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Industrial policy for a circular industrial transition in Sweden: An exploratory analysis

Marianne Ekdahl, Leonidas Milios, Carl Dalhammar *

International Institute for Industrial Environmental Economics (IIIEE), Lund University, Tegnérsplatsen 4, P.O. Box 196, 221 00 Lund, Sweden

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ABSTRACT

Currently, both the US and the EU are pursuing industrial policies to support climate mitigation objectives. The climate transition will require increased use of material resources, but the envisioned industrial policies do not sufficiently address resource use, despite the current unsustainable global resource-use trajectory. The lack of industrial policy in this field is therefore relevant and timely to address. This exploratory contribution aims to gain an understanding on how an industrial policy for Circular Economy (CE) transition in Sweden could be designed. The methods employed are literature reviews and interviews with 18 senior experts. The research finds that a Swedish industrial policy focusing on the CE transition is needed, together with larger public investments in CE-related technologies. Few existing policy instruments functioning as industrial policy for CE are identified, but many additional instruments could potentially serve this objective. The interviews provide insights into the specific policy needs, the factors determining policy-design, and the choice of sectors and value chains for policies to target. A relevant policy mix includes policy instruments such as green tax shifting, differentiated Value Added Tax, Circular Public Procurement, funding schemes, but also an improved institutional framework. Policy criteria should be based on environmental impact, but also on potential competitive advantages, and close alignment with European Union policies. The study concludes that a policy mix combining new and expanded industrial policy instruments, focusing on correcting market failures, market creation, and capacity-building, can support a circular industrial transition.

1. Introduction

There is increasing evidence that the multiple crises humanity is facing today are all connected to our unsustainable way of life, leading to climate change, biodiversity loss, pollution, waste and resource depletion (IPCC, 2023; IPBES, 2019; UNEP, 2024). Global policy responses are emerging, as climate change objectives have triggered measures for reducing greenhouse gas (GHG) emissions and the overall decarbonisation of the economy. But the main cause of these multiple crises, i.e. our unsustainable production and consumption patterns, has not been tackled effectively, despite global recognition in the form of Sustainable Development Goal (SDG) 12 of the United Nations 2030 Agenda (UN, 2015) and the increasing level of respective policy interventions. The extraction and processing of natural resources are causing more than 90 % of the global loss of biodiversity and water scarcity, and around 50 % of global climate impacts (IRP, 2019). Our resource demand is constantly growing; over the last 50 years, global material extraction has more than tripled and it is projected to increase further 60 % by 2060 (UNEP, 2024).

There is a need for a transition to a sustainable production and consumption system that not only leads to imminent decarbonisation, but also to the decoupling of economic activity from resource use and environmental degradation, safeguarding a sustainable future for humanity (UNEP, 2024; Richardson et al., 2023). SDG 12 is the primary expression of this fundamental shift globally (UN, 2015). Resource efficiency is a step towards decoupling, through achieving improved outputs with fewer inputs and adverse impacts (UNEP, 2024), but structural economic changes will be necessary, i.e., shifting focus from high-pressure intensive industries to low-pressure industries and services. Transitioning from a linear model of economic consumption and production to a Circular Economy (CE), means that resources are used efficiently, materials and products are reused or recycled at their highest possible value, waste is drastically reduced, and extraction of new resources is minimised (Kirchherr et al., 2023).

Governmental policies can play an important role in supporting companies in the circular transition (Lindahl and Dalhammar, 2022),

* Corresponding author.
E-mail address: carl.dalhammar@iiiee.lu.se (C. Dalhammar).

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but CE policy in OECD and EU countries is still in its infancy compared to other environmental policy fields. While a circular industrial transition needs policy support, industrial policies addressing CE are still rare. In comparison, the urgency of climate change (IPCC, 2023) has generated a considerable policy output (Welfens, 2022; Bulkeley and Newell, 2015; EC, 2021a). In response to the growth in climate policy, and necessitated by the green industrial transition, there has been a revival for green industrial policy as an essential pillar of the decarbonisation policy mix (Johnstone et al., 2021; Mazzucato, 2019; Meckling, 2021). Green industrial policy becomes an established part of climate policy mixes (Tillväxtanalys, 2022), and is currently high on the international agenda, i.e. through the EU Green Deal Industrial Plan (EC, 2023a; Kleimann et al., 2023) and the US Inflation Reduction Act (White House, 2023).

Whether at a global or regional level, the transition from a linear production and consumption system to a CE is a significant challenge (Fraser et al., 2024; Iacovidou et al., 2021). Among high-income countries, Sweden is an interesting example, offering a combination of relevant policy features. Sweden has a long-standing environmental policy record (Naturvårdsverket, 2017), including a broad climate policy framework (Swedish Government, 2017), and a national CE strategy (Swedish Government, 2020). Industrial policy (IP) has a long-standing tradition, and recent green IP developments have resulted in high-profile projects such as the Hybrit fossil-free steel project and the Northvolt battery plant (Naturvårdsverket, 2022). Interestingly, Sweden sees a fast-growing interest in circular industrial transition, (i.e. Swedish Enterprise, 2022 and 2024; Flack et al., 2023). Therefore, the evidently underdeveloped area of industrial policy for a circular transition is a highly relevant and timely issue to address.

The literature on green industrial policy and other business-targeting policies for decarbonisation and climate transition is substantial (among recent examples Song et al., 2024, Lechtenböhmer, 2023; Sawyer, 2022). However, there is limited research specifically focusing on industrial policy targeting a CE transition, both from a theoretical and an empirical perspective. This study aims, in an exploratory way, to identify the need for, and the possible policy features of a future industrial policy targeted at CE, through the case of Sweden as an industrial economic system in transition. Eventually, this contribution will investigate particular policy design elements and provide recommendations for policy makers.

The research objectives are broken down into the following: (1) identifying policy instruments that are currently or potentially functioning as a circular industrial policy; (2) understanding appropriate circular industrial policy instruments, and appropriate industry sectors to target, in the development of a Swedish circular industrial policy; (3) identifying how such policy instruments should be prioritised and on what criteria; and (4) identifying the key elements of a prospective circular industrial policy for Sweden.

The next chapter presents the background literature, Section 3 outlines the methods, and Section 4 presents the results from the interviews. In Section 5, the results are discussed in relation to the literature and to current policy developments in order to provide the basis for policy recommendations. Finally, conclusions and recommendations for future research are provided in Section 6.

2. Literature review

To identify the interface of industrial policy and CE and to define the key characteristics of policy intervention within an integrated conceptual domain, a literature review was conducted to get a broad overview of existing research in each policy area. Due to the limited existing research on industrial policy targeting a CE transition, the literature review focused on broader topic areas, such as green industrial policy, CE policy, and policy design. This provided the necessary background on existing and potential industrial policies targeting CE. Subsequently, the review was expanded with the goal of providing a better understanding of circular industrial policy through identifying its key features, the key factors affecting a CE transition, and key factors that influence policymaking.

2.1. Circular economy barriers and drivers

Circular economy (CE) is an umbrella term, representing a state of the economy where products and materials are maintained at their highest value for as long as possible, applying a life-cycle perspective, and designing out waste (Blomsma and Brennan, 2017; Kirchherr et al., 2017a; Milios, 2018). Maintaining high value implies prioritizing the inner circular loops (see e.g. the circular economy diagram by EMF, 2013). A way to achieve a transition to a CE is through the adoption and proliferation of Circular Business Models (CBMs) which have been attracting increasing interest lately (Swedish Government, 2020; Swedish Enterprise, 2022), due to societal expectations, creation of competitive advantages (Naturvårdsverket, 2021), and countering of volatile resource prices. There are several ways to develop a CBM, with the literature pointing to different strategies to achieve circularity and resource efficiency in the economy, e.g. by narrowing, slowing, and closing resource loops (Bocken et al., 2016). For an overview of CBM types in manufacturing industries, see Table 1.

CBMs support product systems that preserve embedded values at the highest possible utility level (Stahel, 1994). Furthermore, circularity stretches beyond individual companies, and needs system-level solutions on the micro-, meso- and macro-levels. System-level circularity upstream and downstream can be realised between companies, within supply chains (Lewandowski, 2016; Nußholz, 2020) or through value networks (Nußholz, 2020). Meso-level circularity includes infrastructure for reuse, logistics for material flows (Naturvårdsverket, 2021), and industrial symbiosis (Södergren and Palm, 2021).

Despite the potential of CBMs to preserve resources and reduce environmental pressures, several barriers to their adoption have been observed in literature. Understanding these barriers, their impact, and ways to address them, is a key requirement for CE policy design. Drivers, on the other hand, act as catalysts for transitions, have a steering effect, increase the potential of policies, and stimulate CBM uptake (Milios, 2016). Existing CE public policy frameworks (EC, 2020; OECD, 2022), and policy proposals (Mont et al., 2017; Flack et al., 2023; Milios,

Table 1
Circular Business Models in manufacturing. The table is categorized with CBM archetypes based on Bocken et al. (2014), and CBM examples from Bocken et al. (2016), Lewandowski (2016), Lindahl and Dalhammar (2022), Mont (2002), Nußholz (2017), Naturvårdsverket (2021), Mont et al. (2017).

CBM archetypes	Examples of business models
Maximise material and energy efficiency	• Extending product values. Ex: remanufacturing parts in automotive industry, sales of refurbished electronics, repair, clothing return initiatives. • Long-life model. Ex: White goods manufactured for long life and repair. • Encourage sufficiency and reduced end-user consumption. Ex: certain high service, high quality brands. • Virtualisation., i.e. turning physical products into digital. • Design for sustainable life cycle: value-increasing collaboration across value chains – for longer use, more users, retake for remanufacturing, refurbishment etc.
Deliver functionality rather than ownership	• Access and performance models, or Product-as-a-Service. Ex: integrated product-service offerings, renting, subscriptions, digitalization.
Create value from 'waste'	• Extending resource value, where "wasted" resources are collected and turned into new forms of values. Ex: take-back-system. • Industrial symbiosis, a specific way to organise the flow of materials and energy through local and regional economies.

2021a) are based on analyses of current barriers, and sometimes also drivers or enabling conditions.

