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On the Right Path to Circularity or Running Around in Circles? A Fresh Perspective on Circular Business Model Barriers

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ABSTRACT

The literature on circular business models (CBMs) has generated barrier categories and taxonomies but provides an incomplete understanding of how firms develop and scale CBMs in practice. We challenge prior literature by relating barriers directly to the CBM dimensions of value creation, value delivery, and value capture. Following this approach, we analyze the Swedish manufacturing industry using qualitative content analysis and arrive at three key contributions. First, there is a distinct set of barriers affecting value creation, value delivery, and value capture. Second, the barriers are underpinned by a unique set of problems, many of which are nondecomposable. Third, most barriers inhibit the scaling of CBMs rather than their initial development. Altogether, this has major implications for understanding the nature of CBMs, productively addressing CBM barriers and problems, and scaling CBMs. We conceptualize these insights into a framework with implications for both the CBM literature and for managers innovating CBMs.

1 | Introduction

Large industrial firms are increasingly attempting to operationalize circular economy (CE) principles using circular business models (CBMs). However, numerous barriers are inhibiting them from developing and scaling such business models. In academic journals, an intense debate is taking place on how best to surmount such barriers and accelerate the transition to the CE (Bocken et al. 2023; Palmié et al. 2023). From a practical standpoint, the European Union (Environmental Protection Agency 2024), the United States and China (ETC CE Report 2022; National People's Congress 2008), intergovernmental organizations and NGOs (EMF n.d.), and industrial firms, such as ABB, Scania, Volvo, and Ericsson (KTH 2023), are exploring and engaging in policies, frameworks, and strategies to accelerate this circular transition.

Various academic studies allude to firms' slow pace in moving to CBMs due to diverse barriers (Frishammar and Parida 2021; Urbinati et al. 2021). We define a barrier as an obstacle, challenge, or hindrance that impedes the successful development and scaling of a CBM (Chhimwal et al. 2022; Milios 2021). The current dominant conceptualization of CBM barriers involves broad categories, such as regulatory, technological, cultural, market, and organizational barriers (De Angelis 2022) or similar categories (Assmann et al. 2023; Försterling et al. 2023). Each category has specific barriers. For example, a "low management risk appetite" is subsumed under the organizational barrier category (Geissdoerfer et al. 2022; Urbinati et al. 2021). Although helpful on a holistic level, the current barrier categorization lacks detail on how its barriers relate to and influence the underlying CBM dimensions,namely value creation, delivery, and capture (Teece 2010).

Despite many efforts to illuminate CBM barriers, firms still find it highly challenging to successfully develop and scale such business models in practice (Frishammar and Parida 2019; De Angelis 2022).Scaling CBMs beyond initial piloting with lead customers is important to ensure the financial incentives and revenue streams necessary to realize circular businesses (Linde et al. 2021). However, many attempts at CBMs remain embryonic and experimental (Frishammar and Parida 2019). Few (if any) incumbent industrial firms are known to have successfully replaced their linear business model with a scaled CBM. In the industrial business-to-business manufacturing sector, firms operate linear business models dominated by-product sales (Brown et al. 2019), have strong lock-in relations with existing customers and value chains (Brown et al. 2019), and face various managerial challenges in going circular or sustainable (Mossberg et al. 2020). Overcoming these CBM barriers is of particular interest to this study given the major environmental impact of emissions and waste generation from industrial activities (see e.g., Aarikka-Stenroos et al. 2022; Kaipainen et al. 2023).

The slowness in scaling CBMs calls for addressing barriers systematically (Urbinati et al. 2021) to overcome potential capability deficiencies in industrial firms and/or an unwillingness to change their business approach (De Angelis 2022). Yet, we argue that existing research on CBM barriers has currently failed to strengthen our understanding of what it takes to develop and scale CBMs, requiring us to revisit the assumptions underpinning the nature of CBM barriers and where they reside. Developing and scaling CBMs entails significant changes to the way a firm creates, delivers, and captures value (Frishammar and Parida 2019; Okorie et al. 2021). Consequently, we need new knowledge on the unique barriers directly tied to the different dimensions of CBMs.

Therefore, this study's purpose is to analyze whether and how CBM barriers can be tied to the three dimensions of a CBM—namely, value creation, value capture, and value delivery. To unpack CBM barriers that are unique to these dimensions, we define a CBM as a business model in which a focal firm and its partners use innovation to create, capture, and deliver value. Here, the aim is to improve resource efficiency by extending the lifespan of products and parts, thereby realizing environmental, social, and economic benefits (Frishammar and Parida 2019). CBMs are prone to diverse barriers because they introduce a radically different business logic that is needed to extend resource loops through improved maintenance, repairs, and refurbishment (Kühl et al. 2022).

Our study provides an analysis of CBM barriers in industrial firms and the problems underpinning them in the context of a single country, Sweden, from 2012 to 2024 inclusive. We used qualitative content analysis of both the academic and the gray literature covering 102 publications, complemented with practical examples from Swedish industry using secondary data. This method has recently gained traction for single-country CE studies (Johansson and Henriksson 2020; Niskanen et al. 2020; Tiscini et al. 2022).

The paper is organized as follows. First, we provide a frame of reference by exploring the concept of CBM and reviewing the previous literature on CBM barriers. We then explain the methods and data analysis. Section 4 provides the results and identifies CBM barriers and their underlying problems. In Section 5, we discuss our findings and provide a framework for dealing with barriers in developing and scaling CBMs. We conclude by outlining the implications for the CBM literature and for managers.

2 | Theoretical Framework

2.1 | What Is a CBM?

There are different conceptualizations of a CBM in the literature (Bocken et al. 2023; Lüdeke-Freund et al. 2019). We draw on the definition proposed by Frishammar and Parida (2019, 6), in which a CBM has three dimensions. First, *circular value creation* centers on the unique circular offering (product and service) (Hansen and Revellio 2020) to customers (or, in barrier terms, what prohibits such offerings from materializing) (Hultberg and Pal 2021). CBM offerings can, therefore, be engineered to slow down, close, or narrow resource flows for an improved sustainability value. For instance, ABB's ABB Ability solution contributes to circular value creation by optimizing grid stabilization and renewable energy integration, thereby reducing carbon emissions and improving grid reliability (ABB Ability n.d.).

In this aspect, value proposition is conceptualized as a part of value creation (Kowalkowski et al. 2012). A value proposition is a promise made by firms to their target groups, addressing customer needs and desires by offering products and services that deliver specific benefits (Freudenreich et al. 2020). It thus encompasses the practices and structures used to create value (Wruk et al. 2019). Value propositions also play a crucial role in co-creating value between stakeholders, aligning their interests, fostering collaboration, and ensuring that the created value is relevant and meaningful in context (Frow and Payne 2011), including in the CE (Sairanen et al. 2024).

Second, *circular value delivery* entails introducing operational processes and activities to deliver the promised value to customers (Reim et al. 2016; Saarinen and Aarikka-Stenroos 2023). To deliver circular offerings, large industrial firms often need to develop new internal capabilities or establish strategic partnerships with their surrounding ecosystem actors (Bertassini et al. 2021; Kaipainen and Aarikka-Stenroos 2022). This shift often involves a transition from product-centric to service-centric business models, emphasizing recurring revenue flows (Frishammar and Parida 2019; Kanzari et al. 2022).

Third, *circular value capture* aims to maximize the economic, environmental, and social benefits from resources, products, and materials when implementing a CBM (Reim et al. 2020) by introducing novel revenue models and cost structures to ensure financial viability (Bertassini et al. 2021). For instance, ABB captures value from its ABB Ability solution through subscription-based services, where customers pay subscription fees for access to advanced grid management features and ongoing support, enabling ABB to generate recurring revenue while continually improving the solution (ABB Ability n.d.).

The core idea of a CBM is resource efficiency—namely, minimizing input resources, waste, emissions, and energy usage by slowing, closing, or narrowing resource flows (Geissdoerfer et al. 2020). This has profound implications for how firms create, deliver, and capture value. Moreover, industrial firms seldom pursue value creation, delivery, and capture without partners (Frishammar and Parida 2021). CBMs often require collaboration by a group of firms in a network (Averina et al. 2022). Unlike traditional business models that strive primarily for economic results, CBMs have various goals, with the environmental complementing the purely economic (Lüdeke-Freund et al. 2019).

Finally, innovating value creation, delivery, and capture dimensions to become increasingly circular has been described as an experimental process, characterized by trial and error and upscaling with one customer at a time (Frishammar and Parida 2019). Here, it is crucial to align the three business model dimensions as the scaling process unfolds (Reim et al. 2021). With these characteristics in mind, it is not surprising that CBM development and scaling are difficult in practice. It requires not only a fundamental change in a focal firm's business logic but also external collaboration with other organizations (Santa-Maria et al. 2022). Given this background, it is unsurprising that CBM barriers are many and strong.

