

DEVELOPING KEY PERFORMANCE INDICATORS FOR CIRCULAR BUSINESS MODELS

A Study of Finnish Small and Medium-Sized Enterprises in the Circular Economy

Master's Thesis
Laura Hakulinen
Aalto University School of Business
Accounting
Fall 2018



Author Laura Hakulinen

Title of thesis Developing Key Performance Indicators for Circular Business Models

Degree Master of Science in Economics and Business Administration

Degree programme Accounting

Thesis advisor(s) Hanna Silvola

Year of approval 2018

Number of pages 118

Language English

Abstract

The objective of this thesis is to identify the key circular economy performance indicators for the small and medium-sized circular business models in Finland. Businesses and especially circular business models have a crucial role in the transition towards the circular economy. While the circular economy is gaining popularity among public and private sector, to date circular business models and their performance measurement have been studied only a little in academia.

The circular business models examined in this study are: product as a service; product-life extension; renewability; resource efficiency and recycling; and sharing platforms. The selection of these circular business models is based on the categorization made by the Finnish Innovation Fund Sitra, which is one of the leading organizations promoting the circular economy in Finland.

The research methodology of this thesis is constructive case study and the motivations are mainly practical; the objective is to help current and future businesses operating in the circular economy measure their circular economy performance. This thesis aims to achieve that objective by identifying useful indicators, of which some might become as key performance indicators for the circular business models.

The research findings indicate that simplified performance indicators covering all the aspects of the circular economy are challenging to develop. Therefore, the main practical contribution of this thesis, i.e. the managerial construction is formed from two indicator pools: the first pool contains internal strategic and operational circular economy performance indicators and the second pool includes the more comprehensive circular economy related indicators.

During the thesis project it became apparent that the research question is currently an important discussion point. Many new academic researches and other surveys such as the report made by WBCSD were published during the year.

Keywords circular economy, circular economy business models, key performance indicators, circular economy performance indicators, small and medium-sized enterprises

Tekijä Laura Hakulinen

Työn nimi Developing Key Performance Indicators for Circular Business Models

Tutkinto Kauppatieteiden maisteri

Koulutusohjelma Laskentatoimi

Työn ohjaaja(t) Hanna Silvola

Hyväksymisvuosi 2018**Sivumäärä** 118**Kieli** Englanti

Tiivistelmä

Tutkielman tavoitteena on kehittää pienille ja keskisuurille kiertotaloudessa toimiville yrityksille KPI-mittareita. Yrityksillä ja etenkin kiertotalouden liiketoimintamalleilla on keskeinen rooli siirtymisessä lineaarisesta taloudesta kiertotalouteen. Vaikka kiertotalouden suosio kasvaa jatkuvasti julkisella ja yksityisellä sektorilla, kiertotalouden liiketoimintamalleja ja niiden suorituskyvyn mittaamista on tähän mennessä tutkittu vähän akateemisessa tutkimuksessa.

Tässä tutkielmassa tarkasteltavat kiertotalouden liiketoimintamallit ovat: tuote palveluna, tuote-elinkaaren pidentäminen, uusiutuvuus, resurssitehokkuus ja kierrätys sekä jakamislustat. Näiden liiketoimintamallien valinta perustuu Sitran tekemään jaotteluun. Sitra on Suomessa yksi johtavista organisaatioista kiertotalouden edistämiseksi kansallisella tasolla.

Tutkielman metodologia on konstrukttiivinen tapaustutkimus ja taustamotivaatiot ovat pääosin käytännönläheisiä; tavoitteena on auttaa nykyisiä ja tulevia kiertotaloudessa toimivia yrityksiä mittaamaan kiertotalouden suorituskykyä. Tähän tavoitteeseen tutkielma tähtää identifioimalla hyödyllisiä indikaattoreita, jotka voisivat muodostaa KPI-mittariston kiertotalouden liiketoimintamalleille.

Tutkimustulosten mukaan yksinkertaisten ja kaiken kattavien kiertotalouden KPI-mittareiden kehittäminen on haastavaa. Sen vuoksi tutkielman olennaisin käytännön kontribuutio eli kehitetty konstruktio on muodostettu kahdesta mittarikokoelmasta: ensimmäinen mittaristo sisältää strategisia ja operationaalisia kiertotalouden suorituskykymittareita pääosin yritysten sisäiseen käyttöön ja toinen mittaristo kokonaisvaltaisempia kiertotalouteen liittyviä mittareita.

Tutkielmaa tehdessä ilmeni, että tutkimuskysymys on hyvinkin ajankohtainen. Projektin aikana aiheeseen liittyen julkaistiin useampikin akateeminen tutkimus sekä WBCSD:n selvitysraportti.

Avainsanat kiertotalous, kiertotalouden liiketoimintamallit, suorituskykymittarit, pienet ja keskisuuret yritykset

Table of Contents

1	Introduction	1
1.1	Background and research gap	1
1.2	Research objectives and question.....	4
1.3	Research scope	5
1.4	Research methodology and methods.....	6
1.5	Thesis structure.....	8
2	Literature review of circular economy	9
2.1	Definition of circular economy	9
2.2	Origins of circular economy.....	11
2.3	Key principles of circular economy.....	12
2.4	Objectives of circular economy.....	13
2.5	Current state of circular economy.....	15
2.6	Circular business models.....	18
2.7	Objectives of circular business models	21
3	Literature review of key performance indicators.....	23
3.1	Definition and purpose of key performance indicators.....	23
3.2	Characteristics of key performance indicators	25
3.3	Strategic performance measurement systems	26
3.4	Financial performance indicators	29
3.5	Nonfinancial performance indicators	29
3.6	Key performance indicators for small and medium-sized enterprises	32
3.7	Key performance indicators for circular business models.....	34
4	Constructive research.....	40
4.1	Identification framework of circular economy performance indicators	40
4.2	Research context: circular business models in Finland.....	44
4.2.1	Product as a service	44
4.2.2	Product-life extension.....	44
4.2.3	Renewability.....	45
4.2.4	Resource efficiency and recycling.....	45
4.2.5	Sharing platforms	46
4.3	Selection of case companies.....	46
4.4	Data gathering process	47
4.5	Validity and reliability issues.....	48

5	Research findings.....	49
5.1	Questionnaire: case companies.....	49
5.1.1	Existing circular economy performance indicators.....	50
5.1.2	Current measurement challenges.....	51
5.1.3	Measurement development needs.....	52
5.1.4	Reasons for not using any circular economy performance indicators yet.....	53
5.2	Interviews: case companies	53
5.2.1	Circular economy and its objectives.....	54
5.2.2	Circular economy in business.....	56
5.2.3	Circular economy performance measurement.....	57
5.2.4	Stakeholder expectations	60
5.3	Interviews: stakeholders.....	61
5.3.1	Existing circular economy performance indicators.....	62
5.3.2	Development of circular economy performance indicators	63
5.4	Sustainability reports of large enterprises.....	67
5.5	Online information.....	70
6	Discussion	75
6.1	Analysis	75
6.2	Construction: indicator pools	80
6.3	Weak market test.....	86
6.3.1	Product as a service	87
6.3.2	Product-life extension.....	87
6.3.3	Renewability.....	87
6.3.4	Resource efficiency and recycling.....	87
6.3.5	Sharing platforms	88
7	Conclusion	89
7.1	Research summary.....	89
7.2	Theoretical and practical contributions.....	91
7.3	Research limitations and future research avenues	92
	References.....	94
	Appendix A. Questionnaire: case companies	106
	Appendix B. Interviews: case companies	107
	Appendix C. Interviews: stakeholders.....	108
	Appendix D. Construction: indicator pools	109

List of Figures and Tables

Figure 1. Location of the constructive approach into the established accounting research approaches. Source: Kasanen, Lukka & Siitonen (1993).....	6
Figure 2. Closed-loop objective of the circular economy. Source: Korhonen et al. (2018)	14
Table 3. The indicator dashboard of Pauliuk (2018) comprised from many literature sources	36
Figure 4. Identification framework of circular economy performance indicators	43
Table 5. Case company questionnaire responses.....	50
Table 6. The indicators already used by case companies sorted by business model category	51
Table 7. Measurement challenges of the case companies	52
Table 8. Measurement development needs of the case companies	52
Table 9. Reasons why case companies are not using any circular economy performance indicators yet	53
Table 10. Details of the case company interviews	54
Table 11. Details of the stakeholder interviews	61
Table 12. List of circular economy related indicators on the sustainability reports of large enterprises operating within the circular economy.....	68
Table 13. Environmental disclosure guidance of GRI Standards.....	70
Figure 14. Butterfly diagram by EMF (2015)	72
Table 15. Circular metrics along the life cycle. Source: WBCSD (2018).....	74
Table 16. Circular economy performance indicator themes.....	76

1 Introduction

1.1 Background and research gap

Due to the fact that our ecosystem is facing severe challenges because of the limited resources, waste disposal capability and energy capacity (Singh, Olugu, Musa, & Mahat, 2018), some transformative systemic changes towards more sustainable low-carbon societies will be ahead of us. One proposed systemic change in terms of our economic system is the circular economy (CE), which would at some extent replace the current linear ‘take-make-use-dispose’ economic system. Circular economy is a relatively young concept, especially in academic research, although the central idea has long roots in several similar concepts. Today the popularized idea of circular economy is promoted globally by national governments, political and economic unions, and business practitioners (Korhonen, Honkasalo & Seppälä, 2018). This thesis focuses on the latter economic agent, i.e. the businesses, and more precisely on the small and medium-sized companies operating in the circular economy.

Business sector has a crucial role in the shift towards circular economy. Through business model innovations and revising their operating and revenue models, companies are able to reshape production and consumption patterns towards more sustainable approach. In case the number and market share of the companies operating in the circular economy increases, indicates it growth and transition towards the circular economy in the national and global level. Business opportunities related to circular economy have been recognized worldwide: China, Japan, Canada, the UK, France, Germany, the Netherlands, Sweden and Finland are among the pioneering countries in terms of circular economy and circular business models (Korhonen et al., 2018; Circulate News, 2018). Due to the complexity of the CE-concept, it is challenging to rank countries since each of them have been taken a different angle on CE-issues; for instance, from the European countries, the Netherlands has the highest material reuse rate (27%), whereas the UK, Germany and France have made the biggest investments in CE-sectors (from €21M to €31M) (Politico, 2018).

However, the Finnish government has set a long-term target that Finland aims to become the global leader in the circular economy by 2025 (Sitra, 2016). Finnish business sector plays a key role in this target; The Finnish Innovation Fund Sitra (2016) has identified that the biggest potential lies in five industries: (1) manufacture of machinery and equipment; (2) the forestry-wood chain: from forest management to paper production; (3)

the food chain: from agriculture to retail and restaurant services; (4) construction; and (5) private consumption, e.g. post-consumer waste utilization. From the business sector perspective, the reception of CE has been positive: according to the survey made by Confederation of Finnish Industries (EK, 2015) circular economy is seen as a potential business opportunity especially among Finnish growth companies.

Circular economy provides wide range of business opportunities starting from product and process redesign aiming at resource and cost efficiency to completely new innovations and business models. For instance, the Ellen MacArthur Foundation (EMF) is developing circular business initiatives together with global corporations such as Google, H&M and Nike (EMF, 2018d). While in the Netherlands new circular business innovations such as Foodlogica and Woodyshousing, are an essential part in building Circular Amsterdam, which as a city pursues to reduce GHG emissions and material consumption without compromising economic growth and employment (Circle Economy, 2016; Amsterdam Smart City, 2018).

The Finnish Innovation Fund Sitra (2017) has listed *The most interesting companies in the circular economy in Finland* including 98 companies, of which some are selected as case companies for this research. The list has been divided into five circular business model categories, which are also at the center of this thesis. The business model categories are: product as a service; product-life extension; renewability; resource efficiency and recycling; and sharing platforms. On the Sitra's list there are many innovative startups and SMEs that can be labelled as circular businesses. There is also a dozen of large enterprises, which are deploying different circular business models.

For clarification, the term *circular business* in this thesis means companies whose core business is built around circular economy principles. By contrast the term *circular business model* refers to the business model that apply circular economy solutions and principles but that are deployed also by companies whose core business might not be in line with the circular economy principles. For example, Finnish oil company Neste deploys a circular business model of renewability alongside its core fossil fuel business. The circular economy solution of Neste is renewable diesel production, in which the company uses side streams of other industries such as food manufacturing and forest industry (e.g. waste and residue fat and vegetable oils) as raw materials. In contrast to Neste, an excellent example of a circular business is Sulapac, which core business is biodegradable cosmetics packaging manufacturing aiming to replace plastic usage as raw material. Sulapac's packages are made

from renewable raw materials, i.e. wood chips. In both previous examples the circulation and utilization of materials is made through renewability.

One other example of slightly different material circulation is the business model of Pure Waste Textiles. The company's core business is upcycling, meaning it utilizes textile industry's waste as raw materials of new textile products. In other words, Pure Waste garments and accessories are made 100% from recycled textiles. (Sitra, 2017)

In order to thrive and reach their business goals, companies need to measure and manage their performance. There are various performance dimensions that companies need to manage, such as financial performance, customer satisfaction and quality. Naturally, for the circular businesses the aspect of how they are performing regarding the circular economy is also crucial. In summary, the circularity dimension is one of the most important performance dimensions of circular businesses. However, the circular economy performance of the companies, i.e. the circularity dimension has been studied very little. To date only a handful of academic studies (i.e. Di Maio & Rem, 2015; Franklin-Johnson, Figge, & Canning, 2016; Linder, Sarasini and Loon, 2017; Figge, Thorpe, Givry, Canning & Franklin-Johnson, 2018; Pauliuk, 2018; Mesa, Esparragoza & Maury, 2018) have been published concerning the business performance indicators of the circular economy.

Each of the aforementioned studies have slightly different approach to the circular economy performance measurement. For instance, Pauliuk (2018) bases his indicator dashboard – presented in the chapter 3.7 – on the perspectives of life-cycle assessment (LCA) and material flow cost accounting (MFCA), whereas Di Maio & Rem (2015) focus on material values kept in the economy, Franklin-Johnson et al. (2016) on resource duration, and Figge et al. (2018) on material circulation. All of the indicators these scholars have developed seem useful for businesses. Nevertheless, none of these studies explicitly states what are the key circular economy performance indicators that small and medium sized circular business models could use. This thesis research aims to fill that gap.

Unlike circularity, the other performance dimensions are widely researched performance measurement topics. Beside the traditional dimensions mentioned above, also sustainability dimension, which is a close concept to the circularity, has gained recent attraction in the academia. The practical motivation of this research is well summarized by sustainability measurement researchers Mata-Lima, Alvino-Borba, Akamatsu, Incau, Jard, da Silva and Morgado-Dias (2016), who claim that by identifying and implementing indicators for sustainability evaluation, an organization will gain benefits such as increased stakeholder awareness regarding best practices of sustainability; changes in target audience

behaviors with regard to actions that contribute to sustainability; continuous measurement of the distance between the baseline condition and the level of sustainability against set tangible goals in the medium and long term; improved environmental quality, ecosystem services and organizational image; dissemination of organizational sustainability practices; and generation of positive externalities through diffusion process and outcomes that stimulate other external stakeholders to incorporate monitoring of sustainability indicators into their own activities. This thesis is motivated against the same practical organizational benefits when replacing *sustainability* with *circularity* and bearing in mind that this research covers only the identification phase of the indicator development process and leaves the implementation phase to the further research.

1.2 Research objectives and question

The objectives of this thesis are mainly practical: to help existing and future small and medium-sized circular businesses measure their circular economy performance beside other performance dimensions, and that way enhance their business performance as a whole. The circular economy performance indicators, the CEPIs, proposed in this research are based on the literature review and empirical data. The empirical data has been gathered through a questionnaire sent to the small and medium-sized companies on the Sitra's list of the most interesting companies in the circular economy (2017); interviewing some of those companies; analyzing the sustainability reports of large companies on the Sitra's list; and going through online information about the past and ongoing CEPI-related projects.

The CEPIs of this thesis are meant for internal and external use, i.e. for management and reporting purposes, yet the focus is on the internal indicators. From the research perspective the indicator pools are the main practical contribution, i.e. the business applicable managerial construction. The more ambitious objective of this research is to contribute to the transition from linear to circular economy in Finnish business sector through a valuable set of circularity performance indicators, which assist businesses to deploy circular business models.

The theoretical aim of this thesis is to contribute to the very recent circular economy performance indicator research area by adding circular business models to the examination.

The research question of this thesis is:

What are the key circular economy performance indicators for small and medium-sized circular business models in Finland?

For the sake of clarity, abbreviation *CEPIs* is used throughout this thesis referring to *the circular economy performance indicators*.

1.3 Research scope

As mentioned, Finland aims to become a global leader in the circular economy by 2025 (Sitra, 2016) and therefore this thesis focuses on the Finnish businesses, which operate mainly in Finland. The country-specific approach was selected also due to two other reasons. Firstly, the concepts of circular economy and circular business models varies in some extent between countries. Secondly, the country-specific legislation might have an effect on the development process of the performance indicators.

The SME-approach was selected due to two reasons. Firstly, the majority of the 98 most interesting companies in the circular economy in Finland listed by Sitra (2017) are small or medium-sized companies. Secondly, according to European Commission (2017) SMEs are important contributors to national growth and to the economy of the European Union. The definition for medium-sized organization in the EU is an enterprise which employs less than 250 employees, which turnover is less than 50M€ or balance sheet less than 43M€. The corresponding figures for small enterprise are less than 50 employees, and turnover or balance sheet less than 10M€.

Since the objective of this research is to identify key performance indicators for circular business models, the focus is on the performance dimension of circularity. Other important performance dimensions such as financial performance, customer satisfaction and quality have been taken into account in such extent that overlaps with circularity dimension. These other dimensions and indicators related to them have been studied a lot in the academic literature, whereas circular economy performance indicators have not.

As said, the focus of this thesis is on the five circular business models (CBMs), i.e. product as a service; product-life extension; renewability; resource efficiency and recycling; and sharing platforms. This framing covers the small and medium-sized circular businesses and the circular business models deployed by various companies in different fields listed on the Sitra's list (2017), and possibly on the side some other companies outside the list.

The fifth framing concerns the process of performance measurement development in organizations. This research focuses on the identification phase of CEPIs and leaves out the screening, ranking (Keeble, Topiol & Berkeley, 2003) and implementation phases of the indicator development process. The construction of this thesis, i.e. the indicator pools, aims to provide a valuable set of indicators from which the companies operating in the circular

economy could select those that might become the key circular economy performance indicators for their business. The proposed indicators in this thesis might need some company-specific modification. In addition, the indicators are intended above all for internal strategic use, since external indicators need standardization before they can be implemented properly.

1.4 Research methodology and methods

The research methodology of this thesis is qualitative. Qualitative approach was chosen due to its practical nature of collecting empirical data directly from the field through interviews (Kasanen, Lukka & Siitonen, 1993). The case company interviews in the field are essential for this study in order to end up in a solution that serves the needs of the companies operating in the circular economy.

More precisely, the research methodology in this thesis is constructive case study. Constructive research approach is classified as normative and empirical research methodology; normative referring to the decision-oriented approach and empirical to the action-oriented approach (see Figure 1), both aiming to assist management in running a company (Kasanen, Lukka & Siitonen, 1993). Hence, in constructive research the focus is on the practical relevance. The aim of the constructive research is to develop new management accounting innovations or tools, i.e. constructions. (Rautiainen, Sippola & Mättö, 2014)

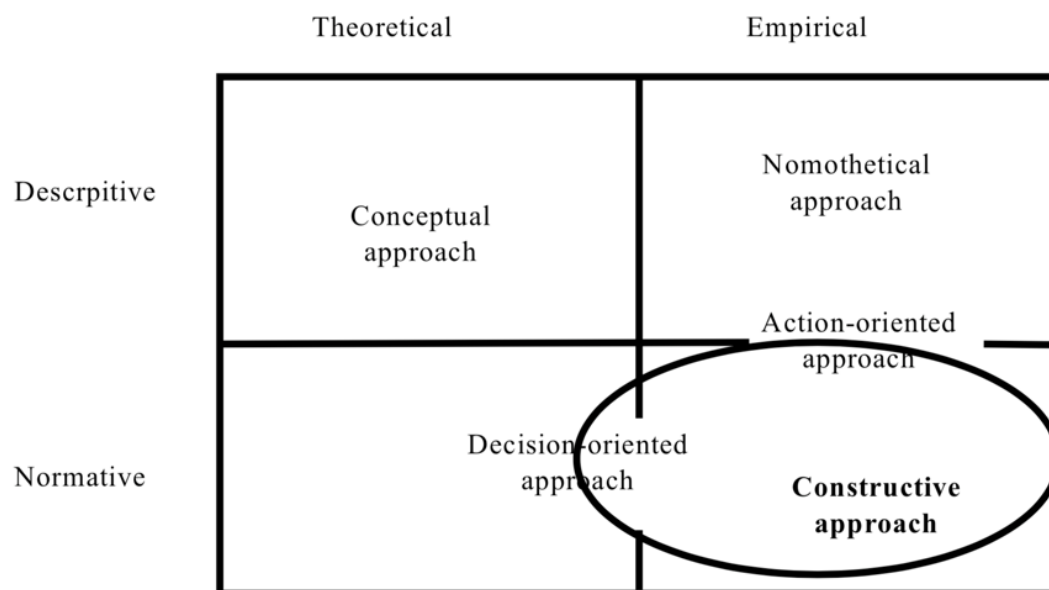


Figure 1. Location of the constructive approach into the established accounting research approaches. Source: Kasanen, Lukka & Siitonen (1993)

According to Kasanen et al. (1993) the most significant managerial constructions in accounting discipline have not been invented merely by academic research, but instead through collaboration between researcher and case companies, and with the help of consultancies. Therefore, in this study the consultancy perspective has been included through consultant interviews alongside with the main data source, i.e. the interviews of the case companies, not forgetting the importance of theoretical framework, because as Kasanen et al. (1993) state “an essential part of the constructive approach is to tie the problem and its solutions with accumulated theoretical knowledge”.

The constructive research approach has a clear process with seven steps. This research follows these steps, which are (Lukka, 2014):

1. Find a practically relevant problem, which also has potential for theoretical contribution.
2. Find out possibilities for a long-term research collaboration with case company / companies.
3. Acquire a comprehensive understanding of the research topic both practically and theoretically.
4. Innovate a solution and develop a problem-solving construction, which might have theoretical contribution as well.
5. Implement the solution and test its functionality (i.e. market test).
6. Consider the applicability of the solution.
7. Recognize and analyze the theoretical contribution of the research.

One of the main factors that separates constructive research approach from other approaches is the market test (step 5), through which the researcher finds out whether the developed constructions work in practice. The market tests have three levels of intensity: weak, semi-strong and strong (Rautiainen et al., 2014). Weak market test, which is applied in this research, means that the researcher has found out whether there is willingness in case companies to implement the developed construction (Kasanen et al., 1993). In this research the weak market test is conducted via email query sent to the case companies, in order to clarify whether the developed initial set of indicators (i.e. the indicator pools) is useful for the case companies in practice.

In this research the empirical data is gathered following the data triangulation approach. Data triangulation is typically used due to its ability to provide better insight and a more depth understanding of the complex phenomenon (Eriksson & Koistinen, 2014). According to Modell (2005) data triangulation can also increase the internal validity and

causal explanations of the study in case divergent data gathering methods produce similar findings. Due to the complexity of CE-concept, the data triangulation is considered to be very valuable for this research. The triangulation of data sources is conducted through case company questionnaire and interviews, stakeholder interviews, document analysis of sustainability reports of large companies using circular business models, and also going through online sources such as circular economy indicator-related project websites. The main data source of this research is the case company questionnaire and interviews, which are complemented by the other data sources mentioned above.

All in all, the empirical data consists 23 case company questionnaire responses, five in-depth case company interviews, five interviews of consultancies, five interviews of public organizations such as research institutes and public foundations, four impact investor interviews, document analysis of 10 sustainability reports of large enterprises deploying CBMs, and five CEPI-related project websites and reports found online.

The in-depth case company and stakeholder interviews were semi-structured gathered around certain themes. The interviewing process helped gaining internal information about the case companies that is otherwise impossible to find out. Since managerial constructions are often developed in cooperation with researchers and consultancies, the second most important data source is the stakeholder interviews.

1.5 Thesis structure

The theoretical part of this thesis, i.e. the literature reviews of circular economy (chapter 2) and key performance indicators (chapter 3), aims to give a comprehensive insight of the research topic. The second chapter covers the concept of circular economy fairly broadly in order to provide deep enough understanding of the novel phenomenon, its origins and current status. The cited academic articles in the chapter 2 are rather new due to the novelty of the circular economy concept, and also for the reason that CE is constantly evolving, and this thesis aims to provide an up-to-date review. The circular economy literature review starts with the target of defining the concept, which is not unambiguous since to date there is no established definition for circular economy. The chapter continues with the brief peek to the origins of the concept in order to understand the fundamental motives and drivers behind it. The second chapter's most important part in terms of this thesis are the subchapters 2.6 and 2.7, which focus on the circular business models and their objectives.

The third chapter provides a literature review of a widely studied concept, namely the key performance indicators. In this chapter the goal is to find out which theoretical findings

are useful in the context of this thesis: small and medium-sized companies and circular business models. Therefore, the most important subchapters are 3.5, 3.6 and 3.7. The chapter 3.5 gives an insight of the nonfinancial indicators such as the sustainability and environmental performance indicators, which form a good basis in the development process of CEPs. The chapter 3.6 describes how KPI-literature discusses the SME-perspective, whereas the chapter 3.7 focuses on the very recent studies regarding the KPIs for circular business models. Considering this thesis, the chapter 3.7 is the most central.

The fourth chapter concentrates on the empirical research; it describes the research context and the five different circular business models currently existing in Finland. The chapter also clarifies, how the case companies had been selected and what was the main criteria of the selection process. Then the chapter describes thoroughly the identification process of the indicators applied in this thesis. After that the thesis naturally continues to the fifth chapter which presents the findings of the interviews and other empirical data.

The sixth chapter reflects the empirical findings with the theory reviewed in the chapters 2 and 3. Based on this analysis the indicator pools are established and presented in the end of the sixth chapter. The proposed indicator pools are then tested through weak market test, and the results are presented in the chapter 7. Finally, the conclusion chapter provides a summary of the key findings and contributions of this research.

2 Literature review of circular economy

The circular economy is still young, yet rapidly evolving and expanding research topic. During this thesis project new studies appeared regularly, and therefore the literature review was updated constantly during the process whenever new findings were published. Hence, the references in this literature review are from the very recent studies. In order to provide in-depth understanding of the constantly evolving phenomenon, this literature review is more extensive than this thesis would require.

2.1 Definition of circular economy

There is no established definition for a circular economy (hereafter CE), yet the existing definitions mainly complement rather than conflict each other. In literature CE is seen as an alternative to a traditional economy. A traditional economy in this context means the dominant neoclassical economics approach, i.e. the linear ‘take-make-use-dispose’ economic model or ‘open-ended’ economic model, which evolved during the industrial

revolution and has been the mainstream practice in developed countries ever since (Ghisellini, Cialani & Ulgiati, 2016; Su, Heshmati, Geng & Yu, 2013). ‘Take-make-use-dispose’ refers to the essence of linear economy; through current production and consumption patterns the economy transforms natural resources into waste, perceiving natural resources as unlimited raw materials. (Murray, Skene & Haynes, 2017).

One widely used CE-definition is created by Ellen MacArthur Foundation (hereafter EMF), which is an organization aiming to “accelerate the transition to a circular economy” by cooperating with various players such as businesses, governments and academia in order to “build a framework for an economy that is restorative and regenerative by design” (EMF, 2018a). EMF was established in 2010 and is now one of the leading CE organizations worldwide (EMF 2018b). EMF defines circular economy as follows (Webster, 2017, p.17):

A circular economy is one that is restorative by design, and which aims to keep products, components and materials at their highest utility and value, at all times. The circular economy is a global economic model that progressively decouples economic growth and development from the consumption of finite resources. It distinguishes between and separates technical and biological materials, keeping them at their highest value at all times. It focuses on effective design and use of materials to optimize their flow and maintain or increase technical and natural resource stocks. It provides new opportunities for innovation across fields such as product design, service and business models, food, farming, biological feedstock and products; and it establishes a framework and building blocks for a resilient system able to work in the longer term.

