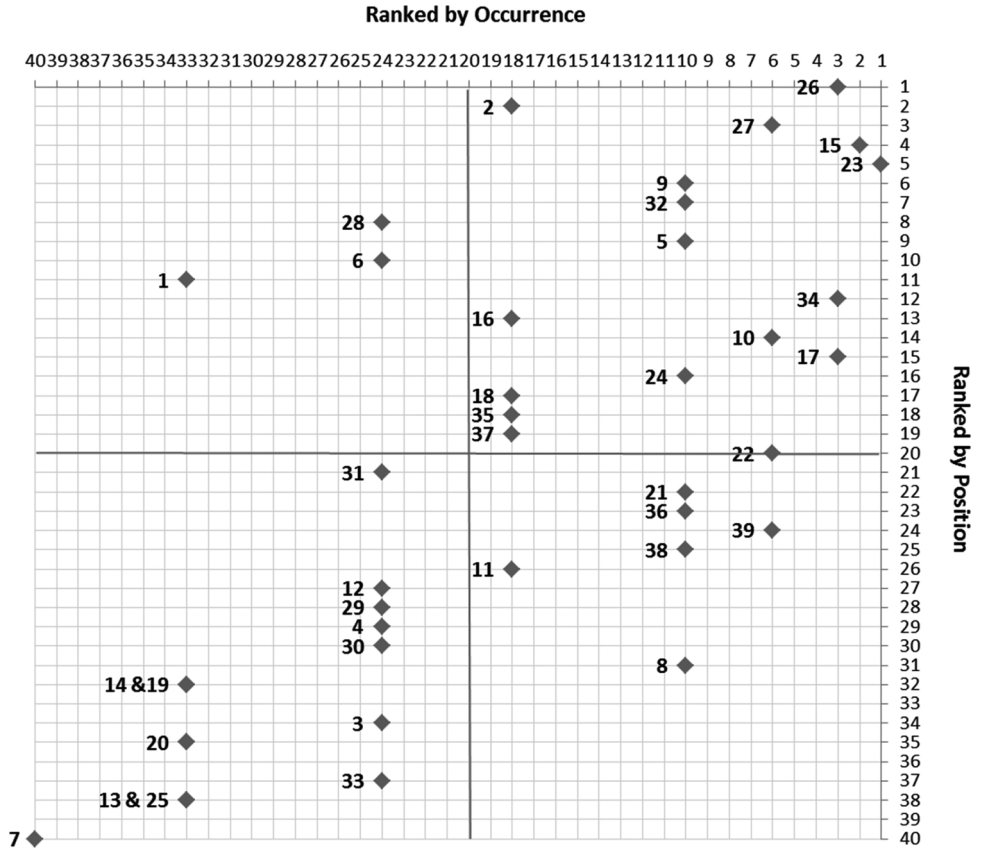

Fig. 2. Perceived importance of changes as indicated by stony materials supply chain.

