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Policy Framework for Material Resource Efficiency

Pathway Towards a Circular Economy

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Policy Framework for Material Resource Efficiency

Pathway Towards a Circular Economy

LEONIDAS MILIOS | IIIIEE | LUND UNIVERSITY



Policy Framework for Material Resource Efficiency

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Leonidas Milios



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DOCTORAL DISSERTATION

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Abstract <p>The strategic direction of the European Union (EU) over the past twenty years has focused on increasing resource productivity and innovation in the economy, aiming at the efficient use and secured supplies of resources, economic growth and job creation, with fewer environmental impacts. One of the basic premises of the new 'Green Deal' for Europe is the promotion of the circular economy. The aim of a circular economy is to create a more sustainable society by decoupling economic growth from resource consumption.</p> <p>The EU Circular Economy Action Plan contains a clear vision that businesses will play a significant role in the shift to a circular economy model, by implementing circular business models that encourage prolonged use of products, components, and materials. The Plan also stresses the importance of appropriate enabling conditions for this shift. Policies that enable the adoption and upscale of such business models play a central role within a framework for material resource efficiency.</p> <p>The overarching aim of this research is to identify gaps in the current EU policy landscape relating to utilisation of material resources, and to investigate appropriate policy interventions. The research uses an interdisciplinary methodology with case studies of Swedish firms adopting circular business models. A 'bottom-up' approach is applied, with business input forming the basis of a proposed policy framework for material resource efficiency.</p> <p>Eight distinct policy measures constitute the core of the policy framework, bundled together in a resource efficiency policy package: eco-design rules for product durability, repairability and recyclability; product standards for repairability and standards for secondary raw materials; circularity criteria in public procurement; quality labelling for reused products; a national reuse target; funding measures for capacity, technology and innovation development in recycling and reuse value chains; support for resource and information exchange platforms; and a ban on the incineration of recyclable waste.</p> <p>The analysis identifies the conditions needed to improve implementation of each individual policy measure, but also reveals instrument interdependencies within the policy mix. Possible ways to improve implementation of the suggested policy framework are discussed.</p> <p>Finally, based on theories of the policy process, a number of challenges are identified in the process of integrating resource efficiency policies in the current policy landscape. Potential future research directions are suggested to help remove these bottlenecks in the transition to a circular economy.</p>			
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Abstract

The strategic direction of the European Union (EU) over the past twenty years has focused on increasing resource productivity and innovation in the economy, aiming at the efficient use and secured supplies of resources, economic growth and job creation, with fewer environmental impacts. One of the basic premises of the new ‘Green Deal’ for Europe is the promotion of the circular economy. The aim of a circular economy is to create a more sustainable society by decoupling economic growth from resource consumption.

The EU Circular Economy Action Plan contains a clear vision that businesses will play a significant role in the shift to a circular economy model, by implementing circular business models that encourage prolonged use of products, components, and materials. The Plan also stresses the importance of appropriate enabling conditions for this shift. Policies that enable the adoption and upscale of such business models play a central role within a framework for material resource efficiency.

The overarching aim of this research is to identify gaps in the current EU policy landscape relating to utilisation of material resources, and to investigate appropriate policy interventions. The research uses an interdisciplinary methodology with case studies of Swedish firms adopting circular business models. A ‘bottom-up’ approach is applied, with business input forming the basis of a proposed policy framework for material resource efficiency.

Eight distinct policy measures constitute the core of the policy framework, bundled together in a resource efficiency policy package: eco-design rules for product durability, repairability and recyclability; product standards for repairability and standards for secondary raw materials; circularity criteria in public procurement; quality labelling for reused products; a national reuse target; funding measures for capacity, technology and innovation development in recycling and reuse value chains; support for resource and information exchange platforms; and a ban on the incineration of recyclable waste.

The analysis identifies the conditions needed to improve implementation of each individual policy measure, but also reveals instrument interdependencies within the policy mix. Possible ways to improve implementation of the suggested policy framework are discussed.

Finally, based on theories of the policy process, a number of challenges are identified in the process of integrating resource efficiency policies in the current policy landscape. Potential future research directions are suggested to help remove these bottlenecks in the transition to a circular economy.

Popular Science Summary

Since the dawn of the industrial revolution the extraction and use of natural resources has been rapidly increasing, and there are no signs of slowing down in the foreseeable future. In 2015, 92.8 billion tonnes of resources entered the global economy, and material resource use is expected to double by 2050, reaching 186 billion tonnes. This intense exploitation of the natural environment causes severe environmental pressures, including climate change and the rapid decline in global biodiversity, leading to the destabilisation of natural ecosystems on which human existence depends. It is becoming increasingly apparent that the present systems of production and consumption exceed planetary system boundaries and pose a direct threat to human development and well-being. For this reason, it is imperative to rethink the way products are produced, marketed, traded, and used, and what happens to them after use.

An alternative way of managing resources, a shift from the common practice of ‘take-make-waste’ approach that currently dominates all economic activities, is the so-called ‘circular economy’. A circular economy stimulates reduction of the economy’s ecological footprint by reducing raw material use and consumption, minimising the production of waste, and keeping the value of resources embedded in products for as long as possible. Conceptually, a circular economy aims at creating a more sustainable society by decoupling economic growth from resource consumption. Operationally, a circular economy promotes the efficient use of resources by closing material loops by recycling, and slowing material throughput by keeping products in use for longer, e.g. through increased durability or repair.

In the European Union (EU), the strategic resource policy direction over the past twenty years has focused on increasing resource productivity and innovation in the economy. This leads to the efficient use and secure availability of resources, to sustained economic growth and job creation, with overall decreased environmental impacts. In 2015, the EU introduced the Circular Economy Action Plan (COM(2015) 614 final), including a clear vision about the implementation of a circular economy in Europe, in which business will play a significant role by implementing circular business models that encourage prolonged use of products, components, and materials. Policy actors at regional, national and supra-national levels also have a very important role to play in this vision by providing appropriate enabling conditions. Taking a step forward, the European Commission unveiled the

new ‘Green Deal’ for Europe in 2020, including as one of its basic premises the promotion of the circular economy.

Improving resource efficiency and effectiveness through novel and circular business models is a difficult challenge that usually faces many barriers, including policies and legal barriers. The overarching aim of this research was to identify these obstacles and develop viable solutions that could lead to effective policies for resource efficiency based on circular economy thinking. Initially the research focused on identifying gaps in the current policy framework in the EU and investigating appropriate policy interventions. Using an interdisciplinary research methodology, including case studies of Swedish firms with circular business models, and by applying a bottom-up approach, the thesis resulted in a revised policy framework for material resource efficiency.

The bottom-up approach is the novel element in this research, as it gives insightful empirical evidence for the introduction of appropriate policy interventions. Only business inputs were considered when devising policy interventions, so the positions of policy officials, policy brokers and industry advocacy associations were not taken into account because of the political interests in their agenda. This is a genuine ‘on the ground’ approach, reflecting the views of business actors offering resource efficient solutions, and directly translates the practical problems of circular businesses to actual policy solutions.

A circular economy applies to all life cycle stages of a product, from production to end of use. The case studies analysed in this thesis comprise companies that are active in the design, manufacture, remanufacture, repair, resale, and collection and recycling of products. Covering all product life cycle stages, the research resulted in a resource efficiency policy framework comprising the following eight distinct policy measures, integrated together in a policy package.

Eco-design for product durability, reparability and recyclability: Specific rules for including mandatory provisions for resource efficient design in new production. There are several ways to increase the resource efficiency of a product throughout its life cycle. Since the design of a product is critical in its overall environmental performance, it is vital that durability, reparability and recyclability considerations are taken into account at this early stage. Depending on the product group, certain properties might be more desirable than others (for instance durability vs. recyclability), so care should be taken in the introduction of such mandatory eco-design rules.

Product standards for reparability and standards for secondary raw material: The key to reusing products and secondary materials lies in the ease at which these can be reintegrated in the economy and their reliability. Standardisation can increase the confidence of economic actors in the performance and quality of second-hand products and secondary materials.

Circularity criteria in public procurement: The large purchasing power of the public sector can steer the market towards more circular and resource efficient solutions. By creating the appropriate market demand, governments create the necessary conditions for upscaling circular solutions that may or may not have diffused onto the market. Public procurement is a strong pull mechanism in the context of product policy, and can be used in combination with eco-design and certification (standards, labels) to drive resource efficiency in product manufacturing and use.

Quality labelling for reused products: A quality label can increase the confidence of a public or private consumer in second-hand products. It is a complementary informative policy measure that can be used effectively in combination with a variety of administrative and economic policy measures for promoting the circular economy.

Legally binding reuse target: This indicates a clear signal for a transition to a reuse society, where products and resources are used as long as possible and their embedded value is maintained along the way.

Funding for capacity, technology, and innovation development in recycling and reuse value chains: Funding mechanisms are key components of a holistic policy approach towards a paradigm shift. It is imperative that appropriate infrastructure, technology, and organisations are in place to increase resource circulation, reuse and recycling. In cases where private investment fails to deliver the necessary innovations, public actors should be filling the vacuum (ideally) by forming public-private partnerships.

Support for resource and information exchange platforms: Exchange of information between stakeholders in a circular economy is paramount. Although the form, ownership and facilitation of such information platforms has not yet been determined, their necessity is emphasised by both public and private stakeholders.

Ban on incineration of recyclable waste: By eliminating the option of incineration, a number of mechanisms will be triggered for taking care of the excessive amount of recyclable materials currently treated as waste (e.g. plastics).

The analysis identified how each policy measure could be implemented individually, but also revealed instrument interdependencies within the policy package and showed possible ways to improve implementation of the policy framework. Based on theories of the policy process, a number of challenges were identified in the process of integrating resource efficiency policies in the current policy landscape. Potential future research directions were suggested to remove the bottlenecks in the transition to a circular economy. Ultimately, the transition to a new economic paradigm like the circular economy is not a straightforward or rapid process. It requires a systemic approach that cuts across various components of society.

List of Papers

- Paper I Milios, L. (2018). Advancing to a Circular Economy: three essential ingredients for a comprehensive policy mix. *Sustainability Science*, 13(3), 861–878.
- Paper II Milios, L. (2020). Overarching Policy Framework for Product Life Extension in a Circular Economy. *Environmental Policy and Governance* (submitted).
- Paper III Öhgren, M., Milios, L., Dalhammar, C., & Lindahl, M. (2019). Public procurement of remanufactured furniture and the potential for procuring product-service systems (PSS) solutions. *Procedia CIRP*, 83, 151–156.
- Paper IV Crafoord, K., Dalhammar, C., & Milios, L. (2018). The use of public procurement to incentivize longer lifetime and remanufacturing of computers. *Procedia CIRP*, 73, 137–141.
- Paper V Gåvertsson, I., Milios, L., & Dalhammar, C. (2018). Quality Labelling for Re-used ICT Equipment to Support Consumer Choice in the Circular Economy. *Journal of Consumer Policy*. doi: 10.1007/s10603-018-9397-9.
- Paper VI Milios, L., Christensen, L. H., McKinnon, D., Christensen, C., Rasch, M. K., & Eriksen, M. H. (2018). Plastic recycling in the Nordics: a value chain market analysis. *Waste Management*, 76, 180–189.
- Paper VII Milios, L., Davani, A. E., & Yu, Y. (2018). Sustainability impact assessment of increased plastic recycling and future pathways of plastic waste management in Sweden. *Recycling*, 3(3), 33.

Contribution to Papers

- Papers I & II L.M. was single author.
- Paper III L.M. performed part of the literature review, developed the discussion around the product-service feasibility of procurement criteria and formatted the final version of the manuscript. L.M. revised the article following peer review comments.
- Paper IV L.M. performed part of the literature review, contributed to the discussion and conclusions of the research and formatted the final version of the manuscript. L.M. revised the article following peer review comments.
- Paper V L.M. performed part of the literature review, developed the discussion of the research findings and proceeded with policy recommendations. L.M. wrote the manuscript and revised it following peer review comments.
- Paper VI L.M. co-developed the research methodology with two of the co-authors. L.M. conducted the literature review and wrote the introduction and literature background sections. L.M. collected data with a geographical focus on Sweden (1/3 of interviews). L.M. contributed to the analysis and discussion of the research findings, and to the policy recommendations. L.M. revised the article following peer review comments.
- Paper VII L.M. developed the idea and research design, developed the plastic waste flow model, developed the scenarios of future waste management in Sweden by 2030, and proceeded with policy recommendations. L.M. wrote the manuscript and revised it following peer review comments.

Other Publications

Journal Articles

Milios, L., & Dalhammar, C. (2020). Ascending the Waste Hierarchy: Re-use potential in Swedish recycling centres. *Detritus*, 9, 1–11. doi: 10.31025/2611-4135/2020.13912.

Wasserbaur, R., Sakao, T., & Milios, L. (2020). A literature review on the interactions of governmental policies and business models for a circular economy. *Journal of Cleaner Production* (submitted).

Milios, L., & Matsumoto, M. (2019). Consumer Perception of Remanufactured Automotive Parts and Policy Implications for Transitioning to a Circular Economy in Sweden. *Sustainability*, 11(22), 6264.

Milios, L., Beqiri, B., Whalen, K. A., & Jelonek, S. H. (2019). Sailing towards a circular economy: conditions for increased reuse and remanufacturing in the Scandinavian maritime sector. *Journal of Cleaner Production*, 225, 227–235.

Nußholz, J. L. K., Rasmussen, F. N., & Milios, L. (2019). Circular Building Materials: Carbon savings potential and the role of business model innovation and public policy. *Resources Conservation and Recycling*, 141, 308–316.

Whalen, K., Milios, L., & Nussholz, J. (2018). Bridging the gap: barriers and potential for scaling reuse practices in the Swedish ICT sector. *Resources Conservation and Recycling*, 135, 123–131.

Conference Papers

Milios, L., Dalhammar, C., Sakao, T., & Lindahl, M. (2019). Towards a Roadmap for a Resource Efficient and Effective Manufacturing Industry in Sweden. Proceedings of EcoDesign 2019 International Symposium, 25-27 November 2019, Yokohama, Japan.

Dalhammar, C., Milios, L., & Richter, J. L. (2019). Ecodesign and the Circular Economy: Conflicting policies in Europe. Proceedings of EcoDesign 2019 International Symposium, 25-27 November 2019, Yokohama, Japan.

Whalen, K. A., & Milios, L. (2019). Circular economy policy at a crossroads: Driving business models for durable products, or enabling faster recycling of short-

lived products? Proceedings of the 3rd International Conference PLATE (Product Lifetimes and the Environment), 18-20 September 2019, Berlin, Germany.

Wasserbaur, R., & Milios, L. (2019). Spurring remanufacturing through public procurement – A case study in the Swedish automotive industry. Proceedings of the 4th International Conference on Remanufacturing, 23-25 June 2019, Amsterdam, Netherlands.

Milios, L., & Whalen, K. A. (2018). Sailing towards a circular economy? Potential for increased reuse and remanufacturing of ship components. Proceedings of the 1st International Conference on Resource Sustainability, 27-29 June 2018, Beijing, China.

Milios, L. (2017). The ‘circular’ building materials challenge: a case-based policy approach. Proceedings of 18th European Roundtable on Sustainable Consumption and Production Conference, 1-5 October 2017, Skiathos, Greece.

Nussholz, J., & Milios, L. (2017). Applying circular economy principles to building materials: Business model innovation in the value chain for buildings. Proceedings of SustEcon Conference – Contribution of a sustainable economy to achieving the Sustainable Development Goals, 25-26 September 2017, Berlin, Germany.

Milios, L. (2016). Policies for increased re-use and recycling in the Swedish plastics value chain. Proceedings of the 12th International Conference EcoBalance 2016, 3-6 October 2016, Kyoto, Japan.

Dalhammar, C., & Milios, L. (2016). Policies to support reconditioning and reuse of ICT. Proceedings of Electronics Goes Green 2016+ conference, 7-9 September 2016, Berlin, Germany.

Project Reports

McKinnon, D., Bakas, I., Herczeg, M., Vea, E., Busch, N., Christensen, L. H., Christensen, C., Damgaard, C. K., Milios, L., Punkkinen, H., & Wahlström, M. (2018). *Plastic Waste Markets: Overcoming barriers to better resource utilisation*. Nordic Council of Ministers, TemaNord 2018:525, Copenhagen.

Watson, D., Gylling, A. C., Tojo, N., Throne-Holst, H., Bauer, B., & Milios, L. (2017) *Circular Business Models in the Mobile Phone Industry*. Nordic Council of Ministers, TemaNord 2017:560, Copenhagen.

Milios, L. (2016). *Policies for Resource Efficient and Effective Solutions – A review of concepts, current policy landscape and future policy considerations for the transition to a Circular Economy*. MISTRA-REES report, Lund.

Dalhammar, C., & Milios, L. (2016). *Policies for a Circular Economy*. MISTRA-REES Policy brief, Lund.

Abbreviations

CBM	Circular Business Model
CE	Circular Economy
EAP	Environment Action Programme
EC	European Commission
EOL	End Of Life
EPR	Extended Producer Responsibility
EU	European Union
GHG	Greenhouse Gases
GPP	Green Public Procurement
IPCC	Intergovernmental Panel on Climate Change
IPP	Integrated Product Policy
MFA	Material Flow Analysis
MS	Member State
OECD	Organisation for Economic Co-operation and Development
REES	Resource Efficient and Effective Solutions
RQ	Research Question
SCP	Sustainable Consumption and Production
SDG	Sustainable Development Goal
SME	Small- and Medium-sized Enterprise
UNEP	United Nations Environment Programme
VAT	Value Added Tax

1 Introduction

Over the last century, the global use of natural resources has increased eightfold (Krausmann et al., 2009; UNEP, 2011) and there is no sign of a slowdown on the horizon. In total, 92.8 billion tonnes of resources entered the global economy in 2015 (Circle Economy, 2019). This figure will continue to grow, as material resource use is expected to double between 2015 and 2050, reaching 186 billion tonnes (UNEP, 2017). Directly associated with this increase in natural resource use is greater pressure on the environment. Human activity is known to destabilise natural eco-systems, so several ‘planetary boundaries’ may be exceeded (Rockström et al., 2009). These changes are apparent from issues such as climate change (IPCC, 2014; 2018), the rapid decline in global biodiversity (IPBES, 2019; WWF, 2018), and the rising pressure on the remaining areas of natural land (Steffen et al., 2015).

Greater efficiency constitutes an important first step in reducing resource use and the associated negative environmental impacts, as this can reduce the resources used per unit of output (Allwood et al., 2011). However, more far-reaching strategies and measures are required, since the actual potential of efficiency improvements is limited in the light of rising customer demand (Allwood et al., 2017). Rebound effects may prevent efficiency improvements from reducing resource use in absolute terms (International Resource Panel, 2011; 2017). In addition, while efficiency can mitigate the business risks arising from a dependency on primary materials obtained from volatile global raw materials markets, it cannot completely eliminate them.

The EU has proposed a revised and more holistic approach for production and use systems in recent years, the Circular Economy (CE). This ‘new’ concept goes beyond the resource efficiency and productivity approaches. It is a strategy that promotes environmentally sound economic systems and is based on well-established scientific disciplines such as industrial ecology and ecological economics (Brueel et al, 2018; Ghisellini et al., 2016; Reike et al., 2018). Its main objective is to minimise negative environmental impacts by a qualitative and quantitative transformation of production systems, and by closing and slowing down resource flows. The implementation of CE practices is intended to decouple the rate of economic growth from an increase in environmental impact (International Resource Panel, 2018).

The CE offers the opportunity to reduce the economy's ecological footprint by reducing raw material use and consumption, minimising the production of waste, retaining the value of resources for as long as possible, and rethinking processes throughout the value chain (Geissdoerfer et al., 2017). The circular economy could also play a significant role in helping to achieve the Paris Climate Agreement objective to keep global temperatures below the 2 degrees Celsius threshold above pre-industrial levels. This is because half of the world greenhouse gas emissions could be linked to the extraction, processing, use and disposal of materials (OECD, 2012).

The circular economy is an essential building block not only for the implementation of Sustainable Development Goal (SDG) 12 'to ensure sustainable use and production patterns' but also SDGs 6, 8, 9, and 11-15 (Pardo and Schweitzer, 2018). The start of a transition towards CE is therefore an important strategic decision, implying the shift from 'necessity' – efficiency in the use of resources, rational management of waste – to 'opportunity', by designing products that can be used for longer and reused after reaching their end-of-life (EOL).

In the following sections (1.1 and 1.2), a historical overview of the strategic development of resource efficiency in the EU and in Sweden is presented. In sections 1.3 and 1.4, specific gaps in research into resource efficiency policy are presented, and the research objectives of this thesis are outlined in detail. In section 1.5, the overall research scope of the thesis is presented, together with its associated limitations. Finally, the target audience and an outline of the thesis are presented in sections 1.6 and 1.7.

1.1 Strategic development of resource efficiency in the European Union

Resource efficiency considerations, in terms of materials and energy, as well as waste-related concerns about pollution, hazardousness and public health, have a long history in European policy efforts. The EU¹ has long held the strategic vision and the policy agenda for resource use and waste for its constituent Member States (MS). Historically, the policy agenda has been formulated in response to identified internal deficiencies and/or external problems.

Concerns over the depletion of global resources in the 1970s led public policymakers to conceptualise 'closed-loop' approaches in the economy by promoting reuse and recycling of waste in order to reduce energy inputs (Stahel and Reday-Mulvey, 1981). In the 1980s, several industry-specific concepts that

¹ Also in its previous forms as the European Economic Community and the European Community.

integrated these ideas, industrial ecology (Frosch and Gallopoulos, 1989; Jelinski et al., 1992) and later industrial symbiosis (Lombardi and Laybourn, 2012), appeared and informed potential policy options for resource efficiency in industry and the economy at large. Such notions were also found in sustainable development policies that emerged after the Brundtland Report and the Rio UNCED (United Nations Conference on Environment and Sustainable Development) process in the late 1980s and 1990s, for instance Agenda 21. This included the principle of integrated life cycle management through reduced waste production, recycling and reuse (UNCED, 1992). By the beginning of the 2000s, the 3R (Reduce, Reuse, Recycle) concept had permeated national policymaking, particularly in East Asia (Kojima and Damanhuri, 2009). In the past decade, the circular economy concept has emerged within global and national policy circles, facilitated by ‘policy entrepreneurs’ (Cairney, 2018), such as the Ellen MacArthur Foundation (Cooper-Searle et al., 2018).

Fitch-Roy et al. (2019) identified three waves of European level policy development in the area of resource efficiency, reflecting the above patterns of conceptual development. Phase one was an expansive period of policy development, starting in the 1970s and reaching up to the 2000s. Taking stock of scientific outputs, such as the ‘Limits to Growth’ (Meadows et al., 1972) and one of its own research reports, ‘The Potential for Substituting Manpower for Energy’ (Stahel and Reday, 1977; see also Stahel and Reday-Mulvey, 1981), the European Commission (EC) was increasingly influenced to integrate a ‘closed-loop economy’ thinking in the framing of its policy development. The notion of closed-loop production, as presented in the Stahel and Reday (1977) report, suggested that new employment opportunities could be created through increased recycling and reconditioning of waste products. Such ideas proved attractive to the EC, faced with the challenges of countering rising EEC unemployment and energy prices in the wake of the global oil crisis.

Towards the end of the 1990s, another report commissioned by the EC laid the foundations for the conceptual approach to a European product policy, which took a life cycle perspective. The term Integrated Product Policy (IPP) appeared, defined as ‘*Public policy which explicitly aims to modify and improve the environmental performance of product systems*’ (EY, 1998, p. 33). It identified five building blocks vital for the development of the EU’s integrated product policy, namely managing waste, creating markets, green product innovation, allocating responsibility, and transmitting environmental information.

This new concept was introduced in EU policy documents in the Green Paper on Integrated Product Policy (IPP) (COM(2001) 68 final). The implementation strategy of the EC was concerned with strengthening the environmental orientation of both supply and demand of products, and was finally adopted in 2003 in the EC communication ‘Integrated Product Policy: Building on Environmental Life-Cycle Thinking’ (COM(2003) 302 final). IPP aimed at a market transformation, in which environmentally sound and resource-efficient products become the mainstream and

lead to ‘green’ mass markets, improving resource efficiency in manufacturing and consumption activities in the EU and beyond (Rubik and Scholl, 2002).

By the early 2000s, a second phase in resource efficiency policy development started to emerge. Sustainable development principles increasingly influenced EU waste and resource policy, as EU actors reframed closed-loop economy ideas into a new policy agenda. Notions of sustainable consumption and production, featured as a critical objective of the UN WSSD (World Summit on Sustainable Development) Johannesburg Conference (Rio +10) in 2002, started influencing the direction of EU policy. The Johannesburg Plan of Implementation devoted a whole section (22) to preventing and minimising waste and promoting reuse, recycling and use of environmentally friendly alternatives (UN, 2002).

Prior to the WSSD, the European Council had adopted its first Sustainable Development Strategy (SDS) in Gothenburg in 2001. The SDS and WSSD, in turn, informed the development of the Sixth Environmental Action Programme (6EAP), ‘Towards Sustainability’, in 2002. Departing from previous EAPs, a thematic perspective on sustainable development issues was introduced, identifying the need for cross-cutting policies (European Communities, 2002).