Korhonen et al. (2018) have studied the CE concept from a critical scientific perspective bridging CE and sustainability science. These scholars suggest the following definition:

Circular economy is an economy constructed from societal production-consumption systems that maximizes the service produced from the linear nature-society-nature material and energy throughput flow. This is done by using cyclical materials flows, renewable energy sources and cascading-type energy flows. Successful circular economy contributes to all the three dimensions of sustainable development. Circular economy limits the throughput flow to a level that nature tolerates and utilizes ecosystem cycles by respecting their natural reproduction rates.

As many other scholars also Prieto-Sandoval, Jaca and Ormazabal (2018) have tried to combine the most important CE-components into an extensive definition in order to achieve the demanded consensus among economic agents. They define CE as:

An economic system that represents a change of paradigm in the way that human society is interrelated with nature and aims to prevent depletion of resources, close energy and material loops, and facilitate sustainable development through its implementation at the micro (enterprises and consumers), meso (economic agents integrated in symbiosis) and macro (city, regions and governments) levels. Attaining this circular model requires cyclical and regenerative environmental innovations in the way society legislates, produces and consumes.

All of the above CE-definitions demonstrate that one commonly used definition of the complex concept is challenging to formulate. Since circular economy is currently a buzz word, the concept would most certainly need a clear and common definition, because at the moment various players in the society modify and take advantage of the concept in a way that may in the end not be aligned with the CE-principles.

However, certain factors can be observed in all of the previous definitions: (1) resource efficiency and value creation through circular material flows, and (2) regeneration of production and consumption patterns. These two elements are also included in the principles of CE, which are more closely discussed in the chapter 2.3.

2.2 Origins of circular economy

The concept of CE originates from various concepts and schools of thought that have been developing over time. Korhonen et al. (2018) state that the theoretical origins of CE are for instance: industrial ecology (Frosch & Gallopoulos, 1989; Graedel, 1996), and its sub-concepts industrial ecosystems (Jelinski, Graedel, Laudise, McCall & Patel, 1992) and industrial symbiosis (Chertow & Ehrenfeld, 2012), cleaner production (Stevenson & Evans, 2004), eco-efficiency (Schmidheiny, 1992), biomimicry (Benyus, 1997), cradle-to-cradle (Braungart & McDonough, 2002), product-service systems (Tukker, 2015), blue economy (Pauli, 2010) and natural capitalism (Hawken, Lovins & Lovins, 2000).

According to Murray et al. (2017) CE has roots also in other concepts such as the Spaceship Earth analogy (Boulding, 1966) and performance economy (Stahel & Reday-Mulvey, 1976), which was developed based on the former. In addition to all the aforementioned concepts, there are undoubtedly many other theories and ideas that can be related to the CE.

What unites all these origins of CE is that they are built around the fact that natural resources are finite and will reach their limits sooner than later. These concepts try to solve the fundamental flaw of the current linear economy; taking natural resources as infinite

means of production. One common concept that is very closely linked to CE and its origins is sustainability. The terms *sustainability* and *sustainable development* emerge continuously in the CE literature, and it could be argued that sustainable development is one of the key drivers of CE. At the core of the sustainable development is again the scarcity of resources, i.e. non-renewable natural resources. The original and established definition of sustainable development was formed by WCED (1987):

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

2.3 Key principles of circular economy

The CE-principles can be compressed into the 3R: reducing, reusing and recycling materials in production and consumption (Vasiljevic-Shikaleska, Gjozinska & Stojanovikj, 2017; Franklin-Johnson et al., 2016; Su et al., 2013; Sakai et al., 2011). According to Ghisellini et al. (2016) the principle of reduction refers to the ideology of eco-efficiency¹ aiming to minimize the energy and raw material usage in the processes of production and consumption. The reuse-principle includes methods which enable the products and components to be used again for the same purpose they were originally designed. The third principle, the recycling principle, relates to waste management and according to the European waste directive (2008/98/EC) refers to “any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations”. (Ghisellini et al., 2016)

The European Environment Agency (EEA, 2016) have listed key characteristics of the CE, which have a strong focus on the resource usage: (1) less input and use of natural resources, (2) increased share of renewable and recyclable resources and energy, (3) reduced emissions, (4) fewer material losses/residuals and (5) keeping value of products, components and materials in the economy.

Also, EMF (2018b) highlights the efficient use of resources in its three CE principles: (1) design out waste and pollution; (2) keep products and materials in use and (3) regenerate natural systems. By the third principle EMF (Webster, 2017. p.144) means the idealized

¹ “Eco-efficiency is achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the Earth’s estimated carrying capacity.” (WBCSD, 1992)

schematic of the CE, where “the loop is eventually closed on the biological side and on land via the agency of sunlight, fungi and bacteria and the other communities of life in the soil”. Unlike the 3R approach, EMF underlines the designing phase of products, by which waste is supposed to be avoided in the first place. With the help of suitable and sustainable design the products and components can be repaired and reused more efficiently, and thus waste is minimized.

The two terms which appear a lot in the CE publications are *restorative* and *regenerative*. According to Pauliuk (2018) “‘restorative’ refers to spent resources being fed back into new products and services, and ‘regenerative’ refers to the enabling of living systems to heal and renew the resources that are consumed”. These two concepts can also be seen as the key principles of the CE.

In his master’s thesis Mouazan (2016) constructed an overview of the eight key circular economy principles based on related schools of thoughts. These principles are clean materials, resilience, renewable energy usage, systems thinking, resource-efficiency, cascading, acting locally and performance principle. Only one of these eight principles is considered in all of the investigated schools of thought; namely the principle of resource-efficiency.

2.4 Objectives of circular economy

The ultimate objective of the CE is to decouple economic growth from resource consumption and environmental degradation (Murray et al., 2017; Ghisellini et al., 2016). In other words, the CE pursues economic growth like traditional linear economy. Yet, unlike traditional economy CE aims to economic growth that does not compromise the environmental and social sustainability goals (Korhonen et al., 2018). However, what separates CE objectives from the UN’s sustainability goals is that CE focuses on the environmental benefits and economic systems and only indirectly consider social issues (Geissdoerfer, Savaget, Bocken & Hultink, 2017; Murray et al., 2017).

According to Korhonen et al. (2018) “the environmental objective of CE is to reduce the production-consumption system virgin material and energy inputs and waste and emissions outputs by application of material cycles and renewable-based energy cascades”. Whereas, the economic objective of CE focuses on decreasing costs of feedstock, energy, waste management and emissions control, and creating new market opportunities for businesses. Korhonen et al. (2018) take social sustainability into account and according to

them the social objective of the CE highlights changes in consumer preferences such as shifts towards sharing economy and collaborative consumption. (Korhonen et al., 2018)

In terms of resource consumption, one of the practical objectives of the CE is to close the material flow loops in the economic system by promoting the implementation of the cyclical closed-loop production patterns such as production service systems² or product as a service -systems offering product remanufacturing, repairing and refurbishing services. This aim of closing the loops will enhance the efficient use of raw materials and energy, thus minimize waste and greenhouse gas emissions and reduce the demand of virgin resources. Ideally these circles would eliminate all waste to zero. (Manninen, Koskela, Antikainen, Bocken, Dahlbo & Aminoff, 2018; Vasiljevic-Shikaleska et al., 2017; Ghisellini et al., 2016)

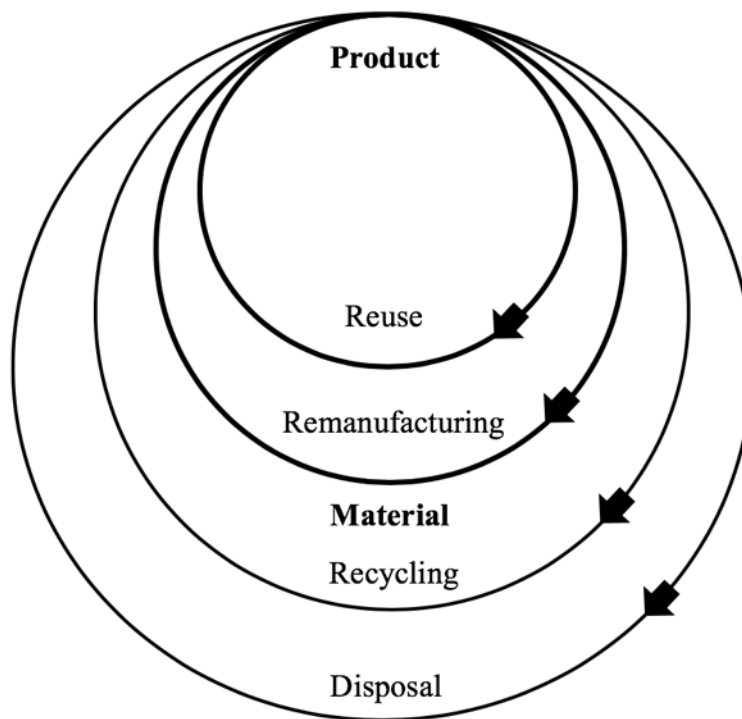


Figure 2. Closed-loop objective of the circular economy. Source: Korhonen et al. (2018)

Figure 2 illustrates the closed-loop objective. The aim is to maximize the time the value of a product spends within the circles of reuse, remanufacturing and recycling; particularly in that order of circles. The inner circle, namely the loop of reuse, repair or refurbishment is the most desirable, then comes the remanufacturing circle and finally material utilization i.e. recycling. When the material cannot be recycled anymore, the second last option is the combustion to energy and the final option is landfill disposal. Hence,

² Product service systems are systems providing both products and product-related services such as transportation, installation, upgrade, maintenance and repair services (Wang et al., 2013).

product durability can be seen as a desired product characteristic keeping its value longer within these material loops. (Korhonen et al., 2018)

In addition to closed-loop economic model enhancing material use of existing products at the end of product life, CE takes into account product life cycle more comprehensively. All stages of the product lifecycle, i.e. beginning, middle and end of life, are considered in CE (Manninen et al., 2018). The other practical objective of CE is the idea of design to re-design, meaning carefully considering the designing phase of the product. By disruptive product design product reuse and material utilization can be achieved better. (Murray et al., 2017)

In addition to previous aims, the higher-level targets of CE are redesigning systems within industries restoratively, redefining the concept of value and reshaping production and consumption patterns (Murray et al., 2017). It can be argued that this kind of wider cultural change is simultaneously an enabler and an objective of CE. Without a systematic change in how we value private ownership, autonomy and economic growth, CE cannot be achieved.

2.5 Current state of circular economy

This chapter takes a look at the current state of CE emphasizing the topicality of the subject. CE has attracted recent interest among policymakers, business world and academia worldwide (Geissdoerfer et al., 2017; Franklin-Johnson et al., 2016). In pioneering countries such as China, Japan, Canada, the UK, France, the Netherlands, Finland and Sweden governments and businesses have made numerous CE initiatives. For instance, the Chinese government adopted the circular economy law in 2008, as the first country in the world. (Korhonen et al., 2018) In addition to that, in May 2017 the British Standard Institution launched the first circular economy standard “BS 8001:2017 – Framework for implementing the principles of the circular economy in organizations” (BSI, 2017).

In addition to certain national governments, many business foundations and consultancies have strongly contributed to the current condition of CE. Most visible contributions are made by Ellen MacArthur Foundation (EMF), and McKinsey and Company. In Finland the main CE-promoters are for example Sitra, Gaia Consulting, Ministry of the Environment, Business Finland and Motiva.

According to the estimations made by Ellen MacArthur Foundation the global circular economy markets are worth of \$1.000 billion. In Europe it has been estimated that the net benefit of the CE for the European economy could be even up to €1.800 billion by 2030, and the corresponding number in Finland's economy is €1,5-2,5 billion. Businesses are at the

heart of this value creation; in Finland the biggest potential lies in five sectors: (1) manufacture of machinery and equipment; (2) the forestry-wood chain: from forest management to paper production; (3) the food chain: from agriculture to retail and restaurant services; (4) construction; and (5) private consumption (post-consumer waste utilization). (Sitra, 2015 and 2016)

CE provides wide range of value creation opportunities starting from product and process redesign of the businesses aiming at resource and cost efficiency to completely new innovations and business models. For instance, the Ellen MacArthur Foundation develops circular business initiatives together with global corporations such as Google, H&M and Nike (EMF, 2018d). Whereas in the Netherlands new circular business innovations such as Foodlogica and Woodyshousing, are an essential part in building Circular Amsterdam, which pursues to reduce GHG emissions and material consumption without compromising economic growth and employment (Circle Economy, 2016; Amsterdam Smart City, 2018).

In Europe the European Union has been promoting CE during the past four years. The kick-off was in 2015 when European Commission announced *Closing the loop – An EU action plan for the Circular Economy*, which has been implemented with annually updated *Circular Economy Package*. The CE approach of the EU is mainly economic-oriented focusing on the economic growth and value creation, but also aiming to achieve the UN's Sustainable Development Goals for 2030. (Manninen et al., 2018; Antikainen & Valkokari, 2016)

In contrast to the EU, the Chinese approach towards CE can be described as a top-down political aim in contrast to other countries where CE is more like an instrument for designing bottom-up environmental and waste management policies initiated by NGOs and environmental organizations. In China the transition to CE is an inevitable consequence of the fact that limitations of natural resources are on the way of the country's industrial development, which was not the case in developed countries during the industrial revolution. (Ghisellini et al., 2016)

What comes to the academia, the current status of academic CE-research can be portrayed as rapidly emerging area of research, which is on a journey of self-discovery. The number of CE-publications have been increasing exponentially over the last five years. As being a very young research area, CE-research is seeking its own direction; some disagreement over the definition of CE and the relationship between sustainable development and CE still exist. The academic roots of the concept are in Europe, yet most

of the research has been conducted in China after the implementation of CE law in 2008. (Manninen et al., 2018; Geissdoerfer et al., 2017)

The successful execution of CE requires consideration of all levels of the society: macro, meso and micro. The macro level in terms of CE means the development of collaborative networks such as eco-cities, eco-communities and eco-regions. In addition to these networks macro level includes collaborative consumption models (e.g. sharing and lending) where the ownership is divided with several consumers and laws enforcement. At the meso level the current infrastructure and services should be exploited more efficiently through the concepts such as eco-industrial parks, industrial symbiosis³ districts and waste management. The micro level consists for example cleaner production techniques (e.g. lower GHG emissions), eco-design⁴ and consumers' responsibility. (Vasiljevic-Shikaleska et al., 2017; Ghisellini et al., 2016) From the business perspective WBCSD (2018) adds the nano level, meaning the product and component level in which the life cycles and raw materials play important roles. The nano level is the most important in terms of this thesis.

Regarding the macro level and consuming patterns, the current consumption model emphasizes individual ownership of property, whereas in CE consumption can be described more as a sharing economy⁵. The next big step towards CE is tackling one of the cultural barriers, i.e. shaping consumer behavior and attitudes in accordance with CE principles. While certain national governments, numerous businesses and researchers are promoting CE, consumers and the change in consumption culture are the key players in order the shift towards CE to be successful. (Hazen, Mollenkopf & Wang, 2017; Vasiljevic-Shikaleska et al., 2017; Antikainen & Valkokari, 2016; Ghisellini et al., 2016)

Also some criticism has emerged over the CE concept. Zink and Geyer (2017) claim that CE might create a rebound effect; by increasing production efficiency through the material reuse, production costs and therefore end-product prices decrease, which finally leads to rise in consumption, which in turn has negative environmental effects. Some authors state that as long as the economic growth is desirable outcome, environmental impacts

³ "The essence of industrial symbiosis is taking full advantage of by-product utilization, while reducing residual products or treating them effectively. The term is usually applied to a network of independent companies that exchange by-products and possibly share other common resources." (Zhu et al., 2007 in Ghisellini et al., 2016)

⁴ "Ecodesign aims to design products where the minimizing of their environmental impact throughout their life cycle is considered." (Paula Pinheiro, Jugend, Dematte Filho & Armellini, 2018)

⁵ "In the sharing economy, office spaces are shared or empty office spaces are converted to housing, cars are not necessarily owned rather used by many individuals who utilize the digital economy for coordinating the shared use. Vacation apartments can be used by many families by benefiting from digital economy thus preventing the building of new spaces that would be empty for most of the year." (Korhonen et al., 2018)

increase. This is due to the fact that economic growth consists growing consumption patterns and entropy⁶. (Korhonen et al., 2018)

Nevertheless, CE has gained mostly positive publicity and is being heavily promoted by many public organizations. According to the European Environment Agency (EEA, 2016) there are seven enabling factors of CE: (1) eco-design; (2) repair, refurbishment and remanufacture; (3) recycling; (4) economic incentives and finance; (5) business models; (6) eco-innovation; and (7) governance, skills and knowledge. This thesis focuses on the fifth factor, i.e. on the business models.

2.6 Circular business models

There are many slightly different definitions for business models in literature. Osterwalder and Pigneur (2010, p.14) outline business model as a concept that “describes the rationale how an organization creates, delivers and captures value”. Bocken, Short, Rana and Evans (2014) add value proposition to the above-mentioned listing. According to Teece (2010) a business model frames how a company creates economic value from resources and competences. Hsieh, Nickerson and Zenger (2007) specify that value creation takes place through problem solving; value is created if the solution to a customer’s problem is produced with less costs than is its value i.e. selling price for the customer. Clearly, all the definitions contain the fundamental idea of value creation.

The logic of value creation is also focal element in the transition to a more sustainable economic model, e.g. the CE. This transition requires disruptive business model innovations⁷, which redefine the business purpose and the logic of value creation by renovating production processes and revenue models. A sustainable business has a value proposition that offers ecological and/or social value in addition to economic value. It includes also cooperation within networks, i.e. between companies, industries and their stakeholders. (Antikainen & Valkokari, 2016; Bocken et al., 2014)

In literature (Antikainen & Valkokari, 2016; Bocken et al., 2014; Manninen et al., 2018) circular economy business models or circular business models (hereafter CBMs) are

⁶ “... due to the second law of thermodynamics, entropy, recycling will always require energy and will always be incomplete generating wastes and side-products (increasing entropy, decreasing exergy) of its own.” (Korhonen et al., 2018)

⁷ “Learning about market conditions is an important part of business model innovation, i.e. the process of devising and realizing a novel way to create and appropriate economic value.” (Linder & Williander, 2017). “Business model innovations for sustainability are defined as: Innovations that create significant positive and/or significantly reduced negative impacts for the environment and/or society, through changes in the way the organization and its value-network create, deliver value and capture value (i.e. create economic value) or change their value propositions.” (Bocken et al., 2014).

usually classified as a subcategory of sustainable business models⁸, which aim to create social and environmental value in addition to economic value. Sustainable business models set their purpose and measure their performance based on the triple bottom line approach (i.e. environmental, economic and social sustainability), where society and the environment are counted as important stakeholders of the company in addition to customers, investors, shareholders, employees and suppliers (Stubbs & Cocklin, 2008). What separates CBMs and sustainable business models is the aspect of social benefits, which CBMs take into account only implicitly.

What comes to the contrast between CBMs and linear business models, the main difference is that CBMs create value by exploiting retained value of used products and materials, whereas value creation of linear models is dependent on virgin resources (Linder & Williander, 2017). Linder and Williander (2017) define CBM as “a business model in which the conceptual logic for value creation is based on utilizing economic value retained in products after use in the production of new offerings”. Typically, CBMs operate around two main ideology: creating value from waste or providing performance instead of products (Stål & Corvellec, 2018). For instance, circular businesses treat waste as valuable raw material as does TerraCycle, and offer products as services rather than traditional ownership of a product which stimulates collaborative consumption and aims at a sharing economy. Good examples of the former are sharing platforms for consumers such as Uber and Airbnb (Antikainen & Valkokari, 2016). CBMs are also collaborative in nature; companies comprise industrial symbiosis whereby waste and residuals of certain company or industry can be used as raw materials in another company or industry. (EEA, 2016)

CBM-innovations evolve around the entire product lifecycle: beginning of life, i.e. in extraction and manufacturing stages; middle of life, i.e. wholesale, retail and logistics; and end of life, i.e. repair, reuse and remanufacturing stages (Manninen et al., 2018). Based on the phases of the lifecycle Vasiljevic-Shikaleska et al. (2017) have categorized CBMs into three main categories: (1) circular innovation models; (2) circular use models; and (3) circular output models. The circular innovation models concentrate on the developing phase of the products aiming to design longer lasting products that can be for example maintained, repaired, upgraded, remanufactured or recycled. The focal element of recyclable products is the development of bio-based or fully recyclable materials. The subcategories of circular

⁸ “A business model that creates competitive advantage through superior customer value and contributes to sustainable development of the company and society” (Lüdeke-Freund, 2010).

innovation models are product design model⁹, process design model¹⁰ and circular supplies model¹¹. (Vasiljevic-Shikaleska et al., 2017)

The second main category, circular use models, focuses on the use phase of the product. These models aim to utilize the value of the products as efficiently as possible by extending its lifetime. Circular use model types are product as a service model (covered in the next paragraph), sell and buy-back model¹², sharing platform¹³, lifetime extension model¹⁴ and tracing facility model¹⁵. Lastly, circular output models, as the third main category, take advantage of the added value of product after the use. These businesses for instance refurbish and resell used products or recaptured materials, convert waste into raw materials and provide collection systems for useful resources and by-products. (Vasiljevic-Shikaleska et al., 2017)

One widely researched type of CBMs is product-service systems or product as a service -model (hereafter PSS). Tukker (2015) defines PSS as “a mix of tangible products and intangible services designed and combined so that they are jointly capable of fulfilling final customer needs”. In other words, PSS is a model which offers access to a product through leasing or renting; the ownership stays with the seller and the customer buys access or right to use (Linder & Williander, 2017). Consequently, in PSS the manufacturers or retailers become service providers selling the performance instead of the ownership of the product (Vasiljevic-Shikaleska et al., 2017) and byers become users (Antikainen & Valkokari, 2016).

PSS has been researched since the mid-1990s among various research fields such as sustainability, business management and engineering design. What makes PSS an environmentally sustainable business model is the fact that materials are used more efficiently and reused as long as possible since businesses pursue to maximize the service life of products. (Tukker, 2015) Mont (2002) provides a list of key elements of different PSSs: (1) combination of products and substituting services; (2) services at the point of sale

⁹ “Provides products that are designed to last longer and/or be easy to maintain, repair, upgrade, refurbish, remanufacture or recycle.” (Vasiljevic-Shikaleska et al., 2017)

¹⁰ “Develops processes that increase the reuse and recyclability potential of by products and waste streams.” (Vasiljevic-Shikaleska et al., 2017)

¹¹ “Provides input materials such as renewable energy, bio-based, less-resource intensive or fully recyclable materials.” (Vasiljevic-Shikaleska et al., 2017)

¹² “Sells a product on the basis that it will be purchased back after a period of time.” (Vasiljevic-Shikaleska et al., 2017)

¹³ “Enables an increased utilization rate of products by enabling or offering shared use/access/ownership.” (Vasiljevic-Shikaleska et al., 2017)

¹⁴ “Extends the useful life of products and components through repair, maintenance, or upgrade.” (Vasiljevic-Shikaleska et al., 2017)

¹⁵ “Provides services to facilitate the tracing, the marketing and trade of secondary raw materials.” (Vasiljevic-Shikaleska et al., 2017)

(e.g. personal assistance, product use explanations and marketing); (3) different concepts of product use; (4) maintenance services; (5) revalorization services (e.g. reclaiming products, reutilizing reusable parts and recycling materials). Examples of PSSs are on-demand media streaming services (Netflix), mobility as a service e.g. peer-to-peer car sharing systems (Zipcar), lighting as a service (Philips) and clothing as a service -models.

2.7 Objectives of circular business models

In theory, it could be assumed that the objectives of CBMs are similar with CE-objectives, yet naturally the key objectives vary among companies depending on the industry and business model. In order to form key performance indicators for CBMs one of the aims of this research is to find out what are the main business goals of the companies operating in circular economy. This chapter reviews how the existing academic literature describes the business goals of CBMs.

Traditionally a business is considered to be successful based on their economic performance, and thus the business objectives are mainly financial. As Merchant and Van der Stede (2011) state “the primary objective for for-profit organizations is to maximize shareholder (or owner) value, or firm value for short, subject to some constraints, such as compliance with laws and adequate concerns for employees, customers and other stakeholders”. This originates from the Keynesian ideology introduced by Milton Friedman (1970) in which the guiding idea is that businesses’ sole purpose is to maximize their shareholders’ wealth. From the sustainability perspective this profit-normative approach (Upward & Jones, 2016) is too constricted. Sustainable development and CE both deal with the corporate responsibility beyond the responsibility to the shareholders, taking into account also other stakeholders of the business such as society and environment.

Unlike in conventional businesses, a more comprehensive view of value is adopted in many contemporary sustainable business models integrating economic, social and environmental targets of a company (Manninen et al., 2018). This more comprehensive view of value is linked to the stakeholder theory first introduced by Freeman (1984) and advanced by many other scholars after him. Stakeholder theory addresses the more extensive view of organization’s stakeholders and their demands to be considered in managerial decisions. According to Freeman (1984) a stakeholder is “any group or individual who can affect or is effected by the achievement of the organization’s objectives”. Thus, society and environment are both essential stakeholders of a company. It has been studied that preserving stakeholder collaboration assist an organization tackle social and environmental problems

and improve its long-term performance, also the financial performance (Savage et al., 2010). As collaboration is also one principle of CE, different CBMs throughout the value chain should cooperate with each other; starting from the designers, through suppliers and service providers ending up to the end-of-product-life companies (Vasiljevic-Shikaleska et al., 2017). Hence, CBMs aim, or at least should aim at higher rate of collaboration with stakeholders.

While in theory CBMs seem win-win solutions in terms of business profits and sustainable development, there has been some concerns over the business logic of CBMs in practice. For instance, CBMs relying on renting and leasing such as PSS have difficulties in implementation due to possible challenges with consumer preferences, necessary profound changes in network configurations and increasing financial risks (Stål & Corvellec, 2018). In addition, Melissen and Moratis (2016) remark that “the dominant coordination mechanism within our current socioeconomic system is that of the free market and this means that, in order to survive, a business has to try to increase its market share and profits.” However, the profit maximization objective is not always in line with sustainable development.

The other concern of some scholars is the social dilemma, i.e. the concerns that the consumers might not be satisfied with the sustainable products and services and therefore the desired positive influence on our society is not reached. For this reason, CBMs should aim at developing products and services that beside sustainability have some other appealing factors for the consumers. In other words, CBMs should be targeting to win-win-win situation that “finds a balance between the self-interests of involved actors and thereby influences and facilitates their actions in order to cooperatively shape the circular business model” (Antikainen & Valkokari, 2016).

As can be observed, CBMs’ objectives differ at least in some extent from the objectives of more traditional linear businesses. What comes to the objectives, in order to achieve them, organizations need to measure their performance. Usually businesses measure their performance with performance indicators, of which the most important are the key performance indicators. Key performance indicators have a long and diverse history in academic research, and the next chapter reviews this research area, naturally focusing on the useful aspects for CBMs.

3 Literature review of key performance indicators

At the core of any business is the question “why it exists”. The *why* is translated into the key business objectives, and these objectives form the strategy of the business. In order to achieve these objectives, the organization needs key performance indicators that are aligned with the strategy, and therefore provide answers for the questions of how the organization is performing in terms of its objectives and what should be done next.

Key performance indicators (hereafter KPIs) are widely researched subject in management and accounting studies. The number of performance measurement publications per year have increased substantially over the last three decades. While researchers agree that performance measurement has a high relevance in terms of efficient and effective organizational management, the questions of what should be measured and how, create constant debate among scholars. (Neely, 2005; Kennerley & Neely, 2002)

This chapter focuses on reviewing KPI-related literature in order to understand how performance measurement practices have been evolving over time and how organizations traditionally measure their performance. Above all, this chapter aims to find out what aspects of traditional performance measurement literature can be used in order to form KPIs for circular businesses, whose aims are beyond the economic or financial performance, and whose “why” is most likely something else than maximizing shareholders’ wealth.

3.1 Definition and purpose of key performance indicators

According to Kennerly and Neely (2002) performance measurement is “the process of quantifying the efficiency and effectiveness of past actions”. This process naturally includes performance measures or indicators, of which some are the most important ones, i.e. the key performance indicators (KPIs).

According to Lo-Iacono-Ferreira, Capuz-Rizo and Torregrosa-López (2018) KPIs “are indexes used to evaluate the crucial factors related to a defined goal”. According to Bogetoft (2013) KPIs “are numbers that are assumed to reflect the purpose of the firm in some essential way”. According to Parmenter (2010) KPIs “represent a set of measures focusing on those aspects of organizational performance that are the most critical for the current and future success of the organization”. Simply put, KPIs are the most relevant of all the performance indicators of a certain business.