2.2 | Barriers to CBMs in the Previous Literature

In the CBM literature, there has been important conceptual and empirical progress in identifying diverse barriers (Assmann et al. 2023). These barriers are often divided into internal and external barriers, which may in practice partly overlap—namely, barriers inside a focal firm and those residing in the external environment (Försterling et al. 2023; Galvão et al. 2022; Hina et al. 2022).

Internally, firms are challenged with technological barriers, such as technical know-how (Kühl et al. 2022), and organizational barriers that include strategies and policies and lack of resources (Guldmann and Huulgaard 2020). Externally, barriers extend beyond individual firms into collaboration barriers—for example, in the value chain of a focal firm (Geissdoerfer et al. 2022) or with ecosystem partners (Aarikka-Stenroos et al. 2022; Kaipainen et al. 2023). Furthermore, firms are prone to market, cultural, and regulatory barriers that shape their external environment (e.g., Shao et al. 2023; Tan et al. 2022) and may interfere with CBM design and scaling. Examples include consumer resistance to novelty (Guldmann and Huulgaard 2020), unfavorable tax levels (Awana et al. 2024) and lack of clarity over what counts as waste or by-products (Kühl et al. 2022). Table 1 illuminates these key CBM barrier categories consisting of technological, organizational, collaboration, market, cultural, and regulatory barriers (e.g., Assmann et al. 2023).

Barriers to CBM in the previous literature are diverse (Tura et al. 2019). That said, "... few companies seem to face definitive barriers" (Galvão et al. 2022, 1520)—in other words, most barriers seem possible to address one way or another. Moreover, it appears that the severity of barriers varies according to the type of CBM in question (Vermunt et al. 2019), depending on (i) the type of firm (Guldmann and Huulgaard 2020), (ii) what circular principles are applied (Försterling et al. 2023; Kühl et al. 2022), and (iii) whether the CBM is designed as a novel startup in an incumbent alongside other business models or transforming existing ones, or through acquisitions (Geissdoerfer et al. 2022).

However, no prior studies have, to our knowledge, examined the barriers in direct relation to the three dimensions of the CBM despite numerous prior literature reviews (Hina et al. 2022; Tan et al. 2022) and case studies (Awana et al. 2024; Geissdoerfer et al. 2022; Guldmann and Huulgard 2020). The studies closest to directly identifying barriers per CBM dimension have linked them to the business model canvas (Asgari and Asgari 2021) or explored the pivotal role of financial barriers focused on the close connection with the value-capture dimension alone (Saarinen and Aarikka-Stenroos 2023).

Finally, the barriers or barrier categories can prohibit both the initial development of a CBM and its subsequent scaling (Awana et al. 2024). By scaling, we mean the gradual replacement of a traditional linear business model (such as resource-intensive product sales) with an emerging circular business model (providing advanced services that are more resource efficient) (Hultberg and Pal 2021). Thus, we view scaling as a process where the result is growth (Jansen et al. 2023)—in our case, the growth of CBMs. Drawing on the broader scaling literature, this means adding customers, capacity, and capability (O'Reilly and Binns 2019); spreading pockets of excellence (Shepherd and Patzelt 2022); or replicating successful business model attempts across markets (Reuben et al. 2021). However, while the prior CBM literature mentions the need for scaling (Hultberg and Pal 2021; Ingemarsdotter et al. 2021), it is still largely uninformed about which barriers affect what—the initial development of a CBM or its subsequent scaling.

3 | Methods

3.1 | Research Approach

To analyze CBMs in Swedish manufacturing industries, we relied on qualitative content analysis (Mayring 2014). This method analyzes texts in their context, adheres to content analytical rules and step-by-step analysis (Faria-Schützer et al. 2021), and has been used in recent CE studies in a single-country context (Johansson and Henriksson 2020; Niskanen et al. 2020; Tiscini et al. 2022). Our study traces the literature from May 2024 back to 2012 when the "circular economy" gained traction in the Swedish press (The Circularity Gap Report 2022). Because Sweden has been among the first countries to build awareness and set national goals for eco/CE pathways (Johansson and Henriksson 2020), we focused on Swedish industrial firms whose decade-long CBM implementation enabled us to identify the barriers associated with the development and scaling of CBMs.

TABLE 1 | CBM barrier categories with illustrative examples.

CBM barrier category	Specific barrier examples	Selected authors
Technological barriers	• Technology transfer • Speed of technological change • Lack of appropriate technology to facilitate circular principles	Assmann et al. (2023); Guldmann and Huulgaard (2020); Kühl et al. (2022)
Organizational barriers	• Firm strategies and policies • Financial challenges and difficulties obtaining investments • Operations and processing • Circular economy skill deficiencies • Difficulties in scalability and product design • Lack of specific resources • Organizational linear lock-in • Risk of product sales cannibalization • Risk aversion by business leaders	Assmann et al. (2023); Awana et al. (2024); Försterling et al. (2023); Geissdoerfer et al. (2022); Guldmann and Huulgaard (2020); Hina et al. (2022); Kühl et al. (2022); Saarinen and Aarikka-Stenroos (2023); Tan et al. (2022)
Collaboration barriers	• Deficient collaboration with suppliers, partners, customers, competitors, and local community • Outdated value chains and networks • Limited access to critical materials • Access to financial markets • Information sharing and clarity of communication	Agarwal et al. (2023), Awana et al. (2024); Försterling et al. (2023); Geissdoerfer et al. (2022); Saarinen and Aarikka-Stenroos (2023); Assmann et al. (2023)
Market barriers	• Market conditions, dynamics, uncertainties, guidelines, and certifications • Market demand, underpinned by customer acceptance and behavior • Infrastructure, including complex shipping proximity and costly logistics	Assmann et al. (2023); Guldmann and Huulgaard (2020); Tan et al. (2022)
Cultural barriers	• Societal, social, and ecological considerations in intervening circular designs	Assmann et al. (2023); Försterling et al. (2023); Guldmann and Huulgaard (2020); Hina et al. (2022); Kühl et al. (2022); Shao et al. (2023)
Regulatory barriers	• Unfavorable tax levies and policies • Legislative hindrances, such as policies designed by bureaucratic and noncooperative government • Lack of clarify over waste, by-product, and resource status	Awana et al. (2024); Geissdoerfer et al. (2022);Hina et al. (2022); Kühl et al. (2022); Ranta et al. (2018)

Although the CBM is drawn from domain theory whose underlying knowledge we seek to uncover, a *method theory* was also mobilized in our analysis. Method theory is a theoretical lens derived from a field other than domain theory, offering a vocabulary and syntax to gain new insights (Lukka and Vinnari 2014). We use the literature on problem solving (Nickerson and Zenger 2004; Nickerson et al. 2012) as the method theory. By positioning "problems" as the key unit of analysis, this literature provides our analysis with valuable support in three respects. First, it enables us to identify and code the unique problems underpinning each CBM barrier. Specifically, the problem-solving literature contends that firms simply cannot choose which new knowledge to acquire or create (Nickerson and Zenger 2004)—for example, to address a certain CBM barrier. Instead, firms should focus on problems that are *valuable*—that is, problems that can yield knowledge or capability if solved, where "solving" often takes place in collaboration with customers or suppliers (Nickerson et al. 2012). This is consistent with the fact that problem solving in CBMs often cuts across firm boundaries (Frishammar and Parida 2019, 2021). Second, it enables analyzing the specific nature of problems—whether highly complex or more easily solved by making a principal distinction between low-complexity (decomposable) and high-complexity (nondecomposable) problems. This distinction sheds light on how best to address problems underpinning CBM barriers, given their specific nature. Third, by focusing directly on solving valuable problems to improve firms' value creation and value capture (Nickerson et al. 2012), employing problem solving as our method theory provides a theoretical justification for analyzing barriers from the perspective of the three CBM dimensions—value creation, delivery, and capture.