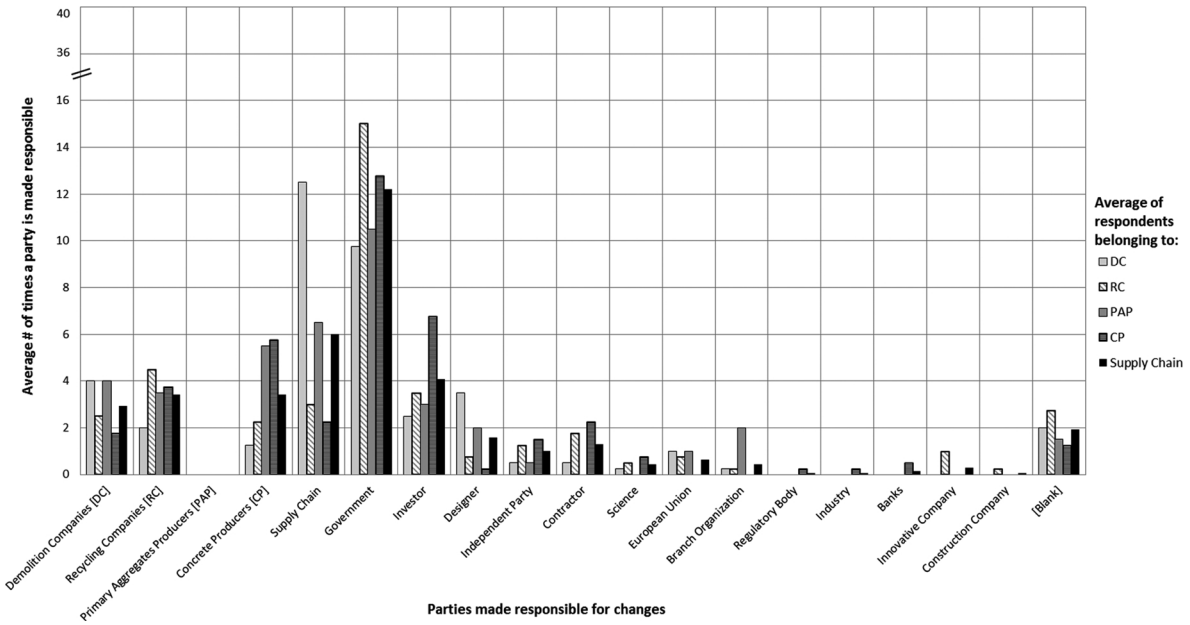

Fig. 3. Expected responsibility per party as indicated by the supply chain companies.

4. Results

The results are discussed in the tables and figures following the steps as indicated in Fig. 1.

4.1. Identification of changes

The first step delivers a list of 40 needed changes (Table 1), from branch representatives. The table reveals that only 6 changes originates from multiple branches. It suggests that each branch has different stakes.

Further, CP and PAP representatives named more changes (both 17) than the RC and DC representatives (9 and 8 respectively). In addition, both RCs and DCs mostly named specific changes for their branch. This is in stark contrast with the CP and PAP-representatives, who both named more fundamental changes, e.g. about CE knowledge. This might mean that DC and RC see less need for changes than PAP and CP.

4.2. Importance of indicated changes

Fig. 2 provides a scatter plot of the relative importance of changes ranked in two ways, i.e. ranked by occurrence (horizontal axis) and by position (vertical axis). Ranking by occurrence is done by counting the number of times that the respondents selected a change in their top 10. It measures the overall most frequent selected changes, which provides information of the SMSC's attention to each change.

Ranking by position is done through the application of a medal table ranking, i.e. the way in which countries are ranked for obtaining gold,