Fig. 1 illustrates a typology of barriers and drivers in relation to companies' internal capabilities or external pressures. Barriers having specific relevance for industrial policy and for understanding conditions relating to the Swedish industry have been identified to facilitate the development of this research contribution. Main regulatory barriers are current laws and regulations influenced by linear thinking, lack of incentives for CE, and lack of specific CE policies and regulations. Market barriers include market failures, mispricing of raw materials, consumer behaviour, and limited availability of recycled raw materials. There are also technological barriers, such as product design, and value chain-related barriers, such as transaction costs and lack of value chain collaboration. For the complete overview of identified barriers see Annex S2, Table S2.

Main CE drivers relate to economic factors, regulatory pressure, and strong market forces (see Table 2). Fiscal and taxation systems are key framework conditions that shape the behaviour of economic actors and what is considered feasible and viable (Domenech and Bahn-Walkowiak, 2019). But this also applies to other areas, such as innovation and R&D systems, and public CE strategies (Domenech and Bahn-Walkowiak, 2019).

2.2. Circular economy policy

CE policies aim at resource decoupling through overcoming barriers, countering externalities and market failures (OECD, 2018; Swedish Government, 2022a), and supporting new CBMs (Whalen, 2020; Dalhammar and Milios, 2016). Policies can be categorized in several ways, with the most common typology including (i) administrative and regulatory, (ii) economic and financial, (iii) informative, and (iv) support and capacity building (R&D) policy instruments (Mont and Dalhammar, 2005). Table 3 is based on top-level policy categories, a horizontal/vertical policy dimension, as well as a sectoral dimension. Policy examples are based on potential relevance from an industrial policy perspective.

The policy categorisation is performed as an adaptation based on Mont and Dalhammar (2005), Wasserbaur et al. (2022), and Milios (2020). The policy examples are from Domenech and Bahn-Walkowiak (2019), Ekvall et al. (2016), Hennlock et al. (2021), Lieder and Rachid (2016), Milios (2020), Milios (2016), Milios (2021b), OECD (2022), POLFREE (2016), Wilts and O'Brien (2019), Wilts and Von Gries (2015).

In ideal conditions, CE policy design should be conducted in a systematic fashion (Ekvall et al., 2016; Wilts and O'Brien, 2019), but this is never possible in real-life policymaking. Typically, policies are adopted when there is a political momentum for change, but they are not always well coordinated with other policies. Further, in the EU the European Parliament may vote on single policies, when it would have been preferable to vote on larger "package" of policies, to obtain a better overview of how they work together. A main problem in CE policymaking generally is that existing waste policies may act as barriers for re-use, repair, remanufacturing, and recycling (for an overview see Lindahl and Dalhammar, 2022). Thus, effective policymaking requires that both that existing policies are revised, and new ones introduced. Despite this state of affairs, a few generic factors that should guide CE policy design can be identified. Knowledge is the first requirement for policy design: on material flows, content of possible dangerous substances, and effects on other policies (Naturvårdsverket, 2021). This is particularly relevant

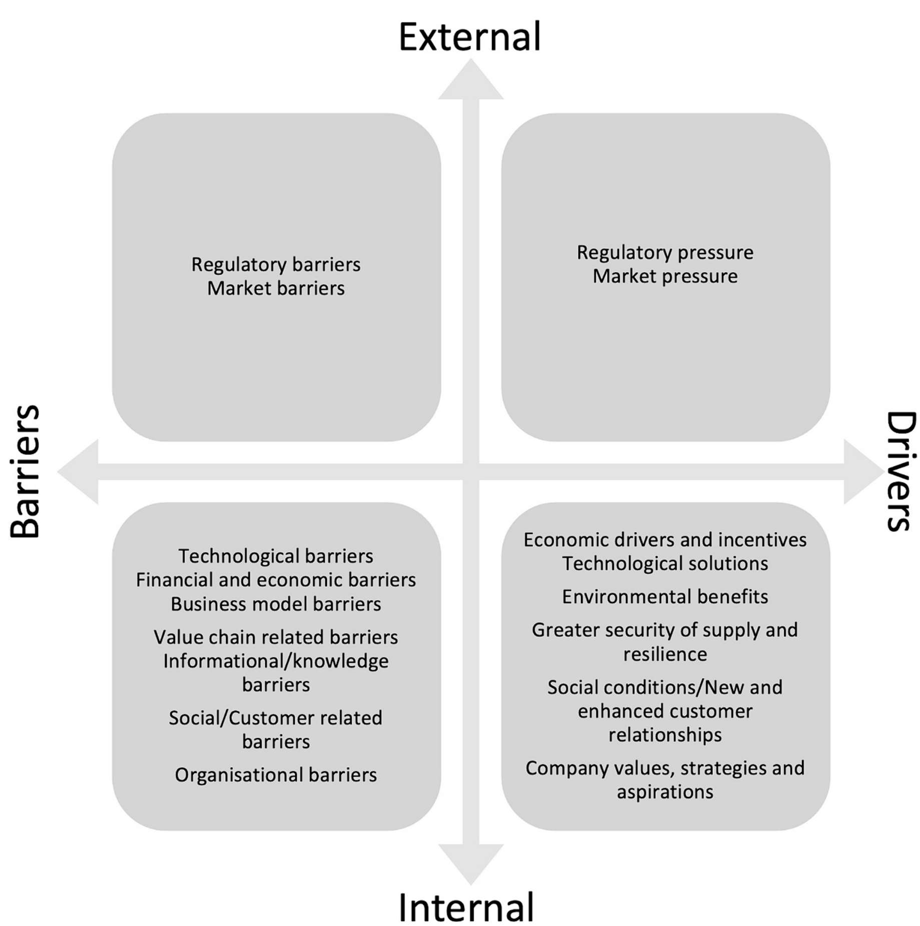

Fig. 1. Typology of barriers and drivers for circular industrial transition. The figure summarises barriers and drivers affecting companies either externally or internally. Adapted from Mont et al. (2017), Milios (2016), and Kirchherr et al. (2017b).

Table 2
Drivers for circular economy. Main categorisations from Fig. 1.

Economic or market-related drivers	• New business models based on dematerialisation, asset sharing and extended product use • Rising or volatile costs of virgin raw materials • Material supply risks • Cost savings through reusing and recycling • Market triggers material innovation • Strengthening of competitiveness	(Brändström et al., 2024; Govindan and Hasanagic, 2018; Milios, 2016; Mont et al., 2017)
Regulatory	• Increased governmental intervention • Taxes on natural resources • Circular public procurement • Legal compliance requirements • Legal pressure to decrease certain material resources • Public CE strategies and regulatory targets	(Domenech and Bahn-Walkowiak, 2019; Govindan and Hasanagic, 2018; Milios, 2016)
Organisational	• Extended producer responsibility participation • Best Available Techniques (BAT) in industrial processes • Company innovation • Company values and culture • Company CE strategies and targets • Perceived environmental and social benefits	(Brändström et al., 2024; Domenech and Bahn-Walkowiak, 2019; Govindan and Hasanagic, 2018; Milios, 2016; Mont et al., 2017)

for CE policies, since existing environmental and climate policies are based on long-established indicators on GHG emissions and pollution, among others, but CE data and indicators are not well-developed yet. In fact, CE policy design is hampered by a lack of measurement methods (De Pascale et al., 2021; POLFREE, 2016). In addition, criteria for policy selection need to be decided, such as maximisation of environmental gains (EEA, 2013), or generation of as large circular transitional potential as possible (Swedish Government, 2022a). This should be done while maintaining a systems perspective, ensuring that policies reinforce positive feedback loops (Milios, 2018). However, there is generally a clear trade-off between instruments with the highest potential for increasing material resource efficiency, and those that could be most easily introduced (POLFREE, 2016).

2.3. Green industrial policy

As decarbonization necessitates industrial transition, the global climate agenda has reinvigorated green industrial policy to support and foster industry's pathway to net-zero GHG emissions. Green industrial policy has drawn considerable interest in recent literature (see Andersson et al., 2021; Terzi et al., 2022; Rodrik, 2014; Coffey and Thornley, 2015; Meckling, 2021; Weiss and Seric, 2021; Allan et al., 2021; Juhász et al., 2023).

Green IP usually combines industrial and environmental policy tools (Meckling, 2021), supporting certain sectors or technologies with the aim to reach both environmental goals and increased competitiveness, productivity, job creation, or restructuring goals (Hallegatte et al., 2013; Söderholm and Frishammar, 2018). There is also a strong connection between green industrial policy and innovation policy (Hallegatte et al., 2013).

Green industrial policy is usually motivated by market failures (Rodrik, 2014; Andersson et al., 2021), such as incorrect pricing of natural and environmental resources, including carbon, leading to externalities realised as environmental damage (Fischer, 2017; Nill and Petschow, 2003). When the best policy option – correct pricing and

Table 3
Policies for circular economy and resource efficiency.

CE policies	Horizontal – policy examples	Vertical - sector policy examples
Administrative & regulatory	• Targets – national or EU • Circular public procurement • Producer responsibility • Product standards for CE • Waste legislation	Manufacturing: • Recycled content mandates Construction: • Industry standards • Material passports
Economic & financial	• Tax shifting • Taxes on virgin raw material • Preferential taxes/subsidies on recycled materials • Differentiated VAT reduction on reuse, repair • Incineration taxes • Product taxes on hard-to-recycle products • Funding for investments or R&D • Investments and support in innovation, technology etc.	Mining: • Raw material policies • Primary material tax
Informative	• Info on product content • Certification schemes for secondary raw materials • Promotion of education & skills	
Support mechanisms and capacity building	• Take-back infrastructure for reuse, remanufacturing • Value chain interventions • Industrial symbiosis • Collaboration platforms • Funding and policies for R&D and innovation • Investments in collection and recycling • Incentives for secondary markets	Electronics: • Take-back systems for reuse

internalisation of costs – is non-feasible, green industrial policy provides an important policymaking toolbox, constituting the "second best" policy choice (Rodrik, 2014; Söderholm and Frishammar, 2018).

Another motivation for green IP is market creation. The market creation approach recognises the state's role as an active player in the innovation system, fundamental for expanding the knowledge base of the private sector and taking larger or long-term "entrepreneurial" risks to spur innovation, than private venture capital is capable of (Mazzucato, 2013).

