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Chapter 11

Barriers and Practical Challenges for Data-driven Decision-making in Circular Economy SMEs

Anne-Mari Järvenpää, Jari Jussila and Iivari Kunttu

Abstract

The circular economy (CE) model is seen as an alternative model to the linear economy models, which seem to be reaching their physical limits. The CE business model aims to reuse materials and decrease the need for virgin materials. This requires the implementation of a reverse supply chain, close collaboration between actors, as well as well-organized logistics. For this reason, the CE companies have typically high demand for digitalized processes and the utilization of data on both operational and business development dimensions. Also the utilization of big data collected from the companies' business environment can provide new opportunities for business development in CE. Despite the fact that utilization of data collected from the business environment and operations enables data-driven approaches for various decision-making functions in companies, many companies still struggle to figure out how to use analytics to take advantage of their data. In the small- and medium-sized enterprises (SMEs), in particular, the managers are facing difficulties with ever-increasing amounts of data and sophisticated analytics. Indeed, prior research identified several kinds of barriers to the effective utilization of data in SMEs. Still, research on data-driven decision-making remains scarce in CE context. This chapter presents a case study consisting of seven cases, all representing SMEs operating in the field of CE in Finland. In the case study, the barriers and practical challenges for data-driven decision-making in CE SMEs are investigated. Based on the case study results, this chapter proposes that utilization of data, lack of resources, lack of capabilities, and regulation are the main barriers to data-driven decision-making in CE SMEs.

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1. Introduction

Whereas the current linear economic model based on "take–make–dispose" is reaching its physical limits not least due to the unbearable amounts of waste, CE-based economy system is emerging as an alternative to this model (Suchek et al., 2021). The CE incorporates a regenerative system that minimizes the entry and waste of resources, emissions, and expenditure of energy through slowing down, closing, and straightening the energy circuits (Geissdoerfer et al., 2017). CE is based on closed-loop production systems and material flows. It aims to reuse materials and decrease the need for virgin materials, which requires the implementation of a reverse supply chain and cooperation between actors (Urbinati et al., 2017). The principal logic of the CE is to convert waste into resources by applying technical or biological conversion. The outcome of the conversion can be re-used in an industrial process or returned to the biosphere (McDonough & Braungart, 2010). The business concepts related to the area of CE aim at addressing sustainable development needs by minimizing resource input and waste, emissions, and energy leakage without jeopardizing growth and prosperity (Urbinati et al., 2017). Sustainability enriches corporate value with relational meaning and dialogue by making the aims of the corporation more transparent and demonstrating mutual responsibility (Ciasullo & Troisi, 2013) for social, environmental, and economic development.

Technological advancements, especially in the past decade, have revolutionized the way that both every day activities are conducted (Mureddu et al., 2020). To be successful in the rapidly changing CE business environments, the companies operating in this area have typically high demand for utilization of data on both operational and business development dimensions. It is known that exploratory utilization of data collected from business processes, customers, competitors, and other sources enable data-driven approaches for various decision-making functions in companies. In addition to that, ever-increasing big data provides opportunities for innovative companies in new business and process development (Visvizi et al., 2021) in terms of, for example, material flows, customer behavior, or logistics planning. However, many companies still struggle to figure out how to use analytics to take advantage of their data. The managers are facing difficulties with ever-increasing amounts of data and sophisticated analytics (Ransbotham et al., 2016; Susha et al., 2017). This is particularly true for firms operating in the CE business environments, in which a firm may obtain significant competitive advantages by coming up with new innovations and customer solutions. On the other hand, operational requirements related to, for example, supply chain management, production, and material flows are significantly higher in CE business than in many other business areas. For the companies, data-driven decision-making

can reduce costs, improve operations efficiency, increase stakeholder loyalty, and increase communication flows within the organization and ecosystem (Pulkkinen et al., 2019; Troisi et al., 2020). For this reason, it is natural that the CE companies show increasing interest in investing in business intelligence and other practical data-based tools that enable them to make systematic planning for the future at both the strategic and operational level (Järvenpää et al., 2020). Business data also provide the companies with a basis for rapid and rational decision-making concerning their key operations, including business and product development. However, due to their relatively small organizations with limited competences and resources, SMEs are often rather streamlined and limited in their financial resources and capabilities. For this reason, developing capabilities to utilize data in their business analytics and operations is particularly important for SMEs (Järvenpää et al., 2020).