By 2005, the EU had set the stage for its future policy direction concerning resources conservation and the sustainable management of resources by introducing two ‘Thematic Strategies’. One was on the sustainable use of natural resources (COM(2005) 670 final) and the other on the prevention and recycling of waste (COM(2005) 666 final). Following global developments in the field of Sustainable Consumption and Production (SCP), the EU introduced an integrated Action Plan for Sustainable Consumption and Production and Sustainable Industrial Policy (COM(2008) 397 final). The SCP Action Plan proposed the implementation of a series of measures to improve the energy and environmental performance of products throughout their life cycle, and to stimulate demand and consumption of better-quality products, thereby creating a ‘virtuous circle’. Some early notions of the circular economy seemed to emerge in these policy documents, although the basis of the SCP Action Plan mostly related to resource efficiency practices, while the consumption side of resources and product demand was not considered in any detail.

Finally, a new phase in integrating circularity into EU resource use and waste policy emerged in 2010. A pivotal point in EU resource policy was the ‘Europe 2020 Strategy for Smart, Sustainable and Inclusive Growth’ (COM(2010) 2020 final). Several guiding principles for future economic and social development in the EU are outlined in this strategy. Some of the principles led to several initiatives that are still shaping the EU resource policy. Direct derivatives of the Europe 2020 Strategy are the ‘Eco-innovation Action Plan’ (Eco-AP) (COM(2011) 899 final), the ‘Flagship Initiative for a Resource-efficient Europe’ (COM(2011) 21 final) and the ‘Roadmap to a Resource Efficient Europe’ (COM(2011) 571 final). Through these

strategic documents, the EC reframed resource efficiency as an important component of EU global competitiveness, and as a means of boosting employment and business profitability through an economic ‘transformation’. Since then, the EC has consolidated policy development specifically under the circular economy discourse, placing it within broader economic priorities (Fitch-Roy et al., 2019).

Currently, the guidance in EU environmental policy is drawn from the General Union Environment Action Programme to 2020, called ‘Living well, within the limits of our planet’ (Decision No 1386/2013/EU), also known as the Seventh Environment Action Programme (7EAP). The programme identifies nine priority objectives and sets out a long-term vision of where the EU wants to be in 2050. Guided by the long-term vision ‘*In 2050, we live well, within the planet’s ecological limits*’, the 7EAP identifies three priority action areas for the EU, one of which specifically focuses on a resource efficient circular economy.

The chronology of EU strategic policy documents is presented in Figure 1.



Figure 1. Timeline of EU resource-related strategies 2000-2020.

The EU Circular Economy package, comprising the EU Action Plan for the Circular Economy (COM (2015) 614 final) and amendments of several EU Directives (on waste, packaging and packaging waste, landfilling, end-of-life vehicles, batteries and accumulators and waste batteries and accumulators, and waste from electrical

and electronic equipment) was published by the Commission on 2 December 2015. The CE package aims to improve competitiveness by protecting EU businesses against scarcity of resources and volatile prices, help to create new business opportunities, and innovative, more efficient production and consumption. The CE Action Plan (COM(2015) 614 final) particularly emphasises that economic actors, such as business and consumers, are key drivers in the process of moving towards a circular economy. Local, regional and national authorities are expected to act as catalysts in this transition, but the EU also has a fundamental role to play in supporting it, by ensuring that the right regulatory framework is in place for the development of the circular economy in the single market. The EU CE Action Plan also presents the potential policy interventions that would enable the development of CE in EU-28, identifying interventions in different life cycle stages and priority areas for action. One of the priority policy objectives is the mitigation of plastic pollution in the environment and the increase of resource efficient production and consumption of plastics. To this end, the ‘European Strategy for Plastics in a Circular Economy’ (COM(2018) 28 final) was introduced in 2018.

The number and complexity of interactions among the related actors in a circular economy create a complicated policy landscape, which inevitably extends across the different parts of production and consumption systems and affects directly or indirectly several other parts in the value chain. Based on the narrative of the CE Action Plan (COM(2015) 614 final), the policy landscape of the circular economy today in Europe is presented in Figure 2.

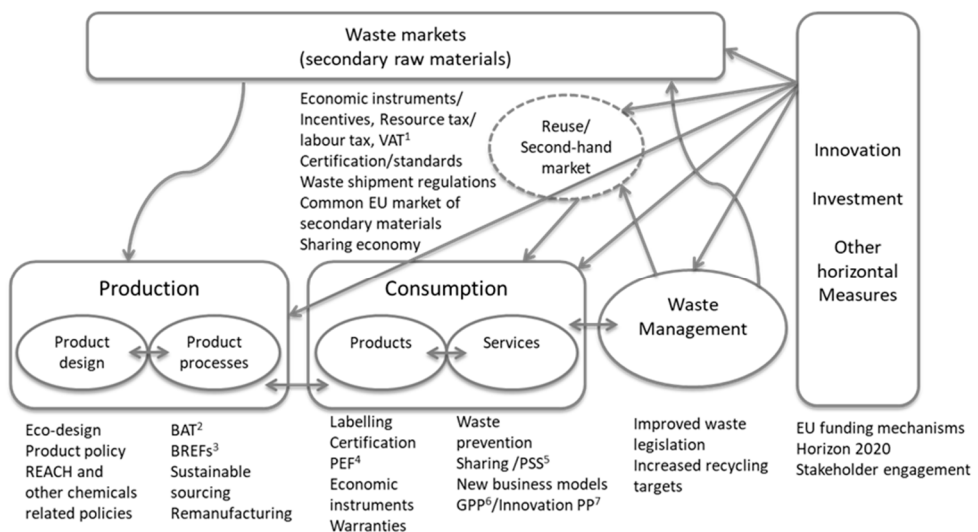


Figure 2. EU policy landscape (Miliotis, 2018). 1. Value Added Tax; 2. Best Available Techniques; 3. BAT Reference documents; 4. Product Environmental Footprint; 5. Product-Service System; 6. Green Public Procurement.

In late 2019, a new European Commission was formed, with Ursula von der Leyen as president. The new ‘von der Leyen Commission’ put forward a very ambitious strategic direction for the EU, introducing ‘The European Green Deal’ (COM(2019) 640 final). Within the roadmap of actions associated with the ‘Green Deal’, a revision of the CE Action Plan was scheduled for 2020. On 11 March 2020, the new CE Action Plan for the EU was published², including ambitious initiatives with a life cycle perspective, and focusing on a variety of resource-intensive sectors such as textiles, construction, plastics, electronics, packaging, batteries and vehicles (European Union, 2020).

At Member State (MS) level, in addition to EU legislation, the countries are free to devise their own policies for resource efficiency, provided they do not counteract EU regulations. Most countries incorporate material use and resource efficiency in a wide variety of other strategies and policies, including those on waste and energy, industrial development and reform programmes, or in national environmental or sustainable development strategies. Waste management and recycling initiatives, as well as waste prevention plans and initiatives on the use of secondary raw materials, play a prominent role in resource efficiency policies in MS (EEA, 2016).

Since 2016, several MS have drafted CE strategies and roadmaps, and these are currently in different stages of implementation. Existing CE roadmaps are identified in Denmark (Government of Denmark, 2018), Finland (SITRA, 2016), France (France Republic, 2018), Italy (Government of Italy, 2017), Netherlands (Government of the Netherlands, 2017), Portugal (Government of Portugal, 2017), Slovakia (OECD, 2017), and Slovenia (Government of Slovenia, 2018).

Although the focus of this section has been exclusively on the European policy approach to CE, it is worth noting that policy developments in the EU have the potential to directly or indirectly influence policy responses on a wider global scale. The term ‘Brussels effect’ refers to the indirect influence of EU policies on the production systems of other economic areas around the world (Bradford, 2012). By imposing certain regulations for compliance in the EU single market, the EU makes explicit the rules of the ‘game’ to all economic partners who wish to enter the single market and do business within European jurisdictions. This leads to a notable ‘Europeanisation’ of important aspects of global production and commerce. Regulations on products, chemicals, waste trade, recycling and material resource specifications would indirectly – but firmly – be promoted in other economic areas of the world, and influence their production processes towards increased resource efficiency.

² The new CE Action Plan was officially published after the finalisation of the research in this thesis. The novel strategic and policy elements presented in the new CE Action Plan were not considered within the scope of this thesis, and did not influence the findings and the concluding analysis of the research.

1.2 Strategic approach to resource efficiency in Sweden

The policy landscape in Sweden concerning resource efficiency is characterised by a general lack of a national resource strategy or action plan for resource efficiency. However, the main areas of policy interventions for increasing resource efficiency, as identified in EU strategic policy directions, such as the Roadmap to a Resource Efficient Europe (COM(2011) 571 final), are largely covered by the Swedish Generational Goal and the Environmental Quality Objectives, which form the core of the environmental policy framework in Sweden. A recent governmental inquiry presented a number of proposals for the CE in 2017 (SOU, 2017).

The primary legislation governing the environment is the Swedish Environmental Code (Miljöbalken 1998:808). The Swedish Environmental Code refers in general to the sustainable management of resources in Sweden, by stating that the Code should be applied in a way that ensures that land, water and the physical environment in general are used in a way that secures good long-term management in ecological, social, cultural and economic terms. It also highlights the importance of reuse and recycling in the management of materials and energy sources.

Material resource efficiency is included in the ‘Generational Goal’, which aims at handing over to the next generation a society in which the major environmental problems have been solved without increasing environmental and health problems outside Sweden’s borders. Sweden has 16 Environmental Quality Objectives, some of which relate to resource efficiency, though not always with quantitative targets. Milestone Targets support the Environmental Quality Objectives. These are intended to identify a desired social change and specify steps towards achieving the Generational Goal and one or more of the Environmental Quality Objectives (EEA, 2016).

Following the release of the EU Action Plan for a Circular Economy (COM(2015) 614 final), the Swedish government set up a CE delegation to strengthen the transition to a resource-efficient, circular and bio-based economy, both nationally and regionally (SEPA, 2018). The Government also presented a number of strategies for Sweden during the period 2014-2019 that are significant for the transition to a CE, including: New Industrialisation Strategy (Government of Sweden, 2016a); Sustainable Enterprise Policy (Government of Sweden, 2015a); Food Sector Strategy (Government of Sweden, 2017a); National Procurement Strategy (Government of Sweden, 2017b); Strategy for Sustainable Consumption (Government of Sweden, 2016b); Waste Management and Prevention Strategy 2018-2023 (SEPA, 2018); Mineral Strategy (Government of Sweden, 2015b); Strategy for Sweden’s Global Development Cooperation (Government of Sweden, 2018a); Living Cities Strategy - Sustainable Urban Development Policy (Government of Sweden, 2018b); For a Sustainable Digitalised Sweden – A digitalisation strategy (Government of Sweden, 2017c).

Further to the EU Directives and regulations, including the implementation of Extended Producer Responsibility requirements, Sweden has recently introduced a number of additional far-reaching legislations relevant to CE principles. These include a reduction on value added tax (VAT) on repairs of certain product groups and a tax on chemicals in certain electronics (SEPA, 2018).

The amendment to the VAT Act (1994:200) meant that, from 1 January 2017, VAT was reduced from 25 per cent to 12 per cent on bicycle, shoe, leather goods, clothing and household linen repairs. Through changes in the Income Tax Act (1999:1229), tax relief was introduced for the installation, repair and maintenance of personal computer and ICT equipment, and appliances (such as washing machines, fridges etc.) carried out in households.

On 1 April 2017, the Act (2016:1067) on the Tax on Chemicals in Certain Electronics came into force. The tax applies to appliances, vacuum cleaners, mobile phones, tablets, routers, TVs, gaming consoles and computers, and covers both manufacturing and import (Government of Sweden, 2016c). The purpose is to reduce the supply of dangerous substances to the domestic environment and encourage the use of more health-friendly alternatives.

1.3 Research gaps

The strategic policy efforts of the EU for increasing resource efficiency in Europe have been intensified in recent years, with an increasing number of roadmaps, action plans and associated legislation. However, this strategic vision for a shift to a circular economy requires a comprehensive set of enabling conditions that can remove existing barriers in production, resources utilisation and material recovery operations, which are currently embedded in a ‘linear’ economic system. The adoption of ‘circular’ solutions in the design of products and business models is a key parameter of the circular economy (Planing, 2015; Preston, 2012), but the viability of such solutions is often dependent on supporting policies. Policy actions would be required at different policy levels (international, EU, national and local), which inevitably makes policymaking a very complex task.

It is important to fully understand how current policies relate to a circular economy, including the type of policies that could incentivise new business solutions. The EU CE Action Plan (COM (2015) 614 final) explicitly states that a shift to a circular economy could be achieved through innovative initiatives by the business sector, while the policy actors need to find the most efficient and effective ways to facilitate this shift. This makes it important to identify inefficiencies and inaccuracies of past policies, outline the complexity of the current policy landscape, and design effective policy mixes for the future.

Designing effective and efficient policies and policy mixes brings its own challenges, as no single policy is considered to be effective in stimulating resource efficiency (Bahn-Walkowiak and Wilts, 2017; Sterner and Coria, 2012). The approach of a policy mix has been suggested as a possible way forward to address these shortcomings in environmental policy (OECD, 2007). However, designing policy mixes is a demanding exercise that requires inputs from affected stakeholders and extensive understanding of policy development processes, not least the implementation challenges. Policy mixes for resource efficiency are not yet common in the ‘real world’, but rather constitute exceptional cases (Bahn-Walkowiak and Wilts, 2017).

Due the complexity of the policy landscape (Figure 2), a novel approach to policy development would be required, one that dictates a holistic view at systems level. A comprehensive policymaking approach requires a thorough understanding of the underlying premises of the problem and involves targeting its relevant aspects. Policy aimed at conserving resources and increasing material resource efficiency in production and consumption would need to intervene in all relevant life cycle stages of products.

A **first research gap** in the resource efficiency policy agenda in Europe is addressed by identifying the type of policy interventions required to support or complement the existing resource policy landscape, and at what operational level. Research is also needed to identify relevant parameters of policy design and its associated barriers and drivers, in policy domains where such policy interventions are entirely lacking or misrepresented within the life cycle perspective of resource policy in the EU.

Despite the strategic development of resource and waste policy in the EU, specific policy instruments that facilitate the transition to a circular economy are still generally lacking. This implies a need to support policymakers in devising relevant policies, as well as the need to better understand what policy support business actors would require to scale up the transition to a circular economy. The literature focusing on policy interventions for CE is rather limited so far, mainly consisting of macro ‘top-down’ policy frameworks for resource efficiency (Wilts et al., 2015; Ekvall et al. 2016; Hirschnitz-Garbers et al., 2016; Watkins et al., 2016; McDowall et al., 2017; Domenech and Bahn-Walkowiak, 2019). However, recognising the central role that businesses are expected to play within the narrative of the EU CE Action Plan (COM (2015) 614 final), a novel ‘bottom-up’ approach is required in research to identify the policy interventions that can facilitate business operations in companies that have adopted resource efficient solutions.

This ‘bottom-up’ methodology addresses a **second research gap**, the lack of empirical evidence in investigating policy interventions at a circular business model level. There is a need to investigate targeted sectoral policy interventions from the perspective of businesses, to facilitate a more nuanced and informed policymaking

process, taking into account inputs of critical actors that are central to the economy. Researching ‘circular’ business operations ‘on the ground’ will enable the identification of actual policy barriers and the associated required policy interventions for scaling up resource efficient product/service offerings.

Finally, a *third research gap* in the literature of resource efficiency policy concerns the actual systemic life cycle integration of the various resource efficiency policy instruments, taking into account business operational aspects and current economic realities. This makes it imperative to investigate the conditions under which the different policy instruments may interact with each other and promote or hinder progress towards anticipated outcomes, such as the transition to a circular economy.

1.4 Research objectives and research questions

Improving resource efficiency and effectiveness through novel and circular business models is an undertaking hampered by many factors. Barriers of a policy and legal nature play a prominent role. The overarching aim of this research was to address these challenges and produce viable solutions that would promote efficient and effective policies for resource efficiency, based on circular economy thinking. Taking into account the research gaps identified in the previous section, the research developed distinct objectives that are formulated in the following research questions.

RQ1: What gaps are identified in the existing policy landscape for material resource efficiency in the European Union and what kind of policies and policy packages are required to address these gaps?

The first research question (RQ1) is mainly concerned with the overall policy landscape for material resource efficiency in the EU and the way the different policy instruments are positioned within a life cycle perspective to address the systemic nature of CE. The objective was to map out the EU policy landscape, identify policy intensity, policy overlaps and policy deficiencies. A secondary objective was to propose ways to better address systemic challenges and provide ideas for policy instrument mixes that can facilitate change.

RQ2: Why do companies find it difficult to adopt circular economy strategies – or to compete with incumbent companies having a ‘linear’ business model – and what policy interventions would be needed to incentivise higher integration of circular strategies in business operations?

The second research question (RQ2) aimed exclusively at uncovering constraining factors of existing policies on CE business activities at company level and offering

potential solutions to overcome the identified barriers. The main concern was focused on ‘*what*’ works or not, and ‘*why*’ it works or not, with the supplementary objective to suggest ‘*how*’ identified barriers can be overcome.

RQ3: How can a policy framework for resource efficiency be designed to enable the uptake of circular aspects in business development?

The third research question (RQ3) had a primary objective to synthesise the research findings of RQ1 and RQ2 and propose a set of requirements for a comprehensive potential policy framework for resource efficiency in the EU, elaborating on the overall empirical findings of the research. The resulting framework presents the necessary minimum policy requirements for transitioning to a circular system, as identified in this research.

1.5 Research scope and limitations

The scope of the research was relatively wide, but certain limitations were needed to narrow down the initial scope towards a manageable breadth of subject matter that would yield useful results of scientific relevance, yet be of use to the target audience (section 1.6).

The scope of research addressing the first research question was inevitably directed towards the EU policy framework. The multi-level governance structure of the EU means that there are separate processes of decision making, distinguished between the centralised administration in Brussels and the governments of individual MS. Policymaking at the EU has a reciprocal two-level character (Lieverink and Andersen, 2005). On the one hand, policymaking in the EU is usually influenced by MS initiatives while, on the other hand, the EU policy framework has a direct influence on national policymaking processes. Therefore, a policy-induced transformation at national level (e.g. in Sweden) could inform and initiate policy transfer effects to the EU as a whole, and/or countries with similar ambitions for transitioning to CE both within and outside the EU.

After starting the research by studying the landscape of the EU policy, the focus was subsequently narrowed down to the national context of Sweden. This involved investigating policy aspects of resource efficiency in a series of case studies, always bearing in mind the reciprocity of policy processes between the EU and national contexts. The aim was to investigate case studies from a wide range of sectors. However, due to time constraints, the investigation was limited to five manufacturing sectors in Sweden, namely the small electronics sector (laptops, smartphones), the automotive sector (cars), the furniture sector (office furniture), the maritime sector (repair and maintenance of vessels), and the sector supplying

building materials and components. Within each sector, only companies that had adopted CE business operations were considered for the case studies (for CE principles, see section 2.2).

The research focused mainly on innovative business players that had adopted a circular business model (CBM) but that had confronted challenges related to the current institutional and socio-economic conditions. The focus was therefore directed towards disruptive businesses that could appropriately represent the transformative nature of CE. However, the findings are also relevant for incumbent firms facing similar hindering factors in transforming their business offerings, usually due to lack of capabilities, company culture and strategic inertia (Huff et al., 1992; Christensen and Bower, 1996; Hopkins et al., 2013).

Although the research was focused largely on a single country of limited market size (Sweden), the outcomes could be expected to inform wider environmental policy processes, both at EU and MS level. Sweden is considered to be a pioneer and role-model in promoting new environmental policies, across various socio-political and geographical jurisdictions, and regularly acts as a reference point for such policies worldwide (Jänicke, 2005). However, the limited number of economic sectors investigated might limit the generalisability of the research in terms of the specific outcomes, although certain elements relate more generally to the wider Swedish economy.

This research took a broad transdisciplinary approach, employing different research methods to investigate the research questions holistically. The approach was firmly in the area of policy studies, including policy analysis and policy processes, in the context of resources and waste management. Various research methods were employed, which could potentially lead to a trade-off compared to a more consistent and linear research design. The literature reviews performed to create the theoretical basis of the research can be considered to provide solid foundations for analysis and discussion of the findings of the case studies. However, the empirical evidence collected through interviews and surveys in the case studies would be dependent on the companies' perception of the proposed policy instruments, which might be constrained within their limited understanding and knowledge of wider policy-making processes. Company representatives (especially in small and medium-size enterprises) are less likely to be fully aware of the wider spectrum of policies that can potentially affect their business in terms of material resource efficiency. Companies would be more likely to focus on policy proposals that diverse actors (from advocacy coalitions to scientists) promote, and support these only if it implies a short- or long-term advantage for their operations. This means that companies' perceptions of policy needs can be limited, and reinforce existing proposed solutions, rather than championing more innovative (and less scrutinised) policy interventions.

The research did not investigate economic policy instruments with fiscal repercussions relating to environmental, resource or waste taxes. Although resource taxes have featured prominently in literature regarding the potential effects on resource savings (e.g. Ekins et al., 2012; Milne and Andersen, 2012), in practice the preference and/or feasibility of such a measure seems to be limited (Fairbrother et al., 2019). From an environmental perspective, taxes could be designed to reflect the full external and social costs of resource extraction and use (Wilts et al., 2015), but from an economic perspective, taxes are assessed as second-best policies due to their inherent impreciseness (Söderholm, 2011).

There are multiple structural barriers connected to the design, implementation and administration of resource taxes. The market power of key sectors can drastically affect the taxation regime, since there is a lack of information and cognitive barriers on various levels (industries, consumers, politics), split incentives in value chains, between companies, and different resources. Environmental taxes are therefore implemented on an exclusively selective basis and they cannot be considered as sending a clear signal to the economic actors involved (Domenech and Bahn-Walkowiak, 2019). In addition to the evidence from resource taxes, proposed tax reductions for reused products have not yet been thoroughly assessed.

Finally, the type of resources considered in the research from a policy perspective was limited to technical materials that are largely used in product manufacturing processes. Natural resources, such as land and water, or biogenic resources were not targeted in this research.

1.6 Target audience

The findings of this research address issues relevant to a variety of stakeholders concerned with policy aspects of a circular economy transition. The main audience of this thesis is actors involved in the policymaking arena. This includes not only politically active decision-makers, but also other actors involved in different stages of the policymaking process, i.e. policy advisors, policy entrepreneurs, advocacy and lobbying actors and civil society in general.

This work is also relevant to the growing body of academic researchers on policy aspects of CE. Specifically, it is of interest to scholars investigating issues relating to policy instrument and policy mix design, policy transition processes, and possibly to scholars interested in evaluating the policy proposals enclosed in this thesis.

Finally, part of the research was conducted with the participation of practitioners (either in public bodies or private enterprises). The intention was that the findings would be useful for any organisation working with CE and resource efficiency policy.

1.7 Thesis outline

This thesis comprises six chapters and seven appended research articles. Chapter 1 introduces the subject matter of the research and explains the motivation for undertaking this research, by identifying relevant research gaps and formulating respective research questions. Chapter 2 provides an overview of the main theoretical and conceptual research perspectives that facilitate the analysis of the research findings. The methodological positioning and approaches to data collection and analysis are presented in Chapter 3, followed by an overview of the key research findings in Chapter 4. Chapter 5 synthesises the results and theoretical perspectives into a discussion and reflection on the work. Finally, Chapter 6 highlights the main contributions of the research to the scientific literature and provides concluding remarks, including suggestions for future research directions.

2 Theoretical background

In this chapter, the theoretical aspects of resource efficiency and circular economy are presented in detail and the concepts are scrutinised in relation to their policy relevance. Basic aspects of policy analysis as a scientific discipline are presented, and the merits and weaknesses of an assortment of relevant policy process theories are discussed. Finally, the principles of long-term policy development are outlined, followed by a comprehensive background section on principles of policy mixing.

2.1 Material resource efficiency

Material resources constitute the necessary building blocks of modern societies. Global per capita resource use is projected to increase from 8 tonnes per year in 2000 to 16 tonnes per year in 2050 (UNEP, 2011), while a sustainable per capita consumption of resources is estimated to be 8 tonnes (Mont et al., 2013). Despite the high rate of material resource use for products, buildings, infrastructure, and all other types of equipment, global stocks of material resources are still sufficient to meet the anticipated demand for the foreseeable future (Allwood et al., 2011). However, increasing resource use could result in scarcities and push the limits of finite, non-renewable resources (Hirschnitz-Garbers et al., 2016). For instance, supplies of available high-grade reserves of economically relevant metals and minerals are expected to be at risk around 2040 for phosphorus (Sverdrup et al., 2011), around 2050 for copper (Sverdrup et al., 2014), and as early as 2030 for zinc, tin, indium and silver (Sverdrup et al., 2013).

Apart from impending resource scarcities, the environmental impacts of production and processing of materials are rapidly becoming critical. Resource extraction and use is closely linked to emissions and waste generation, which contribute to the accumulation of adverse environmental impacts (Hashimoto et al., 2012). The global ecological footprint of human activities increased from less than one planet Earth in 1961 to more than 1.4 planet Earths in 2005 (Galli et al., 2012) and is expected to grow to two planet Earths around 2030 (Moore et al., 2012). To some extent, these environmental impacts can be mitigated by ongoing activities to improve efficiency within existing processes. However, since demand is anticipated to grow, inevitably there will be an increase of overall impacts unless the total requirement for material production and processing is reduced. Consequently,

Allwood et al. (2011, p. 362) argue that this is the goal of material efficiency, and drawing from this notion they propose a definition for material efficiency:

‘Material efficiency means providing material services with less material production and processing.’

In other words, what Allwood et al. (2011) propose is the reduction of materials (in physical units) and processing (by using less energy) of products while retaining the functionality (or the utility) of the product. This, however, constitutes a narrow definition of material resource efficiency, while UNEP (2010, p. 42) suggest a broader and more inclusive definition of resource efficiency:

‘Resource efficiency is about ensuring that natural resources are produced, processed, and consumed in a more sustainable way, reducing the environmental impact from the consumption and production of products over their full life cycles. By producing more wellbeing with less material consumption, resource efficiency enhances the means to meet human needs while respecting the ecological capacity of the earth.’