A third motivation for green IP is the collective good character of development of new technological knowledge, since this has positive spillover effects in the form of knowledge or other benefits (Malhotra and Schmidt, 2020; Andersson et al., 2019). The high risks involved in investments in green alternatives (Söderholm and Frishammar, 2018), and the high costs involved in developing pioneering technologies (Naturvårdsverket, 2022) are barriers, motivating governmental intervention.

A fourth motivation for countries to pursue green IP is strengthening their domestic industry's global competitiveness, i.e., to create first-mover advantages, which can impact technological development in a direction closer to a country's comparative advantages (Rodrik, 2014).

While green IP provides opportunities, it also comes with a range of risks (Dutz and Pilat, 2014). Several risks relate to governments' informational deficit, relating to i.e., characteristics of market/system failures, extent of internalisation/externalisation etc. It is challenging for state actors to select appropriate sectors or industries for investment, i.e., "picking winners" (Rodrik, 2014). Policy failures include the creation of new lock-ins or path-dependencies, the supported technology not being internationally competitive, and the realisation of positive impact abroad (Rodrik, 2014). A second major risk is rent-seeking (Fischer, 2017; Rodrik, 2014), often a result of lobbying by special interest groups (Rodrik, 2014; Hess, 2014). Despite these risks, recent literature points a more positive picture of industrial policy interventions (Juhász et al., 2023).

2.3.1. Green Industrial policy taxonomy

Green industrial policies are usually based on a policy mix affecting different stages of technology development and sector growth, targeting both supply and demand. Main green industrial policy tools include state-aid subsidies; direct government participation; green public procurement, e.g. "domestic sourcing" requirements; targeted public investments, e.g. in infrastructure; innovation policies, such as cluster policies, testbeds, green R&D support (Altenburg and Assmann, 2017; Hallegatte et al., 2013). However, there is a risk of potentially distortive effects of some of these policy interventions both on domestic and international competition, and on international trade. For this reason, special implementation requirements are in place, for instance state-aid is governed by the laws of the EU and the World Trade Organisation (Andersson et al., 2021).

The main industrial policy taxonomy distinguishes between horizontal/vertical interventions, i.e., general policies or sectoral/technology-specific policies (Weiss, 2013). Tax credits for R&D are applied horizontally, rationalized by technology spillovers, while state venture-capital funds are vertical instruments, applied selectively and rationalized by risk-taking externalities (Weiss and Seric, 2021). In the literature, horizontal measures are often preferred, due to their technology-neutral and sector-neutral character, while specific needs and characteristics of individual sectors or technologies are addressed more selectively (Warwick, 2013). Industrial policy packages can also be characterised by policy objectives or type of intervention (Table 4).

Green IP is particularly complex to design. Challenges include high investment risks, navigating the twin dangers of market failure of supported technologies and sectors, and governance failure with unintended negative effects, such as rebound effects, misallocation of capital, or rent-seeking (Hallegatte et al., 2013; Dutz and Pilat, 2014).

The phasing-out of environmentally harmful industrial activities can be challenged by high capital investments and vested interests (Cosbey et al., 2017; Hess, 2014). Phasing-in of green technologies meet a variety of disincentives, such as competition from established actors and technologies benefitting from lock-ins and economies of scale, and path-dependent consumer behaviour (Never and Kemp, 2017). Sensitivity to socio-economic implications is also fundamental (Nilsson et al., 2021). It is necessary to get public buy-in, allowing gradual timelines for change and support measures for those negatively affected (Cosbey et al., 2017).

In the international context, the largest challenge is posed by international trade and state-aid policies (Nilsson et al., 2021). Green IP might be restricted by international trade law, and regulated through multi and bilateral agreements, including the EU and the WTO, prohibiting subsidies (Cosbey et al., 2017).

Table 4
Taxonomy frameworks for green industrial policy.

Taxonomy frameworks for green industrial policy		
Horizontal or vertical policies	Policy objectives	Type of policy intervention Supply-side measures:
• Horizontal, general policies • Vertical, sector specific policies (Weiss, 2013; Warwick, 2013)	• Directionality • Knowledge creation and innovation • Creating and reshaping markets • Building capacity for governance and change • International coherence • Sensitivity to socio-economic implications of phase-out (Nilsson et al., 2021)	• Innovation and technology infrastructure • Higher education and training • Production capacity and operations advancement • Long-term financial capital • Resource access • Infrastructure and network Demand-side measures: • Internal demand and public procurement • External demand and international market development (Andreoni, 2017)

2.3.2. Green industrial policy in Sweden and the EU

During the 20th century, IP was successively used as a tool for Sweden's industrialisation, support for declining sectors during the 1970's, and innovation (Nilsson et al., 2021). Today, green IP is an integral part of Sweden's climate policy (Swedish Energy Agency, 2022). There is no overall Swedish industrial strategy, but IP initiatives, instruments and measures are integrated within and across sectoral national and EU strategies, and programmes. Table 5 presents an overview of recent green IP initiatives in Sweden and the EU.

Swedish green IP is mainly implemented by national agencies (Tillväxtanalys, 2015), but funding is also distributed through EU programmes, such as the large European Innovation Fund (EIF) (Swedish Energy Agency, 2022). In practice, IP and R&D/innovation policies are tightly interwoven. Funding opportunities and subsidies vary widely. Swedish industry has been successful in attracting EIF grants for large scale projects (EC, 2022b; EC, 2023b; Swedish Energy Agency, 2022) while national programme funding is smaller. Public financing is also done via governmental venture capital, export credit, and green credit guarantees (EKN (Swedish Export Credit Agency), 2023; Riksgälden, 2021). The new Green Export Credit Guarantee offers up to 100 % risk cover if projects comply with the EU Taxonomy (EKN (Swedish Export Credit Agency), 2023).

Besides several green IP-related initiatives, supporting Member State industry (i.e. EC, 2023b, 2023c), EU governs the internal market competition policy, steering types of accepted Member State IP state aid. Successively, and particularly during the covid-19 pandemic, EU has allowed more and/or larger national state aid (EC, 2022a, 2023d, 2023e), and allowed state aid for CE objectives. Most of this state aid support has been focused towards sector specific measures. IP has recently become the subject of heated international debate, when China's long-term support for national industry and USA's extensive Inflation Reduction Act (White House, 2023; Stolton, 2023a; Kleimann et al., 2023) have triggered a policy response form the EU: the Green Deal Industrial Plan (EC, 2023a; Stolton, 2023b; Laurent, 2023).

2.4. Industrial policies for circular economy

While there is limited research on circular industrial policy, certain CE and resource efficiency literature studies cover IP instruments (Domenech and Bahn-Walkowiak, 2019; Milios, 2016; Milios, 2020). Some studies make specific policy proposals (Hartley et al., 2020; Ekvall et al., 2016), or analyse the relation between policy and CBMs (Wasserbaur et al., 2022). In some cases, green IP literature includes

Table 5
Recent large green IP initiatives.

Sweden	• Strategies for industrial climate transition (Naturvårdsverket, 2022; Tillväxtanalys, 2022) • Strategy for Green and Digital Transition (Swedish Government, 2022c) • Electrification strategy (Swedish Government, 2022d) • Proposal for a Swedish Strategy for the Bioeconomy (SOU, 2023)
European Union	• EU Green Deal (EC, 2019) • Fit-for-55-package (EC, 2021a) • Updated Industrial Strategy (EC, 2021b) • Green Deal Industrial Plan (EC, 2023a)

circularity aspects (i.e., Nilsson et al., 2021; Altenburg and Assmann, 2017).

For identifying current and potential policy instruments, circular industrial policy is defined – using as a starting point the Hallegatte et al. (2013) definition – as the combination of circular industrial *objectives* and policy *tools* with the aim to develop domestic industry; in this case supporting a domestic circular industrial transition.

There is no specific Swedish industrial policy with circularity as sole objective, but there are overlaps between industrial policy and CE policy, manifested as green industrial/innovation policy instruments including CE objectives or targeting CE, and reversely, several CE policies containing industrial or innovation policy elements. Many policies fall within the wider innovation policy landscape. Such policies are mainly addressing public procurement, differentiated Value Added Tax (VAT) (i.e., for repair), funding of CE-related projects by Swedish or EU programmes for industrial R&D, innovation, pilot projects etc. The Swedish Strategy for CE (Swedish Government, 2020) features a broad range of IP-type policies, but largely unspecific, and not formulated into concrete actions in the CE Action Plan (Swedish Government, 2021). Financial IP instruments are also increasingly including CE objectives: green credit guarantees (Riksgälden, 2021; Swedish Government, 2017), and green export credits (EKN (Swedish Export Credit Agency), 2023).

New industrial policy measures with the objective of supporting circular industrial transition are sometimes proposed in strategy or policy reports (Flack et al., 2023; Tillväxtanalys, 2023), and in public strategies or roadmaps, such as the Swedish Roadmap on sustainable Plastics (Swedish Government, 2022a). Such policy proposals are also developed in the industrial climate transition reports constituting the basis for the Swedish climate policy action plan (Tillväxtanalys, 2022; Naturvårdsverket, 2022), Fossil Free Sweden roadmaps (n.d.). They are also presented in the EU Green Deal (EC, 2019), which covers both industrial policy and CE, and in other EU policies (Hallquist and Vanacore, 2023). Since financing of investments plays an essential role in IP, reports on financing CE opportunities, circular business models or green industrial transition, often suggest financing of circular solutions through industrial policy type strategies or instruments (see e.g., Fossil Free Sweden, 2022; RISE, 2019; EMF, 2021). Such proposed policies mainly include:

- Funding via programmes – new technology, risk-sharing, pilot and demonstration projects, upscaling
- Financial instruments addressing CBM-specific problems, such as PaaS
- Differentiated VAT – addressing the pricing market failure of virgin raw materials being cheaper than recycled materials
- Circular public procurement, aiming for market creation
- Taxation instruments
- New institutions for CE financing – investment banks or investment funds
- New funding policies for market introduction phase
- Classification of resources/waste
- Knowledge and dissemination, including platforms
- Education and skills, including process and method development
- Value chain facilitation, including industrial symbiosis
- Collection systems and take-back infrastructure
- Testbeds and other innovation support infrastructure

A range of proposed industrial policies for CE, identified from the literature, are described in more detail in Annex S3, along with policy proposals from the interviews, to facilitate comparisons between research-based proposals and practitioners' suggestions.