Traditionally, performance indicators are divided into two main categories: (1) financial or cost-based indicators measuring the financial performance of a business; and (2)

nonfinancial or non-cost-based indicators measuring the operational performance (Saunila, 2016; Ishaq Bhatti, Awan & Razaq, 2014). Since the 1980s, nonfinancial indicators have been gaining popularity beside the conventional financial indicators due to the growing complexity of organizations and the constantly changing market expectations (Neely, 2005).

Other categorizing methods exist in literature as well. For example, Brignall, Fitzgerald, Johnston and Silvestro (1991) divide performance measures as follows: (1) result-related indicators i.e. competitiveness and financial performance indicators; and (2) indicators that focus on the determinants of the results e.g. flexibility, quality and innovation. This thesis suggests that circular economy performance or circularity falls into the latter category.

Performance indicators have internal and external purposes. Internally KPIs can be used for management control, analysis and decision-making purposes, e.g. achieving alignment with organizational objectives by managing processes and activities, and improve them continuously (Saunila, 2016; Hervani, Helms & Sarkis, 2005). According to Stefanovic (2015) the purpose of the KPIs is to help managers to recognize the strength and weaknesses of the defined business goals and implement these goals more efficiently in order to gain competitive advantage. Other internal purposes are for example rewarding and motivating, and communication and feedback purposes (Saunila, 2016). KPIs can also be applied to external reporting and communicating with stakeholders. Then the main users of the information are stakeholders such as investors, suppliers, regulatory agencies and competitors (Bogetoft, 2013).

In literature, both financial and nonfinancial indicators are seen as essential measures for internal and external purposes. Cohen, Holder-Webb, Nath and Wood (2012) highlight that investors are able to better assess the key areas of an organizational performance through nonfinancial indicators. On the other hand, Bryant, Jones and Widener (2004) remind that in order the management to understand value drivers of a business, all the core aspects should be measured in addition to financial results.

Hudson, Smart and Bourne (2001) have listed six critical dimensions of business performance based on the comprehensive literature review. According to them these performance dimensions are: finance, quality, time, flexibility, customer satisfaction and human resources. The measures under these six dimensions are for example:

finance: cash flow, market share, sales, profitability and efficiency;

quality: product quality, delivery reliability, scrap and suppliers;

time: lead times, work in progress and delivery time;

flexibility: manufacturing effectiveness, volume flexibility and future growth;

customer satisfaction: user problems, service and integration with customers;

human resources: safety, staff turnover and quality of work life.

Two other dimensions for which the existing academic research have developed performance indicators are environmental/social performance, and learning and growth (Ishaq Bhatti et al., 2014). This thesis suggests adding the ninth performance dimension, thus: the dimension of circularity, to the list above. The aim of this thesis is to develop the set of key performance indicators for this ninth performance dimension crucial for circular business models.

3.2 Characteristics of key performance indicators

Hudson et al. (2001) have listed seven critical characteristics of performance measures. According to them the performance measures should: (1) be derived from strategy; (2) be clearly defined with an explicit purpose; (3) be relevant and easy to maintain; (4) be simple to understand and use; (5) provide fast and accurate feedback; (6) link operations to strategic goals; and (7) stimulate continuous improvement.

In addition, performance indicators have to be usable, comparable and consistent (Lo-Iacano-Ferreira et al., 2018). They also need to be SMART, i.e. Specific, Measurable, Achievable, Relevant, and Timely (Doran, 1981). Carlucci (2010) emphasize the characteristics of relevance, reliability, comparability, consistency and understandability. The demand of measurability refers to the fact that even though qualitative information is important when assessing the performance of a company, due to their nature the performance indicators can only express quantitative aspects (Lo-Iacano-Ferreira et al., 2018).

Parmenter (2010) have listed seven characteristics of KPIs from consultative point of view. According to him the KPIs must: (1) be nonfinancial measures; (2) be measured frequently; (3) be acted on by the CEO; (4) clearly indicate what action is required by staff; (5) tie responsibility down to a team; (6) have a significant impact; and (7) encourage appropriate action. According to him the second characteristic, a frequent measurement, means that the KPIs should be tracked more often than on a monthly-basis, otherwise they cannot be the most crucial indicators. The sixth characteristic refers to the requirement of KPI to have a link to and an effect on one or more of the critical success factors of the business, the strategic objectives of the organization and more than one balanced scorecard perspective. In other words, the organization should measure only what it *needs* to measure.

In academic literature, also financial indicators are included in KPIs unlike Parmenter (2010) states. Financial indicators are covered more comprehensively in financial accounting literature, whereas in contemporary management accounting literature nonfinancial performance indicators are emphasized.

Parmenter (2010) also draws distinction between performance indicators and result indicators. According to him performance indicators are current- or future-oriented, guiding the management what needs to be done next, and result indicators measure the results of the past events. Unlike performance indicators, result indicators are mainly financial measures. Examples of result indicators are customer and employee satisfaction, profit figures and ROI-measures.

In academic literature the similar distinction is made between leading and lagging indicators. Lagging indicators are history-oriented indicators measuring the final outcomes of certain actions, whereas leading indicators guide management in its future actions. Leading indicators provide information about the cause of the results, guiding the decision-maker to either take or avoid certain actions in order to either achieve or avoid certain outcomes. This is crucial when making strategic decisions. Leading indicators are not meant for measuring current conditions, but instead “they should form part of an organizational initiative toward continual improvement of operating processes”. (Pojasek, 2009)

For the aforementioned reasons leading nonfinancial performance indicators (and thus KPIs) are better at measuring the performance of sustainable businesses such as circular businesses. On the other hand, also lagging indicators are needed for example for reporting purposes.

3.3 Strategic performance measurement systems

Strategies are at the heart of businesses. Simons (2000) divides strategies into corporate strategies and business strategies. According to him a corporate strategy “defines the way that a firm attempts to maximize the value of the resources it controls”, whereas a business strategy considers the question of how to compete in certain product or service markets. In order to formalize and implement business strategies companies use performance measurement applications. (Simons, 2000)

Academic research of performance measurement applications can be divided into two main streams: management control systems¹⁶ and (strategic) performance measurement

¹⁶ “Management control is the process by which managers ensure that resources are obtained and used effectively and efficiently in the accomplishment of the organization’s objectives” (Anthony, 1965, p.27).

systems (PMSs). The latter has been a fast-growing research area since the mid-1980s, and it is also studied from the perspective of small and medium-sized companies (Garengo, Biazzo & Bititci, 2005). Yet, the majority of the existing PMS-research is for large organizations, and therefore the subject is covered only superficially in this thesis.

Strategic performance measurement systems (SPMSs) are applications of KPIs. These systems are sets of financial and nonfinancial performance measures developed for managerial purpose of aligning actions with the strategy (Rodrigue, Magnan & Boulianne, 2013). The aim is converting strategy into a consistent combination of indicators (Chenhall, 2005). Traditional performance measurement systems are focused on the financial and historical measures, while SPMSs developed after the mid-1980s emphasize the balanced and more comprehensive perspective (Hudson et al., 2001). Franco-Santos (2012) states that these contemporary systems “facilitate the development, implementation, and review of business strategies by focusing people’s decisions and actions on strategic goals and by encouraging a continuous dialogue about strategic endeavors”.

Kennerley and Neely (2002) highlight that PMSs need to be balanced and dynamic. Some researchers also emphasize that the measures need to be interconnected through cause-and-effect relationships (Franco-Santos, 2012; Malmi, 2001). Many scholars see clarity and simplicity as the key characteristics of SPMSs, especially when considering SMEs (Garengo et al., 2005).

According to Franco-Santos et al. (2007) the PMSs have five roles: (1) traditional performance measurement/monitoring; (2) strategy management; (3) communication; (4) influence behavior; and (5) learning and improvement. Proper PMSs can also have positive effect on managers’ cognition and motivation (Hall, 2008), and employee performance and satisfaction (Lawson, Stratton & Hatch, 2003).

In literature and practice, the most well-known SPMS is the Balanced Scorecard (BSC) invented by Kaplan and Norton (1992). BSC implies that the performance of an organization needs to be measured comprehensively from four perspectives, which are financial, customer relations, internal processes and learning and growth. BSC is composed from financial and nonfinancial measures, short-term and long-term objectives, lagging and leading indicators, and internal and external business performance targets, aiming to balance all these aspects listed above through cause-and-effect relationships. The initial idea of BSC was to link the four perspectives and the measurements to the strategy and vision of an organization. Since then, the BSC has been evolving a lot due to a vast amount of research

and is nowadays one of the most used tools of strategic management systems, also in Finnish companies. (Kaplan & Norton, 1992; Malmi, 2001)

BSC has been studied mainly in large organizations, yet some SMEs have also applied BSC. The literature indicates that in some occasions BSC helps SMEs in long term planning by supporting the strategy implementation and innovation processes (Lonbani, Sofian & Baroto, 2016). Some practitioners have suggested adding certain aspects to the original BSC. For instance, Parmenter (2010) adds two complementary perspectives: environment/community and employee satisfaction. Sustainability researchers have suggested three alternatives how to incorporate sustainability issues into the original BSC: (1) generating a separate sustainability BSC; (2) adding a fifth perspective; or (3) integrating sustainability indicators to the original four perspectives (Butler, Henderson & Raiborn, 2011). This thesis suggests incorporating circularity into the BSC using the second or third method.

BSC has gained a lot of popularity among companies, yet also other PMSs for managerial purposes have been developed. These are for example the performance prism (Kennerley & Neely, 2002), the organizational performance measurement (OPM) (Chennell, Dransfield, Field, Fisher, Saunders and Shaw 2000), the integrated performance measurement system (Bititci, Carrie & McDevitt, 1997), the levers of control framework (Simons, 1995), the SMART pyramid (Lynch & Cross, 1991), the results and determinants framework (Brignall et al., 1991), and the performance measurement matrix (Keegan et al., 1989). All the previous systems, except the OPM model invented by Chennell et al. (2000), are more or less developed for large enterprises.

The OPM (Chennell et al., 2000) is based on the principles of alignment, process thinking and practicability. Alignment refers to the objective of performance indicator selection based on the encouragement of employees to align their efforts with the strategic objectives of the company, whereas process thinking refers to the link between measurement system and process monitoring, control and improvement. The third principle, practicability, combines alignment and process thinking and transforms them into a purposeful measurement system. (Chennell et al., 2000)

In addition to the OPM, also Laitinen (1996) has developed a performance measurement system suited for small companies, called the integrated performance measurement system (IPMS) for small firms. The IPMS includes seven performance dimensions (financial, competitiveness, costs, production factors, activities, products and revenues) and the causality between these dimensions. One noteworthy highlight made by

Laitinen (1996) is that seemingly small firms include also qualitative and informal measures to their IPMS in addition to traditional financial and nonfinancial indicators.

As both KPIs and SPMSs include financial and nonfinancial indicators, these two categories of indicators will be covered next, yet paying more attention to nonfinancial indicators, since they fit better into the scope of this research.

3.4 Financial performance indicators

Traditionally the business performance is measured mainly through financial indicators related to the cash flow, such as operating profit, profit margin, current ratio and economic value added. Upward and Jones (2016) call conventional businesses as profit-normative businesses, which perceive their success only through economic performance. Nowadays organizations have a pressure to produce value to multiple stakeholders in addition to their shareholders, and thus nonfinancial measures are gaining more popularity beside the traditional financial metrics (Franco-Santos, 2012). Even though nonfinancial indicators have been gaining their foothold, most well-known KPIs are still financial: gross margin, ROI, debt ratio and price-to-book (Bogetoft, 2013).

Merchant and Van de Stede (2011) divide financial indicators into two categories: market measures (stock price changes and shareholder returns), and accounting measures (operating profit, EVA, ROI etc.).

The advantages of financial indicators are cost-effectiveness, relatively easy composition and comparability; especially for publicly traded firms the financial indicators are timely and relatively accurate. The biggest downsides of financial indicators are myopia and controllability problems. Particularly accounting measures contribute to short-termism in managerial decisions. (Merchant & Van der Stede, 2011; Kennerley & Neely, 2002)

According to Merchant and Van der Stede (2011) the profit maximization objective is a future-oriented vision focusing on long-term targets. These authors state that financial performance indicators focusing on accounting profit and return metrics are too short-sighted, yet in many large organizations the top-level managerial decisions are based mainly on financial measures.

3.5 Nonfinancial performance indicators

Over the past few decades financial indicators have been complemented by nonfinancial performance indicators due to a growing interest on corporate responsibility and sustainability issues. The importance of nonfinancial information is growing constantly

especially among large public-interest companies. From the beginning of the fiscal year 2017, the EU directive 2014/95/EU has required large public-interest enterprises that employ more than 500 employees to disclose certain nonfinancial social and environmental performance information in their annual report (European Commission, 2014). However, the directive does not take a stand on what sustainability indicators should be disclosed.

In addition to sustainability indicators, traditional nonfinancial indicators are for example quality, flexibility, customer satisfaction and internal business performance (Bahri, St-Pierre & Sakka, 2017). In terms of this research, one important example of nonfinancial performance indicators are particularly sustainability indicators. Sustainability indicators follow the triple-bottom line approach; measuring environmental, economic and social sustainability. Examples of conventional sustainability indicators for businesses are percent of sales revenues from “green” products, recycling revenues, fines and penalties for pollution, sustainability awards, diversity of workforce and management, volume of hazardous waste and percentage of suppliers with environmental certifications (Epstein & Rejc, 2008). Yet, sustainability issues and thus indicators evolve continuously. Certain sustainability issues are acknowledged globally, such as energy efficiency, resource consumption (water and other raw materials) and the management of solid waste and wastewater.

Regarding the sustainability indicators, Global Reporting Initiative (GRI) is widely used guideline for reporting corporate responsibility issues worldwide. GRI-standard provides guidelines for organizations to present sustainability reports that include the estimation of the organizations’ ability to contribute to the sustainable growth. The standard has guidelines for environmental, social and governance metrics. (Cohen et al., 2012). Also other standards beside GRI have guided organizations to measure their sustainability performance. These are for example the WBCSD Eco-Efficiency Metrics, ISO 26000 Social responsibility), ISO 14001 (Environmental management) and ISO 14031 (Environmental performance indicators), the Sullivan Principles, the UN Global Compact, the ICC Business Charter for Sustainable Development and the standards of OECD (Mata-Lima et al., 2016; Keeble et al., 2003).

Eco-efficiency measurement combines two aspects that are also relevant regarding the circular economy: product or service value and environmental influence. The equation is simply: product or service value divided by environmental influence, yet the number of possible eco-efficiency ratios varies between business models. Examples of generally applicable value indicators, i.e. eco-efficiency ratios’ numerators are (WBCSD, 2000):

Quantity of products or services produced or sold (mass, volume or number)

Economic value of products sold (net sales)

Examples of generally applicable environmental influence indicators, i.e. denominators (WBCSD, 2000):

Energy consumption (total, or in renewable or fossil fuel types)

Water consumption (sum of all fresh water)

Material consumption (excluding energy and water consumption. By types: renewable, nonhazardous etc.)

GHG emissions (CO₂, CH₄, N₂O, HFCs, PFCs, SF₆. In metric tons of CO₂ equivalents)

In addition, WBCSD (2000) have listed the potential generally applicable value indicators: net profit, earnings or income, and influence indicators: total waste and acidification emissions to air. In terms of GHG emissions, Greenhouse Gas Protocol by WBCSD (2002) provides useful and standardized calculation tools that enable reliable calculations of GHG emissions for companies.

Environmental performance indicators (EPIs), which are important CE-related metrics, have gained attention among researchers and practitioners. EPIs can be either financial or nonfinancial metrics indicating the impact an organization has on environment. According to Husgafvel, Pajunen, Dahl, Heiskanen, Ekroos and Virtanen (2017) the developed environmental sustainability indicators cover certain themes which are: air emissions (CO₂, SO₂, NO_x, dusts and metals), water effluent, solid residues (solid wastes, hazardous wastes and utilization rate), efficiency (energy, material and water), production of raw materials (primary material consumption, energy consumption), transportation, total GHG-emissions and legal aspects. ISO 14031 standard mentioned earlier groups EPIs into three categories: environmental condition indicators (ECIs), operational performance indicators (OPIs), and management performance indicators (MPIs). The latter two categories include indicators that are useful for businesses.

Examples of OPIs: recycled or reused materials used; packaging materials reused per unit of product; water reused, toxic materials used in the production process; renewable energy used; carbon dioxide equivalence per unit driven; number of products which can be reused or recycled; percentage of a product's content that can be reused or recycled; durability of the product; percentage of products designed for disassembly, recycling or reuse; resource consumption per unit of service provided; quantity of hazardous, recyclable

or reusable waste produced per unit; and quantity of waste converted to reusable material per unit. (ISO 14031)

Examples of MPIs are: benefits and costs of environmental management to the organization; number of environmental improvement suggestions submitted by employees; time to respond to environmental incidents; ROI for environmental improvement projects; and savings achieved through reductions in resource usage, prevention of pollution or waste recycling. (ISO 14031)

Such as environmental sustainability, also life-cycle assessment (LCA) is an essential concept related to the circular economy. ISO 14044:2006 standard provides guidance for life-cycle assessment. LCA includes altogether 16 environmental impact categories that the companies are recommended to assess, such as: energy consumption, material depletion, waste problem, water resource impacts and biodiversity. In terms of LCA, as part of the Europe 2020 Strategy “A Resource-Efficient Europe” European Commission (2012) has developed the Product Environmental Footprint (PEF) which is a multi-criteria measure of the product’s or service’s life-cycle environmental performance. European Commission provides detailed guidance to calculate and assess PEF.

In addition to LCA, also material flow cost accounting (MFCA) is a concept that strongly relates to the circular economy. MFCA is an environmental management accounting tool, which focuses on the material usage reductions and related economic performance improvements (Christ & Burritt, 2016). ISO 14051:2011 provides a general framework for MFCA and ISO 14052:2017 provides guidance for practical implementation in a supply chain.

Since circular economy aims to sustainable development the aforementioned KPIs and standards related to sustainability, and especially environmental sustainability performance form a good basis for a further development of CEPs. Both LCA and MFCA frameworks are involved in the indicator dashboard of Pauliuk (2018) described in the chapter 3.7.

3.6 Key performance indicators for small and medium-sized enterprises

As said, KPI-literature focuses mainly on indicators developed for large enterprises, yet these theories are not straightforwardly applicable for small and medium-sized enterprises (hereafter SMEs). Fortunately, the SME-approach has been gaining a foothold in recent studies. Since this thesis focuses on SMEs, the literature of KPIs for SMEs will be covered rather thoroughly.

In academic literature, the fundamental differences of SMEs and large organizations in terms of strategy and performance measurement are summarized into three aspects. Compared to large businesses, in the SMEs:

external uncertainty of the environment is greater (Garengo et al., 2005);

innovation capability plays a bigger role in the survival and growth of the business (Saunila, 2016);

strategies are rarely explicit and rather evolve over time (Bahri et al., 2017).

Based on the comprehensive literature review Hudson et al. (2001) have listed characteristics differentiating SMEs from large enterprises: (1) personalized management with little devolution of authority; (2) resource limitations of managerial capacity, human resources and finance; (3) reliance on a small number of customers and operating in limited markets; (4) flat and flexible organizational structures, which lead to misconception of performance measurement, i.e. PMSs are seen as too boreoarcic and rigid systems; (5) high innovatory potential; (6) reactive mentality, i.e. decision-making processes are informal, mainly based on intuition, and tend to focus on short-term decisions; and (7) informal, dynamic strategies. In terms of the seventh characteristic, Tenhunen, Rantanen and Ukko (2001) add that the visions and strategies are rarely documented, and the owner-manager might be the only person in the company, who knows them. In this case the owner-managers tend to use both financial and nonfinancial measures to assess the business performance (Chong, 2008). According to Cocca and Alberti (2009) also the lack of proper IT infrastructure is one crucial difference. Compared to the large enterprises, where enterprise resource planning (ERP) systems support in performance measurement processes, the SMEs tend to use mainly excel or other simple and affordable software (Garengo & Biazzo, 2012).

For the aforementioned reasons, the KPIs and PMSs developed for SMEs need to support the uncertainty, innovativeness and evolution. According to Saunila (2016) these measurement systems need to be dynamic and changeable; in other words: “extremely flexible and reactive to market changes” (Pekkola, Saunila & Rantanen, 2016). More precisely, the systems should be based on: (1) the information already available within the company; (2) the activities and business practices of a company, instead of an explicit strategy; (3) the cash flow-related historical measures and complemented by measures guiding future activities; and (4) simplicity and affordability (Bahri et al., 2017). Hudson et al. (2001) highlight that the performance measures should be “clearly defined, have an explicit purpose, be relevant and easy to maintain and simple to understand and use”.

Pekkola et al. (2016) add that the systems should have an owner-focus and focus on the day-to-day business.

Even though researchers highlight the importance of predictive nonfinancial metrics in PMSs of SMEs, research has shown that SMEs still tend to measure only mandatory aspects of a performance such as the cash flow, and thus use only historical financial indicators in practice. This is due to the lack of resources and the flat organizational structures, where the employees have many simultaneous positions and limited time for measurement activities. In addition, the (owner)-managers are in charge of both operational and managerial functions, which naturally leads to prioritizing operational activities. Therefore, SMEs tend to measure mainly financial and operational performance, paying less attention to the other essential aspects of a business performance such as sustainability issues, innovation, human resources and R&D. (Singh et al., 2018; Bahri et al., 2017; Cocca & Alberti, 2009; Garengo et al., 2005; Hudson et al., 2001)

In addition, as some studies show, SMEs have difficulties in addressing their critical success factors, and therefore unlike the theory suggests, performance measures are often weakly aligned with the strategy (Garengo et al., 2005). Thus, theory and practice do not always go hand in hand in terms of performance measurement in SMEs.

As comes out in the next chapter, many KPIs developed for CBMs require a lot of data and business resources, which SMEs usually do not have. In addition, due to the complex nature of CE certain KPI-characteristics mentioned above, such as simplicity, operational performance focus and easy data accessibility are challenging to achieve. Therefore some compromises must be made in order to develop indicators for small and medium-sized CBMs.

3.7 Key performance indicators for circular business models

There is no consensus in academia which existing metrics are the most reliable and relevant for the companies operating within the CE principles, and especially for the small and medium-sized enterprises. This chapter introduces the academic studies related to circular economy performance measurement and takes a closer look at the indicators suitable for the small and medium-sized CBMs.

Pauliuk (2018) has comprised a dashboard of indicators related to the circular economy performance invented by various scholars. The dashboard is formed in order to assist organizations to implement the CE standard published by the British Standard Institution (BSI), i.e. BS 8001:2017. Pauliuk (2018) criticizes the standard of letting

organizations responsible for selecting the appropriate CE indicators. He proposes combining the guidance provided by the standard with the already standardized tools such as life-cycle assessment (LCA) and material flow cost accounting (MFCA). The indicators of the Pauliuk's dashboard which are in the scope of this research are presented in the Table 3, and some of them are described more thoroughly in this chapter.

Circular economy indicator	Formula
Total restored products Or parts thereof And ratios based thereon	$C1 + C2 + C3 + C4$, where $C1$ = direct re-use of end of life (EoL) products $C2$ = refilling or refurbishing of EoL products $C3$ = redistribution of EoL products $C4$ = remanufacturing of EoL products
Total restored material	$Os + Ns$, where Os = old (post-consumer) scrap Ns = new (fabrication) scrap
Total recycled material	$Rc_cl + Rc_ol$, where Rc_cl = closed loop recycling ¹⁷ Rc_ol = open loop recycling ¹⁸
Recycled content RC for product or organization	$(Rc_ol + Rc_cl) / (P + Rc_ol + Rc_cl)$, where P = production
Recovery rates	$Os/O, C1/O, C2/O, C3/O, C4/O$, where O = outflow from use phase (collected material)
Longevity indicator	$A + B + C$, where A = initial lifetime of a product B = earned refurbished lifetime of a product C = earned recycled lifetime of the material of a product (Source: Franklin-Johnson et al., 2016)
Quantity of material restored and its quality	
Material circularity indicator CIRC (actual cumulative service in percent of maximal service)	Too many variables for SMEs
Circular economy index CEI	Material value recycled from EoL product(s) / Material value needed for (re-)producing EoL products Value = market value (Source: Di Maio & Rem, 2015)
Product-Level Circularity (ratio of recirculated economic value from EoL components over total product value)	Source: Linder et al. (2017)
Material Circularity Indicator MCI	Too many variables for SMEs (Source: EMF, 2015)
Material stock per service unit MSPS (service generated by material in the use phase)	$S / serv$, where S = in-use stock $serv$ = service unit
Material input per service unit MIPS (service generated by material consumption)	$serv / C$, where C = consumption or MI = material input (sum of the used resources) (Source: Ritthof, Rohn & Liedtke, 2003)
Value-based resource efficiency VRE (value added divided by energy and material costs)	Too many variables for SMEs (Source: Di Maio et al., 2017)

¹⁷ i.e. upcycling. "Material from a product system is recycled in the same product system." (Geyer et al., 2016)

¹⁸ i.e. downcycling. "Recycling is sometimes called downcycling when the recycled material is of lower quality and functionality than the original material." (Geyer et al., 2016)

Waste and losses in comparison to alternative life cycles	W = waste, ΔW L = losses, ΔL
Net environmental benefits of recycling	$D*(E_{prim} + E_{landfill}) - E_{repro}$, where D = the total amount of displacement caused by the recycling activity E_{prim} = environmental impacts of primary material production $E_{landfill}$ = environmental impacts of landfill activities E_{repro} = environmental impacts during scrap collection and reprocessing (Source: Geyer et al., 2016)
Resource footprints: water, land, material footprints or a combination thereof (footprint dashboard) Life cycle GHG emissions and changes thereof	ISO 14044:2006 guidance
Cumulative energy demand CED or cumulative exergy demand	Too many variables for SMEs
Eco-cost value ratio EVR (costs of reducing environmental damage over product price)	Too many variables for SMEs (Source: Scheepens et al., 2016)

Table 3. The indicator dashboard of Pauliuk (2018) comprised from many literature sources

Franklin-Johnson et al. (2016) have invented an indicator for resource duration called longevity indicator, which is also included in the above dashboard of Pauliuk. According to Franklin-Johnson et al. (2016) this indicator can be used for environmental assessment performance linked to circular economy. The indicator measures “contribution to material retention based on the amount of time a resource is kept in use”. The metric consists three components: (A) initial lifetime of a product, (B) earned refurbished lifetime of a product and (C) earned recycled lifetime of the material of a product. Thus, longevity = A + B + C. In a perfectly circular system the longevity equals infinity. The longer the material is in use, the better is the company’s contribution to the circular economy. The longevity indicator is suitable for circular business models, which aim to lengthen product lifetime through durable products in customer use, product return and refurbish systems and/or effective recycling processes of materials. It can be measured for example in days, months or years depending on the nature of the product. (Franklin-Johnson et al., 2016)

Figge et al. (2018) have continued the research of Franklin-Johnson et al. (2016). They add circularity metric alongside to the longevity indicator. According to them, these both indicators are independent, yet they complement each other. Like the longevity indicator, also the circularity metric indicates the extent to which non-renewable resources are used eco-efficiently. The aim of the circularity metric is to measure the contributions the company makes to the circular use of resources. Noteworthy is that, unlike in the longevity indicator, the variables of this metric are related to the activities which are controllable for the company. The circularity metric has three variables similar to the longevity indicator: (N^A) initial use, (N^B) refurbishment and (N^C) recycling. Thus, circularity = the number of times a

resource is used in a product system = $N^A + N^B + N^C$, where N^A always equals 1. The result of the circularity metric can be either 1 (fully linear product system) or something between 1 and infinity (fully circular product system). (Figge et al., 2018)

The calculations of the circularity metric are fairly simple and therefore relevant to this research. The equations are following (Figge et al., 2018):

$$Circulation = N^A + N^B + N^C$$

$$N^A = 1$$

$$N^B = (ab) \left[\frac{1-(ab)^n}{1-(ab)} \right], \text{ where } a = \text{the \% of sold products that are returned, } b = \text{the \% of returned products that are refurbished, and } n = \text{the number of cycles.}$$

$$N^C = \frac{p}{1-p} \left[\frac{1-(ab)^{n+1}}{1-(ab)} \right], \text{ where } p = \text{the fraction of the overall material that will be recovered through refurbishing, and thus } \frac{p}{1-p} = \text{the \% of the overall material recycled after an infinite number of cycles.}$$

Figge et al. (2018) provide a simple example of the calculations: If overall 50% of the sold products are returned, then $a = 50\%$. If 50% of these returned products are refurbished, then $b = 50\%$. Then N^B equals 0.25 after the first cycle, meaning that 25% of the overall products sold are refurbished. If the process is capable to recover 50% of the material within refurbished products, then 12,5% of the overall material can be recovered through refurbishing, and thus $p = 12,5\%$. Then N^C equals 0.18, meaning that 18% of the overall material of sold products is recycled. Then the circularity equals 1.43, meaning that the resource or material in question is used 1.43 times in a product system after the first cycle.