This chapter considers the data-driven decision-making and management mechanisms and practices in innovative SMEs operating in the evolving CE-related industries. This study aims at answering the following research question: *What are the barriers and practical challenges in data-driven decision-making in circular economy SMEs?* This question is aimed to be answered at both the strategic and operational level through a qualitative comparative case study consisting of seven cases, each representing a SME operating in CE in Finland. Thus, this study presents a qualitative multiple case analysis using the case companies as a unit of analysis. For this reason, the study contributes to the existing research on data-driven decision-making and management by focusing on the SMEs. The study extends the existing literature concerning barriers to the use of data in a complex but increasingly important business area of CE. The findings of the study may also have significant managerial interest, given that managers, particularly in SMEs are facing difficulties with ever-increasing amounts of data and sophisticated analytics. This chapter is organized as follows. Section 2 outlines the theoretical background of the chapter, and focuses on four main barrier types. Section 3 presents the methodological choices of the chapter. Section 4 focuses on the results obtained from the analysis of the empirical data. Discussion and concluding remarks are presented in Section 5.

2. Challenges for Data-Driven Decision-Making in SMEs

The rapid progress in industrial digitalization has caused a massive increase in the amounts of data. This data, collected from the operational or business processes of the companies provide new sources of value (Ruohomaa, 2020). Data-driven decision-making is an approach to managing big data throughout the entire decision-making cycle of the organization, where the role of the data-driven management is to base business decisions on data analytic thinking to make use of data in prescribing actions, predicting future developments, and driving change (Troisi et al., 2020, p. 538). Thus, the impact of utilization of data on the economy has also been referred to as "the new oil" (Hilbert, 2016). However, large and multinational companies often have capabilities to fully deploy

data in their business on both operational and strategic levels, many SMEs are still lacking competence and resources for data-driven decision-making (Iqbal et al., 2018). It has been shown that big data analysis tools and technologies as themselves do not allow the automatic attainment of innovation (Troisi et al., 2021), competitive advantage (Watson, 2016), or increased stakeholder value. This may be particularly problematic for SMEs that typically do not have capabilities or resources to allocate for full-scale deployment of these kinds of tools (Järvenpää et al., 2020).

2.1. Utilization of Data

Järvenpää et al. (2021) discussed what kinds of data is typically used in data analytics in SME context. The data can be (1) machine-generated – when it comes from, for example, machines, sensors, mobile phone applications, or computer networks; (2) human-generated – when it is collected by people, for example, personal information; and data generated in technology-mediated interactions via, for example, documents, emails, and social media services; and (3) business-generated – including transaction data from point-of-sale or enterprise resource planning systems (Olshannikova et al., 2017; Saggi & Jain, 2018). In addition, the data may also originate from company internal or external sources. The external data sources include open data, acquired data, customer-provided data, and freely available data (Hartmann et al., 2016).