In the UNEP definition, resource efficiency concerns the full life cycle of a product, addressing equally the materiality of a product, the environmental impacts of processes for resource extraction and production, as well as the final consumption.

To reduce the adverse environmental impacts of excessive resource use, economic development should be ‘decoupled’ from the amount of resources consumed. In turn, this should be decoupled from the impacts that resource use exerts on the environment. The notion of ‘decoupling’ is an alternative, or rather a complementary concept, to resource efficiency. It is defined by UNEP (2011, p. 8) as *‘using less resources per unit of economic output and reducing the environmental impact of any resources that are used or economic activities that are undertaken’*. Figure 3 illustrates the two key aspects of decoupling, namely resource decoupling and impact decoupling.

Resource decoupling means reducing the rate of resource use per unit of economic activity. This is achieved through using less materials, energy, water and land resources for the same economic output. Resource decoupling leads to an increase in the efficiency with which resources are used. Such a decoupling can be expressed through increased resource productivity (usually expressed as the ratio DMC/GDP), while resource decoupling can also be demonstrated by comparing the gradient of economic output over time with the gradient of resource input. In contrast, impact decoupling requires increasing economic output while reducing negative environmental impacts. Such impacts arise from the extraction of required resources, production processes, the use of commodities, and in the post-consumption phase (e.g. waste).

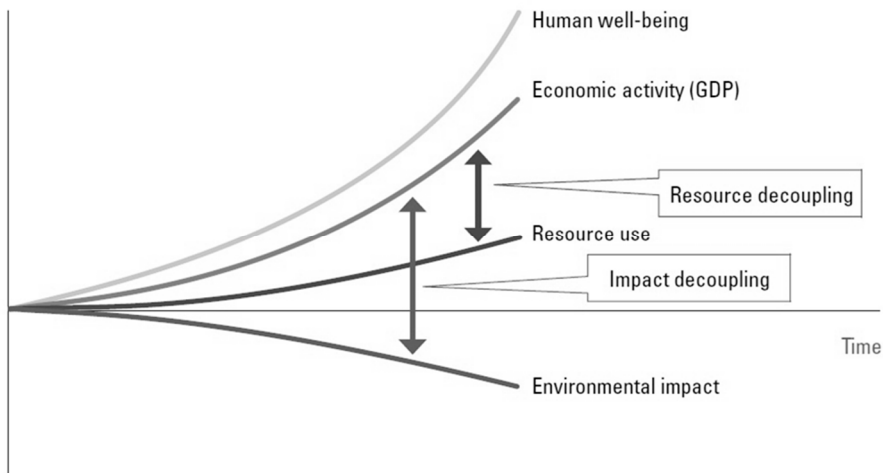


Figure 3. Graphic representation of the concept of 'Decoupling' (UNEP, 2011).

A distinction can be made between 'relative' and 'absolute' decoupling. Relative decoupling of resources or impacts means that the growth rate of the environmentally relevant parameter (resources used or some measure of environmental impact) is lower than the growth rate of a relevant economic indicator (e.g. GDP). Such relative decoupling seems to be fairly common. Absolute decoupling means that resource use declines, irrespective of the growth rate of the economic driver (UNEP, 2011).

If we are to elaborate on different approaches for material resource efficiency and strategies for achieving material resource efficiency, it is important to bear in mind that material resources can be measured in both physical and monetary terms. In the following sub-sections, aspects of material resource efficiency from a physical and economic perspective are elaborated further.

2.1.1 Physical resource efficiency

Material efficiency refers to the anticipated low material input and the avoided associated environmental impacts that result from reducing the amount of engineered and processed materials used to produce one unit of economic output. Allwood et al. (2011) suggested that the urgent need for increased material efficiency derives from the limited (economic) availability of natural resources and the environmental benefits of lower material use. Strategies for reducing material demand through material efficiency were identified by Allwood et al. (2011; 2013), including the longer life, more intense use, repair and resale of products; product

upgrade, modularity and remanufacturing; using less material to provide the same service; and yield improvements, reducing yield losses, and recycling.

Research into the environmental impacts of increasing the lifetime of certain products through repair, remanufacturing and reuse has shown that, in some cases, opposite effects were observed (Gutowski et al., 2011). For example, in a case study in the UK, refurbishing a C-rated washing machine and using it for an additional nine years could save 220,000 tonnes of CO₂e per year, compared to replacing it immediately by a new A-rated washing machine (WRAP, 2010).

The most common material resource efficiency option, often promoted by relevant binding legislation, is the option of ‘recycling’. However, several operational challenges are embedded in strategies for recycling. Allwood et al. (2011) indicated that high uncertainty over the availability of recycled material requires large stocks of recycled materials, to match the supply with demand in an open market for recyclables. The logistics and infrastructure for material collection and sorting are complex and highly specialised by waste stream. The time delay between production and disposal creates inefficiencies, as demand for goods is growing faster and represents the sum of replacement and new demand, while the supply of recycled material cannot match this increasing demand (Ayres, 1999).

2.1.2 Economic resource efficiency

The physical dimension of material resources is undeniably linked to human economic activities and, as such, material resources adopt an additional dimension – the economic value of resources. There is a strong correlation between economic growth and the consumption of energy and materials, as well as the gradual depletion of easy-access resources such as topsoil, land, fresh water, fossil fuels and other minerals (von Weizsäcker and Ayres, 2013). On the other hand, taking into account that planet Earth is a closed finite system with a certain amount of non-renewable resources, it is apparent that material resources should be managed in such a way that the future yield is not compromised and that future generations will not be worse off. In this way, material resources can be viewed as a ‘bank account’ where the capital (deposited amount) remains constant over time to generate a steady supply of interest for humans to live on (Andersen, 2007). Therefore, the aspect of economic resource efficiency in modern industrialised societies is becoming increasingly relevant (if not more relevant than the physical aspect of resource efficiency).

The notion of ‘resource scarcity’ can be quite misleading, as the critical factor that renders a resource as ‘scarce’ is whether the price of the resource is increasing over time or not (von Weizsäcker and Ayres, 2013). Historically, increasing prices are perceived to indicate scarcity of a resource, while declining prices imply that resources are in abundance.

In contrast to the physical approach to resource efficiency, Söderholm and Tilton (2012) argue that concerns over potential future resource scarcities do not represent a strong motive for introducing policies aimed at promoting greater material efficiency, but that environmental externalities and information failures in the relevant material markets do. The role of the markets is fundamental in signalling such scarcities, while the role of public policy is to make sure that existing prices reflect all costs to society and that the market mechanisms provide appropriate incentives for resource efficiency and for preventing scarcities.

Baptist and Hepburn (2013) state that engineers and scientists tend to define ‘materials’ in different ways to economists. Physical inputs such as iron ore and steel, often measured in units of mass, are considered as material resources by engineers. In contrast, economists do not usually differentiate between ‘material’ in itself and other intermediate inputs to production processes, partly because it is difficult to distinguish ‘raw’ materials from other processed physical components. The approach of many engineers and scientists is that they often consider depletion to be related to a deterioration of a fixed stock of resources. However, according to the economic perspective, the focus is put on economic rather than physical depletion. There is a realisation that resource depletion is a threat in the long run but not the short run, and that depletion can affect renewable as well as non-renewable resources (Söderholm and Tilton, 2012).

At this point, it is relevant to address the issue of ‘opportunity cost’ as it is useful for understanding the economic aspect of resource efficiency. The perception of resource depletion focuses on what society would be required to give up – usually measured in terms of real prices – to acquire one more unit of a given resource (Söderholm and Tilton, 2012). For instance, the real price of copper presumably increases over the long run, so society would have to give up more of other economic activities to obtain another unit of copper, so copper becomes scarcer or less available. Under the opportunity cost paradigm, resource depletion can push production costs and prices up as society is forced to exploit poorer quality and therefore more costly sources of supply. If prices rise to uneconomic levels, then the demand in the various end-uses of a given resource will start falling, ultimately reaching zero. In other words, the total demand for the given resource will practically cease. As resources become uneconomic (i.e. at prohibitively high costs), they may remain unexploited but not depleted. Consequently, the economic depletion of material resources occurs before, probably long before, physical depletion becomes imminent (Söderholm and Tilton, 2012).

Returning to the relationship between resource efficiency and economic utilisation of resources, UNEP (2011) notes that the vision usually adopted by policymakers is that of reducing the resource intensity of GDP so that the GDP can grow indefinitely in a finite material world. However, there is an inherent conflict in this proposition, since resource efficiency tends to reduce prices and thereby primarily impact

negatively economic values and GDP. In practice, efficiency gains are often offset by secondary effects, also known as rebound effects (Sorrel, 2009).

As van den Bergh (2011) points out, when the price of resources is high, the rebound effect is observed to be rather weak. Consequently, it seems that resource prices are one of the most important factors of steering the direction of the economy. An artificial signal of rising resource prices could greatly influence the stabilisation or even induce reductions in the consumption of natural resources, and perhaps tackle the rebound effect without seriously affecting economic growth (Malmaeus, 2016).

Technical innovations or efficiency gains that result in increasing product utility (extended use and service proposition) without significantly affecting the costs of production do not add to GDP volume, unless they stimulate investments in physical capital. Therefore, the neo-classical notion of productivity is found to be relevant only as a micro-economic concept. In practice, GDP growth is mostly explained by capital throughput and accumulation, and a key question is whether capital accumulation can be decoupled from the use of materials (Malmaeus, 2016).

2.2 Circular economy

The circular economy (CE) has emerged as a comprehensive approach for the sustainable use of natural resources (Murray et al., 2017). The CE focuses on maximising the value and utility of resources and energy within production systems, based on the premise that natural resources are scarce and that EOL products may retain some value (Ghisellini et al., 2016). The concept of CE has become prominent in recent years both in policy and business circles (Milios, 2018).

With its roots in industrial ecology and environmental economics (Bruel et al., 2019; Ghisellini et al., 2016), the CE is not a precisely defined concept but follows a few general principles that appear in all definitions available in the literature. Kirchherr et al. (2017) reviewed 114 definitions of CE and identified the most common characteristics of the CE, described as an economic system that replaces the concept of ‘end-of-life’ with notions of total material use reduction; reuse of products by extension of product life through repair, refurbishment and remanufacturing; and finally recycling and recovering materials in production and use processes. The CE is operationalised at multiple levels: the micro-level (products, companies, customers), meso-level (eco-industrial parks, economic sectors), and macro-level (region, nation and beyond). The overarching aim of the CE is to promote sustainable production and use systems, maintaining environmental quality, and ensuring economic prosperity and socio-economic equity.

2.2.1 Conceptual development of the circular economy

The origin of the term ‘circular economy’ itself is widely debated (Murray et al., 2017). It can be traced back more than half a century to a conception that resembles the contemporary general idea of the CE. The literature on the subject (Andrews, 2015; George et al., 2015; Ghisellini et al., 2016; Lieder and Rashid, 2016; Murray et al., 2017; Reike et al., 2018) mentions two critical points in academic publishing that shaped the term CE and framed its conception. These two main contributions refer to Boulding’s ‘The Economy of the Coming Spaceship Earth’ (1966) and Pearce and Turner’s ‘Economics of Natural Resources and the Environment’ (1990).

Elements critical in the concept of the CE were portrayed extensively in Boulding’s ‘spaceship economy’ in which he described Earth as a spaceship without unlimited reservoirs of anything, either for extraction or for pollution (Boulding, 1966). He argued for a new economic model – one modelled after a circular, closed-cycle system – and the requirement of a new ‘circular relationship’ with the world, if humans are to survive on Earth (Boulding, 1966).

However, despite the inspirational conception of an alternative economic system that takes into account the finite resources of the Earth, the term CE was not formulated by Boulding but much later, by Pearce and Turner (1990). They were trying to model an economy applying a materials balance perspective, which follows the first and second law of thermodynamics. In their book ‘Economics of Natural Resources and the Environment’ they presented environment-economy interactions and discussed the implications of ignoring the environment in economics, suggesting that a linear system is the result of ignoring the environment. Their concept of CE (referred as a materials balance model) is one in which ‘the economy and environment are not characterized by linear interlinkages, but by a circular relationship. Everything is an input into everything else. Simply saying that the end purpose of the economy is to create utility, and to organize the economy accordingly, is to ignore the fact that, ultimately anyway, a closed system sets limits, or boundaries, to what can be done by way of achieving that utility’ (Pearce and Turner, 1990).

Pearce and Turner (1990) mentioned that the term CE was first used in Western literature in the 1980s to describe a closed system of economy-environment interactions. However, it was Stahel and Reday-Mulvey (1981) who first referred to a closed-loop economy in a report to the European Commission on job creation, later published as a book. They proposed that materials should ideally be processed in a ‘closed loop’ and that ‘waste’ would return back in the process as a resource, and identified the need to extend product life through repair and remanufacturing (Stahel and Reday-Mulvey, 1981), which are also integral processes of the CE. Stahel’s proposal of increased product durability was actually drawn directly from

Boulding (1966, p. 7) who wrote: *‘I suspect that we have underestimated, even in our spendthrift society, the gains of increased durability’*.

Conceptually, CE encompasses and builds upon a number of complementary approaches, including eco-design (Brezet and van Hemel, 1997; Dalhammar, 2015), lean manufacturing (Nakajima, 2000), industrial ecology (Erkman, 1997), industrial symbiosis (Ehrenfeld and Gertler, 1997), cradle-to-cradle (McDonough and Braungart, 2002), dematerialisation (von Weizsäcker et al., 1997), sustainable consumption (UNEP, 1994; Mont and Heiskanen, 2015), functional economy (Stahel, 1997), and product-service systems (Mont, 2002; Tukker, 2015).

Three core principles are derived from the various definitions that govern CE: a) conservation of natural capital, by creating an equilibrium of use between renewable and non-renewable resources; b) extended lifespan of resources through both biological and technical cycles, i.e. enhancing the circularity of resources and energy; and c) reduction of the negative effects of production systems (Ghisellini et al., 2016; Kirchherr et al., 2017; Reike et al., 2018). To operationalise these principles at micro-, meso-, and macro-levels, several strategies have been proposed in the literature, establishing comprehensive frameworks.

Each of the CE frameworks has its particular focus. Potting et al. (2018) propose the ten-step strategies priority framework, introducing the 10R principle of priority action towards a CE (refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, and recover). The framework further differentiates between the life cycle stages, from the conceptualisation and design of a product to extending its useful life, and ultimately to the useful recovery of its material content or energy. In a similar conceptual framework, Reike et al. (2018) identify the same CE strategies, only differentiating by adding a final recovery strategy, that of ‘re-mine’, integrating concepts such as landfill mining and urban mining to the CE framework.

Moraga et al. (2019) present a simplified version with a five-strategy approach to CE: 1) preserve the function of products or services provided by CBMs such as sharing platforms or product/service systems (use- and result-oriented); 2) preserve the product itself through lifetime extension, with strategies such as durability, reuse, restore, refurbish, and remanufacture; 3) preserve the product’s components through the reuse, recovery and repurposing of parts; 4) preserve the materials through recycling and downcycling and; 5) preserve the embodied energy through energy recovery at incineration facilities and landfills.

Other important aspects that go hand in hand with the proposed conceptualisation of CE strategies include the need for supply chain integration and coordination (Bressanelli et al., 2018), as well as transparency and information exchanges concerning the quality of materials in products (Iacovidou et al., 2019). Finally, Winans et al. (2017) identify exchange of information as one of the major constraints on the effectiveness of CE strategies.

2.2.2 Practical implementation of the circular economy in policy

CE elements in national strategic development can be traced back to the 1980s and 1990s in German and Japanese policy, influenced by the intriguing and then ‘new’ concept of a closed-loop economy (Moriguchi, 2007). These policies, in turn, inspired China to introduce CE as its major strategic framework for industrial development, expecting it to deliver increased economic growth with decreased environmental impacts (Yong, 2007; Feng and Yan, 2007).

The implementation of CE in China, Japan, and Europe – although rooted in the basic principles of CE – seems to have taken a slightly different approach. CE in China comes as a direct outcome of the national political strategy (top-down approach), and its implementation is structured according to both a horizontal and a vertical approach (Feng and Yan, 2007). CE policies in China target the different levels of industrial/societal systems and seem to draw directly from theories of industrial symbiosis and industrial ecology systems (Tang et al., 2020).

Ghisellini et al. (2016) argue that the main focus in the EU is on policies promoting efficient and effective waste management, aiming at improving recycling rates in Europe, and consequently reaping the benefits of higher resource circulation in the economy. Although the latter was not directly regulated by the policies in place, it was largely expected indirectly as a result of the recycling policies. Similarly, Japan adopted an inclusive approach, embracing the 3R principles (Reduce, Reuse, Recycle) and establishing a vision for a ‘Sound material cycles society’, at meso/macro-level (Moriguchi, 2007).

CE development in cities, regions, or nations (macro-level) involves the integration and redesign of four systems: the industrial system, the infrastructure system, the logistics services organisation, and the culture and social system (Mirata and Emtairah, 2005; Feng and Yan, 2007; Ness, 2008). Successful cases of CE implementation, reported by Ghisellini et al. (2016), stress that the transition to a CE can be realised only with the involvement of all actors in society and their capacity to link and create suitable collaboration and exchange patterns. Also, there is a basic requirement for an economic return on investment for the CE paradigm to provide suitable motivation to companies and investors. Interdependence of all actors is paramount for a CE to work, and the links within a CE system are not just economic and material (waste/resources), but also organisational and environmental (Ranta et al., 2017).

Sustaining the loops of production and consumption in the economy by keeping materials in the economy for as long as possible might pose a particular problem, as inevitably material circulation reaches its limits, while the possibility of rebound effects seems genuine (Zink and Geyer, 2017). At some point, the extra cost of improving and refining a circular material flow will exceed the corresponding benefits to society (Andersen, 2007).

2.3 Foundations of policy analysis

Policy analysis can be generally defined as the '*study of the action of public authorities within society*' (Knoepfel et al., 2007). Expanding on this notion, Knoepfel et al. suggest that policy analysis aims to interpret the regulatory functions of the state and, more generally, the political-administrative system, using its influence to steer the economy and the society as a whole. Without disregarding the power relationships inherent in all political administrative processes, policy analysis concentrates on existing or emerging administrative organisations and the actual services they provide to the public (Knoepfel et al., 2007).

Considering the disciplinary approach of policy analysis, there is a wide range of academic subjects that have been associated with it. According to Wildavsky (1979), '*Policy analysis is an applied subfield whose contents cannot be determined by disciplinary boundaries but by whatever appears appropriate to the circumstances of the time and the nature of the problem*'. Therefore, the different disciplinary approaches in policy analysis are used in accordance with the theoretical and normative perspectives on which the position of the researcher/practitioner is based.

There are three major directions in policy analysis that reflect different objectives of analysis, but these are not mutually exclusive. The main difference between the three directions is on the focus of the specific field of analysis. One of the analytical approaches couples policy analysis with the theory of state, the second explains the way in which public action works, and the third focuses on the evaluation of the results and effects of public policy action (Knoepfel et al., 2007).

The area of focus in this thesis revolves around the second approach of policy analysis. The justification of this theoretical approach is linked to the overall empirical research approach of this thesis. The approach does not seek to evaluate any specific policy intervention or policy process, and instead looks at the multi-level, multi-actor and internationalised policy arena of resource efficiency and circular economy that extends beyond the theory of the state.

In this theoretical approach, the use of policy analysis does not aim to explain the general functioning of the political system but to act as a way of understanding the operation and logic of public action, based on available evidence (Dente, 1995; Dente and Fareri, 1993). Several scientific disciplines have been utilised in this policy analysis approach, including administrative science, sciences of complexity (i.e. systems analysis), sociology of (public) decision-making, economic sciences and information sciences (Knoepfel et al., 2007).

This analytical approach emerged gradually through the 1950s and 1960s from the works of four major figures, coming from quite diverging schools of thought in their disciplines, and had a fundamental impact on defining concepts used in this type of

analysis. Lasswell (1951) adopted a mostly managerial approach in his work, deliberately attempting to construct a dialogue between social scientific researchers, economic actors and public decision-makers in an effort to improve the efficacy of public action. Simon (1955) integrated human decision-making processes in the analysis of public decision-making (cf. the concept of ‘bounded rationality’). Lindblom (1959) also had a significant impact on the development of policy analysis by concentrating the analytical focus on the limited room for manoeuvre at the disposal of public decision makers (cf. the concept of ‘incrementalism’). Finally, Easton (1965) applied systems analysis to policy studies, and made a significant contribution to main concepts of contemporary policy analysis.

Contemporary policy analysis of the way public action works can take several different perspectives. Certain analyses focus on the decision-making process and actor strategies. This type of analysis is connected to the application of systems analysis to human decision-making. ‘Public management’ emerged from this approach, in particular, through the work of the OECD (Knoepfel et al., 2007). Other analyses are based on tools and instruments of public intervention. Economic approaches and, in particular, research on the political economy predominate in this approach. The analyses focus on the modes of public action in terms of their efficacy from either a macro- or micro-economic point of view (Knoepfel et al., 2007).

2.4 Theories of the policy process

The theoretical context of analysis must be expanded to include the extended public interaction space if we are to understand the operation and logic of public policy action, including stakeholders peripheral to the strictly governmental and administrative actors. The formulation of public policy is usually a multi-step and multi-actor process affected by temporal and topical parameters of the existing policy landscape and the stakeholder interactions within it.

A number of theories of the policy processes have offered the most appropriate scientific background for analysing such processes and outlining the initial problematisations, the policy design, and the policy decision-making process, both at instrumental level and at macro-strategic level. Several theories have been elaborated over the years, with few of them gaining particular prominence in the political science literature. These include the advocacy coalition framework (Sabatier, 1988), the multiple streams approach (Kingdon, 1995), the punctuated equilibrium theory (Baumgartner and Jones, 1993), the policy feedback theory (Pierson, 1993), the policy arrangements approach (Arts et al., 2006), the discourse coalitions approach (Hajer, 1995), and the theory of political modernisation (Van Tatenhove, 1999).

The establishment of a policy framework for increased resource efficiency, in line with circular economy principles, is also dependent on the wider socio-economic conditions and the potential transition pathways that are envisioned by the political context at a given time. In addition to policy instrumental analysis and policy mix specifications, it is important to consider policy development aspects over time. In terms of socio-technical systems relevant to the nature of resource efficiency solutions, the use of transition theories to analyse wider policy-oriented processes in this context might be suggested. However, transition theories consistently lack the ability to fully integrate such policy level developments in a comprehensive way (Patterson et al., 2017; Smith et al., 2010), limiting their overall analytical contribution and diminishing their level of effect in a potential transition. In order to address the forward-looking and actor-dependent aspects of a policy-aided transition to a circular economy, theories of the policy process could shed a light on the transition pathway. The aim of this thesis is not to elaborate on these issues, but the results of the research help to set the scene for the upcoming transition. As such, a brief discussion of the results will be presented (in section 5.2), using the prism of policy-focused transition to a circular economy.

In the following sub-sections, a few of the established policy process theories are briefly analysed to form a basic theoretical background against which public policy development pathways for a circular economy transition will be discussed. The theories of advocacy coalition framework, policy feedback theory, and political modernisation are chosen for the discussion of the results (in section 5.2), since these theories align satisfactorily with the context of resource efficiency and the socio-political and technological space in which changes must occur. The selected theories address the multi-actor nature of the policy subsystem, the techno-economic lock-ins of existing technological solutions and manufacturing practices, and the requirement of policy diffusion at different policy levels, from the local to the global.

2.4.1 Advocacy coalition framework

The advocacy coalition framework is a well-established theory about understanding policy processes, especially in a long-term perspective. It was developed by Sabatier and colleagues as early as the 1980s (Jenkins-Smith et al., 2014; Weible et al., 2011). According to this theory, there are several advocacy coalitions, including public and private actors, within a certain policy subsystem – meaning all actors participating in policy formation processes within a policy field – competing to influence the direction of policymaking (Sabatier, 1988, 1998). Within the policy subsystem, one coalition is often dominant over other competing coalitions, and exerts more influence on the policy design of the anticipated future policies. The participating actors are conceptualised to act with bounded rationality, and share a

belief system that encapsulates their values and causal approach about the way the world works (Sabatier, 1988).

The advocacy coalition framework distinguishes three levels in this belief system: (1) The deep core beliefs of the coalition constituents, which represent their fundamental normative values and ontological standpoint that is not policy-specific and thereby influence their actions at any given policy subsystem; (2) The policy core beliefs that are bounded by the scope and topic of the policy subsystem and have strong topical components, which can be normative and empirical in nature; (3) The secondary beliefs that deal with limited specific components of the policy subsystem (e.g. one policy instrument) for achieving a desired outcome within their policy core beliefs (Jenkins-Smith et al., 2014). Actors within a coalition are expected to exhibit a high degree of consensus on their core beliefs to coordinate their activities, so coalitions tend to be stable over time (Sabatier, 1988).

However, belief systems of coalitions can gradually shift due to policy learning effects through, for instance, formal policy evaluations or informal trial and error processes. This shift is more likely to be observed on secondary elements of policy instrument design rather than the overall policy direction, since core beliefs are exceptionally hard to change, while secondary beliefs can be more flexible and therefore lenient to change (Sabatier, 1988). The advocacy coalition framework constitutes a primarily cognitive approach to understanding policy change, which highlights the fact that the ideas/beliefs the actors hold determine the direction of policy process. Also, the theory acknowledges the importance of the mobilisation of resources (such as financial resources, information, public opinion etc.) in influencing the ability of a coalition to effect policy change. Another aspect that the theory identifies is that policy changes can also be triggered by factors external to the policy subsystem (Jenkins-Smith et al., 2014; Weible et al., 2011).