Figge et al. (2018) have also modified the longevity indicator initially invented by Franklin-Johnson et al. (2016). The former scholars suggest adding different frequencies of return, refurbishment and recycling to the original equation. They also suggest using both the circularity metric and the longevity indicator simultaneously since by combining them the company can measure the longevity of the circularity, i.e. how long is the circular use of the certain material. However, the complexity of the calculations make these modified indicators demanding for SMEs.

LCA and recycling both play important roles in circular economy and its metrics. Di Maio & Rem (2015) suggest a metric for computing recycling rate, a Circular Economy Index CEI. They emphasize the simplicity of CEI compared to traditional LCA calculations which usually are more complex. CEI also takes into account the important aspect for profit-seeking companies, namely the economic values. Therefore, this metric could be very useful

for the companies, which also need to make profit in order to operate in the first place. The equation of CEI is simply: material value recycled from EoL product(s) divided by material value needed for (re)producing EoL product(s).

Geyer et al. (2016) point out that recycling activities do not always have positive environmental impact when examined broadly, and therefore they propose to use the indicator of net environmental benefits of recycling to calculate the actual environmental impact of recycling activities. The formula is:

$$\text{Net environmental benefits of recycling} = D * (E_{\text{prim}} + E_{\text{landfill}}) - E_{\text{repro}}, \text{ where}$$

D = the total amount of displacement caused by the recycling activity,

E_{prim} = environmental impacts of primary material production,

E_{landfill} = environmental impacts of landfill activities,

E_{repro} = environmental impacts of scrap collection and reprocessing

Unlike other recycling-related indicators the quantity that counts is the material amount displaced, not the amount of material collected or recycled. Displaced material refers to the amount of primary resource displaced by the recycling activity. Simply put, recycling has a positive net environmental impact in case the impacts created by the collection and reprocessing are smaller than the impacts created by the primary material production and landfilling. Environmental impacts are for instance GHG emissions and used virgin materials. (Geyer et al., 2016)

In addition to LCA and recycling, the circularity of products is naturally one essential issue that CBMs need to measure. However, as Linder, Sarasini and Loon (2017) note, there is no standardized metric for product circularity. Due to the lack of such indicator these scholars invented the Product-level Circularity Metric, in which economic value of recirculated parts of a product is divided by economic value of all parts of a product. The economic value could be either market value or cost-based estimation of a value in case the market value of some part does not exist. Range of this metric is between 0 and 1. For example the equation of Product-level Circularity Metric for the combination of two product parts is (Linder et al., 2017):

$$c_{1\&2} = c_1 * \frac{v_1}{v_1+v_2} + c_2 * \frac{v_2}{v_1+v_2}, \text{ where}$$

c_i = circulation of part i

v_i = value of part i

For newly introduced product parts the circularity values are usually not available, so the equation for circulation is:

$$c_i = \frac{r_i}{r_i + n_i}, \text{ where}$$

r_i = the economic value of recirculated parts of the new product part

n_i = the economic value (costs) of nonrecirculated parts, i.e. virgin materials for the relevant product part i

r = max [cost of parts including handling costs such as procurement and logistics costs; sum of market process for virgin materials contained in the product; secondhand market price for used material or component]

Thus, the value for a newly introduced product part is $r_i + n_i$.

Linder et al. (2017) provide a simple example to demonstrate the calculations of the circularity of a plastic toy: a company purchases recycled plastic for €1.000 and the circularity value is unknown, thus $r_1 = €1.000$ and $n_1 = 0$. Then $c_1 = 1$ and $v_1 = €1.000$. Then the company adds the combined material cost of transport (i.e. material cost of packaging) $v_2 = €50$. Given that the packaging material is nonrecycled $c_2 = 0$. The company calculates the material part first: $c_{1\&2} = c_1 * \frac{v_1}{v_1 + v_2} + c_2 * \frac{v_2}{v_1 + v_2} = 1 * €1.000 / €1.050 + 0 * €50 / €1.050 = 0.95$, thus 95% of the material used to produce and transport the plastic toys to retailers is recirculated. The company could also add nonmaterial parts, i.e. work costs to the calculations, yet the material part should always be calculated first since the order has an effect on the resultant circularity value. As can be seen, like CEI, also the Product-level Circularity Metric takes into account the economic values.

Mesa, Esparragoza and Maury (2018) have contributed to the Product-level Circularity Metric by Linder et al. (2017) and also to some other circularity measurement studies described earlier (Di Maio & Rem, 2015; Franklin-Johnson et al., 2016) by adding product family approach to the calculations. Due to the complexity of the equations, these product family metrics introduced by Mesa et al. (2018) suit better for the need of large enterprises and therefore are not in the scope of this study.

Material input per service unit (MIPS) by Ritthof, Rohn and Liedtke (2003) is a useful indicator to assess the resource efficiency of the operating model. In case companies follow the guided instructions when calculating MIPS, the value is comparable also with other companies. The simple formula of MIPS is:

$MIPS = \text{material input (sum of the used material and energy resources)} / \text{service unit.}$

$\text{Material input} = \text{input amount (in kg)} * \text{material intensity (in kg/kg or kg/MJ or kg/kWh)}$

Some material input data are already calculated and available on www.mips-online.info. There are five resource categories to be taken into account in calculations: abiotic (non-renewable) raw materials, biotic (renewable) raw materials, mechanical earth movement or erosion, water and air. Service unit depends on the business; it can be for example rental car kilometers, one wearing cycle of a garment (customer's use, washing and other maintenance) or a furniture (customer's use and maintenance). (Ritthof et al., 2003)

Di Maio et al. (2017) add supply chain into the value-based resource efficiency examination with their indicator called Value-based resource efficiency (VRE). In the calculations value added is divided by energy and material costs.

$$VRE = \frac{GO-S}{E+M} - 1,$$

$$GO - S = \text{added value},$$

$$GO = \text{gross output},$$

$$S = \text{input value of services},$$

$$E = \text{input value of energy},$$

$$M = \text{input value of materials}$$

According to Di Maio et al. (2017) the indicator provides consistent resource efficiency monitoring of processes or products. At the product level VRE monitors also consumers, since final selling price is included in the calculation. The process level VRE focuses on the industries and therefore not in the scope of this study. As values Di Maio et al. (2017) recommend using current market prices.

As can be seen, many CE-related KPIs exist in the literature, yet there is still an evident research gap since the literature does not explicitly answer the question of how and with what indicators small and medium-sized circular businesses could measure their performance. This thesis aims to find an answer to that question through a constructive research approach covered in the next chapter.

4 Constructive research

4.1 Identification framework of circular economy performance indicators

The research methodology and methods applied in this study are described thoroughly in the chapter 1.4. In summary, this thesis research has been conducted using the constructive research approach, meaning that the proposed indicator pools presented in the chapter 6.2

form the construction of this thesis, i.e. the practical management accounting tool. Usually the managerial constructions are developed in close cooperation with case companies, consultants and researchers. However, due to the nature of master's thesis projects, the level of collaboration is lower than in normal case studies. In this thesis, the research perspective has been conducted via comprehensive literature review, whereas case company perspective has been included through questionnaire and in-depth interviews, not forgetting the circular economy consultants and experts that have been interviewed for the sake of consultancy perspective. Other complementary data sources of this thesis are document analysis of the sustainability reports of large enterprises operating in the circular economy, and online information about the past and ongoing projects related to the circular economy performance indicators.

For the sake of clarity, this chapter introduces the framework for identification of circular economy performance indicators, i.e. CEPIs. The framework presented in the Figure 4 is combined by applying the theories invented by Tenhunen et al. (2001) and Keeble et al. (2003), and the principles of constructive research method covered in the chapter 1.4.

According to Tenhunen et al. (2001) one crucial step in the identification process of performance indicators is the selection of relevant performance dimensions that the company needs to measure, e.g. financial perspective, customer satisfaction, quality or employee satisfaction. Naturally, in this thesis the dimension is circularity.

The other vital step according to Tenhunen et al. (2001) in performance indicator identification process is the clarification of the vision, strategy and key objectives of the business. This step is the starting point of the identification process of CEPIs in this research. The visions, strategies and key business objectives of the case companies in terms of the circular economy will be clarified in the case company interviews in the chapter 5.2.

Keeble et al. (2003) have invented a framework for the development of corporate wide sustainability indicators. Although their framework is intended for organizations of all sizes, with a few modifications it forms a good basis for this research. Like in the framework of aforementioned scholars the initial set of indicators, i.e. the indicator pools, has been developed in this research after carefully analyzing the empirical data and theory. The indicator pools consist the existing indicators found in academic literature and empirical data sources, possibly with some modifications.

After establishing the indicator pool, Keeble et al. (2003) shortlisted the pool through a facilitated process of dialogue with the company. In this research the shortlisting process has been replaced by a weak market test including queries carried out via email. The weak

market test aims to clarify, which of the indicators in the indicator pools might work in practice in the case companies. Keeble et al. (2003) continued the indicator identifying process with screening and ranking in order to find out which indicators suit best for the particular case company. Screening and ranking phases include the assessment of shortlisted indicators against a set of company-specified criteria guaranteeing the quality and relevance of indicators (Keeble et al., 2003). However, the objective of this thesis is to develop a set of CEPIs for small and medium-sized circular business models in general, and therefore the screening, ranking and implementation phases are not in the scope of this research.

What comes to the number of metrics, Tenhunen et al. (2001) state that in SMEs the reasonable number of all KPIs is 5-25. Depending on the research perspectives the number of KPIs suggested by other scholars varies between 10 and 20. Since the case companies of this study most likely measure also other dimensions in addition to circularity, the maximum amount of CEPIs in a certain company could be 1-3. However, in this research the indicator pools include more than five indicators per CBM. By conducting a weak market test, this thesis aims to find out which of the proposed indicators might become the key circular economy performance indicators in the case companies.

Identification Framework for CEPIs

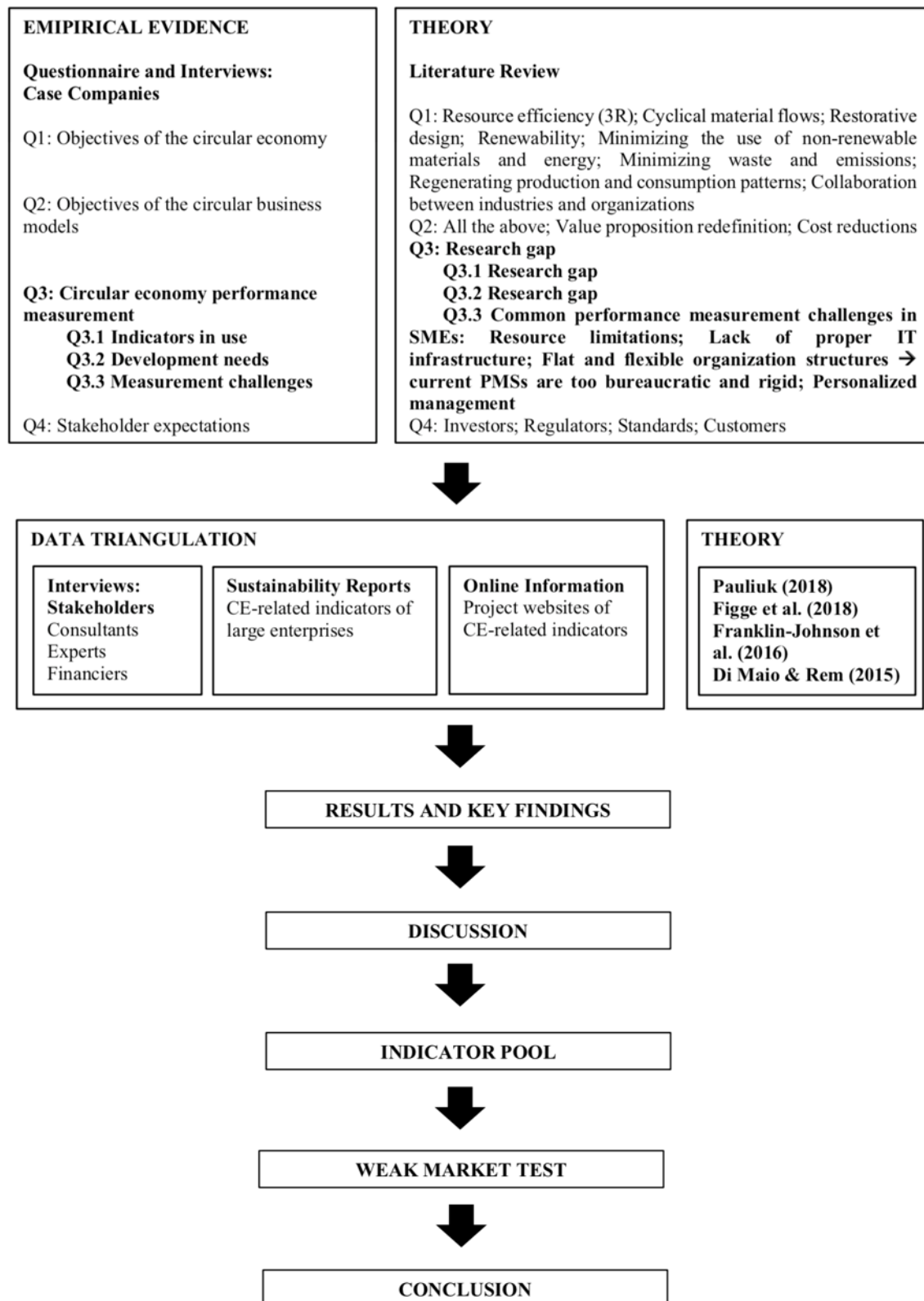


Figure 4. Identification framework of circular economy performance indicators

4.2 Research context: circular business models in Finland

In the recent years numerous Finnish companies have started deploying circular business models. Among them are couple of globally operating corporations and dozens of young SMEs. The latter have launched new innovations inspired by circular economy and the circularity is in the core of their businesses. In large corporations the circular business models have been implemented alongside of the core linear business models.

The following five circular business models (CBMs) are introduced by Sitra (2017). These categories are current circular business model approaches in Finland, yet the concept of CE is continuously developing, and new approaches might emerge sooner or later.

4.2.1 Product as a service

In this category there are altogether 18 companies of all sizes from startups to large enterprises. The operating model in this category is based on the idea of renting or leasing products that are usually owned by consumers. The companies in this CBM-category provide various products for B2C and B2B customers as rental services. The products are for example electric cars (EkoRent), reusable postal packages (RePack), work uniforms (Lindstöm) and compressed air (Tamturbo). In addition to products, some businesses provide more comprehensive solutions as services such as lighting (Lem-Kem), work environments (Martela), industrial warehouse management (Konecranes), mobile facilities (Innorent) and even mobility (MaaS Global), meaning combining the public transport, taxis and the use of private cars based on the monthly fee.

Revenue models of these companies is based on monthly or contract period fees, which include maintenance, repairing and consultancy services. The customer buys a right to use the product, instead of the ownership.

Product as a service -business models' goal is to utilize the entire lifetime of a product and its capacity, i.e. maximize the utilization rate. In addition, these businesses reshape the consumption patterns towards sharing and renting instead of owning.

4.2.2 Product-life extension

To this category Sitra has listed 10 companies. The operating model in this category is based on the repairing and refurbishing of the products and selling or renting them again as products or parts, i.e. components for B2B and B2C customers. The repaired products provided by the companies in this category are for example IT and office equipment (Ekox

Finland, 3 Step IT, Taitonetti.fi), office furniture (RealGreen), smart phones (Swappie), high-quality used clothes (Emmy Secondhand) and forestry equipment (Ponsse).

This business model saves natural resources such as rare earth metals and energy by keeping the value of the components and raw materials in the economy as long as possible.

4.2.3 Renewability

This category consists of 20 companies. The operating model is based on the collaboration between industries and companies because residual and waste, i.e. by-products and side streams, of one business are valuable raw material for another business. The main point is that the goods produced are made of renewable materials; for instance, agriculture fertilizers made from organic waste (Kekkilä), textile fiber produced from paper and cardboard waste or wood (Spinnova and Infinited Fibre), biodegradable cosmetic packaging produced from wood chips (Sulapac), bio-based plastic from lactic acid polymers and additives (ABM Composite), renewable biogas (Gasum), renewable diesel from waste and residue fat and vegetable oil (Neste), biodegradable paper cups (Kotkamills), petrol substitute from organic waste (ST1), and plastic substitute made from cellulose fiber (Paptic).

The revenue model is based on purchasing side streams or waste of another company or industry and produce new goods from the renewable material in question. Or by selling technology which enables the production (Watrec and SFTec).

The goals are related to reducing; reducing agricultural pollution, reducing waste, reducing environmental problems caused by textile production and textile waste disposal, reducing GHG emissions, reducing water and energy usage, reducing microplastics, reducing fossil-based raw materials and reducing carbon footprint of the end users.

4.2.4 Resource efficiency and recycling

This category is the largest what comes to the number of companies on the list: altogether 30 companies. This category more or less overlaps also with other categories. Companies operating under this CBM provide goods and services in many different fields. Some business models are based on the recycling and other for example utilizing resources efficiently. The businesses have invented for example waste-sorting robots (ZenRobotics) and reusable hygiene products (Lunette).

Examples of businesses focusing on recycling are: work clothes made of surplus or recycled materials (Touchpoint), transforming plastic waste into plastic bags (Amerplast), producing interior design materials from plastic waste (Durat), producing rugs from old

sheets and jeans (Finlayson), producing clothes and garments from surplus material and textile waste (PureWaste, Lovia and Remake), deposit-based recycling system for drinks packaging (Palpa) and asphalt raw material made from roofing felt (Tarpaper Recycling).

Revenue models of these companies are based on large quantities of surplus materials and utilization of waste, or sale of the technology. The goal is to close the material loops and utilize the resources as effectively as possible.

4.2.5 Sharing platforms

Companies in this category are operating within sharing economy principles. Companies provide sharing platforms for B2C and B2B customers; platforms for equipment (eRENT), boats (Skipperi), clothes (Zadaa), venues (Venuu), parking spaces (Barking and Rent-a-Park), catering services (Lunchie and ResQ Club), recycling services (Maapörssi), cars (Shareit Blox Car) and other underused goods.

The main revenue model is based on commissions charged from the rental transactions carried through the platform. Other revenue logics can be additional service sale for the users, offering online store concepts for small companies and selling advertising space.

The goal of the sharing platform is to maximize the utilization rate of the asset. In addition, like product as a service model, also this model encourages consumers towards a sharing economy away from private ownership.

4.3 Selection of case companies

The case companies selected for this thesis are listed on the Sitra's list (2017) of *The most interesting companies in the circular economy in Finland*. The list gives a very comprehensive review of the current Finnish companies operating within the CE principles. The first version of the list was gathered by Sitra in 2016 including only 19 companies. The third edition with 100 companies was made in 2017 in association with Deloitte. By the time of this research the list consisted only 98 companies because two companies had been removed during the last quarter of 2017. According to Sitra (2017), reasons for the removal were: one company discontinued its operations and the other one was removed due to more ambitious objectives of the listing. By the time of this research 81 of these 98 remaining companies were SMEs, and thus in the scope of the study. The companies were categorized in five CBM categories introduced in the previous chapter.

The case companies of this study were selected through the questionnaire sent to those 81 SMEs on the Sitra's list. 23 responses were gathered through the questionnaire, after

which five companies were interviewed in order to get more depth view of the companies and their measurement needs. Case companies which responded to the questionnaire are private owned and small or medium-sized. Furthermore, the five interviewed companies represent all five business model categories, they are small, and their core business is built around the CE principles.

4.4 Data gathering process

The empirical data was gathered between May and August 2018 using data triangulation approach, i.e. gathering empirical evidence from different sources. The process started with the short questionnaire invented by the thesis worker. The questionnaire was sent to the small and medium-sized companies (altogether 81 companies) on the Sitra's list. The aim of the questionnaire was to gather knowledge of the existing CE-metrics and measurement needs of the case companies and at the same time chart the possible participants for the in-depth interviews. Through the questionnaire 23 valid responses were gathered. The findings of the questionnaire are described in the chapter 5.1.

After the questionnaire in-depth interviews of five case companies were organized. In these interviews the goal was to deepen the understanding of the existing CE metrics and measurement needs and challenges of the case companies in all five CBM categories. Other objective was to understand the business goals and CE-operations of the case companies and their CBMs in order to form CEPIs that are in line with these goals. The interviewing technique was semi-structured organized around general themes. The findings of the in-depth interviews are presented in the chapter 5.2.

Since managerial constructions are often developed with the help of consultants and experts, five circular economy or sustainability consultants and experts were interviewed. Consultants usually have such R&D expertise the case companies might not have enough resources for. The interviewed experts also had knowledge about current and future projects and initiatives in terms of circular economy performance measurement. The interviewed consultants represent the top CE-related consultancies in Finland, and the experts represented public organizations such as public foundations, research institutions and ministries that enhance circular economy progress in Finland. In addition, four impact investors were interviewed in order to understand the financier perspective. The interviews of financiers gave an insight of what measures are important when making investment decisions.

In addition to interviews the secondary data was gathered and analyzed. The secondary data included indicators found from the sustainability reports of large companies, and online information sources: websites related to the circular economy performance measurement projects.

The final step of the data gathering process in this thesis was the weak market test, whereby the usefulness of the developed construction was tested. The weak market test was conducted via email query sent to the case companies. The gathered responses presented in the chapter 6.3 give valuable information for the possible further development of the CEPIs.

4.5 Validity and reliability issues

According to McKinnon (1998) research validity refers to the essential question of “whether the researcher is studying the phenomenon she or he purports to be studying”, whereas reliability “whether the researcher is obtaining data on which she or he can rely”. McKinnon names four threats to validity and reliability: (1) observer-caused effects; (2) observer bias; (3) data access limitations; and (4) complexities and limitation of the human mind. From these threats especially the second and third concern this study.

Observer biases might occur throughout this research since the nature of the researched concept, i.e. the circular economy, is very recent and young, leading to many different perceptions about the essence of the concept. Observer biases in this research might occur for example due to the observer’s own values and expectations related to the researched phenomenon, and therefore the possible interpretation gaps might have been closed based on these values and expectations.

Furthermore, data access limitations weaken the validity and reliability of this study, since the thesis worker did not have full access to certain important documents such as the formulas of existing circular economy-related indicators used by the case companies.

The time spent with the case companies, i.e. the length of the interviews, was somewhat short. The longer the period spent with case companies the more depth understanding could have been gained. In addition, only five companies out of 81 alternatives were interviewed, which was due to the lack of time the other possible case companies had. These five interviewed case companies do not represent an inclusive sample of all the businesses operating within circular economy since they are small and relatively young, and thus medium-sized and more established companies were not interviewed at all.

In addition, unlike the fifth step of the constructive research (Lukka, 2014) instructs: *implement the solution and test its functionality (i.e. market test)*, this research does not

implement the solution, yet the functionality and relevance of the solution is tested through the weak market test described in the chapter 6.3.

In order to counter possible validity and reliability threats caused by limited data accessibility, multiple data gathering methods, i.e. data triangulation approach, was used in this research.

5 Research findings

5.1 Questionnaire: case companies

In order to gather empirical data and chart information of the possible case companies and interviewees, the small and medium-sized companies listed on the Sitra's listing of *The most interesting companies in the circular economy in Finland* were sent a short questionnaire during May 2018. The number of small and medium-sized companies on the list was 81 in May 2018.

The questionnaire included seven short questions presented in detail in the Appendix A. Some of the questions were yes/no questions and some were open-ended questions. The response rate was 28 percent (23 valid responses out of 81). The total number of responses were 27, but two of them had to be removed because the companies in question were large instead of SMEs and other two removed responses were duplicates. Seven out of 23 companies were medium-sized, and the rest were small.

There were not any material similarities between the answers of medium-sized companies or between small companies or dissimilarities when comparing the sizes. Instead some similarities between responses inside circular business model categories was found. Therefore, the results are grouped by business model categories. The results of the questions 1, 2 and 6 are presented in the Table 5 and the open responses are presented after that.

Question	Question type	Responses
1. Importance of circular economy objectives for the business	Scale 1-5	Total responses 23/23 5: 16 (69,6%) 4: 6 (26,1%) 3: 1 (4,3%)
2. Use of circular economy performance indicators	Yes/no question	Total responses 23/23 Yes: 12 (52,2%) No: 11 (47, 8%)
3. Existing circular economy performance indicators	Open-ended question	13/23
4. Current measurement challenges	Open-ended question	11/23
5. Measurement development needs	Open-ended question	9/23

6. Need for circular economy performance indicators	Yes/no question	21/23 20: Yes (95,2%) 1: No (4,8%)
7. Reasons for not using any circular economy performance indicators yet	Open-ended question	12/23

Table 5. Case company questionnaire responses

Regarding the first question, on a given scale of 1 (strongly disagree) to 5 (strongly agree), the majority, i.e. 69,6%, of the companies identified that the circular economy objectives are in the core of their business. Only one respondent valued the circular economy objectives less important for their business. The company in question is operating in the field, which can be positioned in the circular business model category of resource efficiency and recycling. Noteworthy is that the share of the circular economy solution of the total business of the company in question is 100%, which conflicts with the response. This might indicate that the business in question have been started from other core principles than CE-principles, yet happens to be in line with the CE-principles as well.

Altogether six respondents valued the objectives of the circular economy as 4/5 for their business. Four of these companies are categorized as having the resource efficiency and recycling business model, one is a sharing platform and one operates in the field of renewability. Any causality cannot be found from these responses.

From the results of the first question it can be assumed that the CE-principles and objectives are taken into account in business decisions of the case companies. On the other hand, this questionnaire does not answer the question of how the case companies perceive circular economy and its objectives. Therefore, the in-depth interviews are needed to tackle that question.

Regarding the second question of the questionnaire, responses were split almost half. In every five business model category there were companies that responded yes and companies that responded no. Since there is no standardization of circular economy performance indicators yet and thus due to the lack of elaboration what circular economy performance indicator exactly means, the responses are only approximate. The next chapter maps the indicators already used by the case companies and clarifies the possible unclarities of the question 2.

5.1.1 Existing circular economy performance indicators

As can be seen in the Table 6, all of the case companies have different indicators in use. Only one indicator appeared in several responses: reduction of CO₂ emissions. In addition,

the existing indicators vary depending on the circular business model and are very company-specific. What is also noteworthy to mention is that sharing platform businesses perceive their business model as crucial part of sharing economy and therefore perceive all of their indicators simultaneously as circular economy indicators.

Circular business model	CEPIs already in use
Product as a service	Return rate of products Cycle time of products Disposal rate of products Number of products in use Cleaning time of products Reduction of CO2 emissions
Product-life extension	Reuse rate of components
Renewability	Amount of recycled raw materials Estimated value of the utilization of waste materials Reduction of CO2 emissions
Resource efficiency and recycling	Recycling rate of raw materials Material efficiency Energy efficiency Material circulation Carbon footprint Water footprint
Sharing platforms	Estimated reduction of CO2 emissions Estimated water footprint Number of published rental products Number of registered users Number of rentals per product Number of rentals per user Average rental price and time

Table 6. The indicators already used by case companies sorted by business model category

The responses listed above do not tell anything about the quality of the indicators, nor the equations. These responses only give an approximate view of what kind of indicators the companies operating in the circular economy are already using, and what existing indicators they perceive as CE-related. The in-depth interviews aim to deepen the view of the quality and relevance of the existing indicators and their formulas.

5.1.2 Current measurement challenges

Like the existing indicators also current measurement challenges the case companies have been facing vary between business models and between companies. Lack of expertise and

resources was one of the most appeared challenge in the responses. Other challenges related to the comprehensiveness of the CE-solutions, complexity and reliability of the indicators, material values, and life cycle impacts.