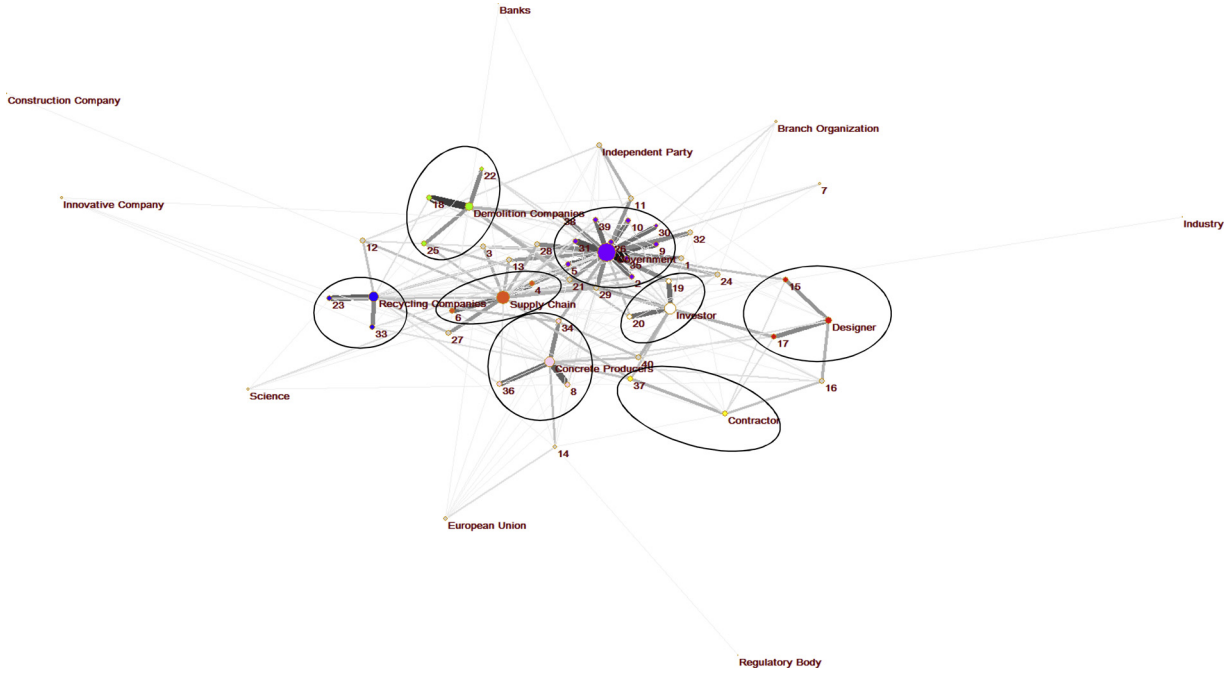

Fig. 4. Social network of expected responsibilities of parties per change.

silver and bronze medals at the Olympics. The changes were ranked in a similar hierarchy by counting the occurrences in position 1, position 2 and so on. It measures the changes with the highest positions first, which provides information about the underlying priority for each change.

Fig. 2 plots the rankings as coordinates for each change. This creates four quadrants, profiling the relative importance of each change. For example, if a change is closer to 1 on both axes, then it means that the change has a lot of attention (high occurrence) and has a high priority (high position).

Four changes appear solidly positioned (in Fig. 2) as key for the whole supply chain [i.e. 15, 23, 26 and 27]. These changes are all seemingly general and organizational in nature, i.e. on CE laws [26] and circular business models [27], with the exception of new recycling technologies [like 23].

On the other end, six changes are definitely not key for the supply chain, nor likely for any individual branch [i.e. 7, 13, 14, 19, 20 and 25]. These changes do not have any particular theme that relates them, for example it ranges from more resources [20] to adopting roads as material banks [13].

In the left-upper quadrant three changes [i.e. 1, 6 and 28] appear to have a high priority but are rarely selected. These changes seem to share a theme on new developments with a theoretical or integral connotation, like the change on research across the supply chain [6] and linking theory to practice [28]. It might suggest that the companies are more commercially oriented and have a harder time understanding the value of research.

Finally, in the lower-right quadrant, some changes [like 8, 21, 36, 38 and 39] are regarded as important by a substantive part of the sampled companies, but were ranked in a lower position. These changes have quite practical and operational themes, like a pre-demolition audit [21] and establishing a material passport [39]. It shows that the companies perceived organization changes [i.e. 26 and 27] as more important than these practical ones.

4.3. Expected responsibility of parties

Fig. 3 shows the perceived responsible parties as indicated per branch and the whole SMSC. It is organized as a bar chart and shows the responsible parties on the x-axis and the number of changes that are assigned to this party on average on the y-axis.

A key observation in Fig. 3 is that actors of the SMSC only assign a small portion of changes to themselves. On average, these four only assign 10 changes out of 40 to themselves (so roughly 25%). This is remarkable, as the negotiating parties thereby apparently don't think they are able to be responsible for the agenda for change.

In line with this point, is another observation, namely the fact that actors inside the supply chain indicated that their whole supply chain must be responsible for 6 changes on average, while they indicated a lower number to any specific branch. This contrast, potentially illustrates that parties have an unclear view of the implementation and that there is no clear assignment of responsibility in the SMSC.