Traditionally, the literature on the advocacy coalition framework recognised that policy change was primarily conceptualised as a result of policy learning or external shocks. However, as the theory progressed, shocks internal to the subsystem, as well as negotiated agreements between advocacy coalitions, have been suggested as influencing parameters of policy change (Weible et al., 2009). Although the focus has been traditionally on the dynamics within policy subsystems, Jones and Jenkins-Smith (2009) argued that macro-level features outside the policy subsystem can also have a significant influence in shaping policy processes.

2.4.2 Policy feedback theory

The policy feedback theory is mainly based on the work of Pierson (1993, 2000) and draws on historical institutionalism, specifically the idea of path dependence and processes of increasing returns in institutions and public policies (Béland, 2010). North (2005) states that path dependence *'is the constraints on the choice set*

in the present that are derived from historical experiences of the past'. Therefore, a critical aspect of path dependence is found in the positive feedback or self-reinforcement of current practices. The mechanism of positive feedback is articulated in the notion of increasing returns (Arthur, 1994; 1996).

Pierson (1993) distinguishes two main types of policy feedback effects: resource effects and interpretive effects with the capacity to critically affect the capacities and interests of actors. Resource effects can be direct or indirect. Direct resource effects arise when a policy allocates funding to a particular interest group, while the indirect effects can be discerned in policies incentivising structures that could redirect funding towards the interest group without being the primary policy goal. Interpretive effects, on the other hand, are *'the impact of policies on the cognitive processes of social actors'* (Pierson, 1993). An example is policy learning from current public policies in which (perceived) successes or failures shape future policy.

There are several design aspects of policies for creating positive feedbacks, such as the size of the benefits provided, their visibility and traceability, the proximity and concentration of beneficiaries, duration of benefits, and programme administration (Campbell, 2012). However, the literature has also acknowledged negative policy feedbacks, along with the mainly positive, self-reinforcing feedbacks that have been analysed (Jordan and Matt, 2014; Weaver, 2010). Campbell (2012) points out that negative policy experiences can undermine, rather than enhance political participation. Despite its wide empirical basis, one shortcoming of the policy feedback theory is the lack of a systematic analysis of the conditions under which feedbacks emerge. Indeed, feedbacks can fail to materialise because of bad policy design, inadequate or conflicting institutional support, or poor timing (Patashnik and Zelizer, 2009).

2.4.3 Political modernisation

The concept of political modernisation concerns the structural processes of social change and their impact on the political domain. These changes are either a consequence of or are connected with developments in the economic, social and cultural domains, related to concepts of reflexive modernisation, globalisation, commercialisation, individualisation etc. (Van Tatenhove, 1999). As a consequence of these kinds of social, economic and political processes, new relationships are emerging between the state, markets and the civil society, so new power relationships between these subsystems, and different ideas and practices on policy are forming (Arts et al., 2006).

Similarly, Jänicke (2008) introduces 'ecological modernisation' as systematic eco-innovation and its diffusion, in which policy modernisation and market competition for innovation combine with the market potential of global environmental

requirements to serve as driving forces to bring about environmental improvements. As political modernisation exerts change throughout the political domain, it affects all policy areas and is not confined in one policy domain or subsystem. Policy process frameworks, such as the policy arrangements approach, through the lens of political modernisation, need to define clearly its application boundaries in order to be meaningful, e.g. by confining itself to environmental policy (Arts et al., 2006).

2.5 Principles for long-term policy development

Policy change processes can take a long time and can have variable directions and outcomes, so a necessary vision and appropriate strategies must be formulated in advance. In this context, the notion of long-term policy design is coming to prominence (Voß et al., 2009). Meadowcroft (1999) notes that long-term policy design approaches appear to be 'reflexive', avoiding monolithic top-down planning and are well aware that full knowledge of the problem in question in advance is limited. Therefore, a dynamic and participatory policy approach would be better suited to deal with the long-term perspective. In such a reflexive policy perspective, governing processes and policy analysis are seen as shaping technological, economic and ecological changes, both in terms of innovative actions and structural change. However, each of the actors involved in these processes has only a limited view of the whole, which makes it difficult to comprehend and assess their view in comparison to the view of others, coupled with restricted capacities to influence policy outcomes (Voß et al., 2009).

In such processes, Voß et al. (2009) suggest a number of fundamental elements: 1) achieving extended coordination between the actors involved; 2) taking a holistic view on socio-economic and (parallel) political developments; 3) preventing unpredictable outcomes; and 4) sustaining a vision for the long-term goals of the policy, without suppressing diversity; while 5) retaining adaptability towards the complex dynamics of change. In order to constructively deal with all these issues in long-term policy guidance, within a short-term context, most approaches to reflexive planning pragmatically combine top-down and bottom-up considerations (Voß et al., 2009).

Critical long-term policy design issues include (Bontoux and Bengtsson, 2016; Howlett and Rayner, 2007; Meadowcroft, 2011; Voß et al., 2009):

- A firm presence and well-defined vision for the targeted outcome of the policy. This vision will then inform the choices of alternative solutions and provide support for change. The vision therefore provides an alternative selection environment compared to the established socio-technical paradigm.

- Actions across diverse policy fields and beyond current agendas and policies. Another critical issue for long-term policy design is the problem of moving away from existing governance patterns and working towards new reflexive policy practices.
- Weak stakeholders are not usually involved, so care should be taken to address this issue and support inclusivity and bottom-up participation in the policy process. Weak stakeholders traditionally perceive that they have only limited power and that they cannot influence the outcome of the policy process.
- Unforeseen dynamics and unintended consequences that arise when the ‘planned’ policy designs start interacting with processes ‘on the ground’.
- A systemic outlook is required, looking at international governance structures to ensure coherence of action.

Policy instruments are the actual tools governments use to implement their policies. Policymakers can select from a wide range of instruments to address a certain policy problem and achieve a desired outcome. However, a distinction should be made between the terms ‘instruments’ and ‘tools’, as they might be perceived similarly when they are not. Instruments constitute a steering function and provide incentives for achieving a certain policy, while tools can be used to achieve a specific purpose. A policy instrument therefore implies some degree of governmental or political intervention (Mont and Dalhammar, 2005).

Policy instruments can be divided into three types (administrative, economic, and informative) in relation to their nature and into two types (mandatory, voluntary) concerning their implementation mode (Mont and Lindhqvist, 2003). Table 1 presents the categorisation of policy instruments as well as some indicative examples of a related measure.

Table 1. Policy instruments typology (Mont and Lindhqvist, 2003).

	Mandatory	Voluntary
Administrative	e.g. bans, standards, quotas, licences, etc.	e.g. standards, agreements between government and industry, etc.
Economic	e.g. taxes, fees, tariffs, subsidies, etc.	e.g. GPP, loan guarantees, charges, etc.
Informative	e.g. reporting requirements (chemicals), labelling, education, etc.	e.g. certification schemes, awareness raising campaigns, EMS, etc.

Other typologies in literature might include more than three categories and distinguish between, for example, voluntary agreements and self-regulation as separate categories (Gunningham et al., 1998).

In conclusion, even though policy instruments might be very well designed, targeting specific elements of a desired outcome, they also reflect context-specific weaknesses regardless of the type of instrument. Applying only one type of instrument is usually insufficient when designing policies that target complex issues, such as a transition to a circular economy, and a mix of policy instruments is preferable (Gunningham et al., 1998).

2.6 Synergistic policies (policy mixes) for systemic change

Realising the complexity of transition processes and the challenges in policymaking for supporting such multi-level and multi-stakeholder long-term processes by employing an individual policy instrument may prove to be insufficient. Applying just one policy instrument would most likely change an individual driver, but would risk prompting unintended outcomes that change other drivers. Ultimately, these changes would counteract or even neutralise the intended effect of the policy instrument. A more complex approach would also have to be taken in the policymaking field, developing a mix of policies that target a specific outcome.

The fundamental basis for any policy mix design derives from considering the problem at hand, whether it requires a policy mix approach or not, for example whether an environmental issue is a ‘single-aspect’ or a ‘multi-aspect’ challenge (Sterner and Coria, 2012). Multi-aspect challenges, as in the case of resource efficiency in a circular economy, require multiple policy objectives, which in turn require multiple instruments. Tinbergen (1952) argues that the number of policy instruments utilised should, ideally, be equal to the number of policy objectives. This proposition about the optimal ratio between instruments and policy objectives is often referred to as the ‘Tinbergen Rule’ (Braathen, 2007).

In addition to the multiple policy objectives justification, the literature indicates three main reasons for adopting a policy mix approach: 1) multiple market failures (including transaction costs and uncertainties); 2) governance constraints; and 3) behavioural factors (Bouma et al., 2019).

Multiple market failures have historically highlighted the need to adopt multiple instruments, especially in the field of environmental policy (Baumol and Oates, 1988; Tietenberg and Lewis, 2010). The main causes for market failures include: 1) ownership externalities; 2) public good externalities; 3) market power; and 4) imperfect information (Bator, 1958; Randall, 1983; Winston, 2007). Lehmann (2012) broadens the justification that multiple market failures require a policy mix by addressing failures of ‘private governance structures’, including market transaction failures to policy responses. Another justification for policy mixes that

is often mentioned separately, but actually is directly related to multiple market failures, is uncertainty (Bouma et al., 2019). For instance, uncertainty about marginal costs, fundamentally a market failure due to asymmetric information, is used to justify the adoption of policy instrument mixes (Benbear and Stavins, 2007). Uncertainty related to ‘imperfect information’ is also often used to justify the adoption of multiple instruments (Bouma et al., 2019).

In the political economy literature, justification for the use of policy mixes does not derive from multiple market failures and objectives, and is instead attributed to political factors and factors relating to the design and implementation of policy (Mees et al., 2014; Weber et al., 2013). Such factors include ‘*political rationales as the main explanation of instrument selection and regime effectiveness*’ (Howlett and Rayner, 2007). A policy mix approach may also facilitate a better functioning of governments, by tackling governance failures such as limited administrative capacity, inefficiencies of government public service delivery, and inconsistencies between policies (Helm, 2005; Keech and Munger, 2015).

Considering behavioural factors, public and private actors’ deviation from the rational choice model is largely due to bounded rationality, bounded willpower and bounded self-interest (Shogren and Taylor, 2008). Actors do not always behave completely rationally, so policy instruments, and especially market-based instruments, may not yield intended outcomes. Due to these behavioural aspects, complementary policy interventions may be required to increase the effectiveness of a policy instrument.

Twomey (2012) mentions the ‘multiple modes of behaviour’ as a justification for policy instrument mixes, and provides examples in which behavioural deviation in combination with environmental externalities justify a multi-instrumental policy response. For instance, routine everyday actions are habitual (e.g. taking the car to work or leaving the tap water running while washing dishes), which makes market-based instruments like charges and fines less efficient, as people do not make decisions on the basis of what is (economically) rational but on the basis of what they are used to doing. The impact of social factors on individual behaviour, including aspects from education, culture, relationships and media, also induces types of behaviour like ‘keeping up with the Joneses’, which cannot be adequately addressed by market-based instruments, and may require additional interventions.

Bouma et al. (2019) suggest that an effective design of policy mix interventions requires a good understanding of the market, governance and behavioural failures that need to be tackled for the intended policy mix to have the desired effect. A policy mix approach should exhibit a number of design characteristics to ensure a higher level of efficacy in addressing the specific problem(s). These are: 1) consistency, 2) coherence, 3) comprehensiveness, 4) credibility, and 5) congruence (Howlett and Rayner, 2007; Rogge and Reichardt, 2016).

The first characteristic of policy mixes is consistency referring to *'how well the elements of the policy mix are aligned with each other, thereby contributing to the achievement of policy objectives'* (Rogge and Reichardt, 2016). Single instruments in a policy mix can be considered consistent when they work synergistically to support a policy objective. This implies the elimination of contradictions between instruments and the existence of synergies within and between the elements of the policy mix.

The second characteristic of an efficient and effective policy mix is the coherence of the policy processes that will develop, implement and monitor the specific instrumental mix. While consistency focuses on the contents of the mix, the term coherence focuses on the design policy process dimension (den Hertog and Stroß, 2013; OECD, 2003; 2016). Consistency and coherence in a policy mix can be fostered by combining primary with supportive instruments. Primary instruments are mainly used to achieve a defined policy objective and ideally should be as non-controversial as possible, despite the fact that usually there is considerable resistance from societal and economic groups with vested interests in maintaining the status quo. On the other hand, supportive instruments are used to minimise or mitigate unintended negative side-effects of primary measures and, therefore, to increase their acceptability and feasibility (Rogge and Reichardt, 2016).

A third analytical dimension relevant for describing the nature of a policy mix and the perception of the affected actors is the credibility of a policy mix (Foxon and Pearson, 2008; Majone, 1997). Credibility refers to the extent to which a policy mix is considered reliable (Newell and Goldsmith, 2001). Credibility may be affected by several factors, such as the commitment from political actors, a consistent instrument mix, and the competencies of implementing governmental bodies (Rogge and Reichardt, 2016).

The fourth characteristic of a policy mix concerns its comprehensiveness. This term refers to the *'...the degree to which the instrument mix addresses all market, system and institutional failures, including barriers and bottlenecks'* (Rogge and Reichardt, 2016).

The final characteristic concerns the necessary congruence among instruments and (socio-economic) goals (Howlet and Rayner, 2007), meaning the compatibility between the strategic objective of a policy goal and the design of the policy mix to achieve the intended outcomes.

In order to effectively respond to and be adapted to the specific context of a policy vision in a long-term perspective, the development of policy mixes needs to consider the following (del Rio and Howlet, 2013; Howlet and Rayner, 2007):

- The full range of policy instruments
- The full cost of policies (including implementation costs, transaction costs, compliance costs)

- Avoiding negative interactions between single policies (i.e. instruments already in place and new ones) and emphasising mutual benefits with existing policies
- The potentially negative side-effects of the instruments on the target groups (e.g. issues of competitiveness in industry or adverse effects on lower-income households)
- The political processes during the design and implementation of the mix.

A comprehensive policy mix needs to go beyond just combining statically individual policy instruments. In a policy mix, the long-term qualitative objectives and short- to mid-term quantitative targets should be combined in a time-dynamic approach to effectively achieve the objectives and targets. A policy mix design also requires forward-looking strategic planning, by relating different policy instruments in a time sequence that enables the optimisation of synergistic effects while minimising the unintended negative side-effects (Ekvall et al., 2016).

3 Research design and methodology

In this chapter the overall research process is presented. Section 3.1 starts with presenting the research approach, as well as the associated scientific positioning. The subsequent sections provide an insight to the methodological approach and the data sources for the analysis. In the final section, the reliability and validity of the research is scrutinised.

3.1 Research approach

The overarching approach is defined by the characteristics of policy research. Policy research is *'the process of conducting research on, or analysis of, a fundamental social problem in order to provide policymakers with pragmatic, action-oriented recommendations for alleviating the problem'* (Majchrzak, 1984, p. 3).

Policy research is not just concerned with the application of the analytical scientific theory (testing hypothesis, causal relations between variables etc.). Instead, it particularly stresses the importance of understanding the internal dynamic and peculiarities of the complex processes of policymaking (Jann and Wegrich, 2007). Weimer (1999) argues that a policy researcher is willing to embrace any method that can potentially assist in giving a better insight and resulting in better advice. Contextually sensitive methods (either quantitative or qualitative) are likely to generate better advice because their findings and inferences are interpretable, meaning that they can be plausibly defended (Collier et al., 2004).

Case studies also constitute a fundamental methodological approach of policy research in other disciplines, e.g. political science, sociology, and public administration (Bennett et al., 2003; Brower et al., 2000; Yin, 1994). Policy researchers are traditionally problem-oriented rather than concerned with theory development. The research therefore focuses on a smaller number of cases to study, since the researcher is investigating in detail the entire case rather than extracting separate variables from a larger sample to analyse.

Falsification is not the relevant criterion for designing a research question, but the main purpose of the research question is to be able to explain the context around the problem accurately and to provide possible solutions (Clark, 2007). According to Majchrzak (1984, p. 8) policy research is *'multidimensional in focus; uses an*

empirico-inductive research orientation; incorporates the future in addition to the past; responds to study users; and explicitly incorporates values’.

In this research, the focus was on policy approaches that induce material resource efficiency in production and consumption systems, within a circular economy paradigm. The research examined current and potential development of resource efficiency policies considering key elements of implementation for individual policy instruments, as well as interactions between instruments that might facilitate or hinder the effectiveness of their combination in policy packages. Ultimately, the research made use of policy process theories to investigate potential pathways of transition towards an alternative state of policy reality within an economic system that is more in line with CE principles.

Figure 4 presents an overview of the scientific journal articles (papers) in relation to the research approach.

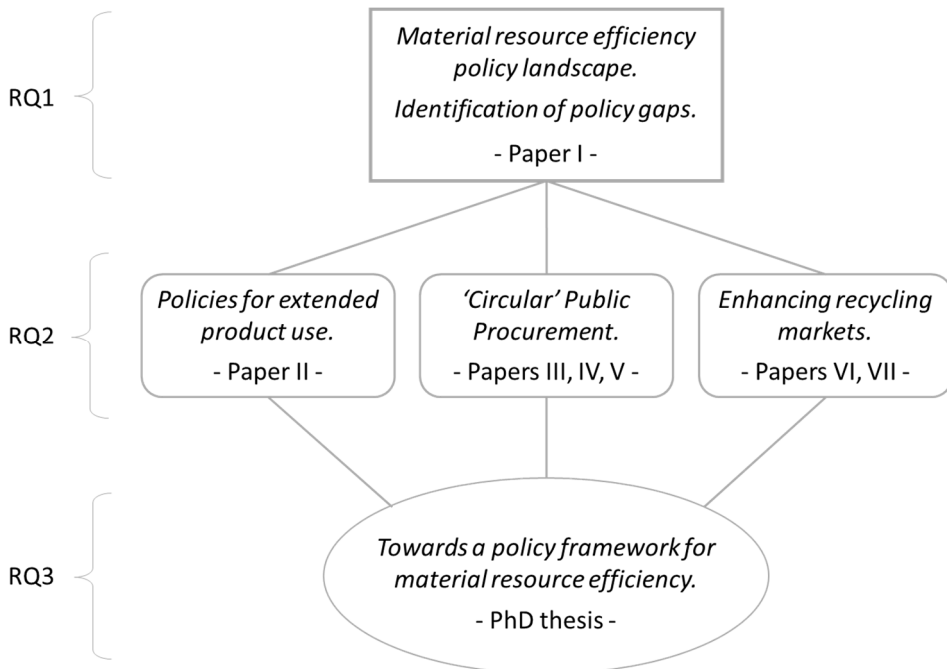


Figure 6. Outline of research approach and the papers included in this thesis.

Table 2 lists the papers in this research and highlights their approach in terms of the policy interventions at different life cycle stages of products, as well as the different methods, approaches and data sources, reflecting the different scope of analysis. The plurality of approaches is a product of the interdisciplinarity of the research, which is further elaborated in section 3.1.2.

Table 2. List of papers included in the thesis

Paper #	CE focus	Approach	Data sources	Methods of analysis
I	Resource efficiency life-cycle approach	Qualitative	Literature	Content analysis
II	Longer life-times, reuse potential of products	Quant/Qualitative	Literature, Interviews (n=14)	Case studies, Content analysis
III	Longer/intensive product use	Quant/Qualitative	Literature, Interviews (n=13)	Case studies, Content analysis
IV	Longer/intensive product use	Qualitative	Literature, Interviews (n=15)	Case studies, Content analysis
V	Longer/intensive product use	Qualitative	Literature, Interviews (n=13)	Case studies, Content analysis
VI	Recycling	Qualitative	Literature, Interviews (n=15)	Content analysis
VII	Recycling	Quantitative	Literature, Interviews (n=7), Statistical databases	MFA modelling

Most of this research was carried out by conducting several case studies of companies operating with, or considering adopting, circular economy strategies. In the context of policy research, case studies allow for the review and testing of hypotheses from academic literature in the specific context of a certain case (Yin, 1994). Individual cases do not allow for generalisations, but they provide empirical evidence in favour of or against previously established concepts and findings. To relate the research to such concepts and findings, the case studies were prepared by reviewing relevant literature, and their findings were discussed in the context of previous research in the respective area. A ‘bottom-up’ approach was used in the case studies in this thesis, to identify precisely the policy interventions that can facilitate business operations in firms employing circular configurations, in line with the literature on CBMs.

A ‘bottom-up’ approach in the CE literature has different meanings, either referring to the actual business actions (e.g. product design, supply chain networks, automation, etc.) (Lieder and Rashid, 2016), or to initiatives taken by environmental organisations, civil society, etc. (Ghisellini et al., 2016). In contrast, the research approach in this thesis uses ‘bottom-up’ to refer to the evidence base on which actions by public policy actors (usually described as a ‘top-down’ element) are expected to facilitate niche innovative circular businesses, by responding to their specific policy support needs. This means that, in this approach, only business inputs were utilised to identify desired policy interventions, without taking into account the positions of policy officers, policy brokers and industry advocacy associations, whose agenda also reflect political interests.

The approach therefore accounts for a genuine ‘on the ground’ approach, reflecting the views of practical implementers of CBMs (despite their potential impartiality or lack of knowledge in policy processes), seeking solutions to their immediate operational problems rather than to the general socio-economic context as a whole. This direct input serves to elevate the practical problems of CE businesses to actual policy solutions through the lens of policy analysis and potential transformative actions outlined in this thesis.

3.1.1 Scientific research positioning

The research approach derives from the researcher’s worldview, consisting a basic premise of perceiving the world and enabling the development of a relevant research methodology. Each worldview is underpinned by philosophical assumptions with distinct characteristics. This research has been developed through the lens of critical realism, which constitutes an epistemological framework that encompasses a wide range of ontologies, fit for interdisciplinary research, especially when researching complex issues (Bhaskar et al., 2010).

A fundamental ontological approach of critical realism is that the world is ‘*structured, differentiated, stratified and changing*’ (Danermark et al., 2001, p. 5). Critical realism reflects a post-positivist worldview, in which the world is independent of human consciousness, but also influenced by observers’ own perspectives and limitations in understanding its true nature. Critical realism views science as a continuous process of understanding a changing, multi-level world. The critical realism philosophical research approach is mainly concerned with researching the causal mechanisms of events and their associated reasoning to gain a better understanding (Danermark et al., 2001). This often necessitates a plurality of research methods that fit the purpose of the research objectives (Sovacool et al., 2018). This research also encompasses a normative approach in seeking to provide answers related to resource efficiency related questions, framed broadly by a sustainable development approach (Sovacool and Hess, 2017).

3.1.2 Inter- and trans-disciplinarity

The approach taken in research reflects an interdisciplinary and transdisciplinary background. This is argued to be an appropriate approach for sustainability issues as these tend to be complex, having different causes and outcomes on multiple levels that transcend narrow disciplinary worldviews (Bhaskar et al., 2010; Høyer and Naess, 2008; Klein, 2017; Stock and Burton, 2011). Both interdisciplinary and transdisciplinary research emphasise problem solving, with a focus on societal or ‘real world’ problems (Klein, 2017; Lang et al., 2012; Stock and Burton, 2011). The main difference is the level of integration between disciplinary perspectives and cooperation among different actors (Klein, 2017; Stock and Burton, 2011). As such,

interdisciplinary research is understood as the combination and integration of elements from two or more academic disciplines that enrich each other to study a phenomenon that does not fit in a single discipline (Sakao and Brambila-Macias, 2018). Transdisciplinary research, on the other hand, is understood as the inclusion of non-academic stakeholders, with academic and non-academic partners temporarily collaborating to address a sustainability ‘problem’ or knowledge gap (Sakao and Brambila-Macias, 2018).

Resource policy, being a part of the broader sustainability discourse, is a topic that is difficult to grasp without examining complexity and considering different disciplinary perspectives. In addition, the field of policy studies is argued to be transdisciplinary in that the inquiry is often problem-oriented, rather than methodology driven. This is particularly true in the development of this research, which was guided in the first instance by the inquiry and resulted in diverse methodological approaches.

The transdisciplinary and participatory approach (Papers II-VI) contributed to addressing ‘real world’ sustainability problems that require new ways of knowledge production in research and decision-making in practice (Sakao and Brambila-Macias, 2018; Blackstock et al., 2007). This approach enabled an advanced understanding of the ‘real world’ problem and generated knowledge that would be more suitable for addressing the problem (Mobjörk, 2010). Discussions and collaboration with stakeholders outside academia during the research process increased the reflexivity of the research (Popa et al., 2015). However, this approach needs to consider the possibility of an ‘epistemic drift’ that can result from the influence of non-academic stakeholders on the research itself (Tranfield and Starkey, 1998).

3.2 Analytical methods

This section describes the main analytical approaches used in this research to create knowledge and derive outcomes that facilitated the overall discussion and analysis of the policy options for resource efficiency within a circular economy framework.

3.2.1 Document content analysis

Policy documents were a main primary data source for Paper I but also informed the research process throughout the course of the subsequent publications. Official EU and national policy documents, as well as EU and national documentation for supporting policy decisions (such as preparatory studies, impact assessments and other related reports), were used for drawing a complete policy map of the current

resource policy framework in the EU. The main source of EU policy documentation was the EU law directory, EUR-Lex³.

Papers II-VI constituted mainly case studies of business actors that operate with a resource efficiency business perspective, so a set of relevant documentation was also analysed to develop the necessary background knowledge for building the case study and proceeding in interviews and further empirical investigation. Such documents included company reports, communication materials, advertisements, and websites. Secondary material (e.g. case descriptions in academic literature) was used to collect information about the business models and products, and the potential drivers and barriers in their operations.