Circular business model	Challenges in measuring
Product as a service	<i>"How to get real time data."</i> <i>"How to assess the life cycle emissions for all parts of a comprehensive solution."</i>
Product-life extension	<i>"How to measure the benefits of the effective reuse and recycling."</i> <i>"How to create indicators that are easy to use."</i> <i>"Challenges in calculating the material re-utilization, in other way than economically."</i>
Renewability	<i>"How to improve the safety factor of the indicators."</i> <i>"What is the value of a material when it cannot be utilized yet and then when it can be utilized."</i>
Resource efficiency and recycling	<i>"How to measure the lifecycle impact of a product."</i> <i>"Very few existing indicators: the indicators have to be created by themselves, which makes comparing difficult."</i> Lack of resources and expertise.
Sharing platforms	<i>"How to measure the impact of own operations on the overall efficiency of the circular economy."</i> <i>"Existing statistics are scattered, and assumptions must be made in the calculations."</i>

Table 7. Measurement challenges of the case companies

The responses above cannot be generalizable to a certain CBM, rather they are company-specific. What unites all the responses is the resource limitations that influence in the background. Resource limitations include lack of time, money and expertise.

5.1.3 Measurement development needs

Table 8 lists the current development needs of the case companies.

Circular business model	Development needs
Product as a service	<i>"Elaborate the indicators and make them more holistic."</i>
Product-life extension	<i>"Highlighting the concrete importance of the indicators."</i>
Renewability	<i>"Based on more detailed operational and longer-term outcomes, the aim is to calculate more accurate impact estimates and the broader environmental and economic impact examples of different total chains. The financial figures should be included, as they are the concrete and the most important measure of investment decisions."</i>
Resource efficiency and recycling	<i>"The effectiveness of different decisions on the various stages of the value chain (e.g. replacing raw materials with recycled raw materials) would be interesting to measure but we do not have the resources / expertise to do so."</i>
Sharing platforms	<i>"Getting carbon and water footprint data of the production of different materials would help."</i> <i>"To create clear measurable indicators."</i>

Table 8. Measurement development needs of the case companies

These responses are similar with the previous question and are also affected by the resource limitations.

5.1.4 Reasons for not using any circular economy performance indicators yet

As came out earlier, the case companies have resource limitations, which was also mentioned in theory. SMEs allocate their resources for day-to-day business and operational aspects rather than measurement processes.

Circular business model	Reasons for the lack of CEPs in use
Product as a service	Lack of resources.
Product-life extension	<i>"It is difficult to find a "scale" whereby measure the operations or find an objective measurer."</i> Lack of knowhow.
Renewability	<i>"No requirements from the customers."</i>
Resource efficiency and recycling	Lack of resources.
Sharing platforms	<i>"Our intention is to introduce an indicator of how much the rental events through our platform reduce the purchase of new goods and thus the carbon dioxide emissions. However, the issue is complex, and a reliable indicator is difficult to develop, so we have not yet been able to prioritize it as a small team."</i>

Table 9. Reasons why case companies are not using any circular economy performance indicators yet

In addition to the resource limitations mentioned repeatedly, the expectations or more precisely lack of requirements from the customers or other stakeholders was seen as one of the reasons why CEPs are not used. The stakeholder expectations are better covered in the in-depth interviews.

5.2 Interviews: case companies

The interviews of five case companies were made during June and July 2018. The selection of case companies was based on the questionnaire responses. The aim was to interview companies from every five CBM-category, both the companies that already use some and do not use any circular economy performance indicators. The aim was to deepen the understanding the case companies' needs and challenges regarding CEPs, and also gather the formulas of the existing indicators. Unfortunately, none of the case companies was willing to give out the formulas of their existing indicators. This was due to the nature of the metrics; the metrics are operational and invented internally for their specified needs.

All the interviewees except one, have been working for the case company in question since the foundation. Due to the sizes of the case companies, the interviewees had many

roles in the organization as can be seen from their titles; CEO, Chairman of the Board, Co-founder and Project Manager. All of the interviewees seemed interested in this thesis project and were willing to have a long-term collaboration if needed.

The interviewees were given assurance on confidentiality of data and identity. The documentation of the interviews was done mainly through recording. One of the interviews was carried out via phone and the recording was not working, and therefore extensive notes were taken during the interview.

Case company	Circular business model	Share of the circular economy solution of the total business	Title of the interviewee and how long has been working for the company	Interview date, place, duration and documentation
Company 1	Product as a service	100%	CEO-Co-founder, from the beginning & Marketing Manager, four months	5.7.2018, via skype, 24 minutes, recording
Company 2	Product-life extension	100%	Chairman of the board and shareholder, from the beginning	25.6.2018, via phone, 22 minutes, notes
Company 3	Renewability	100%	Project manager, 1 year	26.6.2018, via skype, 30 minutes, recording
Company 4	Resource efficiency and recycling	100%	Chairman of the board, from the beginning	26.6.2018, company's office, 24 minutes, recording
Company 5	Sharing platform	100%	Co-founder	27.6.2018, company's office, 14 minutes, recording

Table 10. Details of the case company interviews

The interviews were semi-structured related to four main themes: circular economy and its objectives, circular economy in business, circular economy performance measurement, and stakeholder expectations. The interview framework can be found in Appendix B. Results are presented next.

5.2.1 Circular economy and its objectives

The aim of the first theme was to find out how the interviewees understand the circular economy as a whole and its objectives. As the responses indicate, all interviewees understand the concept similarly, yet the CE-themes appearing in the responses are strongly

linked to their own business models. The responses presented below are in line with theory, and therefore it seems that the concept of circular economy is fairly explicit among the companies operating in the CE even though the concept is relatively vague in global context. However, these companies are among the pioneering CE businesses, and therefore the responses cannot be generalized to cover the CE business sector as a whole.

Product as a service. The interviewee of Company 1 highlighted the material efficiency:

Simply put, the circular economy is that the materials will remain in production and in the economy as long as possible. And also, that the materials of a product would generate economic benefits as long as possible. In my opinion, the sharing economy belongs strongly to the circular economy. It contributes to the efficient use of materials and resources, which is the basic idea of the circular economy.

Product-life extension. The interviewee of Company 2 focused on the reuse and reduce aspects:

The circular economy is the re-utilization of the used products, either as complete products or as components. The objectives of the circular economy are to reduce the amount of waste and at the same time save natural resources.

Renewability. The interviewee of Company 3 pointed out the side stream utilization:

In my opinion the circular economy is particularly the recycling and re-utilization of various substances and materials, in a way that as little waste as possible is generated. In my opinion the main goals of the circular economy are that the side streams that could possibly end up as waste can be reused in some way, and that the recycling or re-utilization is done rationally.

Resource efficiency and recycling. The interviewee of Company 4 compressed the concept to the resource efficiency:

Resource efficiency; that is minimizing the loss of processes, and that the material used remains in circulation.

Sharing platform. The interviewee of Company 5 mentioned the ecosystem constraints:

The bigger phenomenon of the circular economy is that there is a lot of material and side streams that are not exploited and those should be reused in such way that there is no need to produce more burden on the current ecosystem. ... I guess that the highest goal in the circular economy is to make the most of the existing resources and materials.

Certain central CE-themes appeared in the responses above: materials and values remain in the economy, sharing economy, material efficiency, utilization of EoL products and their components, saving natural resources, eliminate waste, material recycling, side stream utilization and material circulation. These themes cover the CE quite thoroughly especially from the CBM perspective and therefore these themes should be included in the CEPIs.

5.2.2 Circular economy in business

Under this theme the interviewees described how their business is contributing to the transition towards circular economy and how their business objectives links with the objectives of the circular economy. As can be seen from the quotes below, the business objectives are somewhat practical and concrete, and strongly in line with the CE-principles.

Product as a service. According to the interviewee of Company 1:

Our goal is to put the already existing materials in efficient use through the sharing economy. We are able to accelerate the utilization rate of the product by dividing its use among more people. Our long-term goal is also to further utilize the components of the end of life products.

Product-life extension. According to the interviewee of Company 2:

Our business is entirely based on the circular economy: we collect the out of use products from the customers, repair and refurbish them, and sell them further. Our aim is to reuse 60% of the products collected from the customers.

Renewability. According to the interviewee of Company 3:

Our goal is to enable the utilization of problematic [side]streams, which are not yet exploited efficiently enough even though it is noticed that these materials have utilization potential.

Resource efficiency and recycling. According to the interviewee of Company 4:

Our entire business idea is based on the circular economy. At present, we are dealing with industrial waste. The aim in the future will also be to utilize consumer waste disposal and by that way to close down the chain. It should not be like that the life cycle of the material ends at some point, but instead it could always be directed the x number of times for the same purpose and then for another purpose. Our goals are to close the chain as far as possible and to implement the principles of the circular economy as perfectly as possible.

Sharing platform. According to the interviewee of Company 5:

If we are talking about the sharing economy, then we are purely the platform that makes it possible. And, of course, we are also reshaping culture through it; we are mainly dismantling existing perspectives, expectations and ideas about how to think about private owning and sharing [the ownership]. ... Our goal is to exploit the existing private property capacity more efficiently than it currently is.

The responses included certain CE-principles and objectives described in the theory as well: sharing economy, maximizing product utilization rate, component reuse of EoL products, product take-back systems, repairing and refurbishing, side stream utilization and collaboration between industries, utilize waste as raw materials, closing the material loops and reshaping consumer culture. Hence, it can be assumed that the case companies have business goals that are in line with CE-principles, which is not surprising since these companies are among the pioneers of the CE businesses. As can be seen the case companies perceive both circular economy objectives (5.2.1) and their CE-related business objectives (5.2.2) very similarly, which supports the fact that these certain themes mentioned above should be included in the CEPis.

5.2.3 Circular economy performance measurement

This theme is the most relevant for this research. The evident research gap has been identified earlier in the literature review. The questions of existing and possible future indicators, development needs, current measurement practices and measuring challenges help identifying and developing the possible CEPis.

The interviews brought out that the current and future measurement needs of the case companies are fairly concrete related to the metrics like: estimated carbon footprint of the operations or reused products per year, estimated reductions in CO₂ emissions per shared product compared to conventional, estimated lifetime of the products and its components, amount of reused material or products, total lifetime of materials, energy usage or savings, water usage or savings, production amounts of renewable materials, values of the side streams or particular (renewable) materials, cost savings achieved through 3R, and life-cycle assessment (LCA). These themes will be taken into account in the CEPis.

Especially internal needs for the indicators exist. According to the interviewee of Company 4:

We want to be the one who manage these [circular economy] things best. Being able to develop our own operations requires that we can measure our own activities and

thus look for the parts [of the process] where we can do things better and improve them.

In the interviews it came out that some companies are already collecting and using data in some ways, yet many development needs, internal and external, were mentioned. The measurement practices of the interviewed case companies vary a lot. During one interview it also came out that the metrics the company is already using in terms of the CE are highly specified for their needs and are not applicable for the needs of the circular business models in general. The metrics the case companies are currently using are mainly operational invented for the sake of process improvement. The current measurement practices and future needs of the case companies are described next.

Product as a service. The interviewee of Company 1 about their measurement practices:

We have calculated the estimated CO2 emissions of our [sharing economy] products compared to the conventional products. ... If there existed a simple and clear metric of the material recycling rate, it would be good to communicate to the customers. ... The other metric we could need in the future is the estimated lifetime of our products. ... We are a small startup, so we don't need to calculate the carbon footprint of our operations yet. ... We could use metrics that are easy and simple to follow and document, and that are standardized for the wider use of companies, so that they are comparable. ... Monitoring the financial benefits would be interesting for businesses; what kind of financial benefits could be achieved by following the principles of the circular economy.

Renewability. The interviewee of Company 3 about their measurement practices:

We collect and use data, but we don't really use formulas or tools. Our circular economy performance measurements are mainly linked to the measuring of the qualities of the materials or production parameters, and through them the estimation of the bigger picture of what is the benefit for the customer [for utilizing the side stream]. ... We have calculated material-specific cases, i.e. what the material-specific benefits might be. As a basis for our calculations we have used the general information produced by the research institutes. ... At some point we tried to calculate the carbon footprint for our process solely. But then it went so complicated that it was left to brood over. Creating boundary conditions is difficult. ... Complexity comes our way when trying to develop formulas.

Resource efficiency and recycling. The interviewee of Company 4 about their measurement practices:

[The existing indicators are] primarily internal metrics built for our use. ... [Our current metrics are] meant for measuring the loss generated in different processes; material loss, energy loss. ... In case the loss is generated in our own processes in certain phases, it is aimed to a) minimize and b) steer back to the circulation. ... Our biggest challenge is that there is nothing ready-made [metrics in the market] and thus we have had to invent our own metrics based on our needs. ... We track the carbon footprint occasionally. For our own processes we have calculated it yearly.

Sharing platform. The interviewee of Company 5 about their measurement practices:

We have discussed a lot about measurements, but they are more or less operational things. Understanding the behavior [of the customers] is the most important thing for us. Initially, we measured the surface level things such as how many rental products we have [on the platform], how many users we have, how many rental transactions we have. But now we are getting more and more involved in measuring from the behavior perspective; how much people spend time in our service, how often they return there, of what they are interested in in our service and so on. ... Of course, the calculation of the carbon footprint becomes relevant at some point, but with the current resources it has not yet been possible.

Certain themes appeared in the responses: indicators simplicity, clarity and comparability; standardization of the external indicators; financial benefits of CE-operations; material qualities; loss and waste generated in the processes; understanding customer behavior; comprehensive view; complexity of the CE; and resource limitations. These themes will be considered in the indicator development process later on.

What comes to the data collection and analyzing process the case companies have different systems and processes. Some of the interviewed companies already had enterprise resource planning systems, which could help measuring processes substantially. On the other hand, one interviewee mentioned that their current ERP system is not suitable for the circular economy performance indicators. Instead they have collected and analyzed data manually in excel sheets, but they expect that someday the measurement could be integrated to the ERP system. One of the case companies used their own dashboards and analytic solutions coded by themselves, and also some other commercial analytic solutions or tools (e.g. Google Analytics). There is an evident need for automated and standardized process, which would also make the metrics more reliable and comparable.

The case companies have many challenges regarding measurement practices. Many of the interviewees mentioned the lack of resources. Also, the young age of the companies was affecting the development of indicators. Many of the case companies are still young startups so they do not see the need for the indicators on a larger scale. They also mentioned that the comprehensive impact of the business operations in terms of the CE is very challenging to measure or estimate. The lack of the standardized formulas was mentioned in some interviews as a challenge. Yet, the complexity of the issues makes it hard to develop clear uniform indicators. One interviewee also mentioned that the side streams they use do not have market values, which complicates the measurement processes. One interviewee also pointed out that the most important thing is to figure out what aspects are the most relevant to measure, i.e. the challenge is to know what the right things are to measure.

5.2.4 Stakeholder expectations

The interviewees perceived that the indicator needs are both internal and external. In some interviews came out that many B2B-customers are interested in the circular economy performance metrics. These metrics are for example carbon footprint of reused products per year. According to the interviewees the stakeholders who have some expectations or even requirements are currently financiers, B2B-customers, cooperation partners and suppliers. Financiers need information in order to make investment decisions and compare the possible investments. In one interview it came out that angel investors use mainly so-called hard numbers, e.g. financial information, when making investment decisions. Yet, in the crowdfunding cases circular economy metrics are also important since the private investors consider the issues that are in line with their values. Some interviewees believed that also standards and regulations will set some measurement requirements in the future.

What comes to the external reporting, none of the case companies are currently publishing the data or metrics. This is due to the lack of benchmark. According to the interviewee of Company 4:

We aren't communicating outside because there is no baseline [for the metrics]. ... Of water savings we communicate outside because it has a clear formula and baseline. ... The best case would be that the industry had common indicators and uniform formulas, through which the comparability would be generated. ... Hopefully in the future along with the laws and standards [the companies] are required to report more externally. ... Standardized reporting will increase the transparency, traceability and reportability.

5.3 Interviews: stakeholders

The stakeholder interviews were organized in August 2018. The selection of interviewees was made mainly based on the recommendations by both case company and stakeholder interviewees. Altogether 14 stakeholders were interviewed: five of them represent consultancies that have specialized in circular economy and sustainability, five of them are circular economy specialists in public organizations such as public foundations, research institutes and ministries. The third stakeholder category is impact investors who invest in companies that have positive impact on society, thus for example in circular businesses.

Stakeholder	Interviewee title	Interview date, place, duration and documentation
Consultancy 1	Sustainability Leader	14.8.2018, via phone, 20 minutes, recording
Consultancy 2	Circular Economy Specialist	16.8.2018, via phone, 23 minutes, recording
Consultancy 3	Business Director	17.8.2018, via phone, 25 minutes, recording
Consultancy 4	Leading Specialist	30.8.2018, via phone, 13 minutes, recording
Consultancy 5	Sustainability Business Consultant	30.8.2018, via phone, 14 minutes, recording
Public organization 1	Leading Specialist	15.8.2018, organization's office, 45 minutes, notes
Public organization 2	Research Team Leader	16.8.2018, organization's office, 45 minutes, notes
Public organization 3	Senior Advisor	20.8.2018, via phone, 29 minutes, recording
Public organization 4	Senior Research Scientist	21.8.2018, via phone, 21 minutes, recording
Public organization 5	Director of Unit	29.8.2018, via phone, 26 minutes, recording
Financier 1	Business Angel	17.8.2018, via phone, 18 minutes, recording
Financier 2	Sweat Equity Investor	20.8.2018, via phone, 8 minutes, recording
Financier 3	Investor	21.8.2018, via phone, 11 minutes, recording
Financier 4	Investment Director	27.8.2018, via phone, 15 minutes, recording

Table 11. Details of the stakeholder interviews

The interviews were semi-structured related to two main themes: existing circular economy performance indicators and development of circular economy performance

indicators. The interview framework can be found in Appendix C. Results are presented next.

5.3.1 Existing circular economy performance indicators

The aim of the first theme was finding out whether some indicators or on-going projects related to the CE-indicator development already exists. The main finding was that the so-called circular economy performance indicators do not exist yet, instead the existing indicators related to the CE-themes that have been developed for different purposes are also applicable for CE-activity measurement. These existing indicators cover themes such as sustainability, resource efficiency and material quality.

For example, according to the interviewee of Consultancy 3:

Many circular economy-related indicators exist for sure. I see that the existing standards and indicators measuring sustainability, quality, efficiency and profitability covers the purposeful circular economy measuring, and that these existing measurement systems are constantly expanding more towards the circular economy measurement.

And according to the interviewee of Consultancy 1:

The relevant CE-related indicators for companies exist, yet I don't recognize any so-called circular economy indicators. For example, in the GRI-standards there are no circular economy indicators, but instead environmental and waste-related indicators... In case the strategy of a company is strongly linked to the CE principles, then the company's economic result mirrors the development of the CE and its contributions to the national economy.

The second point of the latter quote is referring to the example: every time the car sharing -service is used, less private car kilometers are driven. Hence, the turnover of a circular business is an indicator itself; it indicates the impact on society. One metric could then be for example the positive environmental impact of a sharing platform. Environmental impacts include GHG emissions and the use of virgin materials.

What came out in the interviews of financiers, the impact investors globally are interested in the circular economy aspects, yet there are only a few company-specific CE-related indicators that some investors follow. Nevertheless, these indicators are more of a complement information, whereas the more traditional performance indicators are the ones which count in investment decisions. However, all of the interviewed investors saw that the importance of CE-indicators will increase in the future.

According to the interviewee of Financier 4 that invests in the circular economy businesses:

We have invented indicators and tools for measuring the companies operating in the circular economy. There is no common indicator yet, instead the metrics need to be tailored company by company. Since circular economy is such a large theme and inside of it operates many different companies, an all-inclusive indicator is not possible to form. ... Current circular economy performance indicators are based on the ESG framework; environmental and social impacts. The most common metric is CO2 reductions. The flaw of CO2 reduction indicator is that a lot of estimations need to be done and therefore the margin of error is high. Other examples are the employment figures and tax matters. In the renewable energy sector the most used indicator is how much the production of renewable energy replaces the production of fossil fuel production.

These responses of the interviewed stakeholders indicate that CE-indicators are seen relevant in the future among the stakeholders, yet the complexity and unclarity of the CE-concept makes the indicator development challenging. Therefore, the stakeholders rather rely on the existing indicators, which are applicable in the CE-context. These existing indicators that the interviewed stakeholders see relevant are described in the next chapter. Related to the on-going indicator development, the interviewees mentioned certain CE-indicator related projects that are described in the chapter 5.5.

5.3.2 Development of circular economy performance indicators

Regarding the development of circular economy performance indicators (CEPIs), the key findings of the stakeholder interviews were the recommendations of utilizing the existing indicators and standards and keeping the indicators as simple as possible. The interviewees saw that the existing environmental, material and energy efficiency indicators and footprint calculations are suitable for the CE-measurement and the development of new indicators might be unnecessary. For instance, according to the interviewee of Consultancy 1:

From the SMEs' perspective, the purpose is not to develop a heavy environmental impact measurement unless it is their core business... Usually when new indicators are developed, a lot of new monitoring needs are created, and that may lead to distracting attention from what is relevant from a business point of view. Instead when inventing new indicators, it should be clarified what are the most relevant existing indicators. There are financial indicators and the most important nonfinancial

indicators; as an example, the profitability of the circular economy segment of a business is a financial indicator, and the recycling rate is a nonfinancial indicator. If you cannot prove the impact of a recycling rate on a company's value, it may not be relevant.

The interviewees emphasized that circular economy is still a somewhat unclear concept without any commonly used definition, which leads to the obscurity of indicators as well. The interviewee of Consultancy 2 reminded about the purpose of the CE and the importance of material health and social sustainability:

The circular economy is not a pre-fixed model, but instead a goal, a mindset and a tool. The key idea is that circular economy can be perceived and used as an innovation tool, which guides product development and research in the direction of material cycles; service concepts; and material and component recovery. In addition, the circular economy as an economic model is meant to be integrative and restorative. Therefore, in-depth material and chemical expertise in products is important; are the materials used in products such that should be in circulation in the first place or should those be designed another way. Biological and technical cycles should be understood correctly. Recycling is not enough, instead the question is, are there right materials in the circulation. It is important that materials circulate, but the cycles should not be closed at the expense of wellbeing and working conditions. Social sustainability should not be forgotten.

Other possible circular economy indicators mentioned by some interviewees are material circulation, material efficiency, water usage and renewability of raw materials. One interviewee suggested also considering indicators other than financial or traditional nonfinancial. For example, the consumer or customer satisfactions gained through circular economy activity, so called impact indicators. How much consumers value the circular economy product or service.

As the assisting tools in calculations, the interviewees recommended to use databases and data banks that are already widely used. For example, GHG protocol is standardized and most suitable guidance for GHG emission or footprint calculations. Nevertheless, many data banks are commercial, subject to a charge, which might be a challenge for SMEs. Commercial databases ensure the up-to-date and reliable data, whereas databases and banks gathered through public projects may not be up-to-date. In addition, one other challenge in terms of data banks intended for general use is that companies may not want to publish all information about side streams or other material values.

What comes to the link between circular economy indicators, financial performance indicators and BSC, the interviewees saw that the more the circular economy performance indicators are linked to the company's financial performance, the better. It was also seen important that CEPIs are strongly linked to the strategies and objectives of the business, i.e. integrated into the BSC if such exists in the company. Otherwise, the circular economy can become as a separate issue from the core business, which naturally is not a desirable outcome, since it might lead to greenwashing.

Even though both the internal and external indicators were seen relevant according to the interviewees, they underlined that internal indicators should be the priority; the external story which might be more intriguing for the companies cannot be created in case internal processes are not handled first. Many interviewees highlighted that the indicators for external communication and reporting should be standardized, so that they are truly comparable and reliable. This is due to the fact that externally communicated circular economy indicators can be used as brand building tool since at the moment circular economy is the buzz word which interests consumers and investors. Yet, according to the interviewees greenwashing could be avoided through standardization and transparency; companies need to disclose the formulas and data sources used in the calculations. It is important that companies know how to communicate properly about the CE-achievements and how these achievements influence the operational environment.

The interviewee of Consultancy 5 reminded that:

One important thing to keep in mind when developing indicators is that the circular economy cannot be seen as an absolute value, but instead focus on the issues that companies could achieved through circular economy.

Relate to that quote, the interviewees saw that one relevant issue is that indicators are genuine and suitable for the particular business. Indicators should answer the questions of how CE-activities improve business opportunities, and what are the critical day-to-day business aspects to be measured. The relevance of the indicators was seen as the main characteristic of internal indicators. The relevance of the proposed CEPIs is tested in this thesis through the weak market test.

One aspect that should also be kept in mind according to the interviewees is that from a business' perspective nonfinancial indicators always have a financial impact as well; for example, what is the cost of a negative environmental impact created by a company versus the cost of positive environmental impact created by a company. Operating within circular economy principles should also be profitable business, and this aspect should be included in

the considerations. Therefore, financial indicators should also be included in the CEPs since the most sustainable way to operate should also be the most profitable way to operate and assists the business growth. Therefore, the metrics that take into account the costs and added values are important. However, the interviewee of Consultancy 3 reminded how challenging the added value calculations are:

The challenge is to measure the value added of the circular economy; how the benefit of expanding the product or solution lifetime can be measured in euros. It requires in-depth knowhow, which many research institutes are developing.

In addition to business profitability and added values, developed CEPs need to support sustainability, because sustainability, circular economy principles and business profitability should go hand in hand. Regarding this objective, one important point that came out in the interviews is that the circular economy operations of a business do not automatically support the sustainable development goals. For instance, recycling might consume a lot of energy, and thus the operations might have a negative environmental impact after all. Therefore, the CEPs should include indicators that indicate whether sustainable development principles are fulfilled. Indicator-wise this means for example the carbon foot- or handprints of the entire supply chain and operations all the way from transportation etc.

What comes to the desired indicator characteristics, from stakeholder perspective the most important ones are: transparency, unambiguity, clarity and truthfulness. Investors highlighted the comparability. However, comparability was seen important and challenging at the same time. Many estimations and assumptions need to be made in the calculations of CE-issues, and the ambiguity complicates the interpretations. According to the interviewees, comparability could be achieved within industries and between similar companies, but possibly not between industries. One interviewee mentioned that the indicators could be also comparable through trends and as improvement ratios, instead of absolute values of the indicators: how certain indicator has been improving over the fiscal years of a particular company. According to the interviewee of Financier 2:

It is important that companies measure their circular economy activities since when something is measured, it is also monitored and pursued. At the moment the metrics are very company-specific, e.g. scales can be different, and the comparability is almost impossible. The point is, how to get normalized and standardized indicators that enable comparability of the impact created by companies.

Since impact investing is a growing trend in Europe, circular economy indicators that indicate positive impacts on society are welcomed among impact investor. One aspect that

counts is for example creating new workplaces. Nevertheless, the interviewed investors seemed little doubtful about the possible circular economy indicators and their comparability.

One interviewee recommended that SMEs could benchmark large companies in the same field and their measurement practices. The benchmarking is done next through document analysis of sustainability reports of large enterprises operating in the circular economy.

5.4 Sustainability reports of large enterprises

As mentioned in the stakeholder interviews, it is relevant for the SMEs to benchmark large companies in the same field and their measurement practices. In order to benchmark what kind of indicators large enterprises are using related to the circular economy, a document analysis of ten sustainability reports were conducted. All ten large enterprises are listed on the Sitra's list and they have applied different circular economy business solutions alongside their other businesses. Table 12 below lists the indicators reported by these large enterprises.

Enterprise	Circular business model	Indicators related to the circular economy
L&T	Product as a service	Carbon footprint of services Emission reductions Waste recycling rate Material recycling rate Emission savings
Lindström	Product as a service	Textile waste recycling rate Textile waste recovery rate
Martela	Product as a service	Rate of renewable energy sources Recovery rate of waste
Ponsse	Product-life extension	Waste recycling rate
3 Step IT	Product-life extension	Carbon savings resulting from the reuse of a laptop Reuse rate of leased devices Reuse rate of incoming plastics as packaging material
Gasum	Renewability	Renewable fuel consumption Recovery and recycling rates of waste Carbon dioxide emission reductions of the life cycle of Gasum biogas Total volume of water withdrawal by source
Neste	Renewability	GHG emission reductions of renewable products The share of waste and residues in the renewable raw materials

		Energy saving measures Total volume of water withdrawal by source Reuse rate of waste
Fortum	Resource efficiency and recycling	Rate of CO ₂ -free electricity production Rate of renewable energy and fuels in production Energy efficiency improvement Utilization rate of gypsum originated from energy production Material recovery rate of waste received from customers Water withdrawal in production operations Material recovery Recycle rate of waste and by-products
UPM	Resource efficiency and recycling	Recovery or recycle rate of total process waste Rate of renewable fuels used
Tori.fi (Schibsted Media Group)	Sharing platform	GHG intensity Energy intensity CO ₂ emissions potentially saved by the user's second-hand trade

Table 12. List of circular economy related indicators on the sustainability reports of large enterprises operating within the circular economy

The carbon savings of 3 Step IT are calculated as follows: “laptop manufacture typically produces 225kg of CO₂; and shipping adds 25kg of CO₂. The energy consumed during three years’ laptop use produces around 50 kg of CO₂. The CO₂ estimate for the second shipping, typically for a shorter distance than the first, includes the carbon footprint of the refurbishing process”. Similarly, the calculation of emission reduction figures of L&T is based on the estimations provided by international Greenhouse Gas Protocol reporting standard, reference values provided by fuel classification of Statistics Finland and emission calculation model of the VTT Technical Research Centre LIPASTO (2017) database. The figures are based on the comparison of the production emissions using recycled material and corresponding production emissions when using virgin raw materials. (L&T, 2017) Also Neste reported that its calculations are based on the data provided by Statistics Finland and Renewable Energy Directive. As can be seen, the calculations are based on the estimations and third-party data. Naturally, the estimations and data sources need to be standardized and commonly used before the metrics can be truly comparable.