3. Methodology

This contribution is an exploratory interview study, based on a context-specific case research approach. Since there is not sufficient research on industrial policy targeted specifically towards CE, an exploratory qualitative research approach is considered the most appropriate (Stebbins, 2001). While the topic of industrial policy for CE is a *little-known phenomenon* as such, its two constituent topic areas – green industrial policy and CE policy – are *better-known* and *partially known phenomena* respectively, enabling a complementary approach of the subject matter by synthesising knowledge from both research fields and exploring their interactions and cumulative effects.

Exploration starts in acquiring an understanding of the phenomenon, necessitating flexibility in data collection and open-mindedness about where to find them (Stebbins, 2001). As most policy research is problem-oriented and context-specific, it needs to be contextually sensitive (Clarke, 2007). Context is therefore a critical explanatory element (Maxwell, 2004), which is represented in this study by the Swedish policy landscape. Context-sensitive methods can increase the potential impact of policy research on actual policymaking (Clarke, 2007).

3.1. Conceptual framework

Adapted from Stebbins' (2001) model for using literature in exploratory research, an initial literature review was done to confirm whether indeed there is a limited extent of research on this research topic, namely "circular industrial policy". Using an open-ended and exploratory approach, literature closely related to the research topic was reviewed to provide background and better understanding of the subject for the analysis.

The literature covered three different areas: green industrial policy, circular economy policy, and policy design. Literature on the environmental impact of Swedish industry was also consulted. The identified literature would provide data on existing and potential industrial policies targeting CE and anchor the interview material in empirics and existing research through insights into related policy research areas.

Relevant literature databases were used to search for sources, including Web of Science and Scopus, with search phrases comprising combinations of (circular* OR circular econom*), industr* polic*, policy, polic*, manufactur*, sustainab*, green, climate, industripoliti*, grön, and klimat*. Besides this, literature on policy design was identified with combinations of the keywords policy design, policy making, public policy, and design*. Grey literature was identified through Google searches or on public governmental websites. In many cases, the snowball method provided relevant literature, through references in already identified literature.

The literature review facilitated the understanding of circular industrial policy through identifying its key features, key factors affecting circular transition, and key factors that influence policymaking, i.e., criteria for policy design. This understanding enabled the formulation and structure of the interview guide, and helped identifying relevant interview questions. The interview guide was based on an analytical (or conceptual) framework, in turn based on the literature review and focusing on the main policy instrument features, the main factors influencing policy design, and the main relationships and dynamics

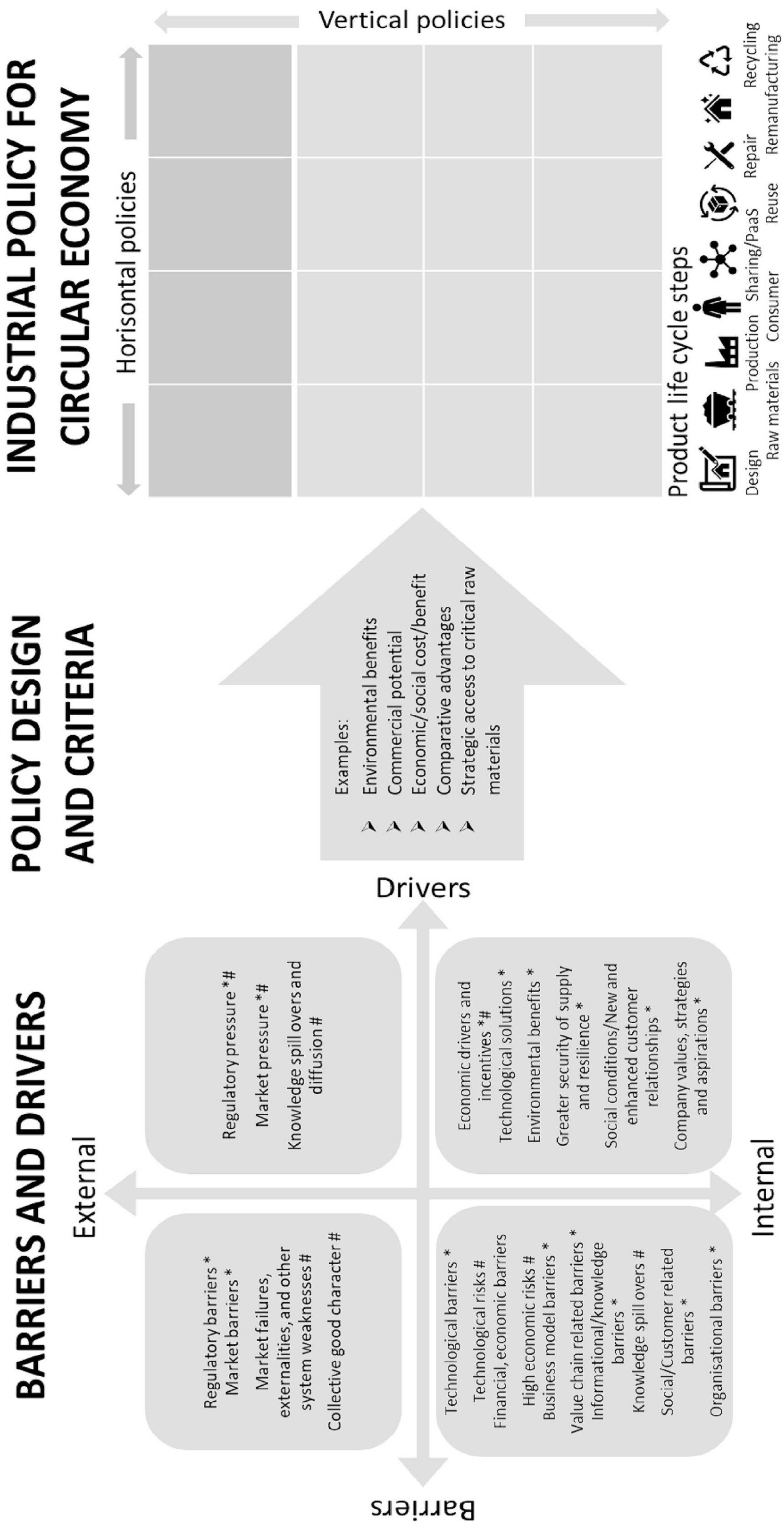

Fig. 2. The conceptual framework for analysis. Key barriers and drivers for circular industrial transition:
* Barriers and drivers, identified in CE literature; # Factors hampering and incentivising internalisation of environmental costs, identified in Industrial Policy literature; *# Barriers, drivers and factors identified in both CE and IP literature.

between these issues. The conceptual framework is presented in Fig. 2. It includes the inhibiting or driving factors for circular industrial transition and CBM – the matrix to the left. This matrix is conceived by combining the inhibiting and driving factors identified in CE policy literature and green IP literature. For this purpose, the matrix of internal and external barriers and drivers for CE (Section 2.1, Fig. 1) is used. The matrix was complemented with key factors hindering the internalisation of environmental costs, and factors driving/incentivising the greening of industry. Certain barriers and drivers could be identified in both the CE and green IP literature streams.

The identification of barriers and drivers is a prerequisite for policy design, with the objective of formulating circular industrial policies – the arrow pointing towards the policy matrix. Policy design is also guided by a set of criteria, such as environmental benefits, commercial potential, economic/social cost/benefit analysis, etc. Included here are key examples from the literature, presented already in Sections 2.1 and 2.3.

Further in the conceptual framework, a possible circular industrial policy consists of a policy package, including policy instruments of different policy types. It was essential to combine green IP and CE policy characteristics, while keeping the focus on broad or top-level issues, avoiding an overly complex framework. A policy matrix was designed based on the two main IP categories – horizontal and vertical IP instruments (Section 2.3). The policy matrix also needed to reflect CE policy categories, and several CE policy categories or targets could theoretically be chosen (i.e., horizontal/vertical, administrative/economic/informative/supportive policy). Since circular flows and life-cycle analysis is crucial and typical for CE policy, the product life cycle steps were introduced in the policy matrix, to identify relevant points of intervention for the intended policy package. Addressing the full product life cycle, and the circular flows value chain – including design phase, raw materials, production, use phase, sharing, reuse, repair, remanufacturing and recycling – will allow the intended policies to incentivise the main goal, i.e. circular industrial transition.

Following from this analytical framework, the interview guide was structured to reflect barriers, general policy questions, specific policy questions relating to horizontal/vertical dimension, life-cycle stages and points of intervention, and criteria for policy design.

3.2. Stakeholder interviews

The interview contributors were selected via a purposive sampling approach, because of their relevance to the research questions (Bryman, 2012). The 18 selected experts were identified based on their respective knowledge and experience of CE and resource efficiency policy, sustainable industry policy and practices, as well as representativity regarding sectoral and organisational belonging, to ensure insights from academia, politics, industry, industrial and other sector organisations, government administration and non-governmental organisation (NGOs). An additional criterion for selection was the interviewees' formal assignments in relevant committees and delegations.

The interviews were conducted in a semi-structured way (see Bryman, 2012) to provide significant space to reflect the competence and individual views of the respective expert. All interviews except one were conducted via web-conferencing software and were recorded for the most efficient and effective note-taking and attention of the interviewer, enhancing the interviewer-interviewee engagement. Depending on the level of engagement and depth of knowledge of each interviewee, the interviews lasted between 45 and 90 min. The list of interviewed experts can be found in Annex S1.

The interview answers were analysed and coded, considering the number of mentions and importance attached to each topic, while maintaining the exploratory, context-specific policy study methodology outlined earlier in this section. Certain responses were quantifiable, such as mentioning of barriers, naming of sectors, processes, and value chain steps, as well as yes/no questions. Most questions required both a quantitative analysis of number of mentions, and a qualitative, contextual analysis, weighing in the experience and the sectorial belonging of the interviewee, importance attributed to each topic, and the political context.

4. Results

In this section, the results of the interviews are presented following the structure of the interviews, facilitating the subsequent analysis in Section 5 using the conceptual framework developed for this study. Each sub-section outlines a distinct subject that came up in the interviews, and a summary of all the study results is presented in Table 7. The full interview guide is included in Annex S4.

4.1. Barriers and potential for circular industrial transition in Sweden

4.1.1. Barriers for circular transition and upscaling of circular business models in Swedish industry

The first question raised numerous answers from interviewees: there are many barriers to circular industrial transition, mainly stemming from market conditions or regulatory frameworks and the ensuing lack of incentives. The key identified barriers are presented in Table 6.