A major point is the large size of responsibilities that the parties assign to the government. By itself, it is made responsible for 12 out of 40 changes on average by the SMSC. This is noteworthy if you consider the fact that the Concrete Agreement and the occasion of the negotiations are actually voluntary initiatives by the supply chain actors themselves. It earmarks the perceived dependency that the CE transition inside this supply chain has on a legislative party.

A last notable observation is the fact that PAPs is not made responsible for any change, not by themselves nor any other branch. It shows the complete disconnect of the PAP as a meaningful party at the company level to be responsible for a change if agreed in the Concrete Agreement.

4.4. Social network of expected responsibilities of parties per change

Fig. 4 shows a 2-mode affiliation network graph. This graph shows nodes of two kinds: parties, which are labelled in correspondence to the parties on the x-axis in Fig. 3, and the needed changes (which are numbered to distinguish them from the party-nodes). The size of the nodes represents the occurrences in the data

1) Party nodes: number of times that the parties were made responsible for a change;
2) Change nodes: number of times a party was assigned to that change.

All change-nodes have a size 14 or slightly less, because they were all treated during the 14 interviews, with exception of some blank responses. The party-nodes vary in size, since respondents could freely indicate which party they felt should be responsible for a change.

The network shows which party is made responsible for which change, i.e. by means of the arcs between the nodes. The thicker the arc, the more times a party was made responsible for a certain change. This shows the specificity of one change being implemented by one party or potentially multiple parties. Fig. 4 is the result of an islands-analysis, which is a type of network analysis that creates 'islands' (or clusters) based on the identification of maximally connected subnetworks that are formed by values of a selected property inside the island which are larger than values of that island's neighbours (De Nooy et al., 2018). There was no preconditioned limit set for the software to determine clusters. Following from that, the analysis reveals eight characteristic connections of parties made responsible for a specific set of changes.

The government is made responsible for the largest number of changes [i.e. 2, 5, 9, 10, 26, 30, 31, 35 and 39]. Typically the government is assigned to issues on making laws [10; 26 and 35] or clarifying the agenda of CE [2 and 5]. It is good to note here that the changes of the government are typically regarded as important to the SMSC, as 6 out of 9 are in the upper-right quadrant of Fig. 2.

The demolition companies are made responsible for three changes [i.e. 18, 22 and 25]. Typically, DCs are made responsible for the changes that are referring to themselves [22 and 25] or their core activity [18]. This is further supported by the fact that the DC representative actually produced each of these changes. The changes assigned to the DCs are not regarded as very important as they almost all fall in the two lower quadrants of Fig. 2. It suggests that DCs do not really see a need for other parties to be responsible for changes. Similarly, other branches also don't really see an importance to what the DCs do for the whole supply chain.

The concrete producers are made responsible for three changes [8, 34 and 36]. Typically these changes refer to the CPs role as a customer of primary or secondary materials. The changes assigned to the CPs are regarded important by the collective supply chain, but they vary on their individual importance as they fall into the two right quadrants of Fig. 2. Interestingly, PAPs mentioned these changes as important and mostly assigned the CPs as responsible. This shows that the CPs are specifically expected by the PAP to help relieve these needed changes. Interesting as CPs are a customer of PAPs.

Recycling companies are made responsible for two changes [23 and 33]. Typically these changes are tasked to the recycling company as their own research and development tasks. Interestingly, RCs are watched carefully with the task of creating new recycling technologies [23] as one of the top changes on the priority list by the whole SMSC.

Changes [4 and 6] are clearly assigned to the overall supply chain. Interestingly, these changes, which call for action on the whole supply chain, are tasked to that whole supply chain. Both changes are not made important by the collective sample as they both fall in the two left quadrants of Fig. 2.

Also outside parties are made responsible for changes. Investors are made responsible for changes 19 and 20. It shows that the investors

sometimes take role as client to demolish their own buildings, or prepare for future buildings. Interestingly, the DCs have a specific interest in the role of the investors to these changes.

Contractors are made responsible for one change [37], i.e. allowing enough time for the best choice. The contractor is the party that can actually adopt new solutions into their construction work, which is the theme of this change. PAPs seems to have a specific interest in the change made responsible to the contractor.