3.2 | Data Collection

We began with a search on "circular business model" and "Sweden" in the titles, abstracts, and keywords of academic publications using the Scopus database. Figure 1 outlines the

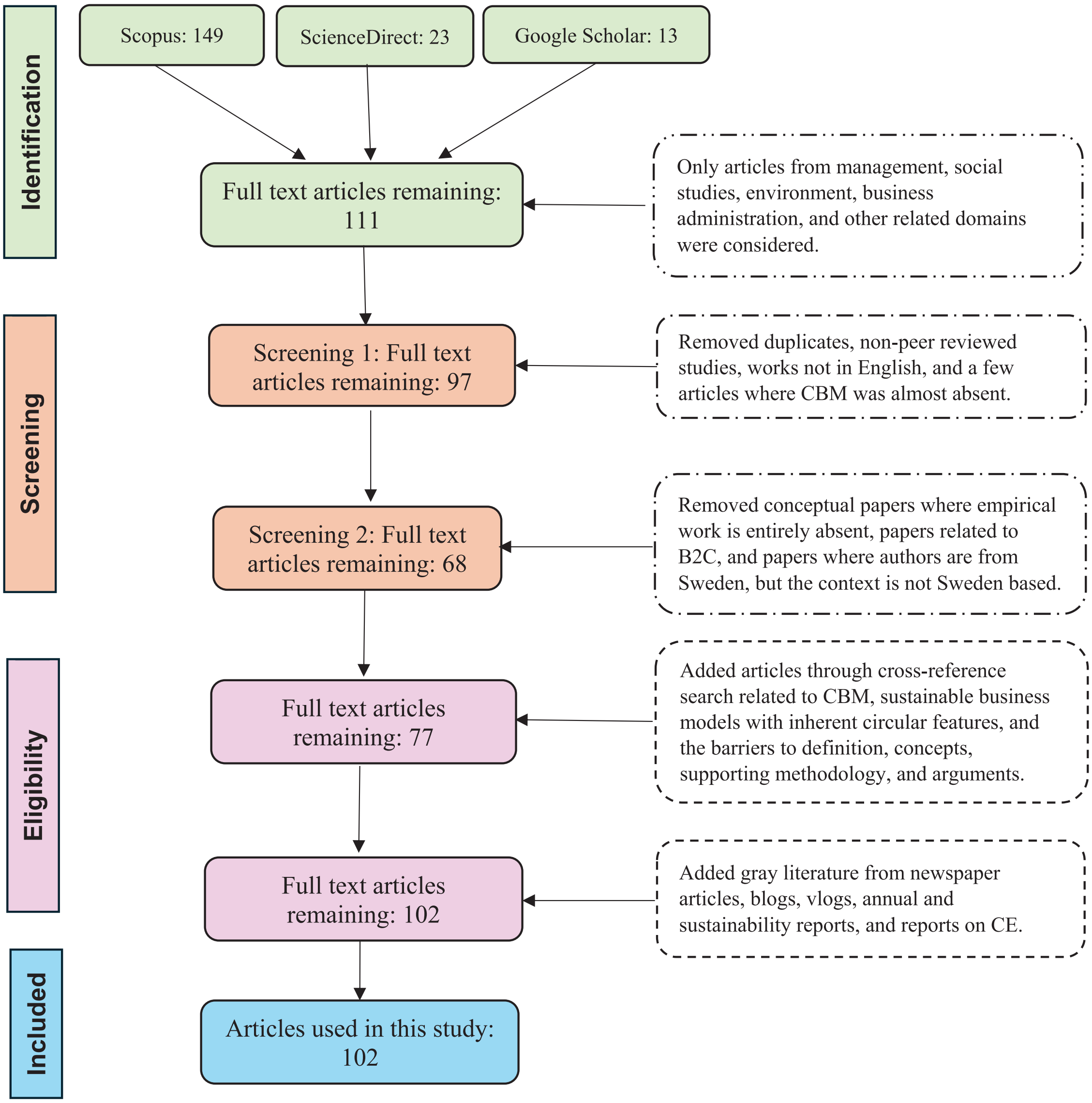

FIGURE 1 | The literature search and refinement process.

entire literature search and selection process. The first search yielded 185 articles. After excluding peripheral domains, such as earth science, material science, agriculture, medicine, fundamental science, and related domains, the number was reduced to 111. Subsequent screening removed articles not in English and those lacking a clear focus on CBM, leaving 97 articles. In addition, articles centered on business-to-consumer settings, conceptual papers lacking empirical analysis, and articles from Swedish authors but without Sweden as a research context were excluded, reducing the total to 68 articles. Next, nine articles pertinent to CBMs, sometimes framed as sustainable business models that manifested inherently circular strategies and their barriers, were identified using a cross-reference search (Geissdoerfer et al. 2020). We also included 25 publications from the gray literature, such as annual reports, sustainability reports, magazines, and newspaper articles addressing the challenges faced by Swedish industrial firms in developing and scaling CBMs. We mostly focused on Swedish industrial firms (SNI/SIC-codes 07-32) when seeking relevant examples (Ny Teknik 2020).

After carefully reviewing the academic literature and making a preliminary identification of underlying problems, we extracted keywords from these problems and used them to search for gray literature (Adams et al. 2017). We applied three screening criteria to ensure the relevance and reliability of the gray literature sources. First, we assessed the credibility of the sources, prioritizing those from reliable sources, such as the European Union, company annual reports, and established news portals, over personal interpretations from blogs, for example (Zhang et al. 2021). These documents are often compiled with oversight, vetted through stakeholder involvement, and validated by external auditors. Second, when multiple reliable sources covered essential points, we either included all of them or chose a single source that comprehensively addressed the relevant issues. For instance, two references from the gray literature addressed the failure to strengthen the feedback mechanism for customer input on the revenue model. Third, if multiple sources met the first two criteria, we selected the preference most favored by the authors, based on their judgment or subject matter expertise. This resulted in a total of 102 articles to underpin the analysis.

3.3 | Data Analysis

Our data analysis employed qualitative content analysis for category development over three phases (Mayring 2015). We followed a process of multiple iterations to obtain distinctions and similarities among first-order codes, second-order categories, and aggregate dimensions (Suleiman and Othman 2021; Gioia et al. 2013; see the coding structure in Figure 2). Researchers independently developed the coding tree to enhance the rigor and confidence in coding and analysis. Any disagreements were collaboratively resolved, ensuring both formative and summative reliability checks (Wei 2015; Mayring 2015) as a means to achieve researcher triangulation (Flick 2004).

At the initial stage, we analyzed the materials and created first-order codes depicting underlying problems faced by Swedish industrial firms regarding CBMs. Customer hesitancy in accepting circular offerings constitutes such a problem. Our analysis revealed 21 unique problems, guided by the problem-solving literature (Nickerson and Zenger 2004; Nickerson et al. 2012). The analysis rests primarily on the academic literature on CBMs. However, this literature often lacks the practical insights and problem examples that firms face during CBM implementation. The gray literature fills this gap by providing detailed, real-world examples (Simsek et al. 2023). Consistent with the method theory adopted, it also helped differentiate between low-complexity and high-complexity problems by examining the challenges that