As can be seen the indicators disclosed in the sustainability reports vary a lot between enterprises and industries. In addition, different data sources and standardized frameworks

are used in calculations. Hence, the comparability between large enterprises are still challenging even though they are required reporting these issues.

One of the most used standards in sustainability reporting of large enterprises, are the GRI Sustainability Reporting Standards. These standards are mainly developed for large enterprises, yet some of them are applicable also in SMEs. Some of the organizations in the Table 12 are still using the G4 Sustainability Reporting Guidelines which have been replaced by GRI Sustainability Reporting Standards (GRI Standards) released on 19 October 2016. All reporting published after 1 July 2018 should be made in accordance with GRI Standards, except the GRI 303 which comes in effect in January 2021 (GRI, 2017). GRI Standards provide some environmental measurement that are applicable for the CE measurement. These are presented in the table below.

GRI Environmental Standard	Disclosure
GRI 301: Materials	301-1: Materials used by weight or volume 301-2: Recycled input materials used (% of total input material) 301-3: Reclaimed products and their packaging materials (% of the products sold)
GRI 302: Energy	302-1: Energy Consumption within the organization (from renewable sources, in joules or multiples) 302-3: Energy intensity ratio (energy consumption gWh / sales) 302-4: Reduction of energy consumption (amount of reductions in energy consumption achieved as a direct result of conservation and efficiency initiatives, in joules or multiples)
GRI 303: Water and Effluents (effective from January 2021)	303-3: Water withdrawal (by sources)
GRI 305: Emissions	305-1: Direct (Scope 1) GHG emissions (tons of CO ₂ equivalent) 305-2: Energy indirect (Scope 2) GHG emissions (tons of CO ₂ equivalent) 305-3: Other indirect (Scope 3) GHG emissions (tons of CO ₂ equivalent) 305-4: GHG emissions intensity (GHG emissions / sales)

	305-5: Reduction of GHG emissions (as a direct result of reduction initiatives, tons of CO2 equivalent)
GRI 306: Effluents and Waste	306-2: Waste by type and disposal method (reuse, recycling, composting, recovery)

Table 13. Environmental disclosure guidance of GRI Standards

Some of the indicators in the Table 13 are applicable in CE-measurements of SMEs, for example 301-2 and 302-3 seem very practical indicators.

5.5 Online information

Various organizations in private and public sector have organized projects regarding circular economy measurement in business sector. Some of the outcomes of these projects are valuable from the SME perspective. These projects and initiatives are presented next.

EMF (2015) has together with Granta Design developed indicators for companies operating in the circular economy. Their LIFE+ -project was co-funded by the European Commission. According to EMF (2015) the results of the project provides indicators designed for the purpose of assessing “how well a product or company performs in the context of a circular economy, allowing companies to estimate how advanced they are on their journey from linear to circular”. The Circularity Indicators of EMF comprise the Material Circularity Indicator (MCI) and complementary indicators. The MCI is composed by calculating virgin feedstock (V) and unrecoverable waste (W), and then the utility factor F(X). The MCI equation for a product is $MCI_p = 1 - LFI * F(X)$; LFI referring to the Linear Flow Index. The variables needed for the product level calculations are:

$$MCI = 1 - LFI * F(X),$$

$$LFI = \text{Linear Flow Index} = \frac{V + W}{2M + \frac{W_f - W_c}{2}},$$

$$V = \text{the mass of virgin material} = M (1 - F_r - F_U),$$

$$F_r = \text{the fraction of feedstock derived from recycled sources},$$

$$F_U = \text{the fraction of feedstock from reused sources},$$

$$M = \text{the mass of the finished product},$$

$$W_0 = \text{the amount of waste going to landfill or energy recovery} = M (1 - C_r - C_U),$$

$$C_r = \text{the fraction of the mass of the product being collected for recycling at the end of its use phase},$$

$$C_U = \text{the fraction of the mass of the product going into component reuse},$$

$$W_f = \text{the quantity of waste generated in the recycling process} = M \frac{(1-E_f)Fr}{E_f},$$

E_f = the efficiency of the recycling process used to produce the recycled feedstock,

$$W_C = M (1 - E_C) C_r,$$

E_C = the efficiency of the recycling process used for recycling the product at the end of its use phase,

$$F(X) = \text{Utility factor} = \left(\frac{L}{L_{av}}\right) * \left(\frac{U}{U_{av}}\right),$$

L = the length of the product's use phase,

L_{av} = the industry average of the length of the product's use phase,

U = the intensity of use (the extent to which a product is used to its full capacity),

U_{av} = the industry average of the intensity of use

As can be seen, it takes several steps and altogether approximately twenty variables to calculate MCI of a product level and even more steps and variables to compute MCI for a department or a company level. Thus, the MCI indicator requires a great amount of data and therefore is probably not suitable for the small and medium-sized circular businesses. One other noteworthy aspect with MCI is that it does not take into account the renewability of materials.

Unlike MCI, the copyrighted CirculAbility Model invented by Enel (2018) takes renewability into account. Enel's overall circularity index, Circular Index (C_i), is formed by combining Circular Flow (C_f) and Circular Use (C_u). Circular Flow refers to the circularity in the flows of materials and energy and Circular Use to the circularity in the use approach. Yet again, the calculation of Circular Index takes multiple steps and over twenty variables, and therefore is not applicable in the scope of this research. Nevertheless, the calculations of the component Circular Use are fairly simple: extended useful life (years) of the product divided by standard useful life of the product. This is applicable in case of product life extension CBM.

Meanwhile this master's thesis research was in progress, WBCSD (2018) published a report concerning the current landscape of circular metrics. The report was made as a part of their circular economy program called Factor 10. Together with PwC WBCSD interviewed 39 companies, 8 NGOs, governments and academia and reviewed 140 annual reports and 25 other relevant sources in five continents and 15 sectors. In its report WBCSD (2018) points out that companies are currently using their own metrics for measuring circularity and these metrics vary significantly. This is in line with the findings of this thesis. As this thesis, also the WBCSD report aimed to understand the current measurement

practices. The objective of the second phase of the project is to develop “a consensus-based framework for how to measure circularity at the company level”. At the time this thesis was completed, the results of the second phase were not published.

In their report WBCSD (2018) introduce some interesting findings. For example, circular economy is perceived a bit differently across industries and continents. Other interesting findings of the WBCSD’s report is the reasons why businesses measure circularity: “1. drive business performance or strategy, 2. justify achievement externally, 3. integrate circularity across the business, 4. manage risks associated with the existing linear business model and 5. know the impact of their circular activities”.

What comes to the measurement frameworks the companies currently use, WBCSD (2018) reports that of the existing frameworks the Butterfly diagram by EMF is the most used framework after the own frameworks of the companies. Other most used frameworks are: ReSOLVE by McKinsey, GRI, 9R Framework (Potting et al., 2017) and Cradle to Cradle. These frameworks are very useful tools for product, process and business model design purposes, yet this thesis focuses on the quantitative performance indicators and therefore these frameworks are described only superficially.

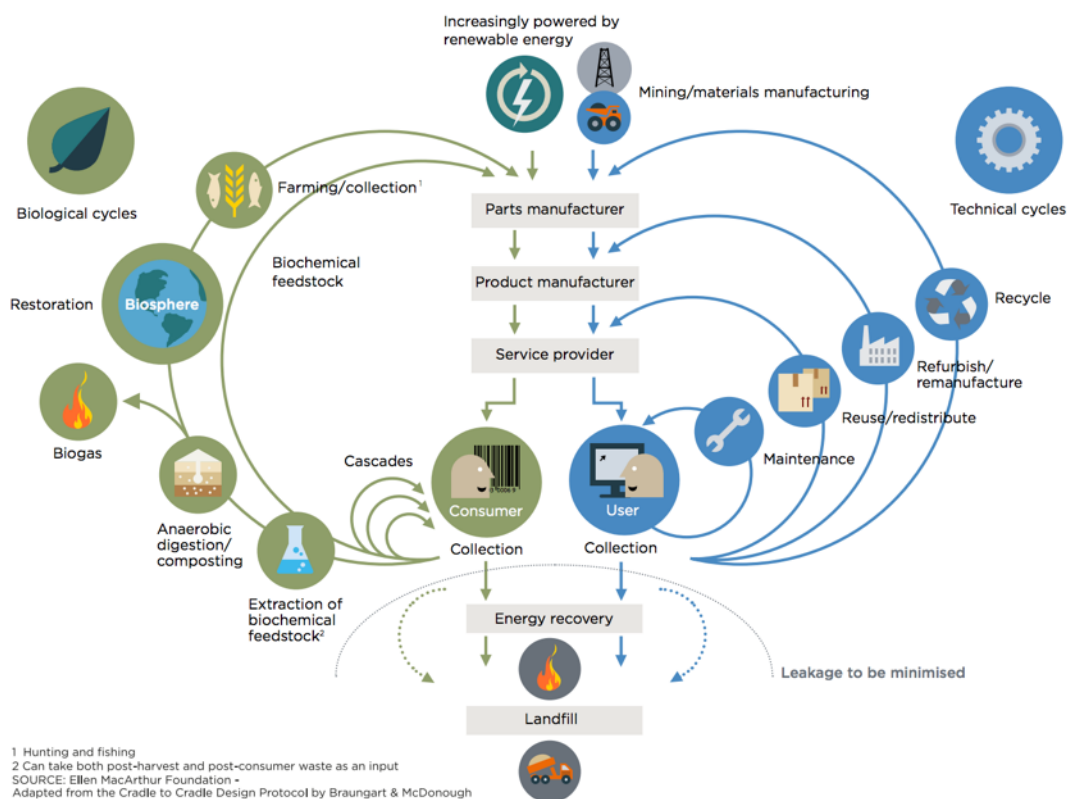


Figure 14. Butterfly diagram by EMF (2015)

ReSOLVE framework by McKinsey has six recommended actions: regenerate (shift to renewable energy and materials; reclaim, retain and restore health of ecosystems; return recovered biological resources to the biosphere), share (peer-to-peer sharing; reuse/secondhand; prolong life through maintenance; design for durability and upgradability), optimize (improve performance/efficiency of product; remove waste in production and supply chain; leverage big data and automation), loop (remanufacture products or components; recycle materials; extract biochemicals from organic waste), virtualize (books; music; autonomous vehicles), and exchange (replace old with advanced non-renewable materials; apply new technologies) (McKinsey&Company, 2016).

9R Framework by Potting, Hekkert, Worrell and Hanemaaijer (2017) gives instructions of what to monitor in terms of circularity strategies within the product chain. 9R refers to Recover, Recycle, Repurpose, Remanufacture, Refurbish, Repair, Reuse, Reduce, Rethink and Refuse. 9R Framework does not instruct explicitly how and with what indicators to measure these strategies.

Cradle to Cradle framework for product innovation include: (1) material health (nontoxicity, nonhazardous, healthiness); (2) material reutilization (biological and technical flows of raw materials); (3) renewable energy and carbon management; (4) water stewardship; and (5) social fairness (McDonough, 2018).

In terms of the circular economy elements the companies are currently measuring are (WBCSD, 2018): materials, energy, water, emissions, land, mineral elements and governance. Unlike this thesis, WBCSD have grouped the existing indicators by the state of the product life cycle. These metrics are presented in the Table 15.

Product life cycle phase	Circular metrics
Raw materials	Material consumption Renewable and recycled materials Certified and responsibly sourced materials Biodiversity
Design	Product design Recyclable product Substance phase-out
Operations	Input and output volumes Operational efficiency and lean operations Renewables Water treatment
Distribution	Renewable and recycled packaging Shared and reused packaging
Use	Product reuse Take-back systems Product efficiency and durability Leasing Communities

End of life	Waste recycling Product end of use Donations
-------------	--

Table 15. Circular metrics along the life cycle. Source: WBCSD (2018)

Also Sitra, Accenture and Technology Industries of Finland had a circular economy measurement related joint-project going on at the time of this thesis. Their project focused on the Finnish manufacturing industry; how CBMs can be applied there and what are the relevant tools and indicators to assist the transition to CE. The results of the project were presented in September 2018, after this thesis was completed. (Sitra, 2018)

What comes to the environmental impacts of product life-cycles, many project and initiatives are in progress. For example, the results of a two-year Carbon Handprint project led by VTT Technical Research Centre of Finland will be completed during the fall 2018. By the time of this thesis, the project was still going on and the results were not presented yet. The project was done in cooperation with Lappeenranta University of Technology and partners such as Neste, Paptic, Gasum and Sitra. The aim of the project is to develop a tool for the carbon handprint measurement based on uniform principles and calculations. The measurement will be useful also for SMEs. The carbon handprint is a measurement of “a net positive action and beneficial environmental and social impacts”. Compared to the traditional sustainability assessment methods such as LCA, carbon footprint and water footprint the carbon handprint focuses on the positive impact instead of negative impact. (VTT, 2016)

One other fairly recent LCA-based research project is called FIMECC made in collaboration between Ruukki Construction, SSAB Europe, Metso Minerals and Aalto University. As a result of this research project two guidebooks were created. The guidebooks focus on sustainable product design and development in metals and engineering industries, which are both very central industries regarding to circular economy. (DIMECC, 2014)

As came out in the case company interviews, some companies have difficulties in finding reliable information about unit emissions and side stream values. The possible data bases that could be useful in CEPI calculations are for example: transport emissions and energy consumption in Finland -database LIPASTO by VTT (2017), national market place for waste and side streams prepared by Finnish Ministry of the Environment and maintained by Motiva coming up in 2019 (Ministry of the Environment, 2018), Petra Waste Benchmarking tool for the estimation of waste amounts and GHG emissions provided by HSY (2015). In addition, some industries have sector-specific data banks such as BAMB

(2018) for building sector in Europe. National FISS -project coordinated by Motiva provides SYNERGie resource database for the use of industrial symbiosis (FISS, 2018).

6 Discussion

6.1 Analysis

The aim of this study is to form a set of indicators that is suitable for the small and medium-sized circular business models in general. More accurately, this means two types of companies operating in the circular economy: circular businesses and circular business models deployed by various medium-sized companies. Circular business refers to the companies whose core business is built around circular economy principles. By contrast circular business model (CBM) refers to the business model that apply circular economy solutions and principles but that are deployed also by companies whose core business might not be in line with the circular economy principles.

The studied CBMs in this thesis are: product as a service; product-life extension; renewability; resource efficiency and recycling; and sharing platforms. The categorization in question goes along with the categorization of Sitra's listing of *The most interesting companies in the circular economy in Finland*. The studied case companies of this thesis are on that list, and the geographical research scope is Finland.

The analysis made in this chapter are based on the theory and empirical evidence gathered through data triangulation: questionnaire (chapter 5.1) and in-dept interviews of case companies (chapter 5.2); stakeholder interviews (chapter 5.3); document analysis of sustainability reports of large enterprises deploying CBMs (chapter 5.4); and online information including project websites of CE-related indicators (chapter 5.5).

As the findings indicate the case companies perceive the circular economy concept and its objectives fairly similarly. In addition, the case companies have clearly internalized key principles of the CE and incorporated them in their core businesses. The rather unclear part of the CE-business for all the case companies is the measurement function, and this is mostly due to two reasons: the complex nature of CE and resource limitations of the companies.

Theory (Di Maio & Rem, 2015; Franklin-Johnson et al., 2016; Linder et al., 2017; Figge et al., 2018; Pauliuk, 2018; Mesa et al., 2018) and empirical evidence highlight certain themes that CEPIs should cover; these are listed in the Table 16. As can be seen the resource

efficiency of primary and secondary materials, energy and water are essential themes, yet material and product quality, life-cycle assessment, social and environmental impact, economic value and design are also important CEPI-themes.

CE themes	CEPI themes
Resource efficiency: Materials Waste Energy Water	Side streams and residuals as raw materials Waste as raw material Renewable materials Input material reductions in production Material circularity and closed loops Ecoefficiency: minimizing virgin material usage Certified or responsibly sourced materials Packaging materials: renewability, recyclability, reusability Loss and residual reduction Waste recovery Waste reduction Energy efficiency Renewable energy usage Water efficiency or savings
Material and product quality	Material health: nonharmful chemicals and materials Take-back systems Reused, refurbished or remanufactured products Product durability
LCA	Footprints or handprints of operations or product life-cycle GHG emissions CO2 reductions compared to a conventional life-cycle
Impact on society or environment	Sharing economy and collaborative consumption Employment Consumers appreciation for CE products and services Customer satisfaction Collaborative production: industrial symbiosis
Economic value	Retained economic value of materials Economic value created through take-back systems Cost savings Cost of positive/negative environmental impact CE-business profitability Financial benefits of CE-activities Value added of CE-activities
Design	Product design Systems thinking

Table 16. Circular economy performance indicator themes

The empirical evidence indicates that the needs and challenges concerning the circular economy performance measurement are somewhat contradictory, which makes the measuring even more complicated. Thus, compromises have to be made in the indicator development process as well. The contradictions to be taken into account are described next.

Internal versus external indicators. The case company data pointed out that both internal and external indicators are needed. However, as came out in the stakeholder interviews, the development of internal CEPs should be a priority. This is due to three reasons. Firstly, the internal processes need to be organized and monitored properly before external story is created. Indicator-wise this means for example the actual environmental

impact created by the CE-operations; in case the recycling activities of a company have negative environmental impact or footprint due to great amount of energy usage or GHG emissions, then the reported recycling rate might give a misleading image of the overall environmental impact of a company. Secondly, the CE-activities and indicators should be integrated into the strategy and BSC, otherwise the CE-activities become disconnect from the core business. This of course requires that right things are measured with CEPIs. Thirdly, external CEPIs need standardization before deployed by the companies. In addition, as theory and stakeholder interviews indicate external indicators need to be transparent, reliable and comparable. In terms of CEPIs, the standardization process and the required three indicator characteristics demand a lot of expertise and development work due to the complexity of CE issues. Therefore, this thesis focuses on the internal indicators.

Standardized versus company-specific indicators. The empirical evidence brought out that the companies already operating in the circular economy have very specific needs in terms of the internal circular economy performance measurement. The needs are more of a company-specific and operational than generalizable. This is not surprising since according to the theory operational activities are usually prioritized in SMEs' performance measurement since the owner-managers are in charge of both operational and managerial functions, and do not have enough time and resources for measurement function. Yet, there is also an evident need for the standardized indicators that enable comparability between companies. Standardized indicators are needed in order to communicate with the stakeholders such as customers and financiers. Companies would also need standardized indicators for benchmarking purposes. Thus, both standardized and company-specific indicators are important.

Simplicity versus comprehensiveness. Both theory and empirical evidence indicate that the performance indicators developed for the needs of SMEs have certain characteristic requirements; they need to be relevant, simple to understand and use, easy to maintain, provide fast and accurate feedback of the current performance, stimulate continuous improvement of the operations, and the data needs to be easy to collect. Nevertheless, the case companies and their stakeholders mentioned that indicators which give comprehensive view of the life cycle impact of the business operations on the circular economy could be useful. However, a holistic view is challenging and complicated to calculate especially when the aforementioned characteristics are taken into account. In addition, due to the complexity of the issues related to the circular economy the explicit impact indicator is very challenging to comprise. The case companies are well aware of the complexity aspect since some of

them have already tried to measure their impact on the CE. All in all, this thesis aims to keep CEPIs as simple as possible and suggests that comprehensive impact indicators should be used as complementary indicators that companies calculated in assistance with experts and consultants, and use existing standards provided by ISO 14044 of LCA, and GHG protocol. In addition, tools such as carbon hand print and SULCA provided by VTT are useful.

Clear (automated) process versus lack of resources. As came out in the case company interviews, the case companies have tried to measure their circular economy performance in many various ways. The case companies recognize that their measurement processes are not clear and need a lot of development which also requires the expertise they do not have. Nevertheless, the current resources are allocated to day-to-day business operations and operational R&D projects instead of measurement process. Some case companies acknowledge that the automated and clear measurement practices would be ideal. Clearly the needs exist but there are not enough business resources to allocate for the development. Like the theory points out the resource limitations (Hudson et al, 2001) and the lack of proper IT infrastructure (Cocca and Alberti, 2009) are the common reasons why SMEs have challenges in measurement function. Therefore, as the interviewed experts suggested: (1) CEPIs need to be simple and have a relevance in terms of business strategies and day-to-day business; (2) too heavy environmental impact measurement system is unnecessary in SMEs; and (3) indicators need to be easy and cost-effective to maintain.

Sustainability versus circularity performance. The stakeholder interviews pointed out that sustainability and circularity performance dimensions cannot and should not be separated from each other since the circular economy aims to sustainable development. In case sustainability and circularity indicators are not closely linked, the risk is that circularity and CE-business have unsustainable outcomes. Therefore, many existing sustainability indicators can be seen as circular economy indicators, or at least sustainability indicators should complement CEPIs. Even though the theory shows that CE deals with the social sustainability issues only implicitly, the interviewed stakeholders recommended to consider social issues in CE-measurement. In addition, in theory a sustainable, or circular, business is also a profitable business in the long term. This thesis takes sustainability indicators into account when identifying relevant CEPIs.

Financial versus nonfinancial indicators. Like sustainability performance dimension, also financial performance dimension should be linked to the circularity dimension. Interviewed case companies and stakeholders proposed using both nonfinancial and financial indicators as CEPIs, whereas theory suggests using mainly nonfinancial

indicators. Interviewed stakeholders validated their point by the fact that in case the economic result and market share of companies operating in the circular economy increase, it accelerates growth and shift towards the circular economy in the national and global level as well. In addition, the theory mentioned also leading and lagging indicators, which both should be included in the key performance indicators. Therefore, the indicators proposed in this thesis are mainly nonfinancial, yet some financial indicators are included. Both leading and lagging indicators are also considered.

Existing versus new indicators. As came out in many stakeholder interviews the existing sustainability and other CE-related indicators are more usable and reliable than possible new indicators. This is due to the standardization of certain existing indicators. Both theory and empirical evidence proposes to measure CE-activities using existing indicators related to standardized frameworks such as ISO 14044 of LCA, ISO 14051 of MFCA, ISO 14031 of EPIs and GRI. Therefore, the indicators proposed in this thesis are mainly linked to the aforementioned standards.

Current versus future relevance. Since many of the case companies are still young startups they have difficulties in addressing the critical success factors, which according to the theory makes the identification of key performance indicators more challenging. As came out in the interviews the case companies have had and still have challenges to figure out what are the most relevant issues to measure. Nevertheless, they also acknowledge that the measurement needs will most certainly change and evolve in the future when the businesses grow, and also external requirements emerge along with new laws and regulations. Hence, some of the proposed indicators that are not relevant today might become relevant in the future. The current relevance of the CEPIs suggested in this study is tested through the weak market test described in the chapter 6.3.

In summary, the indicators proposed in the indicator pools aim to: (1) cover CE-themes of resource efficiency, material and product quality, LCA, social and environmental impact, economic value and design; (2) be primarily operational indicators for internal use, yet some existing standardized indicators could also be used in external communication and reporting; (3) include standardized comparable indicators and indicators that could be modified for the company-specific needs; (4) be as simple as possible, yet complemented by more comprehensive indicators; (5) be relevant from the day-to-day business perspective and cost-effective to maintain; (6) combine sustainability and circularity objectives; (7) include both nonfinancial and financial indicators, and leading and lagging indicators; (8) be at least

related to the existing sustainability and CE-related standards; and (9) be relevant now and in the future.

6.2 Construction: indicator pools

As the analysis indicate one set of indicators suitable for all the companies operating in the circular economy cannot be comprised. Therefore, the managerial construction of this thesis is comprised of two parts:

the first indicator pool: internal strategic and operational CEPIs

the second indicator pool: comprehensive indicators.

All of the indicators in the first and second pool have been selected based on the theory and empirical data analysis made in the chapter 6.1. The indicators of the both indicator pools can be found in the Appendix D and the calculation formulas are described later in this chapter.

The first pool includes circular economy performance indicators (CEPIs) meant for the internal strategic and operational use of circular business models (CBMs). These indicators are customizable for the company-specific use. They have been grouped by the business models: product as a service; product-life extension; renewability; resource efficiency and recycling; and sharing platforms. The comparability of these indicators depends on the industry and the level of similarity of the business models. The comparability can also be achieved by using improvement ratios, i.e. the percentages of how much a certain indicator of a company has improved compared to previous value.

The indicators of the first pool focus on the CE-themes that appeared most in the case company questionnaire and interviews combined with the themes highlighted in the literature: product, component and side stream utilization; material circulation; recycling rates; material efficiency; product, component and material lifetime; waste recovery; upcycling; and material quality. In addition, the indicator characteristics of simplicity, relevance, day-to-day business focus and easy data accessibility have been considered.

The objective of these internal indicators is to become the key circular economy performance indicators of CBMs. This aim requires generalizability, yet due to the multifold needs of the companies the modification possibility is most certainly necessary. The most relevant CEPIs have been screened out through the weak market test (chapter 6.3) conducted via email query sent to the case companies. The calculation formulas of the CEPIs in the first pool are described next.

CEI = circular economy index (Di Maio & Rem, 2015) = *material value recycled from EoL product(s) / material value needed for (re)producing EoL product(s)*. Material values can be either market values or cost-based values. EoL = end of life.

Circular Use (Enel, 2018) = *extended useful life (years) of the product / standard useful life of the product*.

Circulation (Figge et al., 2018) = $N^A + N^B + N^C$

$$N^A = 1$$

$N^B = (ab) \left[\frac{1-(ab)^n}{1-(ab)} \right]$, where a = the % of sold products that are returned, b = the % of returned products that are refurbished, and n = the number of cycles.

$N^C = \frac{p}{1-p} \left[\frac{1-(ab)^{n+1}}{1-(ab)} \right]$, where p = the fraction of the overall material that will be recovered through refurbishing, and thus $\frac{p}{1-p}$ = the % of the overall material recycled after an infinite number of cycles.

The aim is to measure the number of times a resource is used in a product system. Value 1 means fully linear product system, and infinity means fully circular product system.

Customer behavior indicators. Indicators that help identifying consumer preferences and possible shifts towards collaborative consumption. Consumer's appreciation for CE products and services could be measured with traditional customer satisfaction indicators.

Longevity (Franklin-Johnson et al., 2016) = *initial lifetime of a product* (days, months or years) + *earned refurbished lifetime of a product* (days, months or years) + *earned recycled lifetime of the material or components of a product* (days, months or years). The objective is to measure the total lifetime of a certain resource. The longevity ratios are also useful.

Material stock per service unit (Pauliuk, 2018) = *in-use stock / service units*. The metric indicates how much service is generated by material in the use phase. The aim is to move toward service economy so the lower the rate and thus higher the number of service units the in-use material is able to generate, the better the business's revenue model.

Material quality indicators. In order to assess which materials and chemicals should circulate, the CIRCWASTE -project of SYKE (2017) provides information and guidance about harmful chemicals and materials. The sustainability issues need to be considered carefully when sourcing raw materials. All of the renewable or biodegradable raw materials are not automatically sustainably and ethically sourced.

Percentage of recycled input materials used (GRI 301, 2016) = *total recycled input materials used* (total weight or volume) / *total input materials used* (total weight or volume). The objective is to measure the percentage of recycled materials used to produce the company's primary products. Calculations should include packaging materials.

Product-level circularity (Linder et al., 2017) = *economic value of recirculated parts* / *economic value of all parts*. The economic value could be either market value or cost-based estimation of values. Range of this metric is between 0 and 1. For example, the equation of two product parts or components:

$$c_{1\&2} = c_1 * \frac{v_1}{v_1+v_2} + c_2 * \frac{v_2}{v_1+v_2}, \text{ where}$$

c_i = circulation of part i

v_i = value of part i

For newly introduced product parts the circularity values are usually not available, so the equation for circulation is:

$$c_i = \frac{r_i}{r_i + n_i}, \text{ where}$$

r_i = the economic value of recirculated parts of the new product part

n_i = the economic value (costs) of nonrecirculated parts, i.e. virgin materials for the relevant product part i

r = max [cost of parts including handling costs such as procurement and logistics costs; sum of market process for virgin materials contained in the product; secondhand market price for used material or component]

Thus, the value for a newly introduced product part is $r_i + n_i$.