Finally, designers are made responsible for two changes [15 and 17]. Typically this refers to the wish of the parties that the designers must consider more flexible and future oriented solutions for their design. Designers are made responsible for two key important changes, as they both fall in the upper-right quadrant of Fig. 2. A big portion of CPs are interested in these changes and perceive designers are responsible.

4.5. Clarification of importance and responsibility of changes in SMSC

In the third the observed patterns were validated and clarified. This section first discusses the four branch levels and then at the SMSC level.

The DC representative recognized the responsibilities that the DCs assigned to parties in Fig. 3. It stood out that DCs assigned a large amount of responsibilities to the full supply chain. He explained that the DC companies see responsibility from multiple angles, because they are active in multiple lines of work. Therefore, DCs have multiple business models. In Fig. 4, he expected a more important role of investors, because they pay for demolition. This clarifies why DCs made investors responsible for two important changes 19 and 20 for demolishers. It explains that DCs assigned changes to parties that feed their business model.

The RC representative recognized all the results. On Fig. 3, he understood why the government was so often responsible for changes. RCs rely on the government for changes to develop recycling market. He elaborated that RCs feel frustrated after many decades and want the government to help their business. He elaborated that for RCs a viable business case in recycling is dependent on regulations. Exemplary for this was his explanation that the large share of CDW materials being recycled is directly the result of the landfilling ban imposed by the Dutch government several decades ago. Clearly, RCs view of the governments' responsibility favours their business model.

The PAP representative generally recognized the results. On responsible parties, she stated that PAPs think that the government must propose rules to accelerate CE. PAPs made the whole supply chain responsible for more changes than average. She clarified that some of the PAPs have expanded their business into recycling. She also stated that PAPs think that CPs are a bit afraid of buying secondary aggregates. This explains why PAPs made CPs responsible for not allowing dirty aggregates [34]. A final remarkable issue was the 0% responsibility assigned to PAPs. She elaborated that DCs and RCs were far ahead, making PAPs not inclined to take responsibility. However, PAPs negotiated in the Concrete Agreement because they wanted to keep other parties in check. These points illustrate that PAPs responsibility assignments also were directed at the parties that affect their business model.

The CP representative acknowledged most of the results. He did not recognize that most of the CPs would make the government responsible. He stated that contractors and investors should be made more responsible, since they must invest more in circular developments. He expected a difference in perception among the CPs, because of two interviewees were from the ready mix concrete sector, and two were from the prefabricated sector. The representative was surprised by the high ranking of the "standardization of products" change by CPs. He noted that CPs should have a good appreciation of the value of concrete waste materials.

All branch representatives recognized the results at SMSC level. The RC representative recognized a high diffusion of responsibility, since the branches gave 75% of responsibility to parties outside the supply chain, leaving only 25% for the supply chain itself. The branches agreed that the results signify an important implication to the Concrete Agreement, namely the contradiction between the voluntary and self-initiating nature of the Concrete Agreement and the strong agreed opinion of the government as the most responsible party.

5. Discussion

This section discusses the contribution of the empirical findings for the CE implementation literature.

5.1. Changes

The identified changes in the SMSC case are generally recognizable in the academic literature in terms of topics. Some of these are actually proposing similar types of changes. For example, change [26] is associable to the introduction of laws and policies by Govindan and Hasanagic (2018) and changes [38 and 39] are similar to use information by Liu et al. (2018). However, there are also some opposite changes. Change [30] proposes to 'relieve political pressure' whilst Govindan and Hasanagic (2018) call for more strict governance.

Both the CE literature and Table 2 show a large number of changes for the CE implementation in supply chains. For example, Bressanelli et al. (2018) identify 24 challenges for redesigning the supply chain. Kalmykova et al. (2018) catalogue 45 strategies for CE implementation. Similarly, Table 2 enlists 40 changes. Ultimately, these lists show the multifaceted and multi-disciplinary nature of CE.