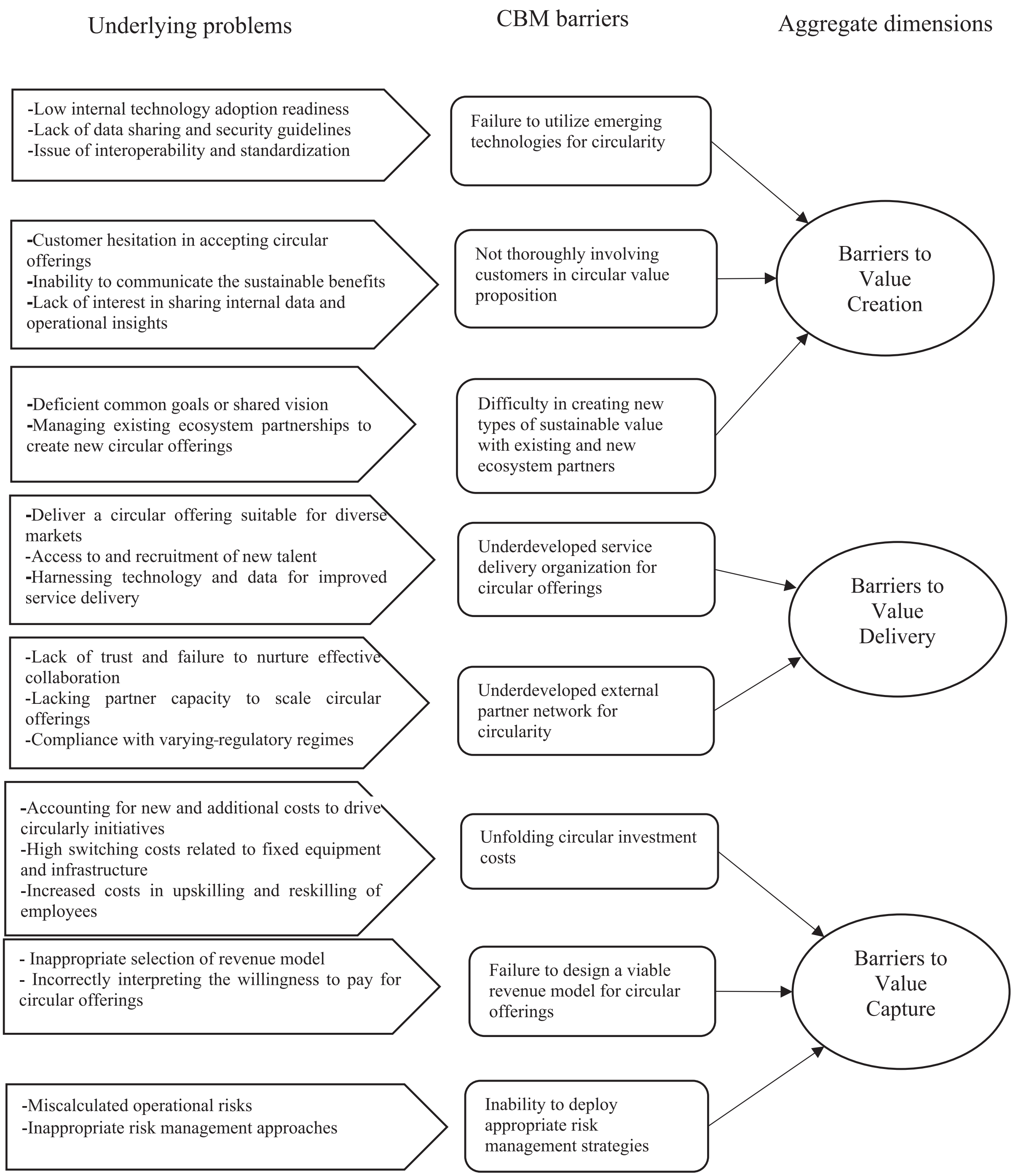

FIGURE 2 | Coding structure.

industrial firms encounter (Garousi et al. 2019). Additionally, the gray literature helped to determine the appropriate CBM barriers (i.e., the second-order categories) and, in turn, the business model dimension (i.e., the aggregate dimensions) for each problem by analyzing its origin and impact and considering potential overlaps between dimensions. During this phase, we engaged in an iterative process of refining the pre-existing underlying problem labels to ensure maximum coverage (Kumara et al. 2021), ultimately leading to the inclusion of 25 gray literature sources for 21 underlying problems.

In the second phase, we identified relationships and patterns among the set of problems. We aggregated the first-order codes so that similar problems were composed as a CBM barrier. For example, a failure to design a viable revenue model constituted a barrier to CBM, with two unique problems underneath.

Finally, in the third phase, we took a theory-driven approach to subsume related second-order themes under the three dimensions of the CBM—namely, value creation, value delivery, and value capture (Frishammar and Parida 2019). For example, customer fear in agreeing to the multi-year service contracts of service-based CBMs (Reim et al. 2016) was analyzed to reflect the problem underpinning the barrier to thorough customer involvement in value co-creation. Here, a specific problem is that the dimensions of value creation, value delivery, and value capture are open to interpretation. They are not mutually exclusive entirely and may partially overlap. To mitigate this problem, we enlisted definitions and prepared operationalizations of the three business model dimensions based on the prior literature (see Table 2). We believe this improved reliability in the process of clustering first-order codes into second-order themes and second-order themes into aggregate dimensions.

4 | Results

In this section, we outline the specific barriers identified and the problems underpinning them from the three CBM dimensions. The barriers reveal a spectrum of key challenges encountered during value creation, value delivery, and value capture activities, which will impede the successful transition to a CBM if not addressed (Chhimwal et al. 2022; Milios 2021). Figure 2 configures all barriers and problems. The aggregate dimensions are used to organize the results.

4.1 | Barriers to CBM Value Creation

Here, the barriers focus on technological considerations underpinning a CBM, deficiencies in co-creation when developing circular offerings, and obstacles in creating value with ecosystem partners.

4.1.1 | Failure to Utilize Emerging Technologies for Circularity

A failure to integrate emerging technologies such as artificial intelligence (AI) algorithms, Internet of Things (IoT) applications, big data analytics, and blockchain erects a barrier (Bressanelli et al. 2022a; Chauhan et al. 2022; Ranta et al. 2021). Such technologies have the potential to improve resource management, production optimization, and supply chain transparency. For instance, blockchain, as a decentralized ledger, facilitates product lifecycle management and helps verify sustainability claims (Bressanelli et al. 2022b; Wolf et al. 2022). IoT can track key resources (energy or materials usage), and AI can optimize production planning (Ramadoss et al. 2018). Blockchain technology improves supply chain transparency, recycling, and reuse, and machine learning algorithms optimize production processes, reduce waste, and enable predictive maintenance (Abideen et al. 2021).

Emerging technologies, therefore, have the potential to improve internal efficiency and product quality, leading to improved value creation for CBMs. However, leveraging such technologies seems highly challenging. For example, SKF, a firm specializing in the manufacture of bearings, seals, lubrication systems, and related products and services, encountered difficulties in applying emerging technologies to achieve circularity in mining operations because these technologies must be tailored to meet the industry's distinct requirements with careful adaptation and integration of technologies. Implementing smart solutions, such as quick-collect sensors in mining, requires customized approaches that address the complexities of ensuring reliability in rotating equipment in this environment (First Mining DRC—ZAMBIA 2024).

The failure to leverage emerging technology is rooted in three problems. First, many industrial firms face a hurdle due to *low internal circular technology adoption readiness*. This arises from limited digital literacy, resistance to change, and inadequate supporting infrastructure (de Sousa Jabbour et al. 2022). An example from the Swedish manufacturing industry is Scania, a leading manufacturer of heavy trucks, buses, and engines, who are in the process of phasing out diesel trucks and transitioning to electric vehicles. The major obstacle lay in the charging infrastructure, which was seen as "the biggest problem" rather than the availability of the technology for electric trucks (Traton Group 2022).

Second, many industrial firms experience a *lack of data sharing and security guidelines* to implement and scale up emerging technologies for CBMs (Rizos et al. 2016). For example, Swedish manufacturers encountered difficulties while navigating the intricate and evolving legal landscape governing data sharing and security. Scaling up emerging technologies, such as IoT, AI, and blockchain for CBM, presupposes robust data practices that comply with, for example, the General Data Protection Regulation (GDPR). However, the absence of clear guidance on interpreting these rules has created uncertainty, hindering technology adoption. Balancing complex legal frameworks with data privacy requirements adds complexity and cost to adopting new technologies, affecting scalability and innovation (Svenskt Näringsliv 2021). Uncertainty over data privacy, security, and intellectual property concerns exerted a negative impact on firms' willingness to invest in and adopt such technologies for CBMs (Ding et al. 2023).

Third, the *lack of interoperability and standardization* is apparent. Given the diverse range of emerging technologies underpinning CBMs, compatibility issues can arise, leading to difficulties in seamlessly integrating these technologies into existing legacy systems. This lack of harmonization hampers efficient data exchange and collaboration among stakeholders

TABLE 2 | Business model dimensions: Definitions and operationalizations.

Business model dimension	Definition	Operationalization: What we looked for in the data
Value creation	• The core idea of value creation for customers is expressed in a variety of terms, including value proposition, value object, offering, and customer benefit (Al-Debei and Avison 2010). • Support a value proposition for the customer. It is about the benefit the enterprise will provide to customers (Teece 2010). • A set of complementary and specialized resources and capabilities (which are heterogeneous within an industry, scarce, durable, not easily traded, and difficult to imitate) may lead to value creation (Amit and Schoemaker 1993). • Firm's unique bundle of resources and capabilities may lead to value creation (Amit and Zott 2001). • A series of activities from procuring raw materials to satisfying the final consumer, which will yield a new product or service in such a way that there is net value created throughout the various activities (Chesbrough 2007). • How company creates the value that it proposed and the origin of competitive advantage (Richardson 2005). • Creation of value through knowledge and resource sharing that binds stakeholders together (Frow and Payne 2011). • Refers to those sets of activities that enable providers and customers to progressively realize this higher value (Chesbrough et al. 2018).	• Value proposition • Customer needs and involvement • Customer benefits • Complementary and specialized resources and capabilities • Bundling of capabilities • Value generation and integration • Value creation or generation with stakeholders • Knowledge and resource sharing • Sets of activities for value creation among actors
Value delivery	• Position in the value network that links to suppliers, partners, and customers (Richardson 2005). • Delivers on the promises of the value creation (Sheehan and Bruni-Bossio 2015) through the established system of activities (Osiyevskyy et al. 2018). • Defining the way internal processes are organized to leverage the available resources for delivering consumer value (George and Bock 2011).	• Market access and adaptation • Strategic partnership and network • Delivery activities related to promised value creation • Partner capacity and process for value delivery • Trust-worthy collaboration to deliver as per requirement
Value capture	• Viable structure of revenues and costs for the enterprise delivering that value (Teece 2010). • Relates to how a business earns its revenue when providing goods, services, or data/information to customers and users (Aagaard and Ritzén 2020). • Refers to economic value gains and is tightly related to value measures and financial performance from a business logic (Bowman and Ambrosini 2000). • An acceptable balance between profits for the focal firm and the profitability of the firm's ecosystem partners (Teece and Linden 2017). • As the process of securing profits from value creation and the distribution of those profits among participating actors such as providers, customers, and partners (Dyer et al. 2018). • The design of appropriate governance mechanisms to ensure that value creation is greater than the cost of realizing that value and that the value surplus is distributed fairly among partners (Chesbrough et al. 2018). • As the mechanisms that make sure that an economic return from value creation and that profits are shared throughout the value creation network (Sjödin et al. 2020).	• Cost structure and considerations • Revenue model • Investment cost and decision • Interpreting willingness to pay • Estimation of risks and risk management approaches