Previous studies in the data-driven decision-making in SMEs (Iqbal et al., 2018; Kim et al., 2003; Parra et al., 2019; Ransbotham et al., 2016) have identified several types of obstacles and challenges in harnessing big data in the operations of SMEs. The challenges may include a low level of understanding of big data and classifying emerging developments such as big data analytics as hysteria and not as a viable business opportunity. Other challenges are lack of adequate infrastructure to analyze data, lack of in-house data analytic experts, lack of representative case studies, and success stories in big data analytics in SMEs. Lack of expertise in selecting suitable solutions and effort needed in order to understand the available data, as well as dirty data and other data quality issues may challenge the data-driven decision-making in SMEs. The SMEs operating in CE are likely to face these kinds of challenges in their business operations and planning. However, the CE SMEs also have their own, specific challenges that are related to their business area. Their key challenges are often related to materials that they are re-using. Material quality issues as well as the barriers related to the information exchange in material flow supply and demand, infrastructure, and transportation are found to be key obstacles for using data in decision-making (Winans et al., 2017). As stated by Strand and Syberfeldt (2020), external data may be the key asset for data-driven decision-making in organizations, but still most organizations primarily utilize internal data. In the field of CE companies, Strand and Syberfeldt (2020) found that valuable data for waste can be found external data sources: maps, orthophotos, and road data; property and civil data; and traffic and weather data.

2.2. Lack of Resources

Typical approaches to utilizing data analytic methods in companies vary from relatively simple statistical and optimization tools in traditional spreadsheet software packages to more sophisticated data visualization and analytics tools including descriptive, predictive, and prescriptive methods (Davenport & Harris, 2017). While large corporations can typically invest in specialist data scientists and in-house technology infrastructure, SMEs often lack both the expertise and the tools to benefit from data analytics (Parra et al., 2019). Ormazabal et al. (2018) and Rizos et al. (2016) have indicated that two main resource-based barriers for CE SMEs include lack of technical and financial resources. What comes to financial resources, it is natural that adopting data analytics tools and technologies require financial resources from the companies in terms of both investments in information managements tools and human resources operating these systems. In fact, inadequate information management systems have been recognized as one of the major barriers for CE activities in SME context (Rizos et al., 2016).

2.3. Lack of Capabilities

Rizos et al. (2016) indicate that the lack of internal technical skills is one of the key obstacles preventing SMEs from taking advantage of the opportunities provided by CE. The SMEs do not have the technical capacity to identify, assess, and implement more advanced technical opportunities that would enable them fully take advantage of CE-related business models. Consequently, these firms often prioritize technologies and tools which they are already operating. Furthermore, the SMEs may not have enough understanding on what kinds of technological solutions (such as analytical methods) are available in the first place and which of these methods could be feasible in their context (Järvenpää et al., 2021).

2.4. Regulation

Flash Eurobarometer Survey number 441 (*Flash Eurobarometer 441. European SMEs and the Circular Economy*, 2016) investigated what issues firms encountered when undertaking CE activities, and which of the following five barriers were significant: (1) lack of human resources; (2) lack of expertise to implement these activities; (3) complex administrative or legal procedures; (4) cost of meeting regulations or standards; and (5) difficulties in accessing finance (Garcés-Ayerbe et al., 2019). According to Garcés-Ayerbe et al. (2019), of those firms ($N = 7{,}843$) that had implemented or were implementing at least one of the CE measures the biggest barrier was complex administrative or legal procedures (perceived by 31% of the respondents) and the second was cost of meeting regulations or standards (28%). Despite the fact, this study was not focused on data-driven decision-making in CE firms, it can be inferred that regulation may also impact data-driven decision-making in CE SMEs. Regulatory barriers frequently mentioned in literature include, for instance, lack of consistent regulatory framework and obstructing laws and regulations (Hart et al., 2019).

3. Methodology

This chapter presents a comparative qualitative case study of seven CE SMEs, all located in Finland. The case companies provide services related to waste management, biogas production, material recycling, the manufacturing of products based on waste materials or consulting, as summarized in Table 11.1. The research data used in this study was collected by two rounds of interviews. First interview round was conducted by two of the authors that interviewed each company representative, mainly CEOs, in May 2021. The interviews lasted about 60 minutes each, and they were recorded and transcribed prior to analysis.

Table 11.1. Summary of the Case Companies Used in This Study.