Product utilization rate. The utilization rate should be monitored continuously in order to increase it if needed.

Recovery rates are indicators of how efficiently products, components or materials are reused. Packaging materials should be included. Examples of recovery rates:

Direct reuse of EoL products / reclaimed EoL products

Redistributed EoL products / reclaimed EoL products

Remanufactured EoL products / reclaimed EoL products

Reused post-consumer scrap / collected material

Reused fabrication scrap / collected material

Reused side stream material / collected material

Reused non-renewable resource / collected resources

Total recycled material (Pauliuk, 2018) = *closed-loop recycling (upcycling) + open-loop recycling (downcycling)*. Since circular economy aims to close the material loops, upcycling is more purposeful recycling method. Therefore, the upcycling rate (upcycled material amounts / total production material amounts) is a useful indicator. Packaging materials should be included in the calculations.

Total restored material (Pauliuk, 2018) = *post-consumer scrap + fabrication scrap* (or industrial side stream). The metric could be calculated as material amounts or to make it more comparable as values. Values could be for example market values or cost-based values of different materials divided by a total production, i.e. material restoration rate. Packaging materials should be included.

Total restored products (Pauliuk, 2018) = *direct reuse of EoL products + refilling or refurbishing of EoL products + redistribution of EoL products + remanufacturing of EoL products*. The metric could be calculated as units or to make it more comparable as values. Values could be for example market values of different restoration methods divided by total product sales, i.e. product restoration rate.

Sharing platform data. Since the aim is to shape consumers' preferences towards a sharing economy and collaborative consumption, all the data gathered from the platform is indicating how the consumer habits are changing.

Waste and loss generated in the processes. Indicates resource efficiency (materials, water, energy) that should be monitored at least monthly and compared to the previous amounts.

Many of the indicators are based on estimation and not on standardized data. This naturally weakens the reliability and objectivity of the indicators. What comes to the measurement interval, continuous monitoring is proposed, yet the interval varies case by case.

The second indicator pool includes the more comprehensive indicators that are more general; some of them are guided by standardized frameworks. These indicators focus on more complex and comprehensive themes: impact on society and environment, triple bottom line approach on sustainability, LCA, CO₂ reductions and economic benefits. Due to the complexity and comprehensiveness these indicators require a lot of estimations and assumptions which make them open to interpretations, and therefore these indicators are recommended calculating in cooperation with consultancies and experts. The calculation formulas of the indicators in the second pool are described next.

Material circularity indicator (MCI) for a product (EMF, 2015)

$$= 1 - LFI * F(X),$$

$$LFI = \text{Linear Flow Index} = \frac{V + W}{2M + \frac{W_f - W_c}{2}},$$

$$V = \text{the mass of virgin material} = M (1 - F_r - F_U),$$

$$F_r = \text{the fraction of feedstock derived from recycled sources},$$

$$F_U = \text{the fraction of feedstock from reused sources},$$

$$M = \text{the mass of the finished product},$$

$$W_0 = \text{the amount of waste going to landfill or energy recovery} = M (1 - C_r - C_U),$$

$$C_r = \text{the fraction of the mass of the product being collected for recycling at the end of its use phase},$$

$$C_U = \text{the fraction of the mass of the product going into component reuse},$$

$$W_f = \text{the quantity of waste generated in the recycling process} = M \frac{(1 - E_f) F_r}{E_f},$$

$$E_f = \text{the efficiency of the recycling process used to produce the recycled feedstock},$$

$$W_c = M (1 - E_c) C_r,$$

$$E_c = \text{the efficiency of the recycling process used for recycling the product at the end of its use phase},$$

$$F(X) = \text{Utility factor} = \left(\frac{L}{L_{av}}\right) * \left(\frac{U}{U_{av}}\right),$$

$$L = \text{the length of the product's use phase},$$

$$L_{av} = \text{the industry average of the length of the product's use phase},$$

$$U = \text{the intensity of use (the extent to which a product is used to its full capacity)},$$

$$U_{av} = \text{the industry average of the intensity of use}$$

The above equation is the simplest alternative. EMF (2015) provides also instructions for more comprehensive approaches for product components, department and company level. The aim is to estimate how circular the business and its products are compared to the linear.

Value-based resource efficiency (VRE) (Di Maio et al., 2017)

$$= \frac{GO - S}{E + M} - 1,$$

$$GO - S = \text{added value},$$

$$GO = \text{gross output},$$

$$S = \text{input value of services},$$

$$E = \text{input value of energy},$$

$$M = \text{input value of materials}$$

Current market prices are recommended as values. VRE provides consistent resource efficiency monitoring of products, processes and supply chain. It monitors also consumers, since final selling price is included in the calculation.

Net environmental benefits of recycling (Geyer et al., 2016)

$$= D * (E_{prim} + E_{landfill}) - E_{repro}, \text{ where}$$

D = the total amount of displacement caused by the recycling activity,

E_{prim} = environmental impacts of primary material production,

$E_{landfill}$ = environmental impacts of landfill activities,

E_{repro} = environmental impacts of scrap collection and reprocessing

The quantity that counts is the material amount displaced, not the amount of material collected or recycled. Displaced material refers to the amount of primary resource displaced by the recycling activity. Simply put, recycling has a positive net environmental impact in case the impacts created by the collection and reprocessing are smaller than the impacts created by the primary material production and landfilling. Environmental impacts are for instance GHG emissions and used virgin materials.

Material input per service unit (MIPS) (Ritthof et al., 2003)

= material input (sum of the used material and energy resources) / service unit.

Material input = input amount (in kg) * material intensity (in kg/kg or kg/MJ or kg/kWh)

Some material input data are already calculated and available on www.mips-online.info. The indicator assesses the resource efficiency of the operating model. In case companies follow the guided instructions when calculating MIPS, the value is comparable also with other companies. Service unit depends on the business; it can be for example rental car kilometers, one wearing cycle of a garment (customer's use, washing and other maintenance) or a furniture (customer's use and maintenance).

Eco-efficiency (WBCSD, 2000)

= product or service value / environmental influence,

Examples of generally applicable value indicators, i.e. eco-efficiency ratios' numerators:

Quantity of products or services produced or sold (mass, volume or number)

Economic value of products sold (net sales)

Examples of generally applicable environmental influence indicators, i.e. denominators (WBCSD, 2000):

Energy consumption (total, or in renewable or fossil fuel types)

Water consumption (sum of all fresh water)

Material consumption (excluding energy and water consumption. By types: renewable, nonhazardous etc.)

GHG emissions (CO₂, CH₄, N₂O, HFCs, PFCs, SF₆. In metric tons of CO₂ equivalents)

In addition, WBCSD (2000) lists the potential generally applicable value indicators: net profit, earnings or income, and influence indicators: total waste and acidification emissions to air. In terms of GHG emissions, Greenhouse Gas Protocol by WBCSD (2002) provides useful and standardized calculation tools that enable reliable calculations of GHG emissions for companies.

6.3 Weak market test

The weak market test was conducted in the beginning of September 2018 via email query which was sent to the case companies which responded to the questionnaire presented in the chapter 5.1. The market test was conducted in order to test the functionality of the indicators in the indicator pools and find out the willingness in case companies to implement the developed construction. In other words, the purpose was to filter out the irrelevant indicators for small and medium-sized business models and gather knowledge, which of the indicators in the indicator pools might become as key CEPs. The weak market test gives valuable information for further research and implementation phase of the indicator development process. The weak market test was carried out through email query, which was sent to the case companies who responded to the first case company questionnaire.

Both indicator pools were sent to the case companies and they were asked to answer a few questions:

1. Which of the indicators in the indicator pools are such that you could implement or are already using in your company?
2. Which of the indicators in the indicator pools are such that you do not see useful? Why?
3. Should a certain indicator be developed further? If yes, then how?

All in all, the weak market test showed that both indicator pools include relevant indicators that are applicable as they are. Yet, some indicators need further development and revision. The more detailed results of the weak market are grouped by CBMs.

6.3.1 Product as a service

Due to the time restrictions none of the case companies using product as a service business model had time to familiarize with the indicator pools.

6.3.2 Product-life extension

One response was received. According to the respondent the most relevant indicator for their business is *longevity* or *circular use* by which they could calculate the lifetime of the product, which would be useful information also for external users such as consumers. *VRE* was also seen as a useful indicator.

In addition, comparability was seen as one important indicator characteristic according to the respondent. Indicators that require lot of data, time and complex calculations were seen irrelevant due to the size of the company in question. The respondent saw that in case the indicators could be easily calculated through web-based or other tools, into which the values could be fed, and the tool calculated the result, then the usability would be greater.

6.3.3 Renewability

Two responses were received. According to one respondent relevant and practical indicators for their business are *percentage of recycled input materials used*, *recovery rates*, *total restored materials*, *waste and loss generated in the process*, *VRE*, and eco-efficiency, energy efficiency and resource efficiency indicators. *MIPS* could also be useful especially for the service providers of low value side streams utilization. Complexity and comprehensiveness were again mentioned as the barriers for the usability in some indicators.

The other respondent saw *material quality indicators* as the most important indicators that are also required by laws in some industries. The respondent also saw *waste and loss generated in the process* as interesting indicators, that could be useful for them in the future.

6.3.4 Resource efficiency and recycling

Three responses were received. According to the responses, all of the indicators in the first pool have been used in the case companies in some form. However, one respondent mentioned that the challenge is that they have too many indicators and it has been challenging to shortlist which of them are the most relevant for their business. On the other hand, in case only couple of indicators are seen as the key performance indicators, they might not give a comprehensive enough view of the whole business.

According to the responses the purpose of the indicators depends heavily on the business and therefore are very company-specific. In addition, some of the indicators,

especially in the second pool, were seen too high-flown and difficult to apply in practice. One respondent doubted that some indicators might not guide to right direction in the internal process development which is the main purpose of the indicators. From the day-to-day business perspective for example *net environmental benefits of recycling* was seen irrelevant.

Certain indicators were seen as the most relevant: *waste and loss generated in the process*, *net environmental benefits of recycling* (regarding CO₂ emissions, which is complicated to calculate in practice), *percentage of recycled input materials used*, recovery rates: *material reuse rate* and *non-renewable resource reuse rate*, and *lifecycle cost savings achieved through the CE-activities*. Other indicators that were seen fairly useful are: *circular use*, *MIPS*, *economic benefits of the CE-business* and *overall impact of a business in the CE*.

According to one respondent they calculate *carbon footprint of the operations* yearly and *GHG emission reductions compared to a conventional product or business model* when making decisions about raw materials. According to other respondent they have been calculating *carbon and water footprints*, *rate of renewable energy used*, and some social aspects. However, due the comprehensiveness of the indicators, the lack of reliability has made the indicators useless.

According to one respondent the ideal number of indicators would be 3-5 indicators both from first and second pool, which would together give a concrete and practical view and also more comprehensive view of the business and its sections.

6.3.5 Sharing platforms

One response was received. According to the respondent most of the proposed indicators are relevant, except a few. *Time spent on the site* was not seen as relevant, since the sharing platform is a tool which objective is that the user finds what she/he is looking for as quickly as possible. *The number of registered users* was seen partly relevant; in case the users register to the platform but do not rent anything, then the indicator does not tell anything. Instead, *product utilization rate* was seen the most important, since the objective of maximizing the utilization rate is necessary for both the company and the customer. *The number of rentals per user* was also seen very relevant, yet according to one respondent the whole funnel, i.e. all of the stages of the customer path, should be measured: the rate of the visitors of the platform that end up in the product site, and then to click “rent” -button and in the end renting the product.

Other indicators that the respondent proposed are usage metrics such as (Marketplace Academy, 2016):

Customer conversion funnel = the proportion of new visitors that end up buying something on the site. This is a useful indicator for track to bottlenecks of the platform.

Monthly active users (MAU) = the number of unique users who have visited the site at least once during a certain time period. The indicator tracks whether the platform is able to attract new users.

Bounce rate = the percentage of visitors who enter the site and leave right away. The indicator measures the engagement rate of visitors and the target level is as low as possible.

Liquidity = the percentage of listings that lead to transactions within a certain time period. A good goal is between 30 and 60.

Provider-to-customer ratio = the number of customers that one provider can serve. The ratio can be for example 1:1 or 1:1000. The ratio depends on the platform and the products.

Repeat purchase ratio = the percentage of the transactions that are repeat purchases, i.e. from users who have already made purchases or rental transactions on the site. The higher the ratio, the better.

What comes to the customer satisfaction one useful metric is *Net Promoter Score (NPS)*, which is the result of the question of *How likely it is that you would recommend the product or the platform to a friend or colleague?* on a given scale. Or *The Sean Ellis Test*, i.e. the question *How would you feel if you could no longer use the product or the platform?*. In addition to the previous usage and customer satisfaction metrics other useful indicators are financial indicators such as: Gross Merchandise Volume (GMV), Customer Acquisition Cost (CAC), and Customer Lifetime Value (CLV). (Marketplace Academy, 2016)

7 Conclusion

7.1 Research summary

Various public and private organizations have developed and are currently developing circular economy indicators on macro, meso, micro and nano level. This thesis concentrated on the micro and nano level, i.e. on companies and their operations and products. Businesses, and especially circular business models (CBMs) have a crucial role in the transition towards the circular economy. Through business model innovations and revising their operation and

revenue models, companies are able to reshape production and consumption patterns towards more sustainable approach.

In order to achieve their CE-related business goals, companies need to measure their performance. In addition to CBMs, this study examined small and medium-sized companies, since SMEs have a huge CE-innovation potential. None of the past or on-going indicator development projects have been trying to answer the research question of this thesis:

What are the key circular economy performance indicators for small and medium-sized circular business models in Finland?

This study was motivated also by other practical aims for the businesses. According to Mata-Lima et al. (2016) by identifying and implementing indicators for sustainability evaluation, a company will gain benefits such as increased stakeholder awareness regarding best practices of sustainability; changes in target audience behaviors with regard to actions that contribute to sustainability; and continuous measurement of the distance between the baseline condition and the level of sustainability against set tangible goals in the medium and long term. Instead of sustainability, this thesis focused on the circularity, which can be seen as a close performance dimension to sustainability.

As the research findings indicate due to the complex nature of CE and lack of established definition, simplified indicators that cover all aspects of the CE are challenging to develop. Therefore, the managerial construction of this thesis includes two indicator pools aiming to cover the CE-themes as comprehensively as possible. The first indicator pool contains internal strategic and operational CEPIs and the second pool introduces the more comprehensive and standardized CE-related indicators. The indicators in the first pool are grouped by five circular business models: product as a service; product-life extension; renewability; resource efficiency and recycling; and sharing platforms. This categorization was based on the Sitra's listing of *The most interesting companies in the circular economy in Finland* including 98 companies, of which some were selected as the case companies of the research.

The indicators of the indicator pools are primarily meant for internal use, which also enables the company-specific modification. When reported externally transparency and reliability need to be considered, and calculation methods and data sources must be disclosed. This thesis recommends using standardized frameworks if possible. The aim of the indicators presented in this study is to become the key circular economy performance indicators for the circular businesses. However, one desired characteristic, namely the comparability of the indicators is challenging to achieve. Therefore, this thesis recommends

comparing companies within industries rather than between industries. The comparability between companies in the same CBM category cannot be achieved after all.

The indicator pools developed in this study include many relevant indicators for the CBMs. These indicators are gathered from many data sources such as academic literature, case company interviews, stakeholder interviews, sustainability reports of large enterprises, and circular economy performance indicator development projects' websites. In order to shortlist the most relevant indicators for the CBMs, the weak market test was conducted. The weak market test gives a valuable information for the further development of the indicators.

7.2 Theoretical and practical contributions

This thesis has strong practical contributions; the indicator pools developed in this study have identified the circular economy performance indicators that might become the key CEPIs for the CBMs. The construction of this thesis, i.e. the indicator pools, helps companies operating in the circular economy to select relevant indicators for their businesses. The indicators might also help other companies than CBMs to embed CE-principles in their operations.

Due to the novelty and complex nature of the circular economy, traditional management accounting literature related to the key performance indicators lacks the indicators suitable for the circular economy performance measurement. The traditional literature focuses on the aspects that are linked to the circular economy, e.g. sustainability, eco-efficiency, life-cycle assessment, material flow cost accounting, quality and environmental performance, yet not specifically on the circularity. Only very recent studies by Di Maio & Rem, 2015; Franklin-Johnson et al., 2016; Figge et al., 2018; and Pauliuk, 2018 have been focusing specifically on the circular economy performance indicators.

Hence, theoretical contributions of this thesis are related to these aforementioned researches. Each of the aforementioned studies have slightly different approach to the circular economy performance measurement. Pauliuk (2018) bases his indicator dashboard – presented in the chapter 3.7 – on the perspectives of life-cycle assessment (LCA) and material flow cost accounting (MFCA), whereas Di Maio & Rem (2015) focus on material values kept in the economy, Franklin-Johnson et al. (2016) on resource duration, and Figge et al. (2018) on material circulation.

The indicators these scholars have developed are very useful for the business sector. However, none of the above-mentioned studies have explicitly stated what are the key

circular economy performance indicators that small and medium sized circular business models could use. This thesis filled that research gap by identifying indicators for the use of SMEs operating in the circular economy. SMEs have a huge innovation potential in terms of CE-operations and business models. Therefore, this thesis brought these two perspectives, namely small and medium-sized enterprises (SMEs) and circular business models (CBMs) into the examination.

7.3 Research limitations and future research avenues

Since the topics of circular economy and circular business models are constantly evolving, some of the indicators introduced in this research might not be applicable in the future. In addition, the case company selection based on the Sitra's list (2017) gives only a current review of the companies operating in the circular economy in Finland, and therefore further research is needed when the circular economy takes more root in the society and business sector. Since the CE does not have a common definition, the further research could tackle also that issue and attempt to create established definitions for the circular economy and circular business models.

All in all, this thesis covers a fairly broad group of current companies operating in the circular economy, and therefore it gives a good basis for further studies when the CE phenomenon gains more ground in Finnish business sector. Due to the scope and time limitations, this study covers only the identification phase of the CEPI development process. The phases of screening, ranking and implementation are necessary subsequent research avenues in order to find out the essential qualitative characteristics of the indicators: relevance, understandability and reliability. The conducted weak market test gives a valuable insight for the further development of the proposed indicators. Nevertheless, due to the time limitations from the case companies side the weak market test covers only a small sample of the companies, and therefore the generalizability of the market test is weak. The weak market test responses give an approximate view of the relevance of the identified indicators.

This research does not take a stand on how comprehensively the proposed indicators cover the fulfilment of the circular economy principles in a certain business. The resource limitations of the case companies, i.e. lack of data systems and accounting professionals, restrict materially the coverage of the indicators since the indicators need to be as simple as possible.

From the financial accounting perspective, the proposed indicators need further development and standardization especially for the sake of reliability; so that they can be

applied in the external reporting or communication of the companies. Standardization would enhance also the comparability.

From the management accounting perspective, it would be interesting to find out how well these CEPIs fit into the BSC framework and do they have a cause-and-effect relationship with other crucial performance dimensions, e.g. whether enhanced resource efficiency decreases costs and increases profits. In addition, the measurement process itself needs development: how the automation and integration into the ERP or other SPMS can be achieved in companies.

References

- Anthony, R. (1965). *Planning and Control Systems: A Framework for Analysis*. Boston, MA: Division of Research, Graduate School of Business Administration, Harvard University.
- Antikainen, M., & Valkokari, K. (2016). "Framework for sustainable circular business model innovation". *Technology Innovation Management Review*, Vol. 6(7), pp. 5-12.
- Amsterdam Smart City (2018). Circular Amsterdam. Online. Available at: <https://amsterdamsmartcity.com/circularamsterdam> [5.9.2018]
- Bahri, M., St-Pierre, J., & Sakka, O. (2017), "Performance measurement and management for manufacturing SMEs: a financial statement-based system", *Measuring Business Excellence*, Vol. 21(1), pp. 17-36.
- BAMB (2018). Building as Material Banks. Available at: <https://www.bamb2020.eu/> [22.8.2018]
- Benyus, J. (1997) *Biomimicry - Innovation Inspired by Nature*, William Morrow and Company, New York, 308p.
- Bititci, U., Carrie A. & McDevitt L., (1997). Integrated performance measurement systems: A development guide. *International Journal of Operations & Production Management*, Vol.17(5), pp. 522-534.
- Bocken, N., Short, S., Rana, P., & Evans, S. (2014), "A literature and practice review to develop sustainable business model archetypes", *Journal of Cleaner Production*, Vol. 65, pp. 42-56.
- Bogetoft, P. (2013). *Performance benchmarking: Measuring and managing performance*. New York: Springer.
- Boulding, K. (1966) "The economics of coming spaceship earth" In H. Jarret (Ed.), *Environmental quality in a growing economy*. Baltimore, MD: John Hopkins University Press.
- Braungart, M. & McDonough, W. (2002) *Cradle to Cradle: Remaking the Way We Make Things*, North Point Press, New York, USA.
- Brignall, T., Fitzgerald, L., Johnston, R. & Silvestro R. (1991). *Performance measurement in service businesses*. London: CIMA.
- Bryant, L., Jones, D. & Widener, S. (2004). Managing Value Creation within the Firm: An Examination of Multiple Performance Measures. *Journal of Management Accounting Research*, Vol. 16, pp. 107-131.

- BSI (2017). BS 8001:2017. Framework for Implementing the Principles of the Circular Economy in Organizations – Guide. The British Standards Institution, London.
- Butler, J. B., Henderson, S. C., & Raiborn, C. (2011). “Sustainability and the balanced scorecard: Integrating green measures into business reporting”. *Management Accounting Quarterly*, Vol. 12(2), pp.1–10.
- Carlucci, D. (2010) “Evaluating and selecting key performance indicators: An ANP-based model”, *Measuring Business Excellence*, Vol. 14(2), pp. 66-76.
- Chenhall, R. (2005) “Integrative strategic performance measurement systems, strategic alignment of manufacturing, learning, and strategic outcomes: An exploratory study”, *Accounting, Organizations and Society* Vol. 30, pp. 395–422.
- Chennell, A., Dransfield, S., Field, J., Fisher, N., Saunders, I. and Shaw, D. (2000). OPM: a system for organisational performance measurement. In Proceedings of the Performance Measurement – Past, Present and Future Conference, Cambridge, 19–21 July.
- Chertow, M. & Ehrenfeld, J. (2012) “Organizing self-organizing systems”, *Journal of Industrial Ecology*, Vol. 16(1), pp. 13-27.
- Christ, K. & Burritt, R. (2016). ISO 14051: A new era for MFCA implementation and research. *Revista de Contabilidad*, 19(1), pp. 1-9.
- Chong, H.G., (2008) “Measuring performance of small-and medium sized enterprises: the grounded theory approach”. *Journal of Business and Public Affairs*, Vol. 2(1), pp. 1–10.
- Circle Economy (2016). Circular Amsterdam – A vision and action agenda for the city and metropolitan area. Available at: <https://www.circle-economy.com/wp-content/uploads/2016/04/Circular-Amsterdam-EN-small-210316.pdf> [5.9.2018]
- Circulate News (2018). Which country is leading the circular economy shift? Available at: <https://circulatenews.org/2018/07/which-country-is-leading-the-circular-economy-shift/> [5.9.2018]
- Cocca, P., & Alberti, M., (2009). “A framework to assess performance measurement systems in SMEs”. *International Journal of Productivity and Performance Management*, Vol. 59(2), pp. 186–200.
- Cohen, J., Holder-Webb, L., Nath, L., & Wood, D. (2012), “Corporate Reporting of Nonfinancial Leading Indicators of Economic Performance and Sustainability”, *Accounting Horizons*, Vol. 26(1), pp. 65-90.

- Di Maio, F. & Rem, P. (2015). "A Robust Indicator for Promoting Circular Economy through Recycling". *Journal of Environmental Protection*, Vol. 6(10), pp. 1095-1104.
- Di Maio, F., Rem, P.C., Baldé, K., Polder, M., (2017). Measuring resource efficiency and circular economy: a market value approach. *Resources, Conservation & Recycling*. Vol. 122, pp.163–171.
- DIMECC (2014). A roadmap towards sustainability. Online. Available at: <http://hightech.dimecc.com/results/a-roadmap-towards-sustainability> [4.9.2018]
- Doran, G. (1981) "There's a SMART Way to Write Management's Goals and Objectives" *Management Review* Vol. 70, pp. 35-36.
- EEA (2016) – European Environment Agency. Circular Economy in Europe: Developing the knowledge base. EEA Report. No. 02/2016.
- EK (2015). Kiertotalous Suomen työnantajayrityksissä. EK:n kyselytutkimuksen tulokset.
- EMF – Ellen MacArthur Foundation (2018a). Online.
Available at: <https://www.ellenmacarthurfoundation.org/> [19.01.2018]
- EMF – Ellen MacArthur Foundation (2018b). Circular Economy Overview. Online.
Available at: <https://www.ellenmacarthurfoundation.org/circular-economy/overview/concept> [19.01.2018]
- EMF – Ellen MacArthur Foundation (2018c). Publications. Online.
Available at: <https://www.ellenmacarthurfoundation.org/publications> [2.2.2018]
- EMF – Ellen MacArthur Foundation (2018d). Programmes – Business. Available at: <https://www.ellenmacarthurfoundation.org/programmes/business> [5.9.2018]
- EMF – Ellen MacArthur Foundation (2015). Circularity Indicators – An Approach to Measuring Circularity. Available at: <https://www.ellenmacarthurfoundation.org/programmes/insight/circularity-indicators> [21.4.2018]
- Enel (2018). CirculAbility Model. Online. Available at: <https://corporate.enel.it/en/circular-economy-sustainable-future/performance-indicators>. [30.6.2018]
- EU (2008) – Directive 2008/98/EC of the European Parliament and the Council on waste and repealing certain directives. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098> [2.2.2018]
- European Commission (2017), "Annual report on European SMEs 2016/2017". Online.
Available at: http://ec.europa.eu/growth/smes/business-friendly-environment/performance-review/index_en.htm [6.3.2018]
- Eriksson, P., & Koistinen, K. (2014). Monenlainen tapaustutkimus. Kuluttajatutkimuskeskus.

- Epstein, M. J. & Rejc, A. (2014). *Making sustainability work: Best practices in managing and measuring corporate social, environmental, and economic impacts* (Second edition, completely revised and updated.). San Francisco: Berrett-Koehler Publishers, Inc.
- European Commission (2012). Product Environmental Footprint (PEF) Guide. Online. Available at:
<http://ec.europa.eu/environment/eussd/pdf/footprint/PEF%20methodology%20final%20draft.pdf>. [20.8.2018]
- European Commission (2014). Non-financial reporting. Online. Available at:
https://ec.europa.eu/info/business-economy-euro/company-reporting-and-auditing/company-reporting/non-financial-reporting_en [25.10.2018]
- FISS (2018) – Teolliset symbioosit toimintamalli Suomessa. Available at:
<http://teollisetsymbioosit.fi/> [22.8.2028]
- Franklin-Johnson, E., Figge, F., & Canning, L. (2016), “Resource duration as a managerial indicator for Circular Economy performance”, *Journal of Cleaner Production*, Vol. 133, pp. 589-598
- Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Boston, MA: Pitman
- Friedman, Milton. (1970). “The Social Responsibility of Business is to Increase its Profits”. *The New York Times Magazine*.
- Figge, F., Thorpe, A., Givry, P., Canning, L. & Franklin-Johnson, E. (2018). “Longevity and Circularity as Indicators of Eco-Efficient Resource Use in the Circular Economy”. *Ecological Economics*, Vol. 150, pp. 297-306.
- Fortum – Sustainability Report (2017).
- Franco-Santos, M. (2012). “Contemporary performance measurement systems: A review of their consequences and a framework for research”, *Management Accounting Research*, Vol. 23(2), p. 79.
- Franco-Santos, M., Kennerley, M., Micheli, P., Martinez, V., Mason, S., Marr, B., Gray, D. and Neely, A. (2007), “Towards a definition of a business performance measurement system”, *International Journal of Operations & Production Management*, Vol. 27(8), pp. 784-801.
- Frosch, R. & Gallopoulos N. (1989), “Strategies for Manufacturing”, *Scientific American*, Vol. 261, pp. 144-152.