(Chiaroni et al. 2021). For example, the smooth integration of IoT devices into industrial equipment to gather and transmit performance data for remote monitoring and anomaly detection was impeded by difficulties in aligning these technologies with pre-existing legacy systems (Swedish Civil Contingencies Agency 2021).

4.1.2 | Not Thoroughly Involving Customers in Circular Value Propositions

Active customer involvement in circular value propositions is vital yet difficult. The co-creation of circular value propositions extends to crafting circular offerings with a strong sustainability proposition while minimizing waste (Frishammar and Parida 2021; Kanda et al. 2021). Therefore, numerous Swedish industrial firms are increasingly involving their customers in design, customization, and collaborative feedback when creating circular offerings. For example, RISE's report examined how firms offering diverse circular offerings, such as car odometers, encountered challenges when not adequately addressing customer needs. This highlighted the importance of engaging customers in the design process and gathering their feedback (RISE n.d.-a). Three problems underpin this barrier.

First, industrial firms developing circular offerings often move from selling products to selling services as part of their value proposition. However, in doing so, they often face *customer hesitation in accepting circular offerings*. Novel offerings require a sizeable investment in time and resources and a new commercial logic—namely, buying services instead of products (Kuah and Wang 2020; Milios and Matsumoto 2019). Moreover, many customers fear that agreeing to multi-year service contracts will lead to lock-in effects and compromise their ability to negotiate (Reim et al. 2020). For example, the anticipated market demand did not materialize for Renewcell, a pioneering startup in textile recycling, when it publicly announced contracts of between 255,000 and 275,000 t over 5 years. Many firms—often advocates of sustainability and circular practices—ultimately decided against procuring circular fibers, reflecting hesitancy and the challenges they faced in adopting such offerings despite the intentions expressed (Dagens Industri 2024a).

Second, the providers' *inability to communicate the sustainable benefits* in the circular offering's value proposition because of its newness (Brydges 2021; Heshmati and Rashidghalam 2021). Examples include the market openings for recycling and remanufacturing and substantial environmental advantages including reduced environmental penalties and minimized waste generation (Kumar et al. 2019; Saxena et al. 2020). The adoption of a circular offering delivers a range of potential sustainable benefits, which may be challenging for the customer to fully grasp. SCA, a leading timber, pulp, and paper manufacturer, encountered difficulties in communicating the benefits of its circular offerings to customers, particularly regarding product substitutability. Merely promoting fossil-free materials was insufficient because the strategy was used industry-wide. Thus, SCA recognized the need to emphasize the unique value proposition of its renewable alternatives to effectively convey its advantages and distinguish it from competing options (SCA 2022).

Third, there is a *lack of interest in sharing internal data and operational insights* from the customer end, which undercuts the ability to effectively communicate the value proposition and offer circular solutions (Tura et al. 2019). This is evidenced broadly in Swedish manufacturing sectors in both customer and partner data (The Circularity Gap Report 2022). Firms may be hesitant to share internal data for fear of losing competitive advantage or facing challenges in protecting their intellectual property (European Union 2017). This reluctance stems from various factors, including concerns over proprietary information, competitive advantage, and data security (Hassandoust et al. 2022). Industrial customers often consider their operational data as an asset that sets them apart from competitors. Thus, sharing this information with external partners, even when co-creating circular offerings, is seen to potentially compromise their competitive position (Adamik and Nowicki 2019).

4.1.3 | Difficulty in Creating New Types of Sustainable Value With Existing and New Ecosystem Partners

The transition to CBMs represents a shift from a firm-centric to an ecosystem-centric view, thus calling for dynamic interactions among diverse stakeholders to generate environmental and socio-economic value (Todeschini et al. 2017; Kanda et al. 2021). This multiactor logic implies value co-creation through reciprocal exchanges among actors beyond the customer (Wieland et al. 2017). This actor constellation could involve existing supply chain partners as well as new partners, such as innovative SMEs, technology providers, service organizations, and recycling firms (Stewart and Niero 2018). One of the major challenges faced by Swedish firms on their path to circularity is to establish effective cross-disciplinary collaboration with ecosystem partners (Business Sweden 2022). This was experienced by Cementa, a key player in the cement and building materials industry, whose new application to mine limestone struggled due to stricter EU climate requirements. Consequently, the firm now plans a SEK 10 billion investment in carbon capture technology, even though various ecosystem actors oppose this, including regulatory bodies, environmental agencies, local communities, emission capture technology suppliers, and research institutions (Dagens Industri 2023). Two specific problems underpin this barrier.

First, there is the problem of *deficient common goals or shared vision*. With diverse partners, such as technology providers, sustainability consultants, and reverse logistics service providers, securing buy-in is challenging (Sjödin et al. 2018; Frishammar and Parida 2019). Here, key hindrances include differing priorities (Gerassimidou et al. 2022), limited awareness and understanding of goals (Tseng et al. 2022), different mindsets due to experience of working in various industries or regions, and diverging perceptions of risks among existing and new ecosystem partners in creating value (Petri and Jacob 2016). A representative example from Swedish industry argued that traditional measures such as GDP failed to account for negative environmental impacts and ecological sustainability. The lack of holistic measurement and valuation of natural capital made priorities difficult to align, and it tainted the perceptions of ecosystem partners, such as CBMs (Regeringskansliet 2013). Another European Union report discussed the challenges faced by Swedish firms in achieving a shared vision, highlighting the lack of common understanding and the differing priorities among ecosystem partners, hindering the realization of shared sustainability and circularity goals (European Union 2016).

Second, industrial firms often encounter challenges in *managing existing ecosystem partnerships to create new circular offerings* when transitioning to CBMs. One significant obstacle is the need for change management because the shift to circularity can disrupt established processes and roles within the ecosystem (Frishammar and Parida 2019). For example, Boliden, a mining firm, faced a problem related to change management and effective communication with investors such as Protean. To restore confidence and credibility in its strategic vision amid growing demand for metals due to electrification and fossil fuel phase-out, Boliden needed to show clear signs of evolving management practices. Protean's investment and expectations underscored the difficulties Boliden faced in managing investor relations and effectively communicating its future strategy (Dagens Industri 2024b). Moreover, reallocating resources to support circular initiatives can lead to uncertainties and resistance among partners (Veleva and Bodkin 2018). Balancing competing priorities and aligning diverse interests poses another hurdle, requiring effective communication and negotiation. Industrial firms also face difficulties in finding a balance between long-term sustainability objectives and partners' short-term financial goals (Frishammar and Parida 2019; Burström et al. 2021).

4.2 | Barriers to CBM Value Delivery

The value delivery dimension focuses on the activities and processes employed to deliver value through a CBM (Okorie et al. 2021). Here, the barriers and problems center on the specific logistic resources and capabilities required for circular offerings and the struggle to collaborate with new ecosystem partners (Averina et al. 2022; Reim et al. 2016).

4.2.1 | Underdeveloped Service Delivery Organization for Circular Offerings

Industrial firms moving to circular offerings shift from selling products (and basic support services) to offering advanced services with greater circular and sustainability value for customers. Here, the role of the service delivery organization—that is, the customer-facing unit—is central. These units need to develop new capabilities because they are responsible for service customization and co-creating value with customers (Hakanen and Jaakkola 2012). For example, Ericsson, a leader in telecommunications equipment, faced significant challenges in transforming its service delivery organization to align with cloud-based services. The primary issue was the need to drastically accelerate technology adoption and innovation, lengthy planning cycles of 6–12 months, a long sourcing process, a lengthy "time to impact period," and accelerating revenue generation (Lindström 2023). Given the need for large-scale changes in the service delivery organization and associated processes, the shift to servitization is faced with three underpinning problems.