Case	Interviewed Person	1st Interview Round	2nd Interview Round (Group Interview)	2nd Interview Round (Group Interview)	Industry	Core Business Area
A	COO	X	X	50	Combined facilities support activities	Waste management, recycling services, and solutions for households and companies
B	Service Manager	X	X	60	The treatment and disposal of non-hazardous waste	Waste management and recycling services for households and companies
C	CEO	X	X	80	The treatment and disposal of non-hazardous waste	Waste management and recycling services for households and companies
D	CEO	X	–	<5	Security services	Disposal of confidential material
E	Quality Manager	X	–	20	Hazardous waste management	Waste processing and disposal
F	CEO	X	–	10	The dismantling of wrecks	Recycling services for wrecks
G	CEO	–	X	<5	Management consulting	CE

Source: Authors.

In the interviews, the researchers used a semi-structured interview template that sought insight into how companies are utilizing data in strategic decision-making. Special attention was paid to the barriers and obstacles of data usage in the CE area. After the analysis of the first interview round, the second round was conducted by three of the authors as a group interview of the company representatives in November 2021.

The purpose of the second interview round was to validate preliminary conclusions, clarify some of the ambiguities and to gain a deeper understanding on the topic.

4. Results

In this section, we summarize the results of the analysis made based on the case-specific interviews. Following the research question, the analysis of results is divided into four sections, each of which presents the key results of the interviews in the four challenge categories identified from literature: utilization of data, lack of resources, and lack of capabilities, and regulation. Some key results from the case data are also summarized in Table 11.2.

Table 11.2. Key Results From the Case Data.

Challenge Category	**Challenge in Cases**
Utilization of data	Data is scattered in various information systems [F] Combining data from various sources is challenging and time-consuming [A] Pre-processing and cleaning of data is challenging and time-consuming [D] Manually inputting of data is needed because data does not automatically transfer between information systems [D]
Lack of resources	Inadequate information management systems [C] [D] [F] Current in-house information systems do not support ad hoc reporting and drilling of essential data [F]
Lack of capabilities	Insufficient competence in using existing information systems [A] [D] [F] Lack of capability in using and refining collected data [A] [D] [F] No in-house competence in developing reporting, automated queries [A] [B] [D] [F]
Regulation	The legislation must be followed, the data must be collected in the form required by legislation [G]

Source: Authors.

4.1. Utilization of Data

The reliability and data quality play a critical role in achieving the desired output. Challenges include missing data, wrong data, and unusable data (Kim et al., 2003), also referred to as "dirty data" and the cleaning of these (dirty) datasets (Iqbal et al., 2018). Many organizations suffer from data quality issues that may lead to bad decisions and a negative data-driven culture (Parra et al., 2019). Based on the interviews, data utilization challenges are mainly caused by various information systems, challenges in data processing, and manual data input.

> At the moment we are in the beginning in developing descriptive analytics, the challenge is that we are still cleaning data and there is a lot to do before we get descriptive analytics in sensible form. (Case E)

> We've never considered our business as data-driven, that we would collect and utilize the data. We have quite a few data collection points that provide fragmented data, which in turn brings challenges to the next steps, namely processing and analysis. Our key challenge is that data is not perceived as fuel for doing business analyses, our expertise has not evolved through data collection and processing. Our situation culminates through many reasons. (Case C)

For waste management company (case A) one critical challenge is that it is not possible to measure fulfillment rates for all waste containers. Therefore, there is missing data on waste container fulfillment rates. This is especially a challenge for optimizing routes of emptying waste containers because there is incomplete information for decision-making. Technologies for measuring waste container fulfillment are not perceived cost effective enough for the company to invest:

> Data is being collected from the fulfillment rates of the waste containers. However, we do not currently have a system that could process and analyze that data. (Case A)

The processing in that case requires real-time processing to be useful for the company. As has been recognized in the literature, the benefit for the company necessitates in addition to real-time data processing also relatively fast responses from the operational management (Watson, 2016):