- Garengo, P., Biazzo, S., & Bititci, U. (2005) "Performance measurement systems in SMEs: A review for a research agenda", *International Journal of Management Reviews*, Vol.7(1), pp. 25-47.
- Garengo, P., & Biazzo, S. (2012), 'Unveiling strategy in SMEs through balanced scorecard implementation: A circular methodology', *Total Quality Management & Business Excellence*, Vol. 23(1), pp. 79-102.
- Gasum – Corporate Responsibility Report (2017).
- Geissdoerfer, M., Savaget, P., Bocken, N., & Hultink, E. (2017), "The Circular Economy – A new sustainability paradigm?", *Journal of Cleaner Production*, Vol. 143, pp. 757-768.
- Geyer, R., Kuczenski, B., Zink, T. & Henderson, A. (2016). "Common Misconceptions about Recycling". *Journal of Industrial Ecology*, Vol. 20(5), pp. 1010-1017.
- Ghisellini, P., Cialani, C., & Ulgiati, S. (2016) "A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems", *Journal of Cleaner Production*, Vol.114, pp. 11-32.
- Graedel, T. (1996). "On the concept of industrial ecology". *Annual Review of Energy and Environment*, Vol. 21, pp. 69-98.
- Graedel, T., Allwood, J., Birat, J., Buchert, M., Hagelüken, C., Reck, B., Sibley, S. & Sonnemann, G., (2011). "What do we know about metal recycling rates?" *Journal of Industrial Ecology*. Vol. 15, pp. 355–366.
- GRI (2017). GRI Standards. Online. Available at:
<https://www.globalreporting.org/standards/>. [30.6.2018]
- Hall, M. (2008), "The effect of comprehensive performance measurement systems on role clarity, psychological empowerment and managerial performance", *Accounting, Organizations and Society*, Vol. 33(2-3), pp. 141-163.
- Hawken, P., Lovins A. & Lovins, L. (2000) *Natural Capitalism: Creating the Next Industrial Revolution*, 1st edition, US Green Building Council, 416p.
- Hazen, B., Mollenkopf, D., & Wang, Y. (2017) "Remanufacturing for the Circular Economy: An Examination of Consumer Switching Behavior", *Business Strategy & The Environment*, Vol. 26(4), pp. 451-464.
- Hervani, A., Helms, M., & Sarkis, J. (2005) "Performance measurement for green supply chain management". *Benchmarking: An International Journal*, Vol. 12(4), pp.330–353.

- Hsieh C., Nickerson J. & Zenger T. (2007) “Opportunity discovery, problem solving and a theory of the entrepreneurial firm”, *Journal of Management Studies*, Vol. 44(7), pp. 1255–1277.
- HSY (2015) Helsinki Region Environmental Services Authority. Petra Waste Benchmarking. Available at: <https://petrajatevertailu.fi/hsy/?mo=main&userID=1543> [22.8.2018]
- Hudson, M., Smart, A. & Bourne, M. (2001), “Theory and practice in SME performance measurement systems”, *International Journal of Operations & Production Planning*, Vol. 21(8), pp. 1096-1115.
- Husgafvel, R.; Pajunen, N.; Dahl, O.; Heiskanen, K.; Ekroos A.; Virtanen, K. Development of Environmental and Economic Sustainability Metrics for the Metal Production Industry—Experiences From University-Industry Cooperation. In *Sustainable Business, Management, and Economics*; Berger, L., Bergman, M.M., Eds.; Frontiers in Sustainability Series 1; MDPI: Basel, Switzerland, 2017; Volume 2, pp. 98–122.
- Ishaq Bhatti, M., Awan, H. M., & Razaq, Z. (2014). ”The key performance indicators (KPIs) and their impact on overall organizational performance”. *Quality and Quantity*, Vol. 48(6), pp. 3127-3143.
- ISO 14031 – Environmental management – Environmental performance evaluation – Guidelines. Online. Available at: <http://mahdi.hashemitabar.com/cms/images/Download/ISO/iso-14031-2013-english-previews.pdf>. [17.8.2018]
- Jelinski, L., Graedel, T., Laudise, R., McCall, D. & Patel, C. (1992) “Industrial ecology: concepts and approaches”, *Proceedings of the National Academy of Sciences of the United States of the America*, Vol. 89(3), pp. 793–797.
- Kaplan, R. & Norton D. (1992). *The Balanced Scorecard: Measures that Drive Performance*, *Harvard Business Review*, (January-February): 71-79.
- Kasanen, E., Lukka, K., & Siitonen, A. (1993), “The Constructive Approach in Management Accounting Research”, *Journal of Management Accounting Research*, Vol. 5, pp. 243-264.
- Keeble, J., Topiol, S., & Berkeley, S. (2003), “Using Indicators to Measure Sustainability Performance at a Corporate and Project Level”, *Journal of Business Ethics*, Vol. 44, 2/3, pp. 149-158.
- Keegan, D., Eiler, R. and Jones, C. (1989), “Are your performance measures obsolete?”, *Management Accounting*, Vol. 70 No. 12, pp. 45-50.

- Kennerley, M., & Neely, A. (2002) "A framework of the factors affecting the evolution of performance measurement systems", *International Journal of Operations & Production Management*, Vol. 22(11), pp. 1222-1245.
- Korhonen, J., Honkasalo, A., & Seppälä, J. (2018) "Circular Economy: The Concept and its Limitations", *Ecological Economics*, Vol. 143, pp. 37-46.
- Lawson, R., Stratton, W. and Hatch, T. (2003), "The benefits of a scorecard system", *CMA Management*, Vol. 77(4), pp. 24-26.
- Laitinen, E. (1996), "Framework for Small Business Performance Measurement – Towards Integrated PM Systems". Research Paper. Publication of Vaasan Yliopisto.
- Linder, M. Sarasini, S. & Loon, P. (2017). "A Metric for Quantifying Product-Level Circularity". *Journal of Industrial Ecology*, Vol. 21(3), pp. 545-558.
- Linder, M. & Williander, M. (2017) "Circular Business Model Innovation: Inherent Uncertainties", *Business Strategy and the Environment*, Vol. 26 (2), pp. 182-196.
- Lindström – Sustainability Report (2017).
- Lo-Iacono-Ferreira, V., Capuz-Rizo, S., & Torregrosa-López, J. (2018), "Key Performance Indicators to optimize the environmental performance of Higher Education Institutions with environmental management system – A case study of Universitat Politècnica de València", *Journal of Cleaner Production*, Vol. 178, pp. 846-865.
- Lonbani, M., Sofian, S., & Baroto, M. (2016), "Balanced Scorecard Implementation in SMEs: Addressing the Moderating Role of Environmental Uncertainty", *Global Business & Organizational Excellence*, Vol. 35(3), pp. 58-66.
- Lukka, K. (2014). Metodix: Konstruktiivinen tutkimusote. Online. Available at: <https://metodix.fi/2014/05/19/lukka-konstruktiivinen-tutkimusote/>. [24.6.2018]
- Lönnqvist, A. (2004), "Measurement of Intangible Success Factors: Case Studies on the Design, Implementation and Use of Measures", *Tampere University of Technology*, Doctoral Thesis. Tampere.
- L&T – Annual Report (2017).
- Lynch, R. and Cross, K. (1991), *Measure Up! Yardsticks for Continuous Improvement*, Basil Blackwell Inc, Cambridge, MA.
- Malmi, T. (2001). Balanced scorecards in Finnish companies: A research note. *Management Accounting Research*, 12(2), pp. 207-220.
- Manninen, K., Koskela, S., Antikainen, R., Bocken, N., Dahlbo, H., & Aminoff, A. (2018), "Do circular economy business models capture intended environmental value propositions?", *Journal of Cleaner Production*, Vol. 171, pp. 413-422.

- Marketplace Academy (2016). How to measure your success: The key marketplace metrics. Available at: <https://www.sharetribe.com/academy/measure-your-success-key-marketplace-metrics/> [6.9.2018]
- Martela – Sustainability Report (2017).
- Mata-Lima, H, Alvino-Borba, A, Akamatsu, K, Incau, B, Jard, J, da Silva, A, & Morgado-Dias, F (2016), “Measuring an Organization's Performance: The Road to Defining Sustainability Indicators”, *Environmental Quality Management*, Vol. 26(2), pp. 89-104.
- McDonough (2018). Cradle to Cradle Products Innovation Institute. Online. Available at: <http://www.mcdonough.com/organizations/cradle-cradle-products-innovation-institute/>. [27.8.2018]
- McKinsey&Company (2016). The circular economy: Moving from theory to practice.
- Melissen, F., & Moratis, L. (2016), “A Call for Fourth Generation Sustainable Business Models”, *Journal of Corporate Citizenship*, Vol. 63, pp. 8-16
- Mesa, J., Esparragoza, I. & Maury, H. (2018). Developing a set of sustainability indicators for product families based on the circular economy model. *Journal of Cleaner Production*, Vol. 196.
- Ministry of the Environment (2018). Press release 18.5.2018. Available at: http://www.ym.fi/fi-FI/Ajankohtaista/Tiedotteet/Jatteilie_valmisteilla_markkinapaikka [22.8.2018]
- Modell, S. (2005). “Triangulation between case study and survey methods in management accounting research: an assessment of validity implications”, *Management Accounting Research* Vol. 16, pp. 231–254
- Mont, O. (2002). “Clarifying the concept of product–service system”. *Journal of Cleaner Production*, Vol. 10(3), pp. 237-245.
- Mouazan, E. (2016) “Understanding circular business models: drivers, obstacles and conditions towards a successful transition”, *Aalto University School of Business*, Master’s Thesis in Creative Sustainability programme, Department of Management Studies.
- Murray, A., Skene, K., & Haynes, K. (2017), “The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context”, *Journal of Business Ethics*, Vol.140(3), pp. 369-380.

- Neely, A. (2005), "The evolution of performance measurement research: Developments in the last decade and a research agenda for the next", *International Journal of Operations & Production Management*, Vol. 25(12), pp. 1264-1277.
- Neste – Sustainability Report (2017).
- Osterwalder, A. & Pigneur, Y. (2010) *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers*. 1st edition. John Wiley and Sons, New Jersey. 280p.
- Parmenter, D. (2010). *Key performance indicators: Developing, implementing, and using winning KPIs* (2. ed.). Hoboken, N.J.: Wiley.
- Pauli, G. (2010) *Blue Economy: 10 Years, 100 Innovations, 100 Million Jobs*. Paradigm Pubns.
- Paula Pinheiro, M., Jugend, D., Demattê Filho, L., & Armellini, F. (2018), "Framework proposal for ecodesign integration on product portfolio management", *Journal of Cleaner Production*, 185, pp. 176-186
- Pauliuk, S. (2018). "Critical appraisal of the circular economy standard BS 8001: 2017 and a dashboard of quantitative system indicators for its implementation in organizations", *Resources, Conservation & Recycling*, Vol. 129, pp. 81-92.
- Pekkola, S., Saunila, M., & Rantanen, H. (2016), 'Performance measurement system implementation in a turbulent operating environment', *International Journal of Productivity & Performance Management*, Vol. 65, 7, pp. 947-958.
- Pojasek, R. (2009) "Using leading indicators to drive sustainability performance", *Environmental Quality Management*, Vol. 18(4), pp. 87-93
- Politico (2018). Ranking how EU countries do with the circular economy. Online. Available at: <https://www.politico.eu/article/ranking-how-eu-countries-do-with-the-circular-economy/> [4.9.2018]
- Ponsse – Annual Report (2017).
- Potting, J., Hekkert, M., Worrell, E. & Hanemaaijer, A. (2017). *Circular Economy: Measuring Innovation in the Product Chain*. Policy Report. PBL Netherlands Environmental Assessment Agency.
- Prieto-Sandoval, V., Jaca, C., & Ormazabal, M. (2018). Towards a consensus on the circular economy. *Journal of Cleaner Production*, 179, pp. 605-615.
- Rautiainen, A., Sippola, K., & Mättö, T. (2017) "Perspectives on relevance: The relevance test in the constructive research approach", *Management Accounting Research*, Vol. 34, pp. 19-29.

- Ritthoff, M., Rohn, H. & Liedtke, C. (2003). Calculating MIPS – Resource Productivity of Products and Services. Wuppertal Institute, Wuppertal, Germany.
- Rodrigue, M., Magnan, M., & Boulianne, E. (2013), “Stakeholders’ influence on environmental strategy and performance indicators: A managerial perspective”, *Management Accounting Research*, Vol. 24(4), pp. 301-316.
- Sakai, S., Yoshida, H., Hirai, Y., Asari, M., Takigami, H., Takahashi, S., Chi, N. K. (2011). ”International comparative study of 3R and waste management policy developments”. *The Journal of Material Cycles and Waste Management*, Vol. 13(2), pp. 86-102.
- Saunila, M. (2016), “Performance measurement approach for innovation capability in SMEs”, *International Journal of Productivity & Performance Management*, Vol. 65(2), pp. 162-176.
- Savage, G. (2010). Stakeholder Collaboration: Implications for Stakeholder Theory and Practice. *Journal of Business Ethics*, 96 (Supplement 1), pp. 21-26.
- Scheepens, A.E., Vogtländer, J.G., Brezet, J.C., (2016). Two life cycle assessment (LCA) based methods to analyse and design complex (regional) circular economy systems. Case: making water tourism more sustainable. *J. Clean. Prod.* 114, 257–268.
- Schibsted – Annual Report (2017).
- Schmidheiny S. (1992) Changing Course – A Global Business Perspective on Development and the Environment, The MIT Press, English Language Edition, 373p.
- Simons, R., (1995). Levers of Control: How Managers Use Innovative Control Systems to Drive Strategic Renewal. Harvard Business School Press, USA.
- Simons, R. (2000). Performance Measurement & Control Systems for Implementing Strategy. Pearson Education, New Jersey.
- Singh, S., Olugu, E., Musa, S., & Mahat, A. (2018), “Fuzzy-based sustainability evaluation method for manufacturing SMEs using balanced scorecard framework”, *Journal of Intelligent Manufacturing*, Vol. 29(1), pp. 1-18.
- Sitra (2015). The opportunities of a circular economy for Finland. Sitra Studies 100. Online. Available at: <https://www.sitra.fi/en/publications/opportunities-circular-economy-finland/> [25.6.2018]
- Sitra (2016). Leading the cycle – Finnish road map to a circular economy 2016-2025. Available at: <https://www.sitra.fi/en/projects/leading-the-cycle-finnish-road-map-to-a-circular-economy-2016-2025/> [3.4.2018]

- Sitra (2017). The most interesting companies in the circular economy in Finland. Available at: <https://www.sitra.fi/en/projects/interesting-companies-circular-economy-finland/> [20.6.2018]
- Sitra (2018). Technology industry growth from a circular economy. Online. Available at: <https://www.sitra.fi/en/projects/technology-industry-growth-circular-economy/> [11.9.2018]
- Stahel, W., & Reday-Mulvey, G. (1976) Jobs for tomorrow: The potential for substituting manpower for energy. Brussels, European Commission: DG Manpower
- Stefanović, M. (2015). “Determination of the effectiveness of the realization of enterprise business objectives and improvement strategies in an uncertain environment”. *Expert Systems*, Vol. 32(4), pp. 494-506.
- Stevenson, R. & Evans, J. (2004) “Editorial to: cutting across interests: cleaner production, the unified force of sustainable development”, *Journal of Cleaner Production*, Vol. 12, pp. 185–187.
- Stubbs, W. & Cocklin, C. (2008), “Conceptualizing a Sustainability Business Model”, *Organization & Environment*, Vol. 21(2), pp. 103-127
- Stål, H., & Corvellec, H. (2018) “A decoupling perspective on circular business model implementation: Illustrations from Swedish apparel”, *Journal of Cleaner Production*, Vol. 171, pp. 630-643.
- Su, B., Heshmati, A., Geng, Y. & Yu, X. (2013), “A review of the circular economy in China: moving from rhetoric to implementation”, *Journal of Cleaner Production*, Vol. 42, pp. 215-227.
- SYKE (2017) Suomen ympäristökeskus – CIRCWASTE – tools. Available at: http://www.materiaalitkiertoon.fi/fi-FI/Tyokalut/Haitalliset_aineet. [22.8.2018]
- Teece, D. (2010) “Business models, business strategy and innovation”, *Long Range Planning*, Vol. 43(2), pp. 172-194.
- Tenhunen, J., Rantanen, H. and Ukko, J. (2001). SME-oriented Implementation of a Performance Measurement System. Lahti, Finland: Department of Industrial Engineering and Management, Lappeenranta University of Technology.
- Tukker, A. (2015) “Product services for a resource-efficient and circular economy – a review”, *Journal of Cleaner Production*, Vol. 97, pp. 76-91.
- UPM – Annual Report (2017).
- Upward, A., & Jones, P. (2016), “An Ontology for Strongly Sustainable Business Models”, *Organization & Environment*, Vol. 29 (1), pp. 97-123.

- Vasiljevic-Shikaleska, A, Gjozinska, B, & Stojanovikj, M (2017), “The Circular Economy – A Pathway to Sustainable Future”, *Journal of Sustainable Development*, Vol.7(17) pp. 13-30.
- Zink, T., & Geyer, R. (2017), “Circular Economy Rebound”, *Journal of Industrial Ecology*, Vol. 21(3), pp. 593-602.
- VTT (2016). Carbon Handprint – a positive indicator! Online. Available at: <https://www.vtt.fi/sites/handprint/>. [30.6.2018]
- VTT (2017). LIPASTO – calculation system for traffic exhaust emissions and energy use in Finland.
- Wang, K., Jiang, Z., Li, N., & Geng, N. (2013) “Optimal production and admission control for a stochastic SOM system with demands for product and PSS”, *International Journal of Production Research*, Vol. 51, 23/24, pp. 7270-7288.
- WBCSD (1992) World Business Council for Sustainable Development. Eco-efficiency Learning Module. Available at: <http://www.wbcsd.org/Projects/Education/Resources/Eco-efficiency-Learning-Module> [26.1.2018]
- WBCSD (2000) World Business Council for Sustainable Development. Measuring ecoefficiency. A guide to reporting company performance. Geneva, Switzerland.
- WBCSD (2002) World Business Council for Sustainable Development. Calculation tools. Greenhouse Gas Protocol. Online. Available at: <https://ghgprotocol.org/calculation-tools> [22.8.2018]
- WBCSD (2018) World Business Council for Sustainable Development. Circular Metrics – Landscape Analysis. Online. Available at: <https://www.wbcsd.org/Programs/Energy-Circular-Economy/Factor-10/Metrics-Measurement> [21.8.2018]
- WCED (1987) – The World Commission on Environment and Development, “The Brundtland report: ‘Our common future’.
- Webster, K. (2017) The Circular Economy – A Wealth of Flows, 2nd edition, Ellen MacArthur Foundation, Isle of Wight United Kingdom, 201p.
- 3 Step IT – Sustainability Report (2017).

Appendix A. Questionnaire: case companies

1. How important the objectives of the circular economy are for your business on a scale of 1 to 5? 1 meaning “not essential for our business” and 5 meaning “in the core of our business”.

The objectives of the circular economy are for example:

- Resource efficiency: minimizing the use of non-renewable resources through product refurbishing and remanufacturing, and reusing and recycling materials (3R: Reduce, Reuse, Recycle)
 - Extending the lifecycle of materials: maximizing the cycle of products, components and their associated value (Cyclical material flows)
 - Designing products more sustainably and easier to recycle in order to avoid waste (Restorative design)
 - Using bio-based and renewable materials and energy
 - Minimizing waste and emissions
 - Reshaping production and consumption patterns to be more sustainable, e.g. through sharing platforms and product as a service –models
 - Collaboration between industries and organizations, promoting the more efficient use of materials, e.g. through industrial symbiosis and eco-industrial parks
2. Do you already use some circular economy performance indicators? (If yes, go to the question 3. If no, go to the question 6). [Yes/no question]
 3. What kind of indicators do you already use? [Open-ended question]
 4. What kind of challenges do you have in terms of measuring the circular economy performance? [Open-ended question]
 5. How would you like to improve your measurement? [Open-ended question]
 6. Do you feel that the circular economy performance indicators could be useful for your business? [Yes/no question]
 7. If yes, what are the reasons why you have not implemented any indicators yet? [Open-ended question]

Appendix B. Interviews: case companies

Theme 1: Circular economy and its objectives

How do you define a circular economy?

What do you think are the objectives of a circular economy?

Theme 2: Circular economy in business

How does the circular economy appear in your business?

What are the key objectives of your company in relation to the circular economy?

Theme 3: Circular economy performance measurement

Depending on the questionnaire responses:

a) If the company is already using some indicators:

Please tell me more about the indicators you are already using.

May I see the calculation formulas?

Why do you measure these particular issues?

How do you collect data?

How essential are these indicators for your business?

Are the indicators meant for internal or external use?

What challenges have you faced in your measuring?

How would you like to improve your measurement practices?

Do you use any strategic performance measurement systems (such as BSC)? If yes, how have you integrated the circular economy indicators into it?

b) If the company does not (yet) use any indicators:

What challenges do you have in terms of the indicator implementation?

What kind of indicators do you need or might need in the future?

Theme 4: Stakeholder expectations

Do your stakeholders have any expectations or requirements in terms of circular economy performance measurement? (Financiers, customers, employees, suppliers, subcontractors, laws/standards)

Appendix C. Interviews: stakeholders

Consultants and experts:

Theme 1: Existing circular economy performance indicators

Are there any circular economy indicators for businesses?

Are there any current or future projects or initiatives going on regarding to the businesses' circular economy performance measurement?

Theme 2: Development of circular economy performance indicators

In your opinion, how should SMEs measure their circular economy performance in the future?

What aspects/characteristics should be taken into account in potential indicators?

What tools, such as databases or ready-made data banks could be utilized in measurement? (Material values, carbon footprints of materials etc.)

Should the indicators be developed for internal or external use, or for both?

Should the indicators be integrated into strategic performance measurement systems (e.g. BSC)? If yes, then how?

What are the challenges involved in measurement and indicator development?

Financiers:

Theme 1: Existing circular economy performance indicators

Are there any circular economy indicators for businesses?

Are there any current or future projects or initiatives going on regarding to the businesses' circular economy performance measurement?

Do you use any information related to the circular economy performance of a business when making funding decisions?

Theme 2: Development of circular economy performance indicators

In your opinion, how should SMEs measure their circular economy performance in the future?

What measurable information the stakeholder of a business (such as financiers and customers) need in relation to a company's circular economy performance?

What aspects/characteristics should be taken into account in potential indicators?

What are the challenges involved in measurement and indicator development?

Appendix D. Construction: indicator pools

The first indicator pool: internal strategic and operational CEPIs			
CBM	CEPI	Theme	Baseline and target level
Product as a service	Circular Use	Resource efficiency: product lifetime extension	Higher rate compared to the previous period
	Longevity (per resource)	Resource efficiency: material lifetime extension	Ultimate target: infinity
	Material stock per service unit	Service economy: increase service per material stock	Lower rate compared to the previous period
	Material quality indicators Renewability rate of raw materials Biodegradability rate of raw materials Nonharmful rate of raw materials	Material health	Target: 100%
	Percentage of recycled input materials used	Resource efficiency: recycled materials as raw materials	Ultimate target: 100%
	Product utilization rate	Resource efficiency: product capacity exploitation	Ultimate target: 100%
	Recovery rates Product reuse rate Product refurbishing rate Component reuse rate	Resource efficiency of the processes	Ultimate target: 100%
	(Sharing) platform data Number of registered users Number of published rental products Number of rentals per product Number of rentals per user Average rental price and time	Sharing economy: enhancing collaborative consumption	
	Waste and loss generated in the processes (per resource: materials, energy, water)	Resource efficiency of the processes: waste reduction	Lower amount compared to the previous period. Ultimate target: 0
Product-life extension	CEI	Economic value: maintain financial value of materials	Baseline: 0 Ultimate target: 1
	Circular Use	Resource efficiency:	Higher rate compared to the previous period

		product lifetime extension	
	Circulation (per resource)	Resource efficiency of a product system	Baseline: 1 Ultimate target: infinity
	Longevity (per resource)	Resource efficiency: material lifetime extension	Ultimate target: infinity
	Material quality indicators Renewability rate of raw materials Nonharmful rate of raw materials	Material health	Target: 100%
	Percentage of recycled input materials used	Resource efficiency: recycled materials as raw materials	Ultimate target: 100%
	Product-level circularity	Economic value: maintain financial value of a product	Baseline: 0 Ultimate target: 1
	Recovery rates Product refurbishing rate Component reuse rate Non-renewable resource reuse rate	Resource efficiency of the processes	Ultimate target: 100%
	Total restored products	Resource efficiency: restorative design and production	Ultimate target of restoration rate: 100%
	Waste and loss generated in the processes (per resource: materials, energy, water)	Resource efficiency of the processes: waste reduction	Lower amount compared to the previous period. Ultimate target: 0
Renewability	Longevity (per resource)	Resource efficiency: material lifetime extension	Ultimate target: infinity
	Material quality indicators Renewability rate of raw materials Biodegradability rate of raw materials Nonharmful rate of raw materials Rate of responsibly sourced raw materials	Material health	Target: 100%
	Percentage of recycled input materials used	Resource efficiency: recycled materials as raw materials	Ultimate target: 100%
	Recovery rates Side stream reuse rate	Resource efficiency of the processes	Ultimate target: 100%
	Total restored material	Resource efficiency: waste utilization	Ultimate target of restoration rate: 100%
	Waste and loss generated in the processes	Resource efficiency of the processes: waste reduction	Lower amount compared to the previous period. Ultimate target: 0

	(per resource: materials, energy, water)		
Resource efficiency and recycling	CEI	Economic value: maintain financial value of materials	Baseline: 0 Ultimate target: 1
	Circular Use	Resource efficiency: product lifetime extension	As high as possible
	Circulation (per resource)	Resource efficiency of a product system	Baseline: 1 Ultimate target: infinity
	Longevity (per resource)	Resource efficiency: material lifetime extension	Ultimate target: infinity
	Material quality indicators Renewability rate of raw materials Biodegradability rate of raw materials Nonharmful rate of raw materials Rate of responsibly sourced raw materials	Material health	Target: 100%
	Percentage of recycled input materials used	Resource efficiency: recycled materials as raw materials	Ultimate target: 100%
	Product-level circularity	Economic value: maintain financial value of a product	Baseline: 0 Ultimate target: 1
	Recovery rates Material reuse rate Non-renewable resource reuse rate	Resource efficiency of the processes	Ultimate target: 100%
	Total recycled material (per recycling method)	Resource efficiency: upcycling and downcycling	Ultimate target of upcycling rate: 100%
	Waste and loss generated in the processes (per resource: materials, energy, water)	Resource efficiency of the processes: waste reduction	Lower amount compared to the previous period. Ultimate target: 0
Sharing platforms	Customer behavior indicators Time spent on the site How often a customer returns to the site Customer satisfaction	Sharing economy: changing customers' habits	Continuous increase
	Product utilization rate	Resource efficiency: product capacity exploitation	Ultimate target: 100%
	Sharing platform data Number of registered users	Sharing economy: enhancing collaborative consumption	Continuous increase

	Number of published rental products Number of rentals per product Number of rentals per user Average rental price and time		
--	---	--	--

The second indicator pool: comprehensive indicators

Indicators	Themes	Framework or guidance
Footprints or handprints of the operations (carbon, water) GHG emission reductions compared to a conventional product or business model Product environmental footprint (PEF) Waste and losses generated compared to a conventional life-cycle of a product	GHG reductions Water management Waste reductions	ISO 14044:2006 (LCA) GHG protocol Carbon handprint, SULCA and LIPASTO by VTT PEF: European Commission (2012)
Material Circularity Indicator (MCI)	Level of transition from linear to circular business model	EMF (2015)
Value-based resource efficiency (VRE)	Resource efficiency: value added per resource input	Di Maio et al. (2017)
Net environmental benefits of recycling	Environmental impacts of recycling: GHG emissions and nonrenewable material usage	Geyer et al. (2016)
Material input per service unit (MIPS)	Service increase per material consumption	Ritthof et al. (2003)
Eco-efficiency of the operations	Eco-efficiency	WBCSD (2000) GHG protocol
Rate of renewable energy used Energy intensity of operations	Energy efficiency	GRI-302
Total lifetime of a product and its components compared to a conventional	Resource efficiency	
Value added of the utilization of waste materials Retained economic value of materials Economic benefits of the CE-business	Economic sustainability Maintaining financial value of materials in the economy	ISO 14051:2011 (MFCA)
Life-cycle cost savings achieved through the CE-activities	Business profitability Cost savings	
Social life cycle indicators Overall impact of a business in the CE	Social sustainability	GRI-401-419