After analysis on the state of the art in CE implementations Kalmykova et al. (2018) find that changes mainly focus on ready-made solutions and rarely on system changes to the economy. However, it appears that the SMSC did suggest such system changes. System changes could address the absence of governmental policy, technology, practical knowledge and awareness (Sharma et al., 2019). Branch representatives pointed to similar changes, like [5, 23, 26, 28 and 29].

5.2. Responsible parties and importance of changes

Both the SMSC results and Kalmykova's et al., 2018 research reveal an imbalance of changes across supply chain activities. The SMSC case found this imbalance in the assignment of responsibility to parties. For example, only 6 out of 40 changes have been mentioned by more than one branch. In addition, only 25% (at best 40%) of all responsibility assignments pointed to branches within the SMSC, whereas 60% was bestowed upon parties outside of the supply chain. These facts show a diffusion of responsibility. All the while the parties are agreeing on how to transition the supply chain towards CE.

Two contributions can be established here, the systemic role of government and the distinct foci of supply chain actors. Firstly, both the empirical study and the CE literature show strong evidence that the government is a core responsible party. Perhaps not surprisingly, because it can give incentives with resources and power (Govindan and Hasanagic, 2018; Cai and Wu, 2014; Gaustad et al., 2018; Maaß and Grundmann, 2018). The SMSC case shows that 25% of responses assigned the government as responsible party. Additionally, the actors who made the government responsible for a change, also regarded the change to be key for the CE transition (6 out of 9 changes), which was also confirmed in the validation workshop. This shows that supply chain actors perceive the government to have resources and power to incentivize supply chain actors.

The government's role can be further substantiated, because it can overcome a lack of mutual interest between actors. Masi et al. (2017) state that the CE changes should focus on overarching goals to allow for the inclusion of future practices and techniques. Similarly, the 9 changes for which the government was made responsible are about organizing change, i.e. formulating the CE definition and making legislation. Clearly the supply chain actors perceive the government must

ensure cohesion between changes (i.e. law, market, business models and technologies).

Secondly, both the CE literature and the results point to different foci between supply chain actors because of high uncertainties and risks that changes cause. Companies are following their own business model first, which drives the circular supply chain (Geissdoerfer et al., 2018). For example, in Table 2 the DCs and RCs only identified a small number of changes applicable to their business, whereas CPs and PAPs identified a larger number general problems. This may be because of the implication of CE for their businesses. DCs and RCs generally benefit from the CE. This may make them anticipate on their competitive advantages amidst external changes (Dubey et al., 2018). On the other hand, CE complicates CPs' business because of the need to use new materials in concrete, i.e. the quality of recycled materials remain uncertain. Clearly, PAPs are affected negatively because CE favours secondary over primary aggregates. Also here, required changes for implementing CE in supply chains can expose businesses to high uncertainties and risks (Masi et al., 2017).

On a final note, also clashes of perception on any possible level of the supply chain attribute to the differences of perception. For example, CPs and PAPs point to general problems, while the DCs and RCs focus on their specific agendas. RCs would stand to benefit from CE, because the material concrete can be recycled (Fischer et al., 2009), and new recycling technologies for concrete would open up the worldwide construction markets (Marinković et al., 2010). It would however pose a big risk for PAPs, because they could lose primary aggregate sales. These specific clashes confirm the finding by Diaz-Lopez et al. (2019) that business model changes could face any mix of possible barriers of implementation. It makes the CE implementation for supply chains situational and requires clarification on a case-by-case basis.

5.3. Clarification

Ideally, circular supply chains would foster collaboration and communication between parties on common goals (EMF, 2015). The discussion suggests this does not apply to the SMSC.

This can be explained by the notion of "bilateral dependencies". In the data various instances were flagged in which a supply chain actor pointed to the one responsible party for their most important changes and explained this was due to a dependency on that party. This appears to be similar to an observation made by Gaustad et al. (2018). They point out that impactful changes can disrupt the position of actors in the supply chain. Therefore, bilateral dependencies in the supply chain may make the actors more defensive toward the change and behave as Gaustad et al. (2018) noted, focusing on risk reductions and evaluating their level of vulnerability.