> We found that processing information must be more real-time to be able to make the right decisions in the right moment. (Case A)

> We have the same system as other companies, and it doesn't meet today's demands. We collect a lot of data from everything, the

> biggest problem is how to put it together, automate processing and visualization. The resources allocated for doing this is scarce, as it has not been needed before. There will be more reporting requirements and the best solution would be reporting models. According to the provided models it would be possible to compile required reports from the data. (Case A)

The information systems used by the companies provide several challenges for the utilization of data. Many of the challenges that the companies face is not related to data analytics software or services by themselves, but to those information systems that generate or originate the data used for data analysis.

> We store information in several systems that do not discuss with each other. It is a challenge to make use of information from different systems. We partially lack data collection automation, some of the information is still stored manually. In general, the waste sector has a single ERP system in use. Software development has been a challenge, and it hasn't developed quite so quickly over the past few years. Knowledge management is not commonplace in any organization in this industry. We need basic knowledge and insight into how this is worth doing – and we need help with that. (Case B)

> Interoperability is a word I hope you write strongly down, it's a challenge in the big picture. It is not worth making solutions for just one company, region, or industry. Information must also serve statistics and reporting to the EU. This has been underthought from a waste management perspective – local and regional measures are made, and the connection is not open through interfaces forward. (Case G)

4.2. Lack of Resources

Based on the interview data, the main resource related challenges are lack of platform and lack of time. Rizos et al. (2016) has suggested that inadequate information management systems include one of the main barriers to CE activities in SME context.

> The challenge is that we have no data platform. (Case C)

> The main challenge is that we are not exploiting data to the extent that could be. We collect a lot of data, but we are a small company, and we do not have the resources (to exploit data). (Case D)

> There is no time to form essential (data) packages. (Case F)

> The same owner has several plants with same technology. There are weekly reports available that could be compared, but they are not used (because lack of time). (Case F)

Based on the interview data, it seems that the companies may possess remarkable amounts of data, but the problem is that there are no dedicated resources in the company that have skill, capabilities, and tools to collect, process, analyze, and interpret the relevant information to support managerial decision-making and operational management in the company.

> We have a lot of data, but compiling information into the necessary form and visualizing it is a stumbling block. For example, if I could get the information necessary for myself from the accounting, it would be relevant. (Case F)

According to the work of Ransbotham et al. (2016) despite the increased access to useful data, companies' ability has decreased to apply analytics insight into strategy and the challenge is to get useful insight for decision-making. They stated that companies are not effective to disseminate and use insight strategically.

4.3. Lack of Capabilities

When asked about the lack of capabilities as a potential barrier for data utilization in CE SMEs, the interviewed company representatives mentioned lack of expertise and infrastructure. Our interview data was quite coherent in this, and most of the interviews supported this finding:

> We don't understand analytics in a way we would be able to design a data platform. (Case C)

The interviewees' insights were in line with many studies. For example, Iqbal et al. (2018) stated that SMEs are still lacking competences and resources for data-driven decision-making and Rizos et al. (2016) indicated that lack of technical skills is one of the key obstacles preventing SMEs from taking advantage of the opportunities provided by CE. As SME's usually concentrate on their core business and competencies, they might miss opportunities to take advantage of data (Iqbal et al., 2018):

> We lead by emotion, not by information. (Case C)

Data utilization in SMEs is hindered by the fact that they are incapable to analyze data by themselves because of the shortage of data analytics expert and high set-up costs (Iqbal et al., 2018). Parra et al. (2019) found that the use of data depends on the senior management technological familiarity and that data analysis are mainly used rather at management level not operational. Nevertheless,

managers data analysis expertise relates to tracking indicators, dashboards, and tailored spreadsheets (Parra et al., 2019).