The first problem is to *deliver a circular offering suitable for diverse markets*. As the majority of Swedish industrial firms are global players, they face the challenge of adapting their offerings to local market conditions (Hopkinson et al. 2018). This slows the diffusion of the CBM and acts as a barrier to scaling (Sandberg and Hultberg 2021). Moreover, unique local conditions, such as different economic conditions, local geography, regulatory restrictions, and different standards related to product quality, safety, and environmental sustainability, can impede profitable delivery of advanced circular offerings (Hopkinson et al. 2018). Scania, a truck manufacturer, faced challenges in delivering its circular offerings—namely, alternative fuel technologies, remanufactured parts and components, vehicle lifecycle services due to varying economic conditions, local regulatory restrictions, and different standards related to product quality, safety, and environmental sustainability across different markets outside the EU (Scania 2023).

The second problem is *access to and recruitment of new talent* for the service delivery organization. Industrial firms increasingly understand the need to hire personnel who have expertise in not only product sales but also advanced service delivery methods (Ziaee Bigdeli et al. 2021). However, accessing such qualified personnel poses a significant challenge, particularly when firms operate outside their national markets (Ziaee Bigdeli et al. 2021). European countries, including Sweden, have difficulties in embracing environmental friendliness as a core aspect of circularity due to labor shortages (Centre for European Labour Market Studies 2009). This aligns with Beyondo's report indicating a talent shortage in Sweden's hiring market, which threatens the country's global economic competitiveness, particularly in emerging fields, such as the transition to a CE (Beyondo 2022). Additionally, a web article by Norran highlighted how Swedish manufacturers focused on the circularity struggle to recruit international talent due to perceived cultural incompatibility risks (Norran 2024).

Another pertinent problem is *harnessing technology and data for improved service delivery*. Many firms lack familiarity with the latest digital technology to optimize their service delivery (Bonnet and Westerman 2020). Therefore, they are often required to make substantial investments in digital technologies—for example, data analysis operations concerning demand and supply and predicting prices for their circular offerings—making the entire process expensive and time-consuming (Rusch et al. 2023). For example, Swedish manufacturers faced this problem when delivering their circular offerings because they needed to undertake the extensive transformation of adopting advanced digital tools for resource efficiency, traceability, and process optimization. (RISE n.d.-b).

4.2.2 | Underdeveloped External Partner Networks for Circularity

Collaborating with external partners during value delivery offers several advantages (Reim et al. 2021; von Kolpinski et al. 2023), including access to innovative ideas, specialized expertise, and agility in expediting circular practices (Parida et al. 2019). By teaming up, industrial firms tap into niche knowledge, synergize strengths, and enhance their offerings (Re and Magnani 2022). Often, external partner networks—for example, startups/SMEs—offer the flexibility needed for rapid prototyping, and intensifying customer reach and markets (Suchek et al. 2021). However, Amokabel AB, a specialized manufacturer of high-temperature cables, experienced a problem where the network owner could not provide sufficient electricity for the firm's business growth. Due to the capacity constraints of the supplier, Amokabel faced reduced production of thermocouple cables for temperature sensing, one of its specialist circular offerings (Dagens Industri 2020). Here, the underlying problems are threefold.

A problem for industrial firms is the *lack of trust and a failure to nurture effective collaboration* with external partners—for example, SMEs and startups (Veleva and Bodkin 2018). Here, there can be confusion over who will assume ownership and take the risks associated with the delivery of circular offerings (Garcia Martin et al. 2023). In addition, newly formed relationships between large industrial firms and SMEs can be affected by an imbalance in negotiating power, which can precipitate startup concerns about intellectual property rights, resource allocation, and fear of losing autonomy (von Kolpinski et al. 2023). For example, H2 Green Steel, a startup producer of fossil-free steel using green hydrogen, and a comparatively smaller firm in the startup phase, was concerned that it was disadvantaged compared to SSAB in terms of electricity allocation from Vattenfall, a state-owned electricity provider of clean energy (Dagens Industri 2024c).

Second, industrial firms face challenges in *lacking partner capacity to scale circular offerings*. Sometimes, external partners lack the funds and need support from larger firms to deliver the promised offerings (von Kolpinski et al. 2023). For example, Husqvarna, a specialized manufacturer of outdoor products, faced a significant component supply shortage, particularly affecting robotic mower production, which was one of the circular offerings it provided. Strong demand, especially for robotic mowers, was disrupted by unexpected lockdowns in China due to Covid-19. This led to production limitations and a record order backlog, impacting net sales and operating margin due to an unfavorable product mix with lower robotic mower sales and higher sales of ride-on mowers for cutting grass (Husqvarna Group 2022).

Third, collaboration between industrial firms with external networks, especially those from different countries, often encounters challenges regarding *compliance with varying regulatory regimes*, certifications, and standardization policies. In a global business landscape, regulatory frameworks can differ significantly from country to country, leading to complex compliance issues that need to be navigated (Suchek et al. 2021). For example, Husqvarna had to recall its robotic lawnmower 435X and 535 models. In spite of using energy-efficient, long-lasting, and recyclable lithium-ion batteries, overheating issues meant they had to recall the models to comply with customer safety regulations (Office for Product Safety and Standard 2022).

4.3 | Barriers to CBM Value Capture

Value capture–related barriers to CBMs center on high investment costs and risk management but also on designing new revenue models and revenue streams.

4.3.1 | Unfolding Circular Investment Costs

Creating and delivering circular offerings require firms to commit substantial up-front investments across a range of domains, encompassing the acquisition of cutting-edge technology, the establishment of essential infrastructure, and the overhaul of operations to align with circular principles (Kaipainen and Aarikka-Stenroos 2022). Despite the benefits of successful CBM offerings, such as reduced environmental impact, enhanced reputation, and the nurturing of innovation, it is a costly journey (Vanhuyse et al. 2022). For example, Tetra Pak, a leading food packaging and processing firm, is known for its significant investment in the development of Tetra Pak E3/Flex technology-enabled sustainable packaging solutions to reduce its environmental footprints. However, the layers in these packaging solutions require meticulous separation to maintain their quality—a process that demands specialized machinery and, therefore, substantial investment (Qureshi 2024).

First, while pursuing CBM, industrial firms are *accounti for new and additional costs to drive circularity initiatives*, such as feasibility studies, product design, market research, certifications, and regulatory compliance for sustainable practices (Guldmann and Huulgaard 2020). These high initial costs add to the standard operational expenses that are necessary to meet industry standards and create a foundation for circular practices, but they strain resources and delay profitability during the initial stages. Industrial firms' investments also drive costs in redesigning products and packaging to align with circular principles and utilizing recyclable or biodegradable materials. Collaboration with value chain stakeholders, such as suppliers, customers, and waste management entities, incurs partnership establishment costs (Nandi et al. 2020). An example is Tetra Pak's investment of approximately €40 million annually to collaboratively develop its recycling infrastructure. However, the firm faced challenges in convincing local authorities and packaging recovery organizations to mandate carton recycling alongside other liquid food packaging because the industry was divided, with debates on carton sustainability versus plastic alternatives (Letsrecycle.com 2022).

Second, another issue arises due to the need for *high switching costs related to fixed equipment and infrastructure*. Creating appropriate infrastructure in terms of facilities and processes to support recycling, refurbishing, and remanufacturing increases up-front expenses and exerts an impact on overall profitability (Sousa-Zomer et al. 2018). Furthermore, ongoing maintenance and updates to this infrastructure can incur additional costs (Vanhuyse et al. 2022). Costs also arise from retooling machines, relocating factories, and establishing new distribution and logistics arrangements. Staff retraining to meet CBM requirements adds to expenditure (Jaeger and Upadhyay 2020). For example, Swedish manufacturers, such as SKF (a global supplier of bearings, seals, mechatronics, lubrication systems, and services), Hako (a manufacturer of high-quality cleaning and municipal machinery), and Epiroc (a leader in the manufacturing of mining and construction equipment), pointed to the investment needed for circular offerings. SKF's integrated solutions program, SKF Rotation for Life, requires investment in advanced bearing technology, failure detection, and reliability services. Hako's fixed monthly cost agreements for repairs, maintenance, and training necessitate ongoing expenditures in service infrastructure and spare parts. Epiroc's batteries-as-a-service model for battery-powered electric vehicles involves costs for battery certification, maintenance, and upgrades (The Circularity Gap Report 2022).