4.1.2. Sectors, processes and value chain steps with potential for circular business model development

Based on the interviews, there is potential for CBMs in most industry sectors, in all value chains and in most industrial processes. The design phase is the step in the value chain having the largest potential, due to its importance for the environmental impact of a product. Several respondents also pointed out the potential that could be achieved through public support to facilitate value chain flows, since logistical flows and interaction along the value chain are fundamental for circular production but generate barriers in the current system configuration. Another approach would be to steer efforts towards sectors where B2B collaboration along value chains is easy, such as mining. There is also large untapped potential in the Product as a Service (PaaS) shift, according to most respondents. The potential of digitalisation to improve production process efficiency is also raised. In terms of commercialisation stages, there is a need for support in the upscaling/"Valley of Death" phase, where there currently is a funding gap.

There is a large difference regarding the CBM potential in different CE material loops. While there is untapped circularity potential for all products in the outer CE loops, i.e., recycling, the CBM potential in the inner CE loops (i.e., repair, reuse, remanufacturing) is mainly relevant for long-lived or more valuable products and in product categories where technological change is slow.

Sectors with potential that were highlighted by the respondents include textiles and textile fibre recycling, ICT and small electronics, critical raw materials, and mining. Some refer to the recommendations of the Swedish CE Strategy (Swedish Government, 2020) and the Circularity Gap Report (Conde et al., 2022), adding the sectors food, construction and property, renewable and biobased materials, as well as those material flows with the highest emissions: steel, concrete, aluminium, and plastics.

Areas with limited circular potential are few. One respondent mentioned products with long lifespan, or produced with long-lived materials, while others saw these as highly circular. Depending on which targets are prioritised, business areas within security or health care can also have less circular potential. While a few respondents saw the potential in repairability, one respondent argued that repair policies are less useful, since policy efforts should be directed towards industrial processes with the largest potential environmental gains.

Table 6
Key identified barriers.

Barriers identified in the interviews	Importance of barrier (number of mentions and/or importance attributed by respondents)
Pricing of virgin raw materials compared to recycled. Virgin raw materials are cheaper than recycled, particularly steel and plastics.	Primary barrier Identified by almost all respondents
Linear economic logic of existing legislation, i.e. product guarantee legislation creating obstacles for remanufactured products; waste legislation, where classification as waste hinders use of secondary resources; accounting legislation negatively affecting PaaS companies, and other companies with specific financial flows.	Fundamental barrier Identified by many interviewees
Lack of knowledge and established CE definitions. Manifested as unclear benefits for industry or society, underused CPP, difficulties to market circular products, or low risk awareness.	Fundamental barrier Identified by many interviewees
Lack of economic policy instruments targeting CE.	Serious barrier Identified by several respondents
Lack of appropriate CE targets and indicators.	Serious barrier Identified by several respondents
Established internal business operations dominated by linear thinking, i.e. accounting and business systems, ICT systems, legal, insurance, rules, and regulations packages, all complicating the transition to circular operations.	Moderate barrier Identified by a few interviewees
Market conditions of global trade structure: low labour costs in production countries, and high labour costs in the countries where repair and remanufacturing take place.	Systemic barrier, relating to the overall economic system Identified by many interviewees
Circular transition and CE imply economic power structure shifts: changes to the landscape of economic actors and their relative positions in the marketplace, triggering resistance from established actors.	Systemic barrier, relating to the overall economic system Identified by several interviewees

4.2. Attitudes towards an industrial policy for circular industrial transition

4.2.1. Attitudes towards green industrial policy in Sweden

The general attitudes towards green industrial policy varied, with the main dividing line between industrial representatives and other interviewees. Most respondents were positive towards green IP in general, seeing it as an essential driver for green transition.

Some industry respondents have a sceptical approach to the type of governmental policy that IP represents, instead emphasizing free-market values such as competitiveness, fair competition and trade rules. A few respondents mentioned Sweden's historically good experience with and outcomes of IP, and one respondent underlined the importance of IP by pointing out the interconnections between IP, innovation policy and technology development policy. For others, IP has negative connotations, associated with 1970's IP subsidies, marked by high costs, meagre outcomes, and distorted competition. The complexity of IP policymaking is a general theme: *"Green IP can be positive, but it is not easy"*, a high-ranking official commented.

4.2.2. Need for a Swedish industrial policy for circular economy

The answers varied along similar lines. Eight respondents provided a clear yes, based on a range of motivations, such as importance for promotion of circular transition, limits to resources and emissions, need for policy upstream in value chains, the benefits in terms of environmental protection, employment and welfare, and the need to match the growing EU portfolio of CE and resource efficiency policies, climate policy, green IP, and green finance. At least three interviewees representing industry were however hesitant, and several respondents of varying backgrounds conditioned their reply to the eventual policy design. Among the respondents that were hesitant towards IP in general, several pointed out the scope and ambition of industry-driven green transformation as sufficient, making public policy unnecessary. Others regarded the Swedish CE policy as sufficient in the form of a policy framework, but several called for more clear governmental vision for circular transition. As alternatives to a new specific policy, interviewees suggested varying policy combinations within existing policy packages, to include CE and biodiversity into existing IP and climate policy frameworks and roadmaps, or to create a holistic green IP, merging climate and CE.

4.2.3. Positive and negative effects of a Swedish industrial policy for CE

Besides the policy benefits mentioned above, the interviewees discussed other positive effects of such a policy. The progressive environmental requirements and general green capabilities provide Swedish industry with competitive advantages. Or as one interviewee phrased it: *"It pays to be an early mover"*. Of course, early movers also contribute to international agenda setting. Sweden could also benefit from existing competitive advantages, such as competence in industrial cooperation, necessary for developing CE value chains. Other economic-wide benefits could follow, such as employment opportunities, new industries, and tax incomes. As a resource-rich country, the growing need for rare earth metals and biobased products is highly relevant – as pointed out by one respondent, Sweden is producing around 95 % of European steel, and has Europe's second largest area of managed forest. The development of CE policy also has standardisation effects and agenda-setting effects. The policy will also bring benefits if entailing a European and global outlook, but there are inherent risks if policies apply unilaterally to Sweden.

Some respondents did not see any negative effects or risks, but a few associated IP with high risks, notably risks for single-sided politics, for competition biases, for a "race-to-the-bottom" with state-aid, for regulatory capture, for failed technology prioritisations and for lock-in-effects, because of the "states cannot pick winners" problem. However, one of the respondents with considerable IP experience pointed out that a trial-and-error approach is necessary.

One interviewee underlined that green and circular transition per definition, in combination with the current fast economic development, leads to some companies being driven out of business. Other risks mentioned relate to the lack of CE knowledge, and the partly unclear objectives of CE, but also the complexity of CE as such. For instance, secondary materials are not per definition sustainable, neither should they be classified as such. *"Circular does not equal resource efficient"*, commented one respondent, while another noted that "*CE is promoted as a solution to something that is not well defined*".

4.3. Policy instruments, sectors, and value chains

4.3.1. Relevance of specific policy instruments

The most supported policy instruments, measured by number of mentions by the interviewees and/or the importance attached to a policy instrument, were the following: circular public procurement, green tax shifting, differentiated VAT, funding via programmes such as Circular Leap, and Industry Leap, R&D support, taxation supporting PaaS and product/service shifts, CE infrastructure development, and value chain interventions.

4.3.1.1. Taxation and VAT. Suggested policy instruments included green tax shifting, lower taxation/VAT on recycled materials and remanufactured products, in repair and sharing services, and the removal of VAT on second-hand goods. Tax shifting was the most supported economic policy overall. Taxation issues relating to the sharing economy and the product/service shift were raised by several interviewees, since servitisation and PaaS BMs have large impact on companies' income streams. Since product purchase costs in a PaaS BM initially far exceed incomes from subscriptions/renting, *"companies are turned into banks"*. The income streams problem can become an insurmountable financial burden for a new company, increasing risks for creating lock-ins in existing linear BMs and production and consumption systems. Designing taxation systems to cater for PaaS BMs is therefore an important policy.

4.3.1.2. Circular public procurement. Respondents generally found circular or green public procurement a very good instrument for promotion of circular transition. Public procurement support by competent authorities (e.g. the Procurement Agency) is considered essential.

4.3.1.3. Funding/state aid. State-aid and funding is the topic with most diverging views, but probably depending on which terms are used (see Section 5.1). Several respondents are sceptical to state-aid or condition their response to compliance with EU state-aid rules. On the other hand, all respondents call for strengthening of existing funding programmes, or creation of additional funding opportunities, for upscaling of new technology, for investment support etc. The Industry Leap programme in Sweden is appreciated, and a specific Circular Leap programme were also called for by some interviewees.

4.3.1.4. R&D support. This was a self-evident policy instrument to respondents. A specific recommendation was the support for process innovation, since most Swedish industry production features complex processes but little product differentiation, and due to the fact that much of the current policy framework tends to focus on product innovation. Testbeds were also called for.

4.3.1.5. Other economic instruments. Risk loans, credit guarantees, and other risk-sharing instruments were mentioned. Credit guarantees can support first-of-a-kind facilities.

4.3.1.6. Infrastructure and interventions along value chains. Several interviewees expressed need for infrastructure support such as electricity infrastructure or housing supporting large industry initiatives, but also logistical support for improvement of recycling processes. The interviewed experts within industrial manufacturing and processing stressed that the complexity of material flow management along the value chains is a problematic issue needing public support. Value networks need to be created, to allow the waste generated in one industry to become raw materials in another industry. The state has an important role to facilitate the interactions, collaboration, and logistics along the value chain, and support the development of material standards.

4.3.1.7. Legislative and administrative policies. While not IP per se, several administrative policies were mentioned, such as product regulation, standardisation, legislation for critical raw materials, quotas on recycled material content, and repair checks. A few regulations, though, have a hindering effect on growth in CE and their removal would be beneficial. Such regulations include the municipal waste monopoly in Sweden that hinders innovation, and waste classification rules which are hindering the use of secondary materials.

4.3.2. Policy design, sectoral focus and value chains

Both horizontal and vertical/sector-specific policy instruments are relevant. In general, interviewees want policies to be broad and open, but horizontal policies are not enough. Vertical/sector-specific policies are needed: in the words of one respondent *"to be effective, policy has to be adapted to products and value chains"*. Innovation often happens in new sectors, and sector-specific IP is important for technological development and upscaling.