The main method of document analysis in this thesis was qualitative content analysis (Flick, 2006). Although there are multiple approaches to this type of analysis, three activities generally characterise this qualitative method: data condensation, the use of data displays, and verifying conclusions (Miles et al., 2013). The use of existing analytical frameworks has contributed to data condensation, while assisting with the systematic identification of themes (Bryman, 2012). For example, Paper I uses the product life cycle perspective to classify the various policy interventions identified in the arsenal of EU regulations. Similarly, the analysis of recycling operations in the case of plastic recycling in the Nordics (Paper VI) is based on a value chain analysis framework, and the business cases are analysed within this framework.

Document analysis can be a time-effective way to gather information and identify how specific issues are understood and represented by the business actors. However, it may be difficult to interpret their content or meaning because the context in which they were developed is not always explicit. Documents may not be transparent and cover only one side of an issue, so triangulation of data sources and data methods is also important (Flick, 2006).

3.2.2 Case studies

The method used in much of the research (Papers II-VI) was case studies. Case studies are useful at providing in-depth descriptions of social phenomena, especially when the research questions are guided by 'how' or 'why' questions (Yin, 1994). Case studies produce context-dependent knowledge and are therefore a key to understanding and learning about a phenomenon, because they are conducted close to real-life, on real-life conditions (Flyvbjerg, 2006). It has been argued that case study approaches can support policy investigations in context (Yin, 1994), so this method was selected to study the policy responses to business-experienced barriers to adopting resource efficiency strategies. Past experiences of policy effects,

³ The database of the Official Journals of the European Union.

irrespective of the level of their effectiveness, are real-life situations from which useful information can be drawn.

When designing case studies, several parameters must be carefully considered. George and Bennet and (2005) suggest that a case study research design should include definition of variables, case selection, variance of variables, and data requirements and specifications. The case selection in this thesis could be argued as indicative of a ‘most similar’ type of case selection (George and Bennett, 2005), as the companies investigated share similarities, including the geographical and socio-economic context and type of business operation.

The research did not aim to construct a generally applicable theory on how resource efficiency policies are designed and implemented. Instead, it aimed at investigating a specific policy context within the Swedish manufacturing sector, so the context-dependent knowledge from case studies actually provided a more ‘*nuanced view of reality*’ (Flyvbjerg, 2006, p. 223).

Case studies can also be used to challenge generalised theories. If one observation is found to be false, i.e. it does not comply with the prescribed understanding of the theory, the theory must be revised (Flyvbjerg, 2006). Specific research findings from past/existing policies could play a role in challenging the current general understanding of designing and implementing relevant resource efficiency policies.

The case study methodology is sometimes criticised for lack of generalisability of the findings, but it is considered beneficial at providing in-depth descriptions (Yin, 1994), as well as context-dependent knowledge. Case study research does not rely on statistical generalisation of the element under scrutiny, but does rely on deeper understanding and analytical generalisation.

3.2.3 Sustainability impact modelling

Sustainability impacts of higher rates of recycling in Sweden were quantified using a plastic waste management flow model (Paper VII). The model outlined the different parameters and criteria influencing the amount of plastic waste recycled, together with the associated costs and labour required for the different scenarios defined. The material flow model enabled a full quantification of impacts throughout the value chain of plastic waste in Sweden.

The model was populated with key data, such as costs for operation, collection and transportation, employment data and GHG emission data, and the model output enabled an environmental (GHG emissions), economic (costs), and social (jobs generated) impact assessment. The model was constructed in a simple and comprehensive way, avoiding over-complication of the value chain. The full methodology and details of data points are presented in more detail in Paper VII.

However, the model outputs must be considered with caution, since the quality and confidence of the results can only be as good as the underlying assumptions of the model. Many assumptions are related to future projections, so there is some uncertainty and unpredictability inherent in the calculations. The missing data points in the model, specific to Sweden, were replaced by EU average values, slightly decreasing the level of confidence in the results.

3.3 Methods of data collection

The main data collection methods for the research in this thesis are presented briefly in this section. A variety of research methods were used to address the research question, and more specific details for each method can be found in the appended articles.

3.3.1 Literature reviews

A standard method for collecting data and background information at the initial stage of each research paper included a literature review. Throughout the research process in this thesis, several literature reviews were conducted and documented. The initial exploratory literature review examined the current policy landscape regarding resource efficiency in the EU. Subsequent literature reviews targeted the selected case studies, most notably the status of business operations and value chain configurations, but also previous research on ‘circular’ business barriers and resource efficiency solutions.

Relevant literature for each thematic research was retrieved from a variety of academic databases, including Scopus, ScienceDirect, Google Scholar, and Web of Science as well as management and policy think tanks and international governmental and non-governmental organisations (e.g. UNEP, OECD, EEA, Ellen MacArthur Foundation). In addition to peer-reviewed literature, ‘grey’ literature sources were also examined, since CBMs are widely discussed by practitioners outside of academia. Although exact sources varied from paper to paper, literature included analysis of books, academic journals, reports, newspapers, conference proceedings, company websites, and company reports.

3.3.2 Interviews

Except Paper I, which was literature based, all other research articles in this thesis (Papers II-VII) included data inputs from interviews. A variety of business stakeholders were interviewed, holding managerial or operational positions within their respective organisations. A number of public officials were interviewed to

obtain their perspective and anticipation of policy solutions pertaining to business-public sector interactions. The format of the interviews was semi-structured, where the majority of the questions were open-ended ‘how’ and ‘what’ questions (Justesen and Mik-Meyer, 2012). The interviews were conducted in person or over the phone. Interviews conducted in person also enabled on-site observations regarding the conditions of business operations and the overall environment or work and decision-making at each organisation.

The purpose of the interviews was to elicit knowledge that was not readily apparent from literature. The semi-structured interviews deliberately included open-ended questions to capture the diversity of opinion among the different stakeholders in the sector. The questions were ‘open’ to ensure that each interview focused on subjects actually important to the stakeholders, and to provide the opportunity to gather information that might be overlooked using a long list of structured questions. In each case, stakeholders were interviewed with a core protocol developed for their stakeholder role. This protocol was sent to the stakeholders in advance, allowing interviewees to prepare their responses in advance and provide as much relevant input as possible. This enabled background knowledge to be collected before the interview. The interviewing approach was ‘active’, involving the interview subject in ‘making meaning’ (Holstein and Gubrium, 1995, p. 4).

3.3.3 Surveys

Much of the research process relied on surveys to collect data but, most importantly, to triangulate the research findings after the preceding steps in the case studies, including a literature review and interviews. A detailed description of the use of surveys in this research is described in Paper II, outlining the purpose and the steps of the survey development.

The surveys consisted of statements on barriers and policy interventions that respondents were asked to score on a Likert-type scale of 1-5 (5 being the most relevant), according to their business operational experience. To develop the survey, a literature review was first conducted to identify key barriers and drivers on business operations and associated policy interventions responding to the identified barriers. Respondents were able to add free-text comments to their ranking and explain why/why not a statement is important. Respondents were asked to fill in additional policy interventions that might have not been included in the survey, ensuring the robustness of the final findings after a) the literature review, b) the interviews, and c) the survey questionnaires. Examples of survey questionnaires can be found in Papers II & III.

3.4 Reliability and validity

The results of a research process must fulfil certain criteria of reliability and validity in order to be judged sufficient and/or satisfactory to support the advancement of knowledge in science (Yin and Campbell, 2003). A wide range of strategies was used in this work to ensure a high level of reliability in the research methods, including a transparent interviewing and data gathering method. Data collection and data analysis were documented and submitted as supplementary material to scientific journals during the peer-review process. This included interview protocols, surveys and databases, making the primary sources explicit. The use of appropriate research methods and their application, as well as the analysis and interpretation of data, were strengthened through the peer-review processes of the scientific journals in which the research was published.

The validity of research relates to the soundness and quality of the findings. Validity can be divided into external and internal validity (Bryman, 2012). External validity emphasises the generalisability of the research findings. With the exception of Papers I & VII, which are based on concrete literature evidence and a well-defined sets of data sources, the rest of the research in this thesis is highly context-dependent, as it mainly comprises case studies. Findings cannot be generalised without considering the context, but case studies can be used for falsification processes of generalised theories. If one observation is found to not follow the prescribed understanding of the theory, the theory must be revised (Flyvbjerg, 2006). Specific research findings from the case studies context could serve as evidence to challenge the current general understanding of resource efficiency policy needs from a business perspective.

Internal validity concerns the validity of the researcher's causality in experimentation. This type of validity is mainly concerned with assessing the researcher's inquiry. This assessment of 'what works' involves a social dimension of producing evidence, such as peer review (Morgan, 2014). In addition to increasing the reliability of research by exposing it to peer-review and academic scrutiny, the research here was also subject to peer-review processes at various stages of the work for feedback. Constant literature reviews monitored developments in the field. Mixed research methods enable triangulation and reflection from multiple perspectives.

Finally, the replicability of this research will depend on the context of future inquiries, as all the empirical evidence is situationally dependent due to a large part of the research based on case studies. The results are also time dependent, given that changes in institutional and socio-economic factors are very likely in the future.

4 Research findings

This chapter addresses key findings of the research, providing a brief overview of the scientific journal articles included in this thesis. The starting point of the research was to analyse the current (as of 2016 onwards) policy landscape in the EU and to identify possible weaknesses and gaps in its resources, products and waste policy framework, since these areas are directly linked to the notion of CE as elaborated in theory. Highlighting the existing weaknesses, the text goes on to analyse specific elements in each policy domain that would need to be introduced (or modified) to drive further resource efficiency in EU economic activities (i.e. manufacturing and consumption). Each section in this chapter presents the findings of each of the scientific articles included in this thesis. An integrated discussion of all the research findings follows in Chapter 5.

4.1 Circular economy policy landscape and identified gaps in policy development

Paper I set out to identify policy areas that have been underutilised in the EU resource efficiency policy framework, and to discuss the potential of upscaling and integrating such policies into a resource-efficiency oriented and comprehensive policy framework within a CE paradigm. A life cycle approach was used in the analysis to identify policy deficiencies at different life cycle stages of a product. The research methodology used for fulfilling the objectives of this paper included an extensive literature review of academic sources in related policy areas at EU and national level. Official EU and national policy documents, as well as EU and national documentation for supporting policy decisions (such as preparatory studies, impact assessments and other related reports), were used for drawing a complete policy map of the current resource policy framework in the EU. For mapping the existing policy landscape in the EU, relevant regulations found in the EU law directory EUR-Lex were scrutinised, and only those specific to material resource efficiency were selected and respectively positioned within the life cycle stage they primarily regulate (see Table 3).

Table 3. Policies affecting resource efficiency in different life cycle stages of a product, at EU-28 level.

Life cycle stage	Production	Use / consumption	Waste management
Mandatory	Batteries and waste batteries Directive 2006/66/EC, amended by Directive (EU) 2018/849	Labelling of energy-related products Directive 2010/30/EU	Waste Framework Directive 2008/98/EC, amended by Directive (EU) 2018/851
	WEEE Directive 2012/19/EU, amended by Directive (EU) 2018/849	Eco-design Directive 2009/125/EC ^a	Batteries and waste batteries Directive 2006/66/EC, amended by Directive (EU) 2018/849
	RoHS Directive 2011/65/EU	Sale of consumer goods and associated guarantees Directive 1999/44/EC	Plastic bags Directive (EU) 2015/720
	Eco-design Directive 2009/125/EC ^a	Single use plastics Directive (EU) 2019/904	Single use plastics Directive (EU) 2019/904
	Packaging and waste packaging Directive 94/62/EC, amended by Directive (EU) 2018/852	Plastic bags Directive (EU) 2015/720	WEEE Directive 2012/19/EU, amended by Directive (EU) 2018/849
	Single use plastics Directive (EU) 2019/904		RoHS Directive 2011/65/EU
	Standardisation Regulation (EU) No 1025/2012		Waste from extractive industries Directive 2006/21/EC
	Marketing of construction products Regulation (EU) No 305/2011		ELV Directive 2000/53/EC, amended by Directive (EU) 2018/849
	REACH Regulation (EC) No 1907/2006 ^a		Landfill Directive 1999/31/EC, amended by Directive (EU) 2018/850
			Packaging and waste packaging Directive 94/62/EC, amended by Directive (EU) 2018/852
		Shipments of waste Regulation (EU) No 660/2014	
		REACH Regulation (EC) No 1907/2006 ^a	
Voluntary	Public procurement Directive 2014/24/EU	Public procurement Directive 2014/24/EU	
	Ecolabel Regulation (EC) No 66/2010	Ecolabel Regulation (EC) No 66/2010	

Note: policies written in black have a direct effect on CE; policies in grey have partial or indirect effects. (a) The Eco-design Directive and REACH regulation serve as a policy framework from which specific implementing measures are formulated and applied by case (product group or chemical compound respectively). To date, the application of eco-design focuses primarily on energy efficiency measures, and material resource efficiency appears very limited (for an overview of eco-design processes in relation to material resource efficiency see Bundgaard et al., 2017).

It is clear that there is a high concentration of mandatory EU legislation towards the end of the life cycle, with the aim to limit resource loss and increase the circulation of materials mainly through recycling. The plurality of mandatory and voluntary policies at the EOL stage are related to the sound waste management in MS and the increase of recycling. However, the increase of recycling, as driven by existing mandatory policy targets, cannot guarantee overall resource efficiency, since the type and use of the recycled material is a key defining aspect of CE. Recycling should result in good quality materials that could be circulated back to the economy

and substitute virgin material resources. Low-quality recycling cannot fulfil the principles of CE, so is undesirable. A gap can also be identified at the EOL stage, especially regarding policies that would promote and upscale quality recycling and market mechanisms that facilitate the reintroduction of recycled materials into production processes.

Policies targeting the use phase are particularly limited and mostly affect resource efficiency only indirectly. No policy implicitly targets resource use at that stage. There is no apparent driver for resource efficiency related to consumption and use of products and services at individual consumer level, nor at businesses and public sector stakeholders.

At the beginning of a product's life cycle, a plurality of directives and regulations govern production processes at EU level, but the majority do not explicitly target material resource efficiency. A policy gap is observed at this life cycle stage. However, the fact that some policies do exist at that level is considered positive, as material resource efficiency considerations could be more easily added in existing policy instruments instead of creating an entirely new policy framework from scratch (for instance by improving criteria for public procurement and eco-labelling to make material resource efficiency more prominent).

Since it is clear that the current EU resource efficiency policy landscape is rather waste-centric, complementary approaches are needed that target all life cycle stages. Specifically, the policy landscape analysis identified three policy areas with a significant potential for promoting higher resource efficiency throughout the life cycle of a product: 1) targeted policies for reuse, repair and remanufacturing; 2) revised public procurement requirements with integrated 'circular' criteria; and 3) policies for facilitating the efficient functioning of waste markets and safeguarding the quality of recycled material. All relevant policy instruments within these policy areas have the potential to directly influence the resource efficiency of products and services, reflecting the core principles of CE and reaffirming the goals of the resource efficiency agenda in the EU.

Systemic challenges, such as the shift towards CE, would be enabled by the development of policy mixes, rather than individual policy instruments applied side by side. Policy mixes are generally better equipped to tackle the complexity of systemic challenges, such as the shift of socioeconomic systems (Rogge and Reichardt, 2016). Although a large arsenal of potential policy measures exists today, their implications and unintended side-effects have not been examined satisfactorily in research and further investigation is required, first at company level (or sectoral level), case by case, and ultimately across the whole economy (Bahn-Walkowiak and Wilts, 2017).

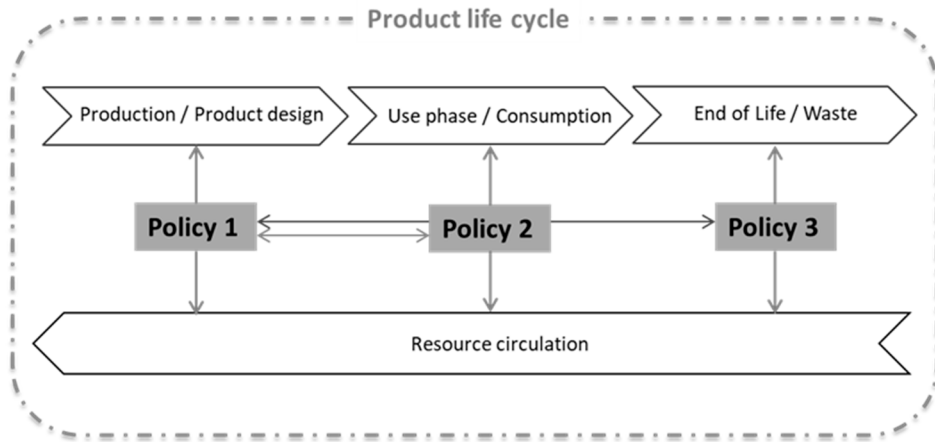


Figure 5. Interactions of the three policy areas across a product life cycle (Paper I).

4.2 Policy framework for product life extension

Paper I set the direction of research in this thesis by identifying the policy gaps in the EU resource efficiency policy framework. Paper II explores policy interventions that would enable extension of the useful life of products by CE strategies such as reuse, repair and remanufacturing, thereby contributing to the goal of resource efficiency in the EU economy. The approach of the research in Paper II is problem-driven, particularly responding to policy constraints that ‘circular’ business operations are facing, and suggesting a comprehensive framework that would lift such constraints and facilitate the diffusion of CE strategies wider in the economic sphere.

To address the research objectives of Paper II, an initial literature review was carried out to determine specific barriers to companies that have adopted circular business models (CBMs) (for CBM theory, see Nußholz et al, 2017), followed by a second literature review seeking to identify appropriate policy responses to the identified barriers to CBMs. By juxtaposing the list of CBM barriers with identified policy interventions from the literature (Wilts et al., 2015; Ekvall et al. 2016; Hirschnitz-Garbers et al., 2016; Watkins et al., 2016; McDowall et al., 2017; Milios, 2018; Domenech and Bahn-Walkowiak, 2019), fifteen policies in total were found to be direct responses to the CBM barriers. This resulted in an extensive list of CBM barriers and their respective policy responses (Table 4).

Table 4. Policy responses to identified circular business barriers.

Type of barrier	Specific barrier in each sub-category of barriers	Policy type	Policy response
Technological	Design barriers, e.g. limited product design for easy disassembly, repair, refurbishment and remanufacturing	Admin.	Eco-design (P1)
	Engineering barriers, e.g. advanced knowledge of materials and chemical properties	Info.	Information about product content (materials/products passports) (P10)
	Lack of product standards for CE	Info.	Quality certification system (P11)
	Widespread planned obsolescence in products	Admin.	Eco-design (P1)
Technology and infrastructure	Lack of advanced technology and equipment know-how with lower-environmental impacts in manufacturing processes	Info.	Promote education/skills (P13)
	Resistance to innovation and technological change in established industries	(✓)	
	Lack of networks and/or supply chains for disassembled products and components (reverse logistics)	Admin.	Take-back infrastructure (P2)
	Waste management systems not able to retain products and components for reuse (capabilities only for recycling and incineration)	Admin.	Take-back infrastructure (P2)
Economic	Limited financial capability for investments in resource efficiency technologies, companies avoid high short-term costs	-	Not addressed
	High labour costs related to product disassembly and source separation of waste	Econ.	Business internal operation mechanism less likely to be affected by public policy. Reduced tax on labour (P6)
Material and product cost	Difficulty to adapt and maintain competitive prices of products	Econ.	VAT reduction on reused products (P7)
	Costs associated with the environmental impacts of production (so-called externalities) are not reflected in the price of materials	Econ.	Charge on virgin raw material use (P8)
	Mismatch between used components and scrap materials with actual demand for products	Info.	On-line platforms/cooperation (P14)

Type of barrier	Specific barrier in each sub-category of barriers	Policy type	Policy response
Organisational	Management	(✓)	Promote education/skills (P13)
	Limited environmental awareness and top management commitment and support for sustainability initiatives, including product life extension strategies. Management resistance to change – limited application of new business models	Info. –	<i>Not addressed Business internal operation mechanisms less likely to be affected by public policy.</i>
Markets	Lack of well-functioning markets for secondary material (of high quality)	(✓)	Charge on virgin raw material use (P8)
		(✓)	Public procurement (P9)
		(✓)	On-line platforms/ cooperation (P14)
	Poor partnership formation and management – uncooperative suppliers	✓	On-line platforms/ cooperation (P14)
	Non-alignment between actors within and across value chains (e.g. between producers and recyclers) to improve cross-cycle and cross-sector performance	✓	On-line platforms/ cooperation (P14)
	Lack of demand from suppliers	✓	Public procurement (P9) VAT reduction on reused products (P7) Charge on virgin raw material use (P8)
Vision/strategy	Unclear/weak strategic and business goals, lack of environmental goals in company vision and corporate values, misalignment of short- and long-term strategic goals	(✓)	Promote education/skills (P13)
Human resources	Lack of appropriate human resources and time	✓	Promote education/skills (P13)
		(✓)	Reduced tax on labour (P6)
	Resistance to organisational change and operational inertia	–	<i>Not addressed Business internal operation mechanisms less likely to be affected by public policy.</i>
	Insufficient technical and environmental training, education and reward systems	✓	Promote education/skills (P13)
	Lack of support and guidance, limited expertise/capability	✓	Promote education/skills (P13)

Type of barrier	Specific barrier in each sub-category of barriers	Policy type	Policy response	
Regulatory	Legislation and regulation	Difficulties associated with the process of applying/complying with legislation and/or environmental management system	(✓) Admin. Admin. Improve waste legislation (P3) Improve public administration and practices (P5)	
		Lack of standardisation of processes and products for CE	✓ Info. Quality certification (P11)	
		Weaknesses in policy coherence at different levels	✓ Admin. Improve waste legislation (P3)	
		No defined targets for resource efficiency in policy	✓ Admin. Set specific targets for reuse and circular economy (P4)	
		Lack of governmental incentives (e.g. financial) for resource efficiency	✓ Econ. Public procurement (P9) Leadership in public authorities (P15)	
		Lack of CE know-how of political decision-makers	(✓) Info. Promote education/skills (P13)	
		Monitoring framework	Lack of clarity, know-how, methodologies and processes, e.g. appropriate LCA modelling for reuse	✓ Admin. Set specific targets for reuse and circular economy (P4)
			Lack of effective approaches and measures to evaluate resource efficiency, difficulties in quantifying resource efficiency	✓ Admin. Set specific targets for reuse and circular economy (P4)
			Communication	Poor communication between relevant actors for increasing resource efficiency, e.g. academia, companies and policy administrations
		Poor communication across the value chain of products (upstream/downstream)		(✓) Info Promote education/skills (P13)
Poor communication across the value chain of products (upstream/downstream)	✓ Info. On-line platforms/ cooperation (P14)			
Informational / Knowledge	Uncertainty and risk	Uncertainty about potential results, market benefits, performance impacts and environmental benefits	✓ Admin. Improve public administration and practices (P5)	
		Uncertainty regarding future legislation	✓ Admin. Improve waste legislation (P3) Leadership in public authorities (P15)	
			✓ – Leadership in public authorities (P15)	

Type of barrier	Specific barrier in each sub-category of barriers	Policy type	Policy response
Cultural / Social	Preferences and user demand		
	Lack of market preference and customer demand for circular products	✓ Econ. Info. Info.	VAT reduction on reused products (P7) Quality certification (P11) Public information (P12)
	Low public pressure, lack of demand from shareholders, investors and community	✓ Econ. Info. _	Public procurement (P9) Public information (P12) Leadership in public authorities (P15)
	Lack of extended product warranties and reuse and repair options	✓ (✓)	Quality certification (P11)
Understanding and perception	Common perception that remanufactured parts and reused materials are inferior to new product materials	✓ Info. Info.	Information about product content (material/products passports) (P10) Quality certification (P11) Public information (P12)
	Lack of awareness, understanding, knowledge and experience with resource efficiency issues among relevant actors	✓ Info. Info.	Public information (P12) Promote education/skills (P13)
	Resistance from powerful stakeholders with large interests in status quo	✓ (✓)	Leadership in public authorities (P15)

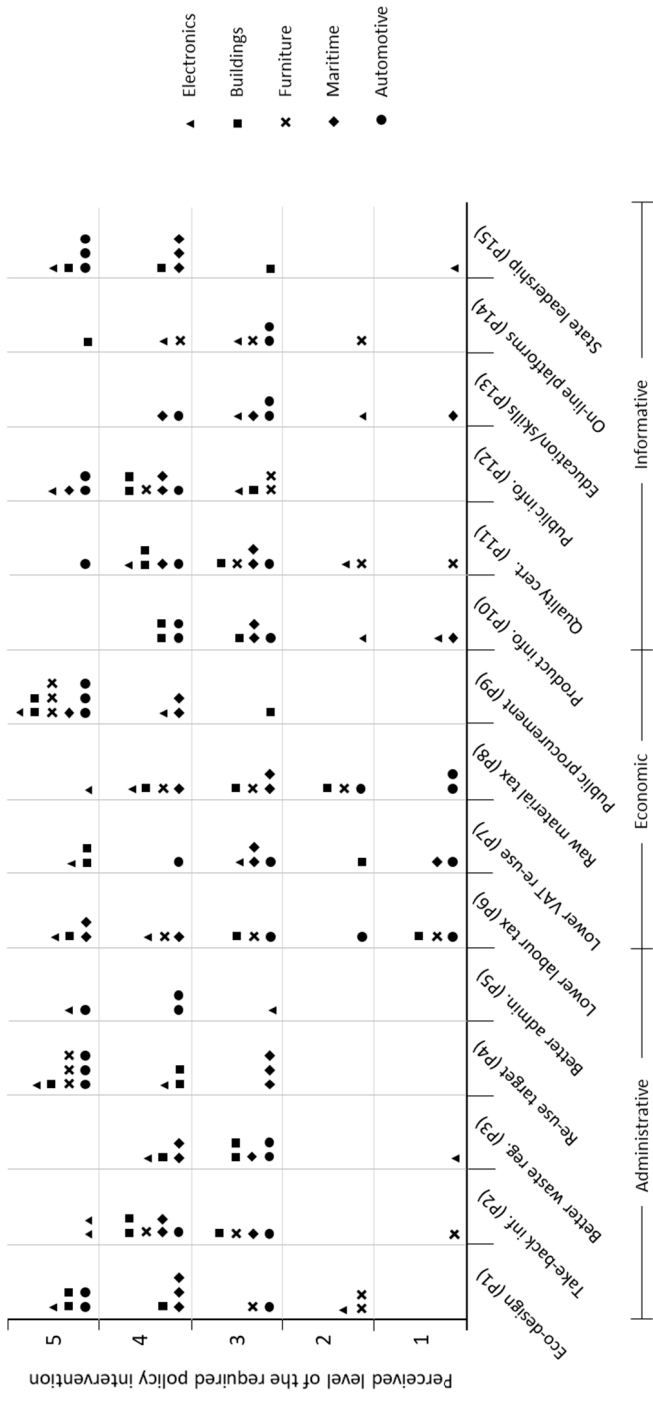


Figure 6. Policy responses ranked by interviewed companies.