> The biggest challenge is that the staff do not have sufficient competence to use systems. Activities focus on standardized programs and systems such as enterprise resource planning and customer management, staff do not have sufficient skills to exploit, and process collected data in Excel or PowerBI. (Case A)

> If the new system is easy to use, it will be easier to deploy it. Due to resistance to change, we need to invest in introducing a new system so that everyone adopts it, and no one is left to use the old one. (Case B)

Ransbotham et al. (2016) categorized companies at three levels of analytical maturity: analytical challenged, analytical practitioners, and analytical innovators. They suggested that analytical innovators are likely to have formal strategy for analytics focusing on skills development, data management, and cultural norms. To further clarify this topic within our case study companies, we specifically inquired about this on the second interview round (group interview) by asking the interviewees: "What kind of bottleneck is competence in utilizing data and what could help you to overcome the competence-based barriers?" Many of the company representatives named the lack of experience on data utilization as the main bottleneck. One central reason for that is the fact that the core business of the companies is not related to data, and the SMEs are reluctant to focus their limited resources outside of their core business area:

> Since we have not been engaged in data processing and utilization, our know-how has not evolved. (Case A)

> In the customer's experience and the end-user perspective, the challenge is to combine the substance into the digital field: to translate the hopes into digital so that an easy-to-use perspective could be made. Developing a customer perspective on the side of waste management companies is of interest to big firms. But it is often the case that is understood coding but there is no understanding of what it is in the field. (Case G)

> Waste management operators are looking too much inward. They should benchmark services from more advanced fields. In many areas, new services have emerged through the use of open data. (Case C)

The interview data also shows that the mindset and culture in the companies focuses on much on technologies and engineering thinking at the operational

level. In this context, the considerations on data utilization or service-oriented business development may sound distant managerial topics:

> The waste industry is often focused on engineering thinking. We should emphasize the importance of customer experience, not just making smooth and efficient systems for ourselves, but that the customer could benefit and thus increase recycling activity. We could develop better service solutions for customers if we have a good understanding of customer experience and the ability to take advantage of service design. (Case B)

> It would be interesting to look at the exploitation of data across corporate boundaries. There are channels to which companies should export information, but we need solutions that go beyond companies and benefit the sector as a whole. (Case C)

In both interview rounds, the company representatives mentioned co-operation with students. Interviewees think that the students have better skills than their staff, and they think that co-operation with students provides valuable ideas for companies. As there is a shortage of data analytics experts in the labor market, co-operation with students could provide new opportunities for companies as well as missing case studies and examples of data analytics in SMEs. This could be one potential way of filling the capability in the companies.

> We can train staff, but we are getting ideas from students' projects that helps us significantly. (Case A)

> It seems like the student knows how to use these instruments (analytic tools) better than us. (Case B)

> A lot of competence comes along through students' work, but conversely, each company has its own systems for which students do not find competence. However, it is knowledge sharing and training, getting from students' know-how to the company and from company to students. I see cooperation with students as important. (Case A)

> Students are a potential resource; we have done several collaborative data analytics projects that have been surprisingly good. Students have such competence, e.g. the features of Excel, which we don't. (Case B)

4.4. Regulation

In the first round of interviews regulation and legislation was mentioned by several companies while discussing data-driven decision-making. Therefore, in the

second interview round we directly inquired: Is the legislation barrier or challenge for data utilization? Based on the interviewees ´opinions, it seemed that regulation may cause barriers, but on the other hand, some of these barriers can be overcome by increasing knowledge and skills within the companies:

> Legislation generally speaking is a lagging force. (Case C)

> GDPR is often misunderstood (in companies) and the development might be stopped just in case. Legislation is important, you can take a great risk if you don't understand it. We need more understanding and a critical analysis of what the GDPR is and what are its requirements for data utilization. It hinders development because it is not exactly known what it actually prevents. (Case C)

We wanted to further understand, whether the industry is data-driven or "legislation driven" and to what degree does legislation impact at decision-making. Hence, we inquired in the group interview: Is the activity controlled by data or delivered under the coercion of legislation?