Preferences for sectoral focus varied between interviewees. A few respondents would prioritize policies that steer support to sectors with the largest GHG emissions: steel, plastics, aluminium, concrete, and food. One respondent referred to the large amount of waste, which is characterising the food and construction industries, but also to the unsustainable practices in the fashion sector. Several respondents called for better recycling facilities, and support to scale up recycling capacity and technology. Particularly, textiles and plastics recycling need technological and logistical development as well as upscaling. One respondent identified a large potential in mining waste, considering the growing demand for rare-earth metals. Only one respondent mentioned the circular nutrient flows in the biological cycle, with the example of fertilizer in the agri-food sector.

Several respondents pointed to the importance of supporting new actors, such as SMEs. Specifically, there has to be state risk investments in the so-called "Valley of death" upscaling business phase, where there is currently a funding gap. One interviewee saw a risk that policy support for established industry sectors will be sub-efficient, and instead underlined the need to steer support towards the inner CE loops – using an example from the transportation sector: policy should support "mobility", and not "cars" – but lobbying from established industry can counteract such policy goals.

All interviewees were positive towards support for the development of new technologies. Several respondents discussed the appropriate level of specificity, pointing out that while technology-neutrality might seem desirable, it is not possible. Green industrial policy cannot be technology-neutral, since the green transition per definition implies technology shifts towards environmentally sound solutions, and green IP must therefore support these new technologies.

Regarding intervention points in the value chains, most respondents recommended focusing on policies upstream, since design and raw materials processing have the largest impact on a product's environmental footprint. Several respondents discussed the importance of well-functioning recycling systems to ensure the development of appropriate logistics and materials flows. Industry representatives underlined the need to increase quantities of high-quality recycled materials.

For policy-makers seeking to promote the inner CE loops, taxation and VAT are fundamental policies: in terms of green tax shifting, higher tax on virgin raw materials, and taxation and other economic and administrative policies to promote the product/service shift. This does not mean *"uncritically supporting all PaaS models"*, in the words of one respondent. Electrical scooters, for example, generate *"much waste and* *little benefits"*. Other suggested taxation policies that include reduced VAT on reuse and recycled materials, removal of the chemicals tax for reused electronics, and lower VAT on repair. However, the views on the benefits of repair policies are divided. In the Swedish context, reuse is seen as more profitable than remanufacturing which has higher labour costs and often need to be done at large scale with industrial remanufacturing process. Nevertheless, remanufacturing can hold great potential for long-lived products.

4.3.3. Size of public investments in CE

All the interviewed experts called for more extensive public investments in CE, and generally more public support for the circular industrial transition. One respondent commented that larger support is needed for CE market creation, where demand today is higher than supply. Another commented that funding has to be adapted for SMEs in terms of i.e., smaller co-funding requirements.

4.4. Criteria for circular industrial policy design

There was consensus among the interviewees that environmental impact is the main criteria for prioritizing industrial policy for CE, measured as environmental gains from a policy or negative environmental impact from an activity. The selection of environmental impact category depends on the policy objective, the time perspective, and the amount of potential environmental damage. Where environmental impact is the largest, legislation is a better instrument than IP. Industry actors generally prefer that policy implementation happens at the European or global level, not at the national level. Several other policy criteria were mentioned, besides environmental impact, including the following: alignment with EU frameworks; market driving or market creating effect; long-term effects and predictability; balance between environmental and socio-economic impacts; measurability and target-based; beneficial to Swedish industry; domestic comparative advantages; knowledge spillover; achievement of synergy effects; upscaling potential; inclusive of new actors, i.e. SMEs; preferably upstream interventions in the value chain; preconditions for new industries, i.e., infrastructure; security of supply chains; avoidance of dependence, particularly for critical raw materials; and high acceptability among stakeholders.

Regarding the determination of criteria for withdrawing IP support measures, all respondents expressed quite similar views. An IP measure should be terminated when either the supported company can securely maintain their operations without the respective measure, or when the business idea is proven not to be viable. Support should aim at stimulating transition, and be beneficial for society, and be continuously evaluated in terms of its efficiency and further need. Dependency on the support measures for a longer time than it is needed should be identified early and avoided.

4.5. Strategic implementation and policy mix

4.5.1. National CE targets

Regarding the need for national CE targets, the opinions of the interviewees was quite diverse. A CE expert noted that CE targets are probably needed, covering wider CE aspects than current national targets for recycling and waste management. But formulating CE targets is significantly more challenging than climate goals, because of the challenges in monitoring and evaluation, and the trade-offs between factors such as material efficiency, recycling and product life, which are resulting in target conflicts. The Finnish target for materials use was raised as a pioneering example. However, industry representatives were hesitant about setting national targets, preferring the introduction of joint EU minimum rules.

The need for CE statistics was also addressed. Data on materials, resource efficiency and CE-related activities are currently lacking, but indicators are currently being developed by the Swedish National Statistics (SCB), the EU and OECD. New type of data that would be required for measuring CE include statistics on product lifetime, utilization rate, remanufacturing, etc., but also on CE business models. However, the development of such data sets is very challenging, something that was emphasized by all the interviewees.

4.5.2. Coordination of CE industrial policy and other green industrial policy

Generally, all respondents underlined that closer coordination between climate, CE, and other environmental policies, such as biodiversity policy, is needed. Climate and CE are interconnected policy areas, and often joint policy initiatives are needed. Among the specific proposals highlighted by the interviewees are the inclusion of CE in the forthcoming national climate action plan, a national arena for stakeholder interactions, and setting up a public-private collaboration platform for CE, which could be modelled on the example of 'Fossil Free Sweden' with sector-specific roadmaps.

4.5.3. Policymaking trade-offs between opportunities and risks

Because of the complexities regarding definitions, scope, and measurability of CE policy, compared to i.e., climate mitigation policy, policy trade-offs caused by conflicting objectives have to be considered. There is a risk that one environmental policy measure causes negative environmental impact in another area, and circularity per se does not equal decreasing resource use. Many trade-offs can be solved with new technology, but improved technology can also reduce the necessary focus on LCA thinking and the importance of product design. The multitude of objectives, besides circularity, necessitates us to *"simultaneously bear more than one thought in mind"*, as one respondent phrased it. Potentially toxic substances in recycled materials is one such issue. On the one hand, conflicting objectives can occur between chemicals and waste legislation, because of the need to recycle and phase out dangerous substances at the same time. On the other hand, there is a risk that companies use non-toxicity as a pretext for non-action, and deprioritisation of CE. Arguments related to trade-offs vis-à-vis economic objectives such as standards of living and effects on consumers and industry also arise.

Another important issue identified was the need for alignment with EU strategies and regulations to avoid policy conflicts and to create policy synergies. Swedish state-aid must not conflict with EU state-aid regulations. EU is perceived as driving both CE policy and IP development fast forward, resulting in growing policy frameworks covering strategies, legislation, and new targets. Keeping up with, benefitting from, and ensuring coordination with, these EU developments was seen as essential.

Finally, the vagueness of the CE concept and the need for knowledge and capacity-building was deemed crucial. From an industry perspective, the identified lack of knowledge, as well as unclear benefits, was perceived as a particular barrier for the circular transition. Wider knowledge and clarity around the CE concept were also seen as prerequisites to allow marketing of circular products and services. Demands on current and future workforce highlighted the need to broaden university education on CE. From the government perspective, also public administrations need more knowledge on CE for developing policy support for circular industry. The lack of broader CE-relevant statistics

Table 7
Summary of interview findings.

Circular industrial transition - barriers and potential	
Barriers to circular industrial transition	• Incorrect pricing of virgin raw materials vs recycled materials • Linearity in economy, legislation, and internal business processes, hindering CBM diffusion and upscaling • Lack of targeted CE policies • Lack of knowledge on CE and diverging CE definitions
Potential for CBM	• Generally, there is potential for CBM in most industry sectors, in all steps in the value chains and in most industrial processes. • Largest potential in the design phase, and supporting value chain flows; in PaaS business models; in textiles, small electronics and critical raw materials sectors.

Industrial policy for CE – stakeholders' attitudes	
Attitudes towards green industrial policy	Mostly positive attitudes towards green IP, although industry representatives are more sceptical. Attitudes are marked by historical experiences of IP.
Need for Swedish Industrial Policy for Circular Economy	The majority believes that a specific Swedish industrial policy for CE is needed. Several are more hesitant, preferring existing CE policy, an industry-driven green transition, or policy combinations with existing policy packages. Consensus on the need for a clear governmental vision for circular industrial transition, and need for coordination of policy packages of CE policy, green IP, biodiversity policy, etc.
Positive effects	• Gains in environmental protection, employment, welfare and new industries • New competitive advantages, based on existing green capabilities • Benefits from existing competitive advantages, such as industrial cooperation • Early mover advantages • International agenda setting and standardisation effects • Benefits from resource-rich domestic economy
Negative effects	Most identified negative effects are connected to general IP risks, such as competition biases, a “race-to-the-bottom”, failed technologies and lock in effects. Also, secondary materials are not per definition sustainable.

Industrial Policy for CE – policy instruments, sectors, value chains	
Relevance of policy instruments	Most supported policy instruments: • Taxation and VAT, notably green tax shifting, differentiated VAT for circular products and services, and taxation supporting PaaS. • Circular Public Procurement • Funding for upscaling, investment support, R&D (but scepticism towards state-aid) • Other economic instruments, including credits and risk-sharing instruments. • Infrastructure support and support for value chain flows and value networks. • Removal of regulations hindering CE growth
Size of public investment in CE	More extensive public investments in CE are needed, through introducing or expanding policy instruments. New institutions are also proposed: • A public-private collaboration for sectoral roadmaps • A new funding programme: ‘Circular Leap’ • A national investment bank and/or investment fund
Horizontal or vertical policies	Both horizontal and vertical policies are needed. Policies should generally be open to all, but targeted sectoral-specific policies are necessary for technological development.
Sectoral focus	• Sector prioritisation can be based on i.e., level of GHG emissions, current levels of waste, or existence of particularly unsustainable practices. • Support for new technology is needed. • Ensure support for new actors/SMEs, and for “Valley of Death” business phase. • Ensure support for “inner CE loops”.
Value chain focus	• Upstream policy support needed: design and raw materials processing. • Need to support recycling systems • Need to support logistics and materials flows via value chain interventions.
Policies for “inner CE loops”	• Taxation and VAT should be used to promote reuse, repair, product/service shift. • Reuse has larger potential in Sweden than remanufacturing. Views of environmental gains from repair policies compared to other CE policies diverge.