Third, industrial firms often experience *increased costs in upskilling and reskilling of employees*. Implementing a CBM requires employees' reskilling in sustainability practices, material recovery techniques, and reverse logistics. These skills are crucial for managing waste reduction, product lifecycle extension, and efficient resource use. Additionally, training in circular design principles enables employees to innovate sustainable products and services, ensuring alignment with CBM goals and improving the firm's environmental impact (Straub et al. 2023). For instance, Volvo Group trains its workforce to handle remanufacturing processes for engines, gearboxes, and other components, ensuring that materials are reused efficiently, minimizing waste, and optimizing resource use throughout its production cycles (Volvo Group 2021). CBM also requires updated digital infrastructure, leading to increased costs in recruiting skilled developers to manage advanced software (Kristoffersen et al. 2021). This digital upskilling is critical to effectively adopt emerging technologies that support circularity. Additionally, regular system updates and cybersecurity measures contribute to further operational and maintenance expenses, ensuring the sustainability of the digital ecosystem (Lahti et al. 2018). For example, in industries such as manufacturing, increased investment is necessary for digital upskilling to manage these emerging technologies because firms must invest in advanced digital infrastructure, recruit skilled personnel, and continuously adapt to evolving software requirements. The costs of designing emission-free production are often high, and investments involve substantial risk due to the employment of new technologies (Swedish Environmental Protection Agency n.d.).

4.3.2 | Failure to Design a Viable Revenue Model for Circular Offerings

Pursuing CBMs requires effective revenue models to capture the value created by new circular investments (Linde et al. 2021). Therefore, industrial firms are exploring approaches such as "product as a service" (PaaS), where products are offered as services to customers, shifting payment from ownership to usage or performance (Frishammar and Parida 2019; Ertz et al. 2019). Other alternatives include remanufacturing, refurbishment, leasing, rental options, upcycling waste into valuable products, and selling individual components, which all have revenue model implications (Frishammar and Parida 2019; Bridgens et al. 2018). Such models could enable firms to cover costs, enhance resource efficiency, and generate profits but are challenging to develop because of two key underlying problems.

First, problems arise at the design, development, and implementation stages of circular offering commercialization. During the early development stage, many industrial firms make an *inappropriate selection of revenue model*. Inappropriately mapping business operations with a particular revenue model often has severe consequences. For example, a report from RISE emphasized the challenges faced by Swedish manufacturing firms due to a mismatch between revenue streams and operational costs, impacting their ability to secure bank credit and investment. This underscored the importance of developing a coherent and viable financial strategy within the framework of a CBM (Linder et al. 2023). A suitable selection depends on the type of circular offering chosen as well as the degree of customer understanding, the extent of digital readiness, and the scope of the digital ecosystem partnership (Tabares et al. 2023).

Second, problems arise from *incorrectly interpreting the willingness to pay for circular offerings*. Understanding whether the need stems from market demand or provider-driven motives is crucial. Incorrect identification can lead to the development of ineffective and unprofitable revenue models (Linde et al. 2021). This problem is amplified when customer feedback is neglected. Failing to strengthen the feedback mechanism for customer input on the revenue model can lead to significant stress, harming the relationship between provider and customer and hindering open, collaborative, and trusted co-creation (Järvi et al. 2018; Linde et al. 2021). These issues demonstrate that both provider and customer must be aligned in their objectives and obligations for successful implementation (Saarinen and Aarikka-Stenroos, 2023). For example, a white paper from Swedish Expert Group for Aid Studies (EBA) explained how Swedish industrial firms face pricing challenges with circular offerings due to complex market dynamics and the need to include environmental and social costs in product pricing decisions. Incorrect pricing can impact product design, raw material extraction, and consumption patterns, leading to inefficient resource utilization and lower recycling rates if environmental costs are not factored in (Slunge et al. 2021).

4.3.3 | Inability to Deploy Appropriate Risk Management Strategies

Risk management strategies are crucial to ensure successful CBM implementation. Risks are characterized by the probability of loss and the potential impact on the organization (Mitchell 1995). Risks pose significant hurdles for organizations as they navigate the complexities of value capture in the CE (Reim et al. 2015). Sandvik, a firm specializing in metal cutting, mining, rock excavation, and materials technology, faced risks driven by external factors beyond its control; consequently, it adopted risk management strategies that focused on adaptability and agility (Sandvik 2022).

Two specific problems underpin this barrier. First, *miscalculated operational risks* pose a serious challenge. Operational risks center on unexpected product breakdowns, which lead to increased repair and maintenance costs (Erkoyuncu et al. 2013). For example, a sudden breakdown occurred at ABB arising from an unexpected cyberattack affecting numerous devices and causing severe damage to electrification and automation (Security Affairs 2023). Operational risk is also tied to the provider firm's capability to deliver the agreed product-service to customers because circular offerings often mean the provider partially takes over the customer's operations (Lüdeke-Freund et al. 2019). Another risk factor commanding considerable attention is unintended and adverse customer behavior, such as overloading or extensive usage that exerts a negative impact on the condition of the product (Reim et al. 2016). An example from the Swedish industry was when SCA, a timber, pulp, and paper manufacturer, intimated that approximately 31% of its circular offering sales came from a specific group of customers. If this customer group behaved adversely, sales could sharply decline. This dependency underscores vulnerability in its circular offerings, because its business model heavily relies on a limited number of buyers. Adverse customer behavior, such as reduced purchases or switching to competitors, could have a severe impact on SCA's financial stability (SCA 2022). Opportunistic behavior, where customers seek to maximize personal benefits without considering the provider's efforts, exacerbates such risks (Handley and

Benton 2012). Another risk is adverse selection, where customers only show interest in purchasing the PaaS fearing that machinery will be prone to breakdown and will lead to unprofitable agreements for the provider (Ulaga and Reinartz 2011).

A second problem underpinning this barrier is *inappropriate risk management approaches*. There are four approaches: risk avoidance, risk reduction, risk sharing/transfer, and risk retention (Reim et al. 2016). Each of these approaches carries its own set of advantages and drawbacks, rendering the decision-making process critical. For instance, risk avoidance entails the selective targeting of customers and refraining from offering circular-based services to everyone. However, this strategy may not be suitable for a firm that perceives profitability in effectively managing the associated risks (Reim et al. 2016). Similarly, if a firm lacks the technological infrastructure to monitor breakdowns or maintenance alerts, pursuing a risk reduction strategy may prove inappropriate. Many Swedish industrial firms faced challenges in implementing effective breakdown and maintenance monitoring systems due to technological deficiencies and inadequate risk reduction strategies. This limited their ability to proactively manage operational risks, resulting in reactive maintenance practices and increased vulnerability to equipment failures and disruptions (Swedish Civil Contingencies Agency 2021). Furthermore, if the firm cannot allocate additional resources to repairs or maintain an adequate supply of spare parts, this strategy may falter. A shortage of resources can lead to customer dissatisfaction where prolonged service times for repairs increase behavioral risks (Linder et al. 2023).

Firms often struggle with their risk-sharing strategy, which involves revenue-sharing agreements with customers or risk transfer to insurance firms. For example, a report by RISE discussed how Swedish firms encountered challenges when implementing PaaS models, particularly in negotiating revenue-sharing agreements and transferring risks to insurance firms. Difficulties stemmed from aligning incentives, determining fair revenue distribution, and implementing effective risk mitigation strategies. The unique nature of CBMs, which involve shared ownership and product lifecycle responsibilities, further complicates the establishment of mutually beneficial arrangements (Linder et al. 2023). Industrial firms may find this strategy inappropriate if they lack the required percentage share, face challenges in negotiation, or struggle with the complexities of involving an insurance party (Toxopeus et al. 2021). Moreover, risk retention can pose difficulties because firms must determine the final price for circular offerings after factoring in the cost of risk. This challenge intensifies when proper customer segmentation is not conducted, leading to such services being provided to the wrong customer cluster (Panjehfouladgaran and Lim 2020).

5 | Discussion and Implications

With increasingly strict environmental policies, regulations, and growing customer demand for circular and sustainable products, industrial firms must develop and scale CBMs to enhance resource efficiency and reduce their environmental footprint (Bocken et al. 2023). Our analysis of Swedish industrial firms reveals that this process is frequently hindered by barriers across the business model dimensions of value creation, delivery, and capture. While these barriers persist over time, they become more pronounced during market scaling than during initial development. Scaling refers to the expansion and replication of CBM initiatives across markets, customer segments, and operations to maximize impact and reach (Hultberg and Pal 2021). Conversely, by development, we refer to creating a CBM concept or "blueprint" and the associated operational processes needed for its initial implementation (Reim et al. 2021).

Moving from development to scaling is challenging. Industrial firms can manage it more effectively by adopting a modular approach that breaks down scaling efforts into interconnected, independently implemented subprocesses and activities (D'Adderio and Pollock 2014; MacDuffie 2013). We visualize this transformation through a framework that connects modularity principles for overcoming barriers to effectively scale CBMs (see Figure 3).