For the SMSC, bilateral dependencies were observed, validated and explained between 1) PAPs dependent on CPs; 2) DCs dependent on Investors; 3) RCs dependent on the government; and 4) CPs dependent on Designers. For example, it was elaborated that investors ask DCs for demolition and pay them for it, and it was also clarified that designers and contractors scope the work of the CPs and determine the CPs ability to reclaim products at the end of life.

The bilateral dependency, if it is known, can help identify how system changes should be implemented or fostered. On this note, Genovese et al. (2017) called that bottom-up initiatives at a supply chain should potentially have some incentives by means of some sort of top-down governmental support. In this way, the bilateral dependency can help navigate such government support to reduce vulnerability between dependent actors by favourably altering their business model.

6. Conclusions

This paper aimed to understand the difficulty of implementing CE and focused on the question: *How do the perceived needed changes and responsibilities inside a supply chain relate to the formulation of the CE transition for that supply chain?*

A few findings from this study stand out and contribute to the existing CE literature. Firstly, it was found that supply chain actors diffuse the responsibility to parties outside of the supply chain. On the one hand this is because supply chain actors see expect the government to 1) provide incentives and 2) create cohesion among changes, since both are otherwise lacking. On the other hand, the diffusion of responsible is partly explained by the distinct foci between supply chain actors, originating from a 3) reactive attitude toward risks and opportunities and 4) clashing views to protect the business. Both these insights are relatable to insights from recent CE literature. In essence, this study is the first to point out underlying reasons for this diffusion of responsibility. It shows that the CE implementation for supply chains are situational and need to be clarified on a case-by-case basis.

Secondly, it was found that supply chain actors tend to have a bilateral dependency to other parties on specific changes. This phenomenon corresponds to observations from other CE literature in which actors mainly focus on their own business model when faced with impactful changes from the supply chain (Gaustad et al., 2018; Howard et al., 2018; Bressanelli et al., 2018). This article contributes to the literature by showing that bilateral dependency can explain the defensive and reactive attitude assumed by supply chain actors. In essence, when a bilateral dependency is known for a supply chain actor, then an obligatory party could change the actors' calculus with suitable incentives.

The bilateral dependencies in the SMSC case, point out that in the future, if the government would act on its responsibility first, then this may trigger a chain reaction of parties following this by making changes that can benefit and further trigger their bilateral dependent counterparts to follow. The right incentives from government, like research funds or stimulating legislation, would trigger the recyclers to create new businesses, and thereby acting on their responsibility, like creating new technologies. New technologies could improve product quality of secondary materials, thereby creating more supply (from demolishers) and demand (from concrete producers, contractors and designers).

Finally, this paper contributes to the CE literature in the construction industry. Adams et al. (2017) and Leising et al. (2018) both state that CE in construction is in its infancy. So far it has only focused on construction waste minimization and recycling. Adams et al. (2017) argue there is a current lack of a good economic case for CE implementation. In addition, they note that there is a lack of incentives for the construction industry to adopt CE. In essence, this is exactly what the bilateral dependency helped to address.

6.1. Limitations and recommendations

This research has a few limitations. Firstly, this study focused on the SMSC case, which was reflected to recent CE literature. However, it cannot point out the commonality of these issues for all supply chains in an empirical way, nor can it exclude events that haven't been observed. Therefore, the empirical findings of this study could be strengthened by more cases to substantiate and deepen the obtained phenomena on diffusion of responsibility and bilateral dependency. The social network analysis approach has proven itself as a powerful approach for this.

Another limitation lies in the methodological set up of this study. Purposive sampling, specifically critical case sampling, was used to collect data. Due to the infancy of the SMSC case not many respondents would suffice through another sampling approach. However, the transition toward CE can only be expected to grow in the future. This would open up the route for more sophisticated and less situational sampling strategies and to attain a more robust basis to study the role of the diffusion of responsibility of actors in a supply chain in transition.

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