Criteria for policy design	
Prioritisation and criteria for policy design	• Environmental impact is the main criterion for policy prioritisation. • Alignment with EU policy framework • Market creation effect • Long-term conditions • Measurability • Comparative advantages • Upscaling potential • Needs of new actors • Security of supply • Avoidance of dependence • Acceptability of policy
Criteria for termination of support measure	When the supported solution is economically viable on its own, or when business idea turns out not to be viable.

Strategy and policy mix

(continued on next page)

Table 7 (*continued*)

Strategy and policy mix	
Assessment of Sweden's CE Strategy	Varying opinions: many interviewees see the need for development of a National CE Strategy and Action Plan.
Need for national CE target	Varying views on need for national CE target(s). Opinions range from CE targets being necessary to a preference for common EU targets. There is a significant need for statistics and indicators on CE and RE. However, measurability is a challenge.
Coordination between policies	Closer coordination between climate, CE and other environmental policies is needed.
Trade-offs between opportunities and risks	• Most trade-offs arise from conflicting economic, social or environmental objectives. • Circularity in itself does not equal resource-efficient. • Certain trade-offs arise from potentially toxic materials, affecting recycling.
Alignment with EU frameworks	Alignment with EU strategies and regulations is needed to create policy synergies and to avoid policy conflicts.
Lack of knowledge on CE	• The CE concept is seen as vague, and knowledge is lacking. • Need for knowledge and capacity-building in industry and government. • Broaden university education on CE.

and indicators is tightly connected to this perceived lack of knowledge.

5. Discussion

In this section, the results of the interviews are discussed in relation to the literature and to current policy developments, followed by policy recommendations.

5.1. Existing policy instruments that relate to industrial policy for circular economy

Today, only a small number of actual policies could be identified as industrial policy for CE. Such policies are usually part of policy packages of green industrial policy, green innovation policy and CE policy, being mostly recycling-related. However, both literature and the interviews provide a multitude of policies which could function as industrial policy for CE. While the interview responses varied in terms of appropriate points of intervention in the value cycles, many brought up recycling. The reasons are probably manifold: current predominance of recycling in CE policy (Chioatto and Sospiro, 2023), the respondents' shifting backgrounds, and differing CE definitions (Kirchherr et al., 2023).

The tendency to define CE as recycling also explains the substantial attention gaps and policy gaps regarding other CE value cycles. Both the interviews and the literature confirmed the insufficient policy attention to the inner CE loops and the waste hierarchy prioritisation (Milios and Dalhammar, 2020). Therefore, there is untapped policy potential in support for CBMs such as PaaS, sharing economy, repair etc. (Mont et al., 2017). Other policy gaps with large potential are economic instruments, capacity-building, and education, developing infrastructure, and extended funding opportunities (Milios, 2021b).

While there are large policy gaps, the public debate currently sees a rapid increase of interest in circular industrial transition, and supporting policies, triggered by growing interest in CE policies in Sweden (Swedish Enterprise, 2022 and 2024; Flack et al., 2023), and a revival for green industrial policy (Naturvårdsverket, 2022). National CE policy is currently developing (i.e., Swedish Government, 2022a and 2024), and green industrial policy is driven forward by the climate transition in Sweden (Tillväxtanalys, 2022 and 2023; Fossil Free Sweden, 2022) and internationally (EC, 2023a; White House, 2023). Considering the urgency to move towards circularity and resource efficiency in the economy, the current upsurge in interest indicates that the time is ripe for developing policies to support circular industrial transition.

5.2. Policy instruments and industrial sectors for a Swedish circular industrial policy

The actual industrial policy landscape for CE is nearly blank, and this was reflected in the widely varying responses of the respondents and their level of specificity. The interviews provided many policy proposals, but sometimes these were relatively vague regarding the appropriate scope and design of specific policies for an industrial circular transition.

The respondents generally had extensive and detailed insights into barriers for circular transition, most of which could be confirmed by literature. The primary barrier was a classic market failure, i.e., incorrect pricing of virgin raw materials respective to recycled raw materials (Rodrik, 2014). Several of the barriers mentioned in the interviews are rarely on the political agenda, from logistical barriers to systemic barriers, and economic power shifts.

Not surprisingly, the key question – is there a need for a Swedish industrial policy for CE? - received varying replies, even though the majority replied yes. This was in line with responses being marked by diverging ideological views on IP, with higher scepticism observed among the private sector representatives. In contrast, there was a consensus on the need for larger public investments in CE. Interestingly, the current Swedish green IP falls under the green innovation policy umbrella.

The suggested policy type with the largest potential was economic and financial policies, mainly taxation and various subsidies, which is in line with the literature on IP instruments. The most supported taxation policy – green tax shifting – has been on the Swedish policy-makers agenda for a long time, but with little result (Henriksson, 2020). The same could apply to the most supported VAT policy, a differentiation on VAT rates, since, paradoxically, the only Swedish CE-specific VAT policy, the reduced VAT on repair, has been raised again (Swedish Government, 2022b), while a new VAT policy on used goods might be realised (Swedish Government, 2024). Considering these complications regarding taxation policymaking, it is important to notice the ongoing policy shift in both EU and the USA towards more IP subsidies (EC, 2023a; Stolton, 2023b; Laurent, 2023), indicating higher acceptability of this policy type (cf. Nilsson et al., 2021; Cosbey et al., 2017).

Several interviewees underlined the need for policy to promote comparative advantages of domestic industry. Several of the sectors mentioned – mining and critical raw materials, steel, clean-tech, forestry, and high-tech manufacturing – are also prioritised in relevant public strategies (Naturvårdsverket, 2022; Swedish Energy Agency, 2022). Likewise, the prioritised recycling sectors – mainly textiles, plastics, and ICT/electronics – are also reflected in existing policy (Swedish Government, 2021).

Lack of CE knowledge was a theme raised by several respondents. The low awareness about the “inner CE loops”, and the subsequent tendency to focus on recycling, is probably a result of this. The conceptual ambiguity of CE and the lack of required internal capabilities of firms to discern and act upon innovative circular solutions (Brändström et al., 2024) could turn into a competitive disadvantage (Falciola et al., 2020) within the trajectory of a potential CE transition. However, the adoption of circularity – and sustainability, broadly speaking – capabilities in firms requires an interdisciplinary approach (Fernandez de Arroyabe et al., 2021; Jerneck et al., 2011).

What can be concluded from this lack of knowledge? Firstly, that agenda-setting is needed. Political visions need to be clear, but also aligned with industry's needs. Secondly, there is a need to bring forward additional CE strategies besides recycling. Thirdly, more CE knowledge is needed overall: in industry, in government, within education, for statistics, etc. Fourthly, the CE concept needs to be clarified to facilitate marketing in circular industry.

5.3. Criteria for selecting circular industrial policy instruments

Consensus was observed on the primary policy criteria to be considered in the development of IP for CE: the environmental impacts of the targeted activity and the environmental benefits achievable by addressing the respective impacts. Even though there was no clear consensus on other criteria, the responses provided a relevant picture of factors to consider in policy design.

Surprisingly, policy support targeting the higher steps in the waste hierarchy only came up once in the interviews, mostly connected to the strong association of CE with recycling.

The need to design policies in alignment with EU law and policy, particularly trade and state-aid rules was a clear requirement from industry respondents. The EU Taxonomy (EC, 2023f) is considered particularly important, since transparent investment criteria will facilitate green industrial policy design and green investments. The explicit inclusion of CE in the Taxonomy is also important. While the large EU Innovation Fund primarily covers decarbonisation/climate-related projects, the EU Taxonomy might give an indication of a future where EU in forthcoming funding schemes will also finance more CE solutions.

CE policymaking is currently hindered by the relative lack of national and/or EU targets. The interviewees had varying views on the need for specific CE targets, but generally emphasized the need for alignment with EU targets and goals, also in the case of adding national CE targets to the Swedish national environmental targets system. The interviews also shed light on the need for CE-relevant indicators and data, ensuring that a new CE indicator framework is broad and goes beyond recycling.

5.4. Key elements of a Swedish industrial policy for a circular economy transition

To identify the key elements of a policy mix for a circular industrial transition in Sweden, it is important to consider a set of requirements stemming both from the identified barriers, drivers, and criteria for IP, resulting from the findings of the interview study, but also the need to shape a national policy in alignment with EU policies and coordinating with other environmental policies within the national framework. The latter would allow for mutually strengthening policy dynamics and avoiding conflicting policies (Milios, 2018; Wilts and O'Brien, 2019).

The main identified policy criterion was environmental impact, and fundamental motivations for IP were market failures (Rodrik, 2014) and market creation (Mazzucato, 2013). Feasibility of the suggested policies is also important, in terms of administrative conditions but also synergies, dynamics and complementarity with existing policies and strategies.

Feasibility also includes policy support and acceptance (Bicket and Vanner, 2016). This was emphasized by the respondents, as policy measures have better outcomes if enjoying high acceptability; but also in literature, since public buy-in and sensitivity to socio-economic implications is considered essential (Cosbey et al., 2017; Nilsson et al., 2021). There is increasing awareness that a transition to a CE must be "just and inclusive", signifying a process of socio-economic transformation grounded in the principles of social and environmental justice (Pianta and Lucchese, 2020; Purvis et al., 2023). In this respect, the diverging views of all the different stakeholder groups regarding a possible industrial policy for CE are necessary to consider.