It is worth noting in Table 4 that the CBM barriers are quite diverse, ranging from pure technological barriers (science and engineering dependent) to socio-cultural barriers that are firmly embedded in cultural norms and social conventions. Another observation is that, for each type of barrier, there can be more than one policy response, indicating that policymakers have a sufficient arsenal of policies to choose from, especially to mitigate political risks (Howlett, 2014).

Fourteen Swedish companies employing CE operations were sent a questionnaire, to measure their perception of the appropriateness of the proposed policies and their level of importance. The respondents were asked to score the policy proposals on a Likert-type scale 1-5 (5 being most important/relevant), according to their business operation experience. The results of the questionnaires were plotted (Figure 6) and categorised according to specific sectoral needs and implementation priority, following the questionnaire results (Figure 7).

Synthesising the data points in Figure 6, an overarching policy framework emerged, including an array of policy interventions that could enable companies engaged in product life extension to scale up their operations, and lead the way towards an overall transition in CE.

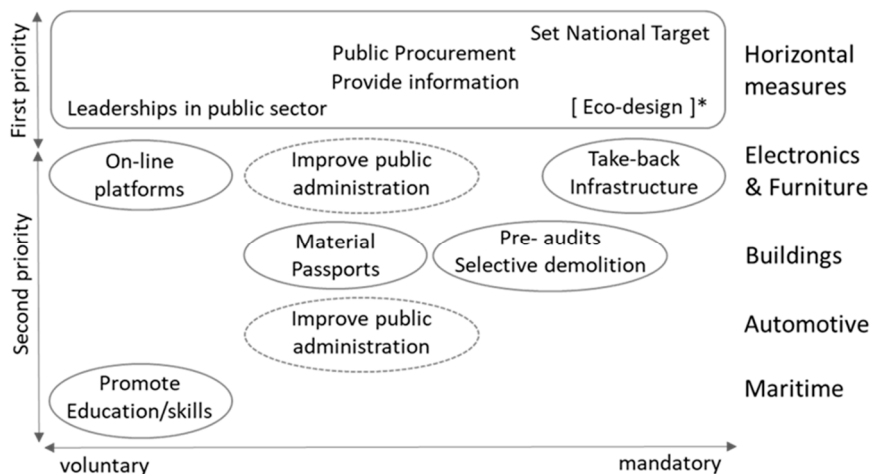


Figure 7. Overarching policy framework for product life extension in a circular economy. Note: The asterisk* denotes a national policy effort towards an EU level policy.

The policy framework in Figure 7 combines a horizontal element – cutting across sectors – and specific policy interventions by sector. Policies need to combine sector-specific insights with cross-sectoral perspectives, as product life extension operations tend to be more aligned with a product type, but changes to the larger CE system can provide efficiency opportunities across sectors, for instance by a shared collection system infrastructure (Heaton and Banks, 1997).

The horizontal measures are categorised as first priority, since their implementation would directly affect the national economy, while the sector-specific interventions would have a limited effect. Here, ‘second priority’ does not mean less important but denotes a sectoral approach – not affecting the wider national economic sphere in the same way. A distinction is made between voluntary-mandatory instruments, as mandatory are legally binding (with potential penal repercussions) while voluntary measures rely mostly on the engagement of the administering actors and the resources available for reaching their objectives. A number of policy interventions appear in the middle of the spectrum, since the mandatory or voluntary nature of each measure can be determined by the design of the selected instruments for implementation.

In conclusion, the findings indicate the need for an overarching policy framework, including wide cross-sectoral policy interventions and sector-specific measures. The framework stresses the critical importance of governmental leadership in driving policy for increased resource efficiency and wider adoption of reuse within the economy. The framework comprises: 1) greater provision and access to information for businesses and the public, so that reuse becomes more accessible, wide-spread and a trusted operation; 2) the setting of a mandatory reuse target, indicating a clear national goal and a business opportunity for increased reuse operation capacity in the future – with a predictable market size; and 3) the introduction of specific requirements in all public purchases that would prioritise ‘reuse’ options, when this does not present any adverse effects. All these policy interventions can be bundled together in a policy mix, providing strong push and pull incentives for increased reuse, and providing a transition-friendly environment for CBMs.

4.3 Conditions for upscaling circular public procurement

Another policy suggested in Paper I is that of public procurement, especially the introduction of material resource efficiency parameters into its selection (core or award) criteria. Paper III and Paper IV take a closer look at the challenges and opportunities of setting such ‘circular’ criteria for the product groups of ICT equipment and office furniture, and explore how public and private stakeholders would respond to a revised approach of procurement requirements that take into account CE principles. Paper V explores the possibility of incorporating the instrument of a quality label (a traditional informative policy instrument; see categorisation of instruments by Mont and Lindhquist, 2003), and discusses the implications of developing such a labelling scheme in the case of the ICT sector in Sweden.

4.3.1 Practice-identified barriers and interventions

In Papers III & IV, the goal was to identify experienced barriers from practitioners that work with public procurement, and explore potential measures that could assist in lifting these barriers for supporting CE practices. The research was based on interviews with public and private actors, mainly municipalities and public agencies in Sweden that deal with public procurement contracts. Private companies that supply the market with ‘circular’ solutions, such as reconditioned or remanufactured products, were also consulted to gather knowledge on their business capabilities and readiness to respond to CE public procurement requirements.

The research targeted two product groups that exhibit different characteristics: 1) office furniture, which are durable passive (non-energy using) products; and 2) laptops, which are also durable but fast-moving (i.e. short replacement cycles) and energy using products. Different product categories were chosen to explore potential differences in the criteria setting approach for public procurement, especially related to properties of these products when extending their useful life (life cycle extension CE strategies). However, the research did not expand to consumable products, since the procurement requirements deviate significantly, which would make comparison of the cases difficult.

From the two cases, the identified barriers in procurement processes are summarised in Table 5.

Table 5. Barriers in public procurement processes for reused equipment.

Office furniture	Laptops (ICT)
<ul style="list-style-type: none"> • Uncertainties about whether purchasing reconditioned furniture is legally permitted. • The sustainability criteria currently applied when purchasing furniture – e.g. chemical content – are easier to comply with for new furniture. • Uncertainties regarding the product quality when purchasing reconditioned goods. • It is more difficult to evaluate offers related to reconditioned furniture than new furniture, especially if a large number of furniture items with similar appearance cannot be guaranteed in the contract (supply risk). • Too few furniture reconditioners, and those that exist are not good at marketing their sector and their products (low visibility of the sector). • In many big procurement contracts, an OEM has to be involved (some of the furniture must be new) but there is space for reconditioned furniture as well; this requires more complicated contract configurations, which are difficult to draft. • The standards applied in procurement are designed for new furniture. 	<ul style="list-style-type: none"> • Performance requirements: it is not critical to procure the right technology depending on the context and purpose. For example, operations that require high performance up-to-date computers vs. others that are not performance dependent (e.g. information or education for the public). • Security of supply: procurement requirements need to take into account the market availability of sustainability solutions that relate to the criteria, otherwise there could be a supply risk and potential distortion in the market. • A need to standardise the stock of computers in an organisation for lean operational and maintenance purposes. • Low awareness of the availability of remanufactured products on the market. • IT staff has a large influence over what is bought, and they prioritise novelty and performance over sustainability and resource efficiency issues. • Uncertainty about the quality and performance of remanufactured laptops makes them a 'de facto' secondary option

Between the two cases, some common barriers emerge, such as concerns about the quality of reconditioned or remanufactured products, supply risks (of uniform large product quantities), low awareness of product life extension solutions, and inability to administer complex procurement processes that might include both new and reused products.

The interviewees suggested several ways to improve the criteria setting processes for more effective procurement processes that could include product life extension considerations and support ‘circular’ solutions. This could facilitate upscaling of such business offerings on the market, while reaping environmental benefits associated with reduced material use intensity (André et al., 2019).

Table 6 presents an overview of measures that public authorities could take to improve their procurement efforts.

Table 6. Measures to improve public procurement processes for reused equipment.

Office furniture	Laptops (ICT)
<ul style="list-style-type: none"> • Resources must be invested in training procurement officers and developing new procurement practices, taking into account available best practices in the field. • The reconditioned furniture sector needs to market itself better. • The reconditioned furniture sector needs to develop capabilities to guarantee a minimum accepted quality level. • The advantages of reconditioned furniture must be better communicated to public procurers. • Methods to trace chemicals in reconditioned furniture must be developed. • When the public sector purchases new furniture, it must be of the highest quality, because only high-quality furniture is suitable for reconditioning. • It is important that new public contracts include both new and reconditioned furniture. This is especially the case for larger contracts, e.g. governmental framework contracts that all governmental agencies can use, or in cases where several cities make a joint procurement. 	<ul style="list-style-type: none"> • When initiating new procurement processes, it is important to carry out proper market surveys and initiate dialogues with suppliers to ensure appropriate supply of reconditioned products. • Investigate whether the procurement of remanufactured computers can be an option for some municipal departments, e.g. educational activities in schools. • Investigate other options, e.g. the potential to reward suppliers that have recycled content in new computers. • Once the procurement is done and contracts signed, municipalities should ensure that the suppliers provide evidence of compliance with sustainability criteria. • Include criteria in the tenders for EOL management that enables the extension of product life. Use the computers as long as possible, and then sell them to remanufacturers.

Common themes emerging from the investigated cases are proper market investigations to identify ‘circular’ solutions provided by relevant actors, compliance mechanisms with sustainability and quality criteria for purchasing reconditioned products, and innovation in new tender forms that include multiple sustainability criteria or scope of operations (e.g. new and reused products in one purchase).

4.3.2 Quality labelling as instrumental synergy to public procurement

Paper V follows on from the major barriers in public procurement identified in Papers III & IV. Uncertainty concerning the quality and performance of reconditioned products cannot be assessed in a public contract, and this ultimately leads to exclusion of potential reuse options in public purchases. The overall aim of Paper V is to investigate the potential of setting up a comprehensive labelling scheme for reused ICT products, not just limited to use in public procurement processes, but also to boost the confidence of consumers regarding the quality perception of reused ICT, and consequently support the market for reused ICT equipment.

The research approach involved two phases, one analysing past experiences in establishing quality labelling schemes using literature sources, and a second analysing the potential for establishing such a scheme in Sweden by interviewing relevant stakeholders. From the literature review, several existing initiatives were identified in European and international settings. The main findings indicated the need for a wide recognition of the certification scheme for it to become a credible and functioning system that consumers will trust and use in their purchasing decisions. Strategic marketing targeting private consumers, procurers, and companies is therefore of high importance. The involvement and active participation of networks are also crucial when developing such an initiative. For the development of a certification scheme, it is important to consider funding, as the industry is usually not in a position to pay for a system requiring expensive technical and auditing inputs, both up-front and throughout the certification period. Electronic products, and especially ICT products, require specific criteria to ensure their quality.

Responses from the interviews with Swedish stakeholders on the potential organisation and application of a certification scheme for reused ICT products revealed a trade-off between the information communicated in the labelling scheme and the cost of covering and verifying this information. Certifying a process or company is easier than certifying a product, while the certification criteria for products need to be specific for ICT and possibly also specific by product category. A credible network supporting the label, including public authorities and reuse organisations, could offer a way to avoid expensive verification processes and gain recognition. It is critical at the early stage of label development that public support and funding become available.

Further uptake of the label can be stimulated by public procurement. There is a unique potential to link the label to public procurement requirements, and to produce an effective policy package for municipalities and other public authorities to use. A national agency, for instance the Swedish National Agency for Public Procurement (Upphandlingsmyndigheten) could take the lead in helping draw up criteria and specifications for the label and provide information to public authorities on how to

use it in their procurement operations. The Agency, either by its own means or by contracting a third-party auditor, could also provide quality audits periodically, to ensure that certified companies uphold their certification obligations. In the annual state budget, the increased costs of the Public Procurement Agency's operations might be fully or partially offset by the reduced costs of procurement in state agencies and other public authorities, as reused ICT equipment is cheaper than new (Paper IV).

4.4 Policy interventions for mitigating market failures of secondary raw materials

An in-depth analysis of the value chain of plastics recycling in the Nordic context highlights the inherent problems that involved actors are facing, and proposes viable solutions to ameliorate the malfunctioning market situation. The choice of plastic as a secondary material commodity was chosen because plastic, although one of the most used materials worldwide, has very low recycling rates (Geyer et al., 2017), and because it has been recognised as a priority waste stream in the EU CE action plan (COM(2015) 614 final). Paper VI investigates the market dynamics between actors through the value chain, and identifies bottlenecks of operations and hotspots for improvement. The policy solutions suggested in Paper VI usually face resistance from incumbent actors (Corvellec et al., 2013; Lätt et al., (2019), so to provide clarity on the greater socio-economic benefits that such policies can stimulate, Paper VII presents a quantitative sustainability assessment of increased recycling of plastic waste in Sweden.

4.4.1 Market-identified barriers and interventions

The overarching aim of Paper VI was to analyse the market of secondary plastic (recycled material), from the point that plastic waste arises until the point when the recycled plastic is purchased for use in the production of new products. A value chain approach was used, focusing on specific barriers that occur in each step of the chain (Figure 8). This approach allowed the identification of current bottlenecks that may occur from one step of the chain to the other, but also shed light on wider overarching issues that persist throughout the value chain, or might affect operations two or three steps away. Consequently, the identification of hotspots in market relations between involved parties in the value chain, facilitated the formulation and analysis of potential future solutions that could be used to tackle these hotspots, with the aim of freeing the market and the flow of recycled plastics.

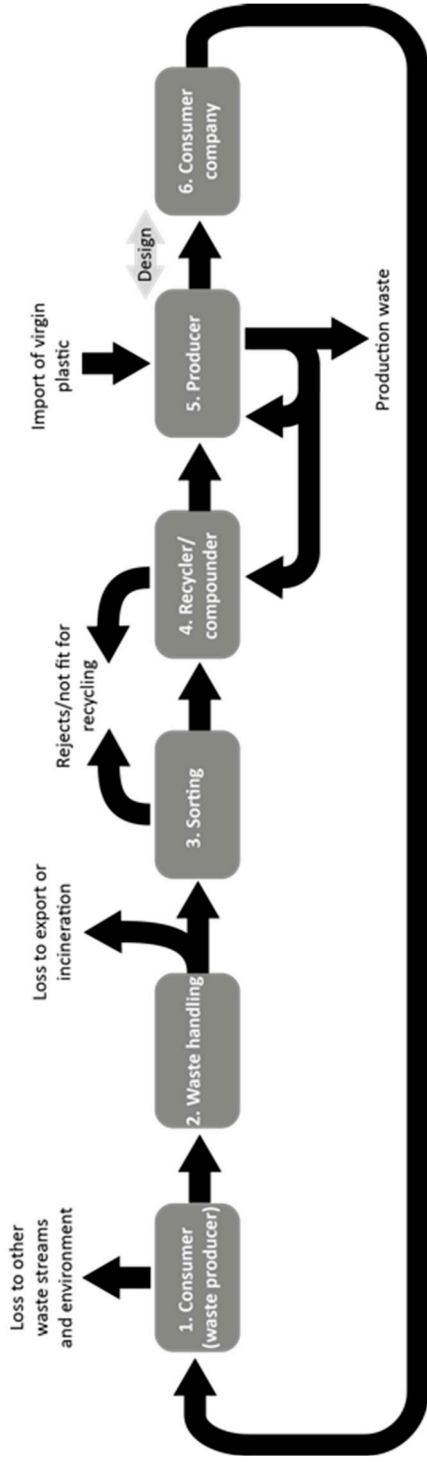


Figure 8. The plastic waste recycling value chain, with each stage indicated by a number (1-6). The black arrows indicate material flows between the value chain stages, and for each stage material exchanges to/from the environment, either by operational losses or inputs (Paper VI).

Research for the analysis of the plastic waste markets and the associated barriers was based on a literature review and the collection of empirical evidence through interviews with stakeholders in all steps of the value chain. The barriers identified in the literature and empirical material were categorised in four broad themes: 1) low demand for recycled plastics, including both low demand from producers because of price and quality issues, and low demand from consumers for products made with recycled plastic; 2) limited market communication and lack of value chain coordination, which ultimately results in lack of traceability of plastics along the value chain; 3) technical barriers for better recycling; and 4) legislative barriers affecting the market of recycled plastics. Some barriers are only evident for a specific step in the value chain or only influence a certain group of stakeholders, while others are characteristic for most of the sectors.

A number of potential policies based on these barriers derive straight from the identified stakeholder needs and the secondary material economics literature. For example, lack of demand for secondary plastic could be addressed by improved public procurement criteria for resource efficiency, or by a preferential taxation framework for secondary raw materials. Improved design for recyclability could increase the supply of easily accessible and toxic-free secondary plastic in the market, while international quality standards would enable the identification of appropriate specifications of recycled plastics for use in industry.

However, the stakeholder interviews also revealed the need for more far-reaching policy interventions (at local, national or international level). Value chain coordination and gradual integration was viewed as the most important intervention, followed by the need for increased investment in innovation, technology, and capacity building. These interventions could have an exclusive public or private character, but the most desirable mode would be that of public-private interventions (Nicolli et al., 2012; Pohlen and Farris, 1992).

Greater coordination and cooperation along the value chain is seen as essential to exploring and exploiting opportunities to increase plastic waste recycling (Roy and Whelan, 1992). This could take the form of online platforms or registers, maintained by public or private actors. It would allow manufacturers, plastics producers, recyclers, sorters and collectors to explicitly express their requirements and facilitate a better understanding of potential solutions, many of which are only attainable if actors along the value chain work together (Nicolli et al., 2012). Mandatory participation and sector involvement for regulating the exchange environment would be required to increase the use and legitimacy of such an instrument.

Increased funding to develop technologies and infrastructure for better exploitation of the plastic waste stream could be part of an existing innovation fund or a specific fund set up for this purpose. Funding opportunities could also be a driver for cooperation between actors along the value chain. However, it is noted that a

funding mechanism for innovation projects could lead to competition among the actors instead of cooperation, and could lead to market distortions. It could also divert innovation from what is actually needed towards whatever is funded. This type of intervention would largely depend on available funds and the political will to distribute the funds accordingly.

Finally, Sweden has set ambitious goals for transitioning to a fossil-free economy and contributing to the Paris agreement climate targets (Parliament of Sweden, 2017). To achieve this, recyclable plastic waste would have to be banned from incineration facilities for energy production. This would be a great challenge, as incineration plants contribute significantly to the heating needs of municipalities, where district heating systems are usually directly linked to a municipal waste incineration facility. Prohibiting the incineration of recyclable plastic waste would lift one of the major barriers to plastic recycling, the supply of waste plastic. It could provide a large quantity of waste of variable quality. To capitalise on this opportunity, a number of complementary measures should already be in place, similar to the ones discussed above.

4.4.2 Sustainability assessment of future policy interventions scenarios

A number of policy responses to the identified barriers in plastic recycling markets (Paper VI) could potentially trigger some controversy among various stakeholders in the political spectrum, especially among regional and national authorities and agencies. Policy interventions that increase budget costs are generally unpopular, and there needs to be a well-formulated and strongly evidenced justification for such interventions before they can be considered for policy development. The most controversial of the interventions proposed in Paper VI are (1) the increased funding for the development of technologies and infrastructure for better exploitation of the plastic waste stream, and (2) the ban on the incineration of recyclable plastic waste. Value chain integration and mandatory participation in information exchanges are also controversial, because such actions might lead to corporate consolidation and market dominance of a few actors, reminiscing notions of cartel forming for the trade and treatment of domestic plastic waste.

The aim of Paper VII was not to analyse these controversies from a political, economic or sociological point of view, but to provide solid data-substantiated evidence on the potential sustainability impacts of such policy interventions. Sustainability impacts were quantified using a purpose-specific MFA-based model of plastics recycling, based on a value chain approach as in Paper VI. The selection of the output indicators to illustrate the sustainability impacts represented the three axes of sustainability. For environmental impacts, the indicator of GHG emissions was used; for economic impacts, the total costs of investments in new capacity and

total operation costs were calculated; and for social impacts, the number of jobs generated served as an indicator.

To model the potential effects of the proposed policies, three general scenarios were constructed. Their parameters were fed into the model to produce the respective outputs, compared with a business as usual (BAU) scenario with a horizon to 2030. The three scenarios were:

Scenario A) Sweden fulfils all targets set by the EU. This scenario represents the minimum required effort by all Swedish stakeholders involved in waste management and plastic recycling operations to just fulfil the legally binding targets set out in the EU Directives.

Scenario B) Sweden fulfils all targets set by the EU, with additional actions retaining plastic waste domestically for recycling and limited exports. This scenario repeats the conditions of scenario A with the addition of the policy options of increased processing capacity. This capacity is attributed to an increased amount of waste that is not exported and treated domestically. This implies that investment in domestic sorting and recycling capacity and increased coordination of waste management actors are already in place.

Scenario C) Sweden fulfils all targets set by the EU, including a statutory ban on the incineration of recyclable plastic waste.

The results of the model are presented in Figures 9, 10 and 11.

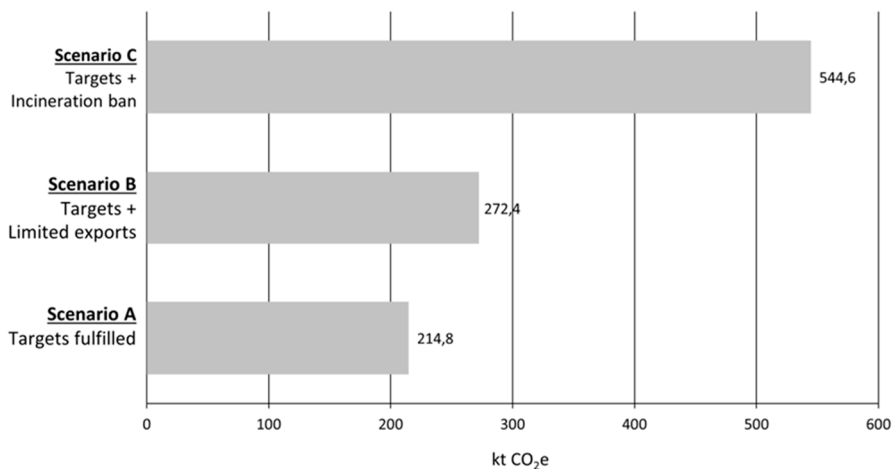


Figure 9. GHG savings of increased plastic recycling in Sweden (Paper VII).

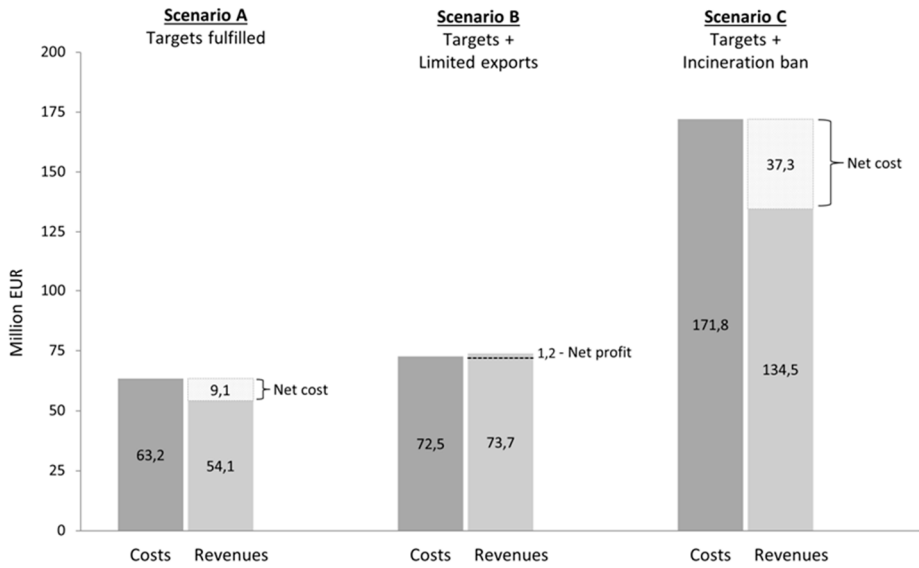


Figure 10. Economic costs and benefits of increased plastic recycling across the value chain (Paper VII).