> The legislation must be followed, the data must be collected in the form required by legislation. For example, the EU Implementing Regulation defines that reporting of reusable building parts and materials must be done in tons, even if no such information can be found. What is asked can contradict what exists. (Case G)

> The idea in all legislation should be permissiveness for development, not to make a regulation that is locked up at this moment. Regulation should enable new innovations, new systems, and their exploitation. (Case G)

> If there is material, which is treated in tons, but the reporting requirement is cubic meters, measuring and monitoring may not go hand in hand. This will bring challenges and errors in the statistics. (Case A)

> Uncertainty where legislation is going to guide, meaning where we should focus on and allocate resources, or do we have any more interests in the first place – it is a legislative problem that cannot be influenced by ourselves, but to live with it. (Case A)

5. Discussion

The objective of this chapter was to increase understanding on the practical challenges and barriers to data-driven decision-making perceived by CE SMEs. In this manner, the chapter increases understanding of how data in its different

forms influences the processes of decision-making, and management on operational and strategic levels. In this chapter, four major challenge themes were identified: utilization of data, lack of resources, lack of capabilities, and regulation. The CE SMEs had several data utilization challenges for decision-making. The data is fragmented in several information systems that do not communicate with each other. Operations rely to some extent on manually inputted data, and there are challenges in automated data collection and developing automated queries to support the discovery of essential information. Concerning lack of resources, the Finnish CE SMEs mostly highlighted lack of platforms and lack of time for hindering data-driven decision-making. The platforms that the CE SMEs use are mostly adequate for reporting but fall short on discovering and visualizing essential information.

Based on the interviews the lack of capabilities for data-driven decision-making in CE included some usual suspects. For example, lack of competence (Iqbal et al., 2018; Rizos et al., 2016) in data and performance management (Aho, 2012; Parra et al., 2019; Ransbotham et al., 2016). These results add to the previous studies on dynamic capabilities of CE firms (Khan et al., 2020a, 2020b) from the perspective of SMEs. Some novel insights pointed out by the managers include the need for a mindset shift from engineering thinking to design thinking: "not just making smooth and efficient systems for our selves, but that the customer could benefit and thus increase recycling activity." It was also pointed out that large firms are more customer oriented, whereas the CE SMEs customer perspective on the waste management is underdeveloped. This may indicate challenge the competitive advantage for CE SMEs if bigger national or international companies enter the same market. Interestingly, several of the SMEs noted that students, who they have collaborated with, have more advanced data analytics skills than they do and that the students can offer valuable help in capability development, and thus fill the competency gaps in the companies.

In CE and waste management industry the regulation and legislation enforce what companies must do, and regulation has been found as a barrier in earlier studies as well (Garcés-Ayerbe et al., 2019). It can be interpreted based on the interviews that in this sense the CE SMEs are more legislative-driven than data-driven. Reflecting on the MoSCoW method of what can be considered as "must have," "should have," "could have," and "won't have" for the design of data-driven decision-making (cf. Kollwitz et al., 2018), the regulation defines what must be done. "Should have" and "could have" in data-driven decision-making are something extra that most SMEs don't have dedicated resources or capabilities to perform.

The CE SMEs also recognized that they could benefit from open data, and application programming interfaces (APIs) for local and regional waste management data, which has been also recognized important in other industries (Jussila et al., 2019). One implication for policy-making in Smart Cities is that SMEs especially need support in terms of open data repositories and APIs to support their reporting and business development (see also Watson & Ryan, 2021). Most SMEs do not have resources themselves to develop needed interfaces for data flow and management. Instead, they need to rely on third-party information system providers that may not have the same incentives or need to meet the legislative

requirements as the CE SMEs. Regional actors could pool together resources to develop information resources and systems to better support CE SMEs business. Increasing funding for CE SMEs development could significantly support meeting the European Union (European Commission, 2018) net-zero greenhouse emissions by 2050 and the national carbon neutrality goals.

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