Policy recommendations must also acknowledge upcoming EU and Swedish policy initiatives, such as new Swedish CE initiatives, including new economic policy instruments, and EU initiatives such as the Green Deal Industrial Plan, the Taxonomy, and the revised state aid framework. Maximising benefits from existing instruments is equally

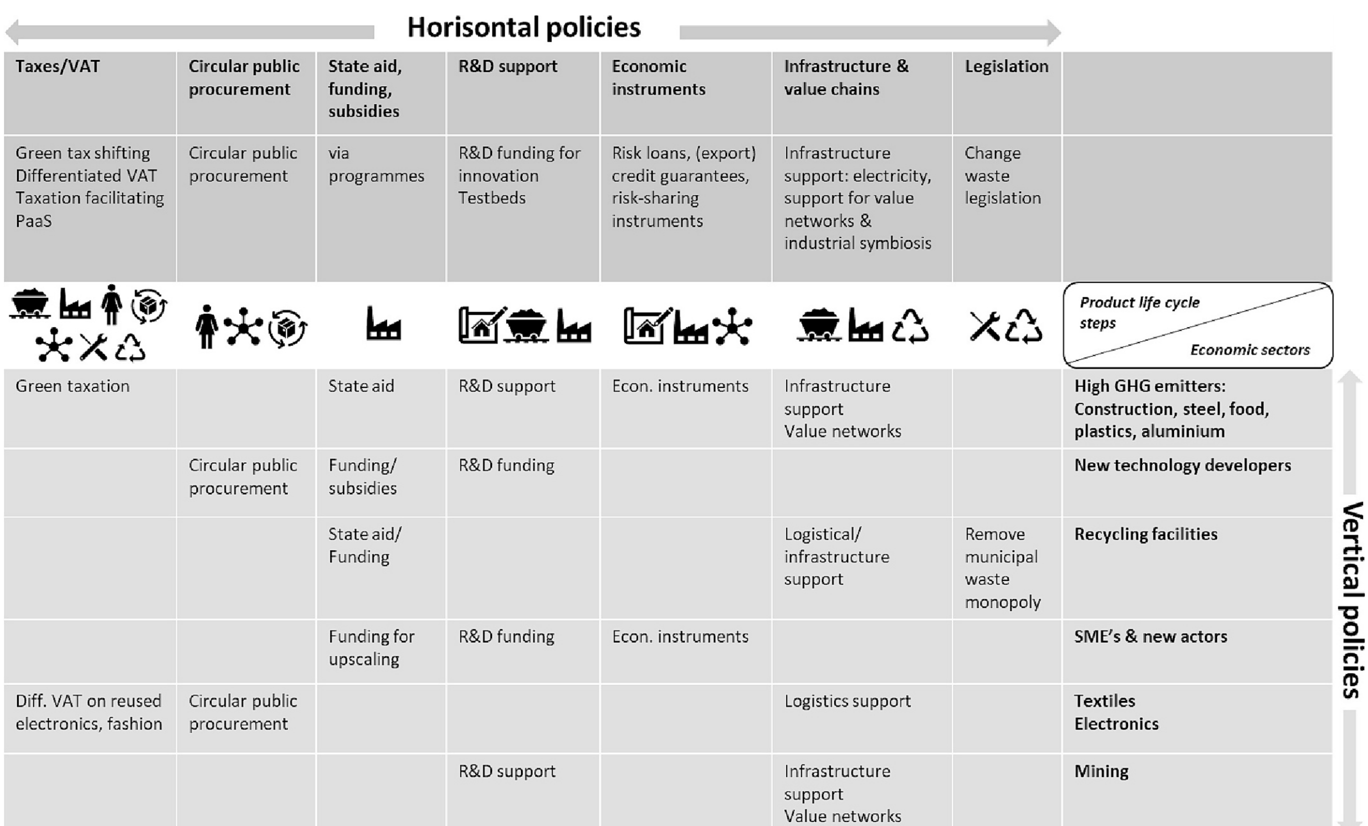

Fig. 3. A framework for circular industrial policy in Sweden.

important as creating new instruments.

In conclusion, the policy recommendations that are presented below are formulated based on the expert interviews, on potential impact in relation to status quo, feasibility, and acceptability, as well as connection to existing and forthcoming policies.

Policy recommendations
• Increase differentiation in VAT and taxation. Pricing is the most fundamental barrier, whether it concerns virgin raw materials vs. recycled, costs of new products vs. repair costs, etc. The largest potential outcome is providing the Swedish Governmental Committee on economic instruments a revised mandate, including taxation policies.
• Consider additional green tax shifting. Despite the political difficulties surrounding green tax shifting, it should be placed on the political agenda, because of the large potential impact, and the broad support among experts.
• Address the financial and legal barriers hindering companies from upscaling PaaS business models.
• Upscaling of funding is necessary as a driver of circular transition. Implementing this requires considering how impact is best achieved. Existing funding programmes should be expanded to clearly include CE objectives. New policy instruments or institutions, such as the proposed 'Circular Leap' programme in Sweden – a specific CE investment fund – is also needed for higher visibility and inspiration to encourage CBM uptake. The comparative advantages of Swedish industry should be taken into account, and funding must also be adapted to suit SMEs in terms of funding model and co-funding requirements.
• Set up a public-private collaboration modelled on 'Fossil Free Sweden'. This organisational model has proved successful in creating collaboration and momentum, resulting in concrete sectoral roadmaps, driven by industry.
• Develop policies targeting other CE resource loops than just recycling. CE logic underlines the importance of keeping as much value as possible for as long as possible. Since the existing CE policies are addressing mostly recycling, additional policies targeting reuse, sharing, repair and remanufacturing are needed.
• Encourage improved use of EU funding opportunities. Swedish companies have relatively low uptake of IPCEI funding opportunities, while they have been successful in attracting EIF funding (European Commission, 2022b, 2023b, 2023e; Swedish Energy Agency, 2022). Considering the speed and scope of EU development within green industrial policy, mobilisation for improved Swedish uptake is needed.
• Ensure knowledge and capacity-building within CE. This is needed both in industry and within public administration. Build up specific university CE education and strengthen CE-related curricula in relevant programmes.
• Develop the Swedish CE Strategy regarding ambition, scope, and milestones planning. The Finnish CE Strategy (Finnish Government, 2021) can serve as inspiration. Ensure coordination of CE policies with climate and biodiversity policies, including green industrial policies.
• Consider setting a specific national CE target, in alignment with EU policy frameworks. Develop appropriate indicators for measuring progress towards the set targets.

In Fig. 3, the results discussed above are presented against the conceptual framework that guided this research (Fig. 2) and illustrates the potential policy framework for a circular industrial policy in Sweden. The framework includes a wide array of both horizontal and vertical policy elements and indicates interventions at the different steps in products' life cycle. Fig. 3 represents the "policy matrix" element of the complete framework presented in Fig. 2, which has been complemented by the proposed circular industrial policies.

5.5. Limitations of the research

The research was affected directly by the lack of prior research on industrial policy for CE, thus necessitating an exploratory approach. The interviews and the analysis were affected by several basic characteristics of the studied policies – most notably the multitude of definitions of CE and the highly politicised character of industrial policy – which complicated the analysis of the results. However, these aspects are not necessarily drawbacks, because as Stebbins (2001) emphasizes, in exploratory research, it is essential not to lose the whole picture and the original ideas brought to light among detailed data, so keeping a relatively high level of abstraction fitted well with this approach. Importantly, the method of exploration develops across several studies, and not only within a specific study (Stebbins, 2001). Moreover, the study could have benefited from limiting the scope to one industry sector, while the current scope is broader. However, the introduction of IP targeting a specific sector only is quite unusual, so the broad perspective might be more appropriate, and produce results that are more useful to policymakers.

6. Conclusion

This study has contributed with initial and exploratory findings in a research field where there is little existing research, and in a policy field with few targeted existing policies. The research set out to investigate the policy interface of CE and industrial policy towards a targeted transition to a CE in Sweden.

Firstly, findings from the literature show that few existing policy instruments function as industrial policy for CE, but many additional instruments could potentially serve this objective.

Secondly, the findings from the conducted expert interviews indicate that further development of such public policies is needed, and give insights into specific policy needs, factors determining policy-design, and the choice of sectors and value chains for policies to target.

Thirdly, criteria for policy formulation should be based mainly on environmental impact, but also on potential competitive advantages, and close alignment with EU policies. However, the identified policy risks and ideological divergences require a careful policy design. Aligning national initiatives with EU policy developments can reduce such risks. This is exacerbated by the complexities and varying definitions of the CE and the ideological character of industrial policy.

Fourthly, key elements of a prospective circular industrial policy for Sweden are identified, and policy recommendations are formulated. The study concludes that a policy combination of new and expanded industrial policy instruments, focusing on correcting market failures, market creation, and capacity-building, along with development of a national CE Strategy, targets and indicators, can support the circular industrial transition. The policy mix should include instruments such as green tax shifting, differentiated VAT, Circular Public Procurement, funding schemes, but also an improved institutional framework. The recommendations were complemented by a policy framework for circular industrial policy in Sweden.

While the study focused on the Swedish context, many findings are likely to be generalizable for other OECD countries, particularly since many findings from the interviews are supported by existing literature. The findings address directly many relevant points of intervention for progressing towards the targets set by SDG 12, especially the sub-targets concerning the sustainable management and efficient use of natural resources (12.2), the reduction of waste through prevention, reuse and recycling strategies (12.5), and supporting companies to adopt sustainable and circular economy practices (12.6). Therefore, this study can actively contribute to the formulation of appropriate industrial policies promoting more sustainable consumption and production patterns.

However, as an exploratory study on a topic with limited prior research, the findings represent a context-specific policy framework. Further studies are needed to further develop understanding of the research field, and to provide more specific policy guidance to policymakers and further insights into effective policy mixes. This would be particularly relevant considering the current high interest and research activity within green IP development and the associated public debate in the EU and globally, but also the current development of CE policy.

Additional research topics that were brought to light during this study include choice of and design of environmental impact indicators as criteria for CE policy, improving understanding of how to better integrate circular industrial policy with climate/green industrial policy, and how to handle and avoid occurring trade-offs. It would also be relevant to examine how industrial policy should be designed to support CBM for the "inner CE loops", and more knowledge is needed on what types of changes to the current linear economic, regulatory and administrative systems would be the most appropriate to promote CBMs.

CRediT authorship contribution statement

Marianne Ekdahl: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Leonidas Milios:** Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Carl Dalhammar:** Writing – review & editing, Writing – original draft, Supervision, Methodology.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT in order to translate the interview guide from Swedish to English. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Declaration of competing interest

The authors declare no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.spc.2024.03.031:

S1: Interviewed experts S2: Barriers to Circular Transition S3: Proposed industrial policies targeting Circular Economy S4: Interview guide.

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