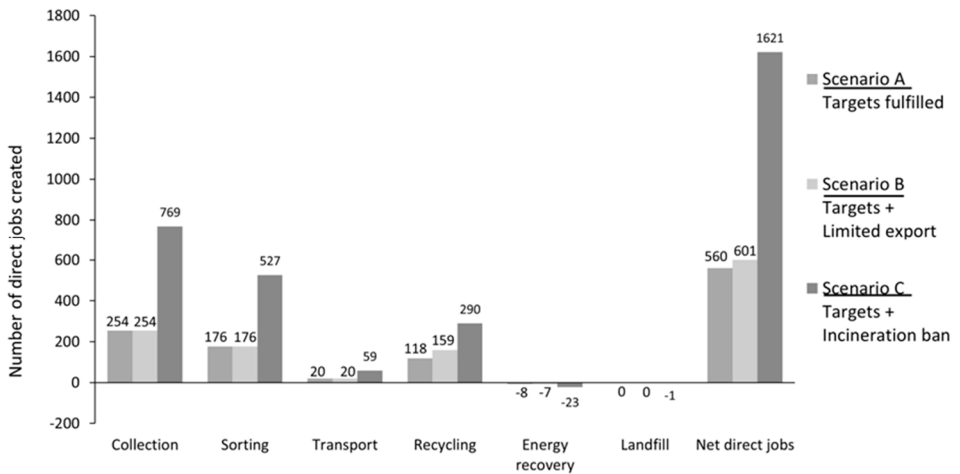


Figure 11. Number of direct jobs created (or lost) at each waste operation (Paper VII).

Comparison of the results in all three impact categories does not give a decisive and clear-cut insight on future policy design of policy instruments for increased plastic recycling. There are mixed signals, with significant trade-offs between economic and environmental impacts of the scenarios. Scenario C appears to have the highest GHG savings potential compared to the other two scenarios, saving roughly twice the amount of GHG emissions across the value chain of plastics. Scenario C is four to five times more expensive to implement than the other two scenarios, but the increased cost in Scenario C has social benefits in Sweden, by creating three times more jobs than the other two scenarios.

In Table 7, the quantitative results of the three modelled scenarios are summarised to allow comparison, and are coupled to their respective qualitative effect, i.e. the level of perceived benefit, assigned by the authors.

Table 7. Summary of quantitative findings and qualitative assessment (Paper VII).

	Environmental Impact (GHG Emissions)		Economic Impact (Costs)		Social Impact (Number of Jobs)		Sustainability Assessment
	Quant.	Qual.	Quant.	Qual.	Quant.	Qual.	
Scenario A	-214.8 kt CO ₂ e	+	9.1 mEUR	-	560 jobs	+	0/+
Scenario B	-272.4 kt CO ₂ e	+	-1.2 mEUR	+	601 jobs	+	+
Scenario C	-544.6 kt CO ₂ e	++	37.3 mEUR	--	1621 jobs	++	+ / ++

Note: The qualitative assignment is indicated by the symbols ++ (very positive); + (positive); 0 (insignificant effect); - (negative); -- (very negative).

The qualitative assessment of the quantitative results indicated that Scenario C would have the most positive sustainability impact in relative terms, so would justify further action towards this direction from policy actors.

5 Synthesis and discussion of research findings

From a systems perspective, policies would ideally be designed to reinforce positive feedback loops enhancing resource efficiency in the life cycle stages of production, use and EOL, until the desired goal of a CE was reached. Subsequently, the system configuration would need to readjust by appropriate policies introducing balancing feedback loops (Meadows and Wright, 2008). A predictive/expecting policymaking process is needed that not only responds to the current state of the ‘problem’ but also acknowledges the drivers and impacts of the policy effects upstream and downstream in the implementation process.

Synthesising the key findings of the research so far, this chapter aims at providing a holistic life cycle approach to policy interventions for a CE transformation. The purpose of this section is to illustrate the breadth of the policy instruments identified in this research and to indicate potential interactions within the policy mix, based on the findings pertaining to each policy. In essence, a meta-analysis of the research findings of Papers I-VII is presented, and the policy instruments are discussed using an inductive logical approach. The empirical findings form the basis of the discussion developed around the individual policy instruments identified in the research, and the chapter expands on the potential interactions of the instruments within a policy mix. The policy mix is empirically constructed, so does not include the full range of potential policies available (for instance, policy instruments such as eco-labels, chemicals regulations and financing policies). This can affect, directly or indirectly, the interface of the resource efficiency policies identified by the case studies, based on the methodological bottom up approach of the research.

This paradigmatic illustration shows the various policy instrument approaches policymakers could use to facilitate CE operations in business and societal actors. Figure 12 illustrates a comprehensive and balanced approach across the life cycle spectrum of a product. This policy approach includes a variety of instruments, mostly of an administrative and informative nature, and inevitably touches many areas of financial concern to public actors (central government and local authorities). Figure 12 also shows further aspects of the policy mix that follow established notions of policymaking at EU level. There is strong interaction and integration of policy instruments between the production and use stages of the life cycle (see point [1] in Figure 12), highlighting the push and pull effects apparent

within the product policy framework. The necessary integration of distinct informative instruments (highlighted in point [2]), denotes an enabling policy approach for increased information cooperation and transparency across the value chain of products. Finally, at the EOL side of the integrated CE policy framework, the policy approach develops according to the waste hierarchy principle (shown by point [3]), which constitutes the basis of EOL legislation in the EU.

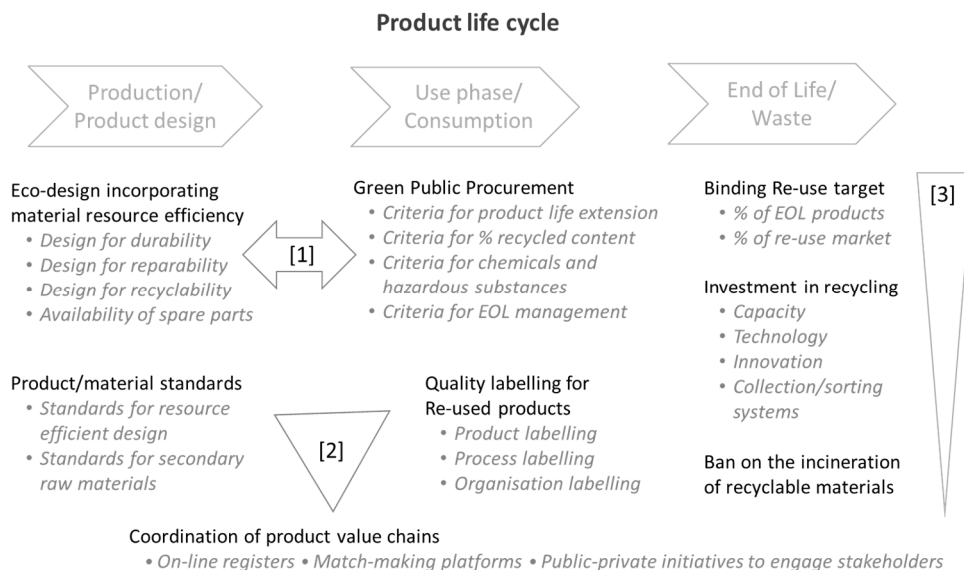


Figure 12. Material resource efficiency policy framework with a life cycle perspective. The policy instruments identified and presented along the product life cycle correspond directly to the findings of Papers I-VI as described in Chapter 4. Other policy instruments not identified in the research findings are not included in this framework, but these could also be significant.

[1] The pull and push interaction of product policy instruments, such as Eco-design and GPP. [2] The wide variety of supportive informative instruments spanning all life cycle stages. [3] A complete arsenal of policy instruments at EOL, which corresponds to the EU waste hierarchy principle.

Taking all the above characteristics of the policy mix into account, a relatively good alignment can be discerned with the theoretical prerequisites for an effective policy mix approach, according to principles elaborated in section 2.6. There is a high level of consistency and coherence in the policy mix shown in Figure 12, which could serve adequately the goals of a CE transition in the EU (congruence), by abiding the theoretical principles of resource efficiency and circular economy as described in theory (see sections 2.1 and 2.2). However, the comprehensiveness of the mix is less optimal, since it does not include a number of policy domains relevant to resource efficiency. Further analysis of the policy mix and its potential interactions (positive and negative) is discussed in the next section (5.1), together with implementation challenges and design constraints.

5.1 Areas of intervention and aspects of policy interactions

The findings of the research (Chapter 4) provided insight to policy approaches that could catalyse resource efficiency efforts towards a transition to a CE. Across the stages of a product's life cycle, several policy interventions have been suggested with potential synergistic aspects, both within the same life cycle stage and across the different stages. The policy measures either derive from existing policy approaches (e.g. eco-design and green public procurement) or constitute novel propositions for consideration by policymakers (e.g. reuse target and reuse quality label). Some of the existing measures suggested in the policy mix have not yet been fully utilised, but they do have a significant potential to contribute to resource efficiency efforts in the EU and Sweden (Paper I).

In each stage of the life cycle, a major administrative measure is highlighted, followed by several supporting measures. The major instruments presented in Figure 12 are i) eco-design regulation in the production phase, ii) green public procurement in the use phase, and iii) a mandatory reuse target in the EOL phase. The supporting measures consist of a mix of administrative, informative and financial instruments (i.e. product and secondary material standards, quality labelling, cooperation initiatives and tools, public funds for capacity, technology and innovation, and a ban on incineration of recyclable materials). No distinction is made between the instruments in terms of importance or priority, as all measures are equally important within a comprehensive and effective approach for resource efficiency (Paper II). However, the ones suggested as major in this thesis are the ones that must be in place if the remaining measures are to fulfil their assigned function.

In the following sub-sections, each of the major instruments will be discussed in more detail and the interactions with the supportive measures will be analysed, identifying potential synergistic or antagonistic effects within the framework. One limitation of this approach is that policy measures outside this policy subsystem do not appear in the analysis and might have potential unintended effects.

5.1.1 Production and product design

Eco-design regulation has a long history in the EU, with the EU Directive 2005/32/EC establishing a framework for eco-design requirements for energy-using products, later revised to also include energy-related products in the scope of the regulation (Directive 2009/125/EC). The aim of the Eco-design Framework Directive is to continuously improve the environmental impact of energy-related products from a life cycle perspective through a regulatory push. Product-specific, or generic eco-design requirements, are drafted in implementing measures

developed and adopted by the European Commission, or in self-regulating measures such as voluntary agreements.

Once an implementing measure is adopted, a product is not allowed to enter the European market until the manufacturer, or its authorised representative, ensures that the product complies with all requirements. In this way, resource efficiency in product manufacturing can be continually improved. However, the implementing measures of the Eco-design Directive have mainly focused on the energy efficiency aspects of products and have not addressed the issue of material resource efficiency (Bundgaard et al., 2017). So far, only few product categories have incorporated material resource efficiency requirements through this Directive⁴, but there is an ongoing process for including more product groups, as a direct response to the EU CE Action Plan. From an environmental perspective, extending the life of certain energy-using products might not be the optimal option in all cases, due to technology and energy efficiency improvements (Cooper and Gutowski, 2017). An exploratory investigation is required for each type of product to identify which resource efficiency strategy would be the most appropriate (Böckin et al., 2020).

The most important design aspects identified by the research refer to eco-design for durability, reparability and recyclability of products, as well as the mandatory availability of spare parts for a defined period of time after a given product has gone out of production (Papers I–V). Multiple positive interactions can be identified with the other policy interventions in Figure 12, which have a potentially synergistic effect in the higher uptake of reuse and the maintenance of material value embedded in products. Designing products that last longer and can be easily repaired directly influences the potential of reuse (Papers II–V). This is a very important parameter to consider, under the proposal of establishing a ‘Reuse target’ (Paper II). The more the products are durable and easily repairable, the easier they would be reused one or more times, making it a realistic option to set mandatory quotas of re-usability in a national economy (Paper II).

In the current manufacturing environment where product obsolescence prevails (McVeigh et al., 2019), it becomes quite challenging to ensure the re-usability of products and therefore a ‘hard’ target for reuse might face unexpected setbacks and improbable results (Paper II). Consequently, the relationship between durability and reparability product design aspects can have a positive impact on a potential ‘Reuse target’. Eco-design requirements on the durability of products also has potential implications for public procurement in at least two ways: 1) if all products on the market are durable, eco-design ensures that all products purchased through public

⁴ Product groups with implementing measures including material resource efficiency requirements are: vacuum cleaners, imaging equipment, home refrigerators, washing machines, dishwashers, electronic displays (incl. televisions), light sources and separate control gears, external power suppliers, electric motors, refrigerators with a direct sales function (e.g. fridges in supermarkets, vending machines for cold drinks), power transformers, and welding equipment.

procurement processes have minimum requirements on durability; and 2) actors who want to promote higher durability than legally required in the public procurement rules can use the established requirements as benchmark to push for higher standards in public procurement. This, provides a ‘dynamic’ interaction between supply and demand of products with durability standards on the market, reflecting the push and pull interactions of eco-design and public procurement policy interventions (Papers II & V).

A number of supportive measures could make the process of setting eco-design regulation more effective and efficient. The administrative policy instrument of standards (process and material standards) directly contributes to the process of eco-design by providing the necessary technical background for setting up appropriate implementing regulations (Schlegel et al., 2019). Technical standards constitute the basis of manufacturing safe and high-quality products, and could assist in establishing material efficiency aspects in products, either in manufacturing or later during the use and EOL phases of products (Tecchio et al., 2017).

Two types of standards could be considered significant for a resource efficient approach. These are standards for secondary raw materials and standards for the reparability of products (Papers II & VI). Setting minimum technical requirements on the use of secondary raw materials in manufacturing would immediately send a clear signal to recyclers about which types of materials and level of quality to aim for. This would clear the uncertainty observed today in the very fragmented and complex markets for secondary materials (Paper VI), especially in the case of plastics, construction and demolition waste, and critical raw materials. Standards would not only safeguard manufacturers against the inherent uncertainty of the quality of secondary materials, but would also set the bar for all relevant actors in the recycling industry. Recyclers would then align recycling processes to produce recycled materials, at least in the minimum quality prescribed by the standard, if they want to be competitive on the market and maintain their business operations. Instances of downcycling or energy recovery would be limited, as long as there is an established market for recycled products with a marginal profit (Paper VI).

Another supportive measure linked to the ability of recyclers to reach secondary material standards is the need for public (or better public-private partnership) funding. The research has shown that there are significant deficiencies in the recycling sector on managing increasing amounts of materials that are collected in suboptimal qualities, making it technically difficult and economically expensive to process, e.g. plastic waste (Paper VI). The technical and economic ability of recyclers to produce a recycled material that reaches minimum technical and quality standards is directly linked to the quality of the material mix they receive.

Since there is an extensive chain of operations from collection to final recycling of products, there are multiple points of intervention, both technically and organisationally, where the final quality of the recycled material can be improved.

Capacity, technology, and collection/sorting operations must be developed to increase the quality of recycled materials. Innovation in recycling processes could provide new sources of raw materials that are equal in terms of properties and quality to their virgin counterparts (e.g. chemical recycling of plastic waste). Funding could be part of an existing innovation fund or a specific fund established for special purposes. Funding opportunities could also act as a driver for cooperation between actors along the value chain, but there could be a risk that a funding mechanism for innovation projects might lead to market distortions. Funding could divert innovation from what is actually needed towards whatever is funded. This type of intervention would be largely dependent on available funds and the political will to distribute the funds accordingly (Paper VI).

There seems to be no shortage of funds at national or international level, rather a shortage of actual investment. Currently, there is a major discrepancy between savings and investment, where public and private investments are low while savings have reached an all-time high during the post-war period in Europe (Varoufakis, 2016). Indications for political acceptance of increased investments seem to appear in the recent EU industrial policy strategy (COM(2017) 479 final, p. 11): *'Investment from within and outside the EU on both infrastructure and new technologies is a precondition for our industry to drive industrial transformation. Europe needs to stimulate more capital investment, facilitate the uptake of promising innovation and provide a favourable environment for the scale-up of dynamic SMEs.'*

Cooperation of actors and gradual integration of production and consumption information aspects, data exchanges etc., are considered paramount within a CE. Policy driven collaborations within and across industrial sectors and consumers are a key component for closing material loops. Aided by public or private funding mechanisms, cooperation networks can act as catalysts in the establishment of product requirements and material standards by linking production, use and EOL aspects of products (Papers II–VI). The quality of recycled materials would determine the possibility of integrating recycled content in new manufacturing processes, which would eventually create products that would be used by environmentally and resource conscious consumers, including public authorities (Papers III & IV). Critical information is needed on the EOL phase and the quality of recycled materials in the manufacturing process of new products. However, in the current policy landscape, there is a missing link at this stage, and actors from different phases of a product's life cycle do not communicate, leading to a lost opportunity of resource integration and material reuse (Paper VI). This is a vital area for policy intervention that has been severely underexplored, except for some specific cases of industrial symbiosis initiatives (Mirata and Emtairah, 2005).

Finally, measures to implement eco-design are adopted at a supra-national level in the EU. An eco-design intervention at national level cannot have a direct effect on imposing eco-design requirements in a wider market perspective (either the EU

single market or internationally), and would affect domestic manufacturers negatively with increased costs and unforeseeable benefits. However, national policy proposals on eco-design can play a role in EU processes by supporting more stringent and resource efficient requirements in products, including aspects of durability and repairability (Paper II).

5.1.2 Product use

Product use regulation refers broadly to interventions in private and public consumption. In the suggested policy framework in this thesis (Figure 12), the focus is placed on policy interventions on the public area of consumption and product use. This policy intervention can leverage significant effects on the economy due to the size of public authorities as a single purchasing actor. Private consumption is dependent on personal preferences and is strongly influenced by economic and behavioural inconsistencies (Twomey, 2012; Weaver, 2014). A public authority could largely be unaffected by such factors, although economic aspects could play a significant role in purchasing decisions of authorities under financial stress (Sporrong and Bröchner, 2009).

The purchasing power of governments is immense, amounting to 17 per cent of the Swedish national gross domestic product (Larsson et al., 2018), and has the potential to steer market development towards desired outcomes. The framing of appropriate criteria for product life extension in public purchases (either by purchasing reused equipment or sourcing used equipment to appropriate reuse stakeholders), and criteria for recycled materials and reduced chemicals, has the potential to create sizeable market effects for upscaling operations of the relevant economic actors. This is greatly influenced by the way requirements are designed to either favour (award criteria) or exclude (technical specifications) a certain product or technology (Aldenius and Khan, 2017). Public authorities can create direct competition between the incumbent and emerging companies (e.g. those with CBM configuration) and induce niche-regime pressures that accelerate transition processes (Schot et al., 2016).

Public procurement criteria may include a wide variety of product requirements, both in technical and functional perspectives, from which the most advantageous offer can be selected for purchase. However, criteria could include several specific requirements that might be mutually exclusive. For instance, criteria might include requirements for a long-lasting product, including recycled content, excluding certain chemical content, and prioritising recyclability at EOL instead of reuse (Papers II–V). Consequently, there is a chance that not all criteria can be met, which could create confusion and conflicts that might not be addressed adequately by the procuring entity and would lead to trade-offs.

The final selection of criteria and the drafting of procurement tenders that consider aspects of resource use and environmental impacts is reliant on the public officials working at the procurement departments. The officials can only consider a certain amount of information and can only identify a limited number of available offers on the market (Paper VI). Public authorities can be expected not to have the same negative preconception towards the quality or reliability of reused products as private individuals (Matsumoto et al., 2017). It is not uncommon that selection bias and user preferences come up during the drafting of tender specifications, as public procurers are more likely to prioritise/prescribe the utility or the product they are most familiar with (Paper VI).

This is also reflected in research by Sporrang and Bröchner (2009), which suggests that procurement officials hold individual preferences/opinions that are mirrored in their procedures for procurement. Before any procurement process, a thorough market investigation is required to establish communication with suppliers to identify offerings and solutions that might not be known beforehand to the procurement officers (Papers III & IV).

Public officials in procurement services need to be equipped with the appropriate set of skills and competencies to allow the identification and handling of resource efficiency criteria in procurement tenders. Training and education of public procurers is considered critical for the future development of procurement criteria and contracting conditions (Papers II–V).

A supportive measure to ‘circular’ public procurement could be quality labelling of reused products. The implementation of a labelling scheme would be determined primarily by the demand for such a label. This is linked to the potential supply of reused equipment in the market. (Paper V). Combined with the policy measure of a ‘reuse target’ by a central government, potentially more used equipment could become available for reuse, thus boosting the need for a quality label to certify that this equipment would be eligible for sale as a good quality product (Paper V). The potentially increased supply of reused products certified by a quality label could theoretically increase uptake in sales by attracting public sector contracts. This may indicate a positive relationship between the availability and credibility of a quality label and the uptake of reused equipment by the public sector through public procurement.

In this life cycle stage, the leadership of public authorities in driving circular economy operations is underlined (Paper II). Governments, either by leveraging their sheer purchasing power or by guiding certification initiatives and information campaigns, could play a significant role in establishing a wide ‘resource efficiency’ narrative in the economy. In contrast to neo-liberal approaches of market optimisation and the ‘invisible hand’ of the markets that can result in optimal conditions for all involved actors, companies employing CBMs feel that they cannot rely on market forces alone and that government intervention is required (Paper II).

The market is not an optimal place, as it fails to internalise associated environmental and social externalities (Røpke, 2005). The notion of direct policy intervention by public actors is readily embraced by companies operating a CBM, but it must be remembered that none of these companies are incumbent firms (Paper II). The reasoning and prioritisation of incumbents could be completely different, as they successfully operate in the existing ‘linear’ economic system and would be more reluctant towards a change in the status quo (Geels, 2014; Hess, 2014).

5.1.3 End of life of products

At the end of life stage, the empirical findings from all case studies investigated in this research indicate a strong adherence to the philosophy relating to the established principle of the waste hierarchy. The policy measures suggested in Figure 12 reflect this approach, with a major feature being the proposed mandatory target for reuse. The level (rate) of the target is not specified, as this is outside the scope of the research, but the introduction of such a target is suggested as a necessity. Current EU and national legislation is focused on recycling and resource-productivity targets, while the actual reuse of products is largely ignored in the setting of national targets (Paper I). Recycling targets have gradually pushed EU MS to develop appropriate infrastructure, including collection and treatment facilities, and to achieve moderate circularity in the economy at raw materials level (EEA, 2013). Similarly, a legally binding target for reuse could theoretically induce respective mechanisms towards the development of appropriate infrastructure and product life extension activities, for instance repair and remanufacturing operations, thereby achieving a higher rate of circularity in the economy at product level.

In Figure 12, several interactions of a reuse target with other policy instruments across the life cycle of a product can be identified. The implementation of a reuse target could directly provide higher availability of EOL equipment towards repair and reuse (Paper II), unlike the current situation in which the majority of EOL equipment collected is redirected to recycling instead of reuse (Richter, 2019). The Extended Producer Responsibility (EPR) schemes that are operating under the current waste legislation are designed with collection and recycling in focus, while the possibility of reuse is underemployed (Milios and Dalhammar, 2020).

It is therefore important that the EPR schemes are adapted to meet reuse targets instead of just achieving certain recycling rates prescribed in the respective waste directives. Current waste legislation does not distinguish between recycling and reuse, since the proposed resource recovery rates include the processes of ‘recycling’ and ‘preparation for reuse’ together in the same target system. A mandatory reuse target could create the conditions for recognising the fundamental difference between recycling and reuse. The latter does not require the destruction of the form and function of a product, so contributes to significant savings in energy use and environmental impacts.

The increased availability of products for reuse could directly impact procurement processes of public and private actors, which might prefer to purchase cheaper reused equipment that can satisfactorily fulfil their functional needs (Paper VI). Coupled with the introduction of a quality label for reused equipment, it is not hard to visualise the complementarity of all three proposed measures.

The policy measures of banning incineration of recyclables and the investment in recycling (Figure 12) also reflect a waste hierarchy approach, addressing recycling with a push and pull approach. Banning incineration of recyclable materials will remove a large amount of recyclables from the incineration (energy recovery) option and redirect them to material recycling (Paper VI). The timing and sequencing of the measures is very important in this instrument combination, since appropriate capacity and technology must be in place to deal with the increased amount of ‘dirty’, low quality and mixed recyclables before they are completely banned from incineration (Paper VII). Funding mechanisms must be able to induce capacity expansion and technology development before a ban by the government comes into effect.

Lastly, it is worth mentioning that policy instruments aimed at improving recycling are equally important in a CE as the ones targeting the extension of life and more intensive use of products. Recent articles in popular media (e.g. Lemille, 2019) have discredited the importance of recycling, by claiming that recycling is a treatment operation of the past that does not belong in a CE paradigm, and instead reflects a linear approach. Looking beyond the sensationalism of such articles, it is important to pay attention to the science of material resource efficiency, which highlights the fact that any product – no matter how many lives of intensive use it can withstand – will ultimately end up as waste. At that point, mechanisms must be developed and be ready to effectively recover as much of its material content as possible for use again in new manufacturing processes. Only then will the circle be closed, and CE achieved, even though 100 per cent recycling of any material is not possible due to physical laws (Georgescu-Roegen, 1977; 1979; Ayres, 1999).

5.1.4 An emerging resource efficiency policy framework and theoretical implications

In the analysis of the policy mix in the previous sub-sections, several interactions between the policy instruments could be identified. These were supported both from the empirical evidence but also from a theoretical perspective.

In long-term policy design, a reflexive approach is considered appropriate, which pragmatically combines top-down and bottom-up considerations (Voß et al., 2009). In this research, particular focus was directed towards weaker stakeholders in the policymaking process (e.g. SMEs) to address their inputs, especially as early adopters of CBMs. Therefore, inclusivity and bottom-up participation in the policy

process was taken into account (Bontoux and Bengtsson, 2016). Given the complexity of the issue of resource efficiency (see section 2.1), it is usually considered insufficient to only apply one type of instrument when designing policies, and it is preferable to adopt a mix of policy instruments (Gunningham et al., 1998).

The policy mix that resulted from the research included eight policy measures (Figure 12) that could be situated at the different stages of a product's life cycle. The life cycle approach enabled the construction of a policy framework that responds to specific needs for policy intervention at each separate stage. However, the framework does not represent a ready-made solution for policymakers; it only outlines the potential use of the different policy instruments, their potential interactions, and a set of conditions for their design and implementation.

Eco-design implementing regulations would need to include clear product design requirements for durability and repairability, as well as the incorporation of recycled content and cleaner materials. Supporting these regulations, a set of mandatory technical standards could streamline the process and make it easy and more transparent. Green Public Procurement is a promising policy measure for adopting 'circular' products in public purchases, and could significantly improve resource efficiency in the economy. Selection criteria and technical specification can be suggested in line with eco-design requirements and standards, thereby creating a strong pull effect in the market. However, it is important for procurement officials to conduct proper market investigations to identify 'circular' solutions provided by relevant actors. Compliance mechanisms with sustainability and quality criteria for reconditioned products could facilitate the decision-making processes for purchasing such resource efficient solutions. Proper training and education of purchasing officials is very important for handling more challenging or complicated contracts, for example by introducing innovation in new tender forms that include multiple sustainability criteria or scope of operations (e.g. new and reused products in one purchase).

At the EOL of products, a series of policy interventions are proposed that could enable resource savings by following the principles of the waste hierarchy. A mandatory 'reuse target' is considered desirable to operationalise waste prevention strategies, by quantifying the level of reuse and thereby preventing the disposal of products (either for recycling, incineration etc.). The amount of prevented waste could be redirected for reuse purposes, either by private consumers or public actors through public procurement operations. The waste that ultimately ends up for recycling needs to be effectively recycled and turned into useable raw materials.

A series of policy measures are proposed, including increased financial support for technology and infrastructure development, the establishment of information and secondary material platforms and coordination networks, and a gradual ban on the incineration of recyclable waste. The measures cut across many sectors and actors,

which fulfils a core fundamental element of policy design, that of achieving extended coordination between the actors involved (Voß et al., 2009).

The policy mix is characterised by a high level of consistency, since the policy instruments are well positioned within a life cycle framework, targeting the multiple facets of a product's life. Also, the coherence of the suggested policy mix is justified by the inclusivity and multi-actor involvement in the process. There are several subsequent steps in the process, from just a suggested framework (presented here) to a fully-fledged adopted policy. The congruence of the policy mix is evident, since all the policy instruments are aimed at the overall objective of transitioning to a circular economy, both at national and EU level. The comprehensiveness of the policy mix, however, is not fully attained, since a number of policy domains that could affect the resource efficiency policy efforts of the EU have not been considered (e.g. chemicals regulations etc.). The empirical evidence in this thesis resulted from a policy gap analysis and a bottom up policy requirements approach, and therefore it was not possible to research all possible policy interventions that relate to resource efficiency within the time constraints of the current research. Further research is needed to expand to additional policy domains and identify interactions with the suggested policy mix in this thesis.

It is worth adding two general comments of policy theory before continuing to the next section.

First, even if the policy instruments presented in the framework do not seem radical or innovative, it is not safe to conclude that their effectiveness would be marginal or negligible. Incremental changes over a period of time and policy layering can pave the way for a gradual but decisive transition (Streeck and Thelen, 2005). Irrespective of the radical nature of a policy, a very important parameter to consider is the consistency of policy over time. A strategic long-term implementation of policy would eventually accrue sizeable effects. An obstacle to consider in this case is the short policy cycles in which politicians make decisions.

Secondly, in contrast to the idea of a top-down designed, consistent and coherent set of instruments, the actual policy development often follows ad-hoc coalitions, and is dominated by the use of windows of opportunities and significant incoherence between specific aspects of resource efficiency, e.g. between resources, waste and energy related policy approaches (Bahn-Walkowiak and Wilts, 2017).

5.2 Political economy of public policy in a circular economy

Resource policies, and especially those targeting resource efficiency and waste minimisation, constitute a subset of national policies with a direct domestic focus. Such policies can have indirect implications to international policy, especially through trade and competition regulations in a liberalised economic global environment. Related to this subsystem of policies can be other policy domains, such as taxation, product policy, chemicals and waste regulation, and trade and competition rules. It is therefore important to position this policy area in a separate subsystem within an advocacy coalition framework (Sabatier, 1988) and identify the associated internal and external actors that will shape its development and future orientation.

5.2.1 Influential actors in the policy process

Within the resource efficiency policy subsystem, it is important to identify the relevant stakeholders in order to analyse what drives their interests and how each advocacy coalition group can influence the policy formulation process. Certain actors may exert disproportionate power over the process, either imposing their beliefs or by forwarding the policy imperative of the coalition in general. Lindblom (1977) asserts that there is a structural power of business in the policymaking process due to its position in the economy and its capacity to manipulate views of citizens. Koop and Meadowcroft (2018) reaffirm that the relationship between government and business is an essential and inseparable feature in the modern political economy reality.

In a modern economy like Sweden's, this is evident by the dominance of incumbent firms in the manufacturing processes, which closely monitor possible policy changes that might affect their operations. In contrast, a minority of innovative smaller firms, which have managed to capture value by using circular economy principles, find consistent obstacles to their operations that would require relevant policy fixes (Papers II–IV). However, the policy response seems unlikely or weak, especially in view of incumbent interventions, seeing the 'circular' business practices as a potential competitor to their current industrial setting (although it is considered as an option in the medium- and long-term perspective). Incumbents claim that no direct threat can be foreseen in their operations, especially since a lot of risk mitigating measures are in place. However, a policy change might affect them more (or in unpredictable ways) than a potential resource shortage in the future (Papers I, II, VI).

The policy landscape is a pluralist system, though disproportionate (Schattschneider 1960). Business has an important role to play, but citizens, politicians and

bureaucrats also play a decisive role. Citizens exercise their power through civic action (either organised in non-governmental organisations, or semi-organised in civic movements), and through their democratic right to vote. It could be argued that there is a double feature in people's power, both mandating politicians' actions and influencing the policy coalition through external pressure (often taking the form of consumer choice, see Paper V).

There is an apparent discrepancy on power asymmetry of citizens compared to business. This could be explained by the not absolute correlation between citizen demands and politicians' actions, and the discrepancy between civic action and consumer behaviour. Politicians not only have to take into account the voice of their electoral base, but also include business and lobbying demands in their decision-making process. Politicians employ this double role as they seek to balance support from industry (money) and consumers (votes) to win an election (Peltzman, 1967). Deciding which aspect of the dipole will weigh down politicians' decisions, it is important to take into account the scope of conflict (Schattschneider, 1960), for example, business interests prevail when the scope is narrow and visibility low. On the other hand, the more the public base cares, the less business interests can disproportionately influence policymaking (Culpepper, 2011).

In the case of Sweden, there is a strong paradox relating to public opinion and public (in-)action regarding the policy domain of resources and waste. There is a strong environmental consciousness in the Swedish people, something that has acquired global recognition, but this fails to translate in purchasing actions. The consumption level of Swedish consumers keeps growing (Roos et al., 2018), irrespective of whether their purchasing choices are more environmentally friendly. In resource policy, it is not only the 'type' of consumption, but also the level of consumption that matters, which civic society and political parties consistently fail to address adequately. Ultimately, the decisive factor in this case is not as much related to the environmental parameters of policymaking (reducing environmental impact) as to the economic parameters of policy (economic growth). Failure to link these two aspects blurs the picture, and neither the general public nor the politicians are enabled (or desire) to take any step away from the current policy pathway.

5.2.2 Policy continuity and path dependence

In a policy subsystem, all stakeholders share common characteristics, including continuity and idea formulation over time. However, that continuity is usually longer than the time politicians have at their disposal to decide upon and implement a certain policy (or set of policies). Nordhaus (1975) states that politicians are constrained by political realities and usually have difficulties focusing on the long-term future when making macroeconomic decisions. Policy decisions in the natural resources realm have inherent long-term characteristics, as potential resource scarcities and environmental impacts caused by overconsumption are issues that

take decades to appear and are practically invisible today to a common actor, despite the mounting evidence (e.g. IPCC, 2018). On the other hand, focusing on tangible short-term policies that show explicit results (e.g. improving economic indicators) would appeal strongly to voters and incumbents alike who see mainly short-term profits/gains as desirable futures.

Rose (1990) points out that one of the most important factors explaining a policy at a specific point in time is actually the policy that preceded it. Governments have no choice but to accept the inherited commitments of past governments as given, particularly as these are incorporated in laws, organisations and budgets. Path dependence emerges as a concept to explain the inherent difficulty of policy change and the persistent nature of policy 'lock-ins'. Pierson (2000) clarifies the concept of path dependence and links it to the notion of increasing returns. The more we go down the same path of policy, the more self-reinforcing or positive feedback the policy acquires. Each step along a path makes that path more attractive than alternative paths for the next step (Pierson, 2000).

A consistent trajectory of product and consumer policies throughout the 20th century emphasises the properties and safety of products and the protection and rights of consumers, all embedded in a liberal (sometimes more than others) capitalist framework in a market and trade system. Informed by the economic theories at the time, efficiency in output and increase in productivity became the holy grail of policy, with business anticipating ever-increasing returns and profits.

Despite a series of changes over the last 20 years, the current policy framework is firmly embedded to previous policy decisions (Paper I). Fossil fuel subsidies, high labour taxes, strict intellectual property rules and control of innovation are all part of a system favouring high productivity and business protection. In a world seeking reduced environmental impacts, none of the above align with a transition to a circular economic system.

Apart from radical change in policy decisions, incremental change can also contribute towards a transition pathway and it is better than no change at all (Paper II). Streeck and Thelen (2005) find that incrementalism is believed to lead to minor changes; although gradual, this can still be transformative in the long-term. In the current debate on resource policy, there is a tendency towards layering of policy instruments, adding new elements on top of old institutional arrangements.

5.2.3 Political modernisation and policy diffusion

It is reasonable to assume that any policy change in a given jurisdiction will have spill-over effects to its partners (either trade, territorial or diplomatic). According to political modernisation theories (Van Tatenhove, 1999) and the internationalisation thesis (Arts et al., 2006), countries compete for business and capital, so it is in the interests of the advocacy coalitions to pressure governments to adopt favourable

policies to attract business and capital from potential competitors, for instance by reducing capital tax rates. However, such tactics might lead to a race-to-the-bottom situation, with immobile asset holders paying the price (Jensen and Lindstädt, 2012).

International policy convergence is becoming increasingly common, and policy decisions in a certain jurisdiction are systematically conditioned by prior policy choices made in other jurisdictions. Policy choices are interdependent rather than independent, as governments adopt new policies not in isolation but in response to what their counterparts in other countries are doing (Simmons et al., 2006).

In EU policymaking, policy diffusion is very common and sometimes not only emulated, but directed from the European Commission for adoption uniformly by all Member States. A policy innovator (or early adopter) would have the advantage of shaping the policy and rendering it fit for purpose in potential future competition in a global stage. Laggards would most likely have to comply with the regulation, rather than designing the regulation or making a free choice on adoption. Sweden has traditionally developed a fair share of innovative environmental regulations and has benefited from them (Jänicke, 2005). However, the resource policy agenda seems to be the harder nut to crack, as it is inextricably linked with another policy subsystem – that of economic policy – and the power asymmetry between the subsystems gradually becomes apparent.

6 Conclusions

The transition to a CE would be improbable without the introduction of necessary enabling conditions that would facilitate the development and uptake of circular business operations. Policies enabling a resource efficient economy, embedded in circular economy principles, constitute a prerequisite for such an ambitious shift in the current ‘linear’ economic reality in the EU and beyond. The research presented in this thesis aimed at analysing the current policy landscape and identifying inconsistencies that hinder the operations of stakeholders engaged in providing resource efficiency solutions. Adopting a ‘bottom-up’ approach enabled investigation of the necessary policy interventions that could lift the identified barriers and enable the development and proliferation of resource efficient solutions in production and consumption systems. Lastly, the research proposed a revised policy framework for resource efficiency, including eight distinct policy instruments in a policy mix with a life cycle perspective.

Firstly, the research identified policy gaps or policy inconsistencies in the existing policy landscape for material resource efficiency in the EU, and analysed ways in which the policy gaps could be utilised for advancing a circular economy. The current resource policy landscape in the EU appears to be rather waste-centric, which only partially covers the circular economy principles promoted by the CE Action Plan (COM(2015) 614 final). Complementary policy approaches are needed that target all life cycle stages.

Three policy areas were identified as having a significant potential for promoting higher resource efficiency throughout the life cycle of a product. These are (1) targeted policies for reuse, repair and remanufacturing, (2) revised public procurement requirements with integrated ‘circular’ criteria, and (3) policies for facilitating the efficient functioning of waste markets and safeguarding the quality of recycled material. It was important to consider the systemic challenges associated with such a shift towards a CE. Ultimately, policy mixes would be needed, rather than singular policy instruments. Policy mixes are generally better equipped to tackle the complexity of systemic challenges, such as the shift of socioeconomic systems (Rogge and Reichardt, 2016).

Secondly, after the gap analysis of the overall resource policy framework, the focus shifted to case studies, aiming to identify why companies find it difficult to adopt circular economy strategies and what policy interventions would be needed to

incentivise the integration of circular strategies in business operations. This research approach was aimed at identifying constraining factors of existing policies on CE business activities and offering potential solutions to overcome the identified barriers. The case studies developed in line with the three policy areas identified in the first step of the research.

Findings on product life-time extension indicated the need for an overarching policy framework, including broad cross-sectoral policy interventions and sector-specific measures. The critical importance of governmental leadership in driving policy for increasing the resource efficiency in the economy was highlighted, and the following instruments were suggested: increased provision and access to information for business and public alike, so that reuse becomes more accessible, widespread and trusted; setting a mandatory reuse target; and the introduction of specific requirements in all public purchases that would prioritise reuse options, when this does not present any adverse effects.

In the promising policy area of ‘circular’ public procurement, the examined cases highlighted several barriers, such as concerns about the quality of reconditioned or remanufactured products, supply risks (of uniform large product quantities), low awareness of product life extension solutions, and incapability to administer complex procurement processes that might include both new and reused products.

Several ways were suggested for improving the criteria setting processes to attain more effective procurement that would be able to support ‘circular’ solutions. Practical policy and management considerations emerging from the investigated cases included: the proper market investigations before any procurement process to identify ‘circular’ solutions; compliance mechanisms with sustainability and quality criteria for purchasing reconditioned products; and innovation in new tender forms that include multiple sustainability criteria or scope of operations (e.g. new and reused products in one purchase).

Analysis of the efficient functioning of secondary material markets focused on plastic waste. A set of business barriers were identified that were broadly categorised into four themes: 1) low demand for recycled plastics, including both the low demand from producers because of price and quality issues, and the low demand from consumers for products made with recycled plastic; 2) limited market communication and lack of value chain coordination, which ultimately results in lack of traceability of plastics along the value chain; 3) technical barriers for better recycling; and 4) legislative barriers affecting the market of recycled plastics.

Based on these barriers, a number of potential policies were identified, including improved public procurement criteria for resource efficiency, a preferential taxation framework for secondary raw materials, improved design for recyclability and toxic-free secondary plastic, and international quality standards and appropriate specifications of recycled plastics for use in industry. Interviews with stakeholders revealed the need for more far-reaching policy interventions at local, national and

international level, including value chain coordination and gradual integration, followed by the need for increased investment for innovation, technology, and capacity building. In view of GHG emission concerns, a ban on the incineration of recyclable plastic waste was proposed, to lift one of the major barriers to plastic recycling, the supply of waste plastic.

Thirdly, synthesis of the results of the analytical stage of the identified policy interventions, and elaboration on the overall empirical findings of the research, allowed development of a comprehensive resource efficiency policy framework that could enable the uptake of circular aspects in business. The overarching policy framework consisted of eight distinct policy measures integrated altogether in a policy package. The policy instruments in the resource efficiency mix are the following.

(1) Eco-design for product durability, reparability and recyclability: Specific rules include mandatory provisions for resource efficient design in new production. There are several ways to increase the resource efficiency of a product throughout its life cycle. Since the design of a product has a critical role to play in its overall environmental performance, it is absolutely necessary that durability, reparability and recyclability considerations are taken into account at this early stage.

(2) Product standards for reparability and standards for secondary raw material: The key to reusing products and secondary materials lies in the ease and reliability that these can be reintegrated back in the economy. Standardisation can increase the confidence of economic actors in the performance and quality of second-hand products and secondary materials.

(3) Circularity criteria in public procurement: The large purchasing power of the public sector can steer market developments towards more circular and resource efficient solutions. By creating the appropriate market demand, governments create the necessary conditions for upscaling circular solutions that may or may not have diffused onto the market yet. Public procurement is a strong pull mechanism in the context of product policy, and can be used in combination with eco-design and product certification to drive resource efficiency in manufacturing and product use.

(4) Quality labelling for reused products: A quality label can increase the confidence of a public or private consumer in second-hand products and encourage use. It is a complementary informative policy measure that can be used in combination with a variety of administrative and economic policy instruments.

(5) Reuse target: This indicates a clear signal for a transition to a reuse society, where products and resources are used as long as possible and their embedded value is maintained along the way.

(6) Funding for capacity, technology and innovation development in recycling and reuse value chains: Funding mechanisms are key components of a holistic policy approach towards a paradigm shift. To increase resource circulation and higher

reuse and recycling, it is imperative that appropriate infrastructure, technology and organisations are in place.

(7) Support for resource and information exchange platforms: Exchanges between stakeholders in a circular economy are considered paramount. Although the form, ownership and facilitation of such information platforms is not yet determined, their necessity is emphasised both by public and private stakeholders.

(8) Ban on incineration of recyclable waste: By eliminating the option of incineration, a number of mechanisms will be triggered for taking care of the excess amount of recyclable materials currently treated as waste (e.g. plastics).

The presented policy instruments interact within the framework and generally reinforce each other, resulting in an overall stronger regulatory and administrative effect. However, this effect could only be assumed in the current research, as there was no evaluation of the policy mix. The latter should be part of future research, together with research on the potential pathway of integration of the policy proposed framework into the national and international efforts for a policy change towards a transition to CE.

6.1 Key contributions of the research

The research made three key contributions in the field of resource policy intervention: (1) a novel methodological approach, (2) rich empirical evidence to support the design and implementation of policy interventions, and (3) an original policy framework for resource efficiency.

The *methodological approach* of policy analysis from a ‘bottom-up’ perspective constituted an original research approach that has not previously been employed widely in policy research. Only a limited number of studies have used this ‘bottom-up’ approach, to the knowledge of the author (see for example Pheifer, 2017). Most research in this area has used a wider stakeholder approach, not focusing on business realities but incorporating broader socio-political elements (examples include Kirchherr et al., 2018; Rizos et al., 2016; and Wilts et al., 2015). The methodological approach included the analysis of case studies of ‘circular’ business actors that have already adopted resource efficiency strategies in their business model, to identify precisely the policy interventions that could facilitate such business operations and lift the experienced – real – business barriers that hinder their operations ‘on the ground’.

A ‘bottom-up’ approach in the CE literature has different meanings, either referring to the actual business actions (e.g. product design, supply chain networks, automation, etc.) (Lieder and Rashid, 2016), or to initiatives taken by environmental organisations, civil society, etc. (Ghisellini et al., 2016). In contrast, the research

approach in this thesis used ‘bottom-up’ to refer to the evidence base on which actions by public policy actors (usually described as a ‘top-down’ element) are expected to facilitate niche innovative circular businesses, by responding to their specific policy support needs. Only business inputs were utilised to produce desired policy interventions, without taking into account the positions of policy officials, policy brokers and industry advocacy associations, which include political interests in their agenda. Therefore, it accounts for a genuine ‘on the ground’ approach, reflecting the views of practical implementers of CBMs (despite their potential impartiality or lack of knowledge in policy processes), seeking solutions to their immediate operational problems rather than to the general socio-economic context as a whole. This direct input serves to elevate the practical problems of CE businesses to actual policy solutions through the lens of policy analysis.

The extensive ‘case study’ research approach constituted another key contribution by providing the necessary *evidence on which the policy interventions* could be scrutinised. The research capitalised on the case studies to extract information on barriers and drivers of CBMs in the case companies, and went on to specify policy needs deriving from the case study conditions. In this respect, the research went beyond the more typical approach of defining the organisational, technological, economic, knowledge/culture, regulatory barriers of business, aiming to specify the capabilities and conditions for business model transformation (e.g. Bressanelli et al., 2018; Guldmann and Huulgaard, 2020; Hirschnitz-Garbers et al., 2016; Lieder and Rashid, 2016; Linder and Williander, 2015; Shahbazi et al., 2016; Tura et al., 2019). The empirical evidence of business practice was instead utilised to connect business barriers to proposed policy interventions.

This resulted in a list of policy interventions deriving directly from business actor needs, which can form a solid basis for the development and implementation of the specified policies by public policy actors. The empirical evidence not only legitimises the effort for further public policy action but also serves as a guidance to political stakeholders towards future policy decisions, by outlining clear policy needs from the business sector. Since business actors have been identified in the EU CE Action Plan (COM (2015) 614 final) as the key drivers in the process of a CE transition, the policy orientation that this research provided constitutes a relevant contribution in the realm of resource efficiency and circular economy policy analysis.

The *resource efficiency policy framework*, resulting from the research by synthesising the findings of the policy gap analysis and the case studies, constituted an original, though not entirely novel, approach that provided a reasonable proposition for a policy-induced transition to a CE in Europe. To date, proposed policy frameworks for resource efficiency go beyond the CE resource management principles and the notion of material efficiency in production and consumption of products, including a wider perspective of resources, such as land, food and water (Bleischwitz, 2012; Domenech and Bahn-Walkowiak, 2019; Ekvall et al., 2017;

Wilts and O'Brien, 2019). The policy framework in this research is much more focused on the domain of manufactured products, and is directly linked to production and consumption practices within the economic system. A narrower approach with a specific focus on product policy has the potential to be rather specific, with tangible and measurable outcomes.

6.2 Future research

Although material resource efficiency policy analysis is not a new research domain, the recent reframing of this policy area within the broader CE concept by international think tanks and the EU – notably in the CE Action Plan (COM (2015) 614 final) – has reawakened interest in resource policy research. The findings of this thesis confirmed the existence of several gaps in design and application of such policy instruments at EU and national levels, and subsequently produced an evidence base on how to ameliorate these deficiencies through an empirical ‘bottom-up’ case study approach. Ultimately, the findings allowed the construction of a comprehensive resource efficiency policy framework, in line with the CE principles pertaining the future EU strategic planning. However, this is just a very early step in the efforts to develop a truly effective and efficient CE in Europe and the Member States. Research is needed in multiple directions to reinforce and further develop the findings of the current research.

The proposed policy framework resulted from the empirical evidence generated by the investigated case studies. To strengthen the content and legitimacy of the suggested policy instruments within the framework, it is important to broaden the evidence base and collect additional empirical material by conducting more ‘bottom-up’ case studies, and expanding to more economic sectors than the ones included in this thesis. Extending future research throughout all the major economic sectors would represent better the business actors from the full spectrum of economic activity, and could support or even challenge the comprehensiveness and integrity of the policy framework presented here.

The empirically backed policy framework, although it responds robustly to business policy needs in tackling experienced barriers, does not guarantee any level of future policy effectiveness. Policy evaluation (both ex-ante and ex-post) would be required to assess its overall efficiency and effectiveness. Employing well-established policy evaluation methods (Mickwitz, 2003; Vedung, 1997), future research could develop assessments both for the individual policy instruments and for the policy mix as a whole. The evaluations could be developed within the confines of national policy, but also at a supranational level (e.g. the EU).

There is much more work to be done concerning trade-offs, as policies become increasingly complex in their objectives (Dalhammar et al., 2019). For instance,

further development of the eco-design and GPP requirements will need to consider trade-offs between strategies, such as design for recycling, reuse, repairability, and durability, as well as trade-offs across separate policy subsystems, for instance chemicals, trade, and financing.

In literature, CE strategies are usually presented as win-win strategies for businesses, but it is increasingly recognised that businesses alone cannot or, for profitability reasons, will not capture societal and environmental value (Whalen and Milios, 2019). It is important to examine in more detail the impacts of proposed legislative measures before implementation, since different outcomes might be expected depending on firm type, customer base (business-to-business or business-to-consumer), and geographical scope of operations (national vs. international).

Finally, this thesis initiated an investigation into the policy change processes that would be necessary for a transition to a CE in Sweden (section 5.2). A clear path for future research lies in the continuation and further development of this research by analysing in-depth policy transition pathways based on theories of policy change and theories of structural socio-technical change (e.g. transition theories). The theoretical and practical research on change management and transition processes is of paramount importance in the case of shifting production and consumption practices according to the CE paradigm. Such research would reveal the necessary requirements for change, map out all relevant stakeholders, and identify points of leverage in the system that could trigger change effects and stimulate transformative processes.

Ultimately, ambitious policies towards a CE transition require examination and reconfiguration of stakeholder values. Traditional environmental policy theory has promoted the role of governments in addressing externalities (Baumol and Oates, 1988), but there is increasing recognition of the need of governments to be strong driving actors in transition processes (Mazzucato, 2018; Raworth, 2017). A future research direction could expand on the revised role of public policy actors in manifesting changes in a directive manner instead of only supporting business actors in a free-market economy.

7 References

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