To effectively implement CBMs, industrial firms first need to address value creation barriers—particularly in the pilot project phase—by focusing on technology utilization, customer involvement, and collaboration with ecosystem partners. Over time, firms transition from initial pilot projects with a single or few customers (Palmié et al. 2023) to broader experiments in niche markets (Hofmann and zu Knyphausen-Aufseß 2022), where they must clarify value delivery by optimizing the service delivery organizations and strengthening external partner networks. Finally, as they pursue mass market rollout (Frishammar and Parida 2019), firms need to overcome value-capture barriers by designing viable revenue models and managing investment costs and risks. By addressing these barriers at each phase,

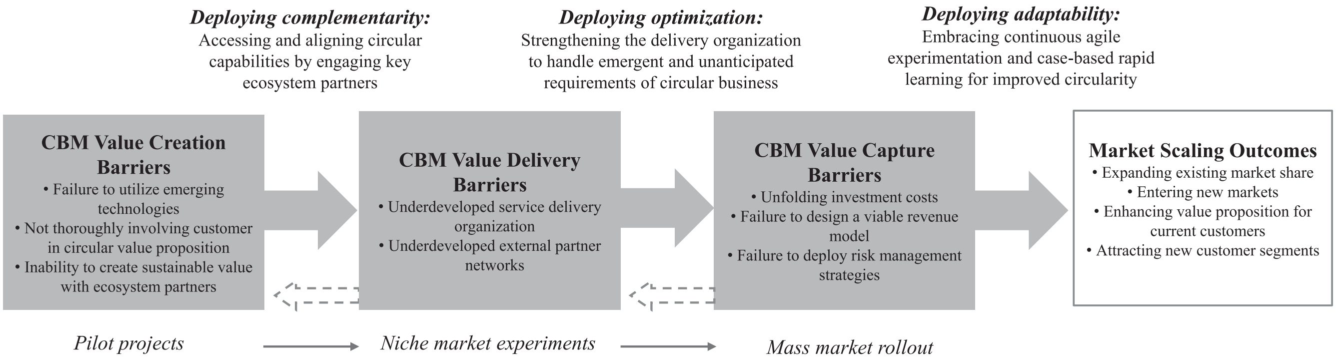

FIGURE 3 | Scaling process and framework for overcoming barriers to CBM.

industrial firms can achieve market scaling by expanding their presence in existing markets and entering into new ones.

To overcome the barriers, our framework outlines three specific scaling recommendations based on modularity principles, each of which has a particular center of gravity. First, one of the core principles of modularity is the deployment of *complementarity*, where distinct modules enhance the overall system by working together (Harmancioglu et al. 2021). In the context of CBMs, this implies aligning external partners' capabilities with a firm's internal needs to make a CBM scalable. In line with the principle, the first scaling recommendation, *assessing and aligning circular capabilities by engaging key ecosystem partners*, is deemed particularly important in executing value delivery once a concept for CBM value creation has been established. It emphasizes identifying and mitigating capability gaps by systematically assessing external partners' resources and competencies. This is crucial because many industrial firms face the challenge of scaling their CBM with limited internal capabilities, when moving from pilot projects into niche markets where the number of customer engagements increases. External partners can provide complementary capabilities, especially innovative startups and SMEs focused on data analytics, machine learning, and other digital capabilities that may be lacking in incumbent manufacturing firms. Furthermore, partnerships may be formed with technology and connectivity providers that support automated processes, tracking stock movements, and issuing maintenance notifications for surplus materials through emerging technologies, such as blockchain, sensor-based RFID, IoT systems, and predictive and prescriptive analytic techniques (Ramadoss et al. 2018). This can help improve resource efficiency in CBM scaling efforts.

The next principle of modularity is the deployment of *optimization*, which centers on refining and developing individual components to ensure high performance while maintaining system flexibility (Gan et al. 2022). For industrial firms faced with value delivery barriers, optimization entails niche market experiments to meet evolving customer demands, paving the way for mass market rollout. By optimizing processes, such as maintenance scheduling, data-driven delivery processes, and customer training, industrial firms can improve value delivery across product lifecycles, enhancing both efficiency and resilience in scaling CBMs. Therefore, our second scaling recommendation is *strengthening the delivery organization to handle the emergent and unanticipated requirements of circular business*. While optimization could be important throughout the full scaling process, it has a center of gravity where value delivery principles and concepts have been established and when the move to a resilient revenue model and revenue streams is the next step. This suggests the need for a persistent focus on building up the customer-facing service organization, given the need to optimize the delivery of circular value and maximize value capture from circular activities (Reim et al. 2015). Moreover, this recommendation ensures adherence to quality standards, regulatory requirements, and customer expectations across the entire lifecycle of products and services, from design and production to distribution and end-of-life management (Gunasekaran and Spalanzani 2012). A robust delivery organization is needed to mitigate the risks associated with unexpected and changing customer behavior (Braunscheidel and Suresh 2009), which can have a direct and negative effect on the revenue model and revenue streams. For example, if customers are excessively using machines under warranty, a proactive delivery organization can establish preventive maintenance schedules, conduct regular inspections, and provide customer education programs to promote proper usage.

Finally, deploying *adaptability* in modularity highlights the need for iterative learning to ensure resilience and effectiveness in response to changing demands and environments (Cagno et al. 2023). Embracing continuous agile experimentation aligns with this principle by allowing firms to adjust their strategies based on real-time feedback, ensuring a more successful and sustainable mass market rollout. By fostering a culture of rapid learning and experimentation, firms can navigate the complexities of CBMs more effectively, ensuring sustained value capture. Taking adaptability into account, our final scaling recommendation, *embracing continuous agile experimentation and case-based rapid learning for circularity*, seems particularly relevant given the inherent traits of customization and costliness associated with CBMs in industrial firms (Geissdoerfer et al. 2022). Firms must be prepared for an extended and continuous learning process over time, characterized by iterative and adaptive approaches (Kaipainen and Aarikka-Stenroos 2022). While this recommendation is valid for the whole CBM scaling process, it seems particularly important in managing the extended implementation stage after the circular value creation, delivery, and capture dimensions have been sufficiently clarified (Frishammar and Parida 2021). Firms can actively learn from managing customer experiences through continuous feedback mechanisms, experiment with various revenue models tailored to circular offerings, and gauge customer willingness to pay for these offerings. In doing so, firms can further improve value capture and refine profit-sharing mechanisms based on customer preferences and market dynamics (Sjödin et al. 2020).

To conclude, CBM development and scaling is an experimental process characterized by trial and error and mimicry (Frishammar and Parida 2019). So, in that sense, value creation, delivery, and capture coevolve and overlap (Minerbo and Brito 2022), which is acknowledged by the "reverse" arrows in Figure 3. However, our analysis alludes to an inbuilt time sequence and center of gravity for the barriers to each of the three categories. We argue that value cannot be captured if it has not been delivered, nor can value be delivered if it has not been created in the first place. This partially overlapping yet sequential logic has received scarce attention in CBM research, although it has been established in traditional and linear business model settings (Minerbo et al. 2021; Ritter and Lettl 2018; Teece 2010). Uncovering it in this study supports our understanding of how industrial firms transition from linear to circular practices and business models.

5.1 | Implications for the Literature

We contribute to the emerging CBM literature (Bocken et al. 2023; Frishammar and Parida 2019) in the following ways. First, we propose a new way of classifying CBM barriers according to the three business model dimensions of value creation, delivery, and capture. Some prior studies have contributed by mapping CBM barriers in relation to the overarching elements of the business model canvas (Asgari and Asgari 2021; Guldmann and Huulgaard 2020). Other studies have uncovered specific

CBM barriers that overlap with our findings—for example, low demand and acceptance of remanufactured products (Agarwal et al. 2023; Agyemang et al. 2019) or high up-front investment costs and long-term economic returns (Khandelwal and Barua 2024; Kumar et al. 2019). However, none of these studies has undertaken a systematic analysis of the barriers called for by Urbinati et al. (2021), addressing each of the business model dimensions. By conceptualizing the findings into a framework (Figure 3), our analysis moves beyond the mere classification of CBM barriers into internal or external (e.g., Galvão et al. 2022; Försterling et al. 2023) or regulatory, technological, cultural, market, and organizational categories (e.g., Tura et al. 2019; De Angelis 2022) into uncovering how the dominance of different barriers varies over time as firms seek to improve circularity implementation. Thus, we advance the understanding of the nature of CBM barriers, the order in which they are likely to appear over time and—by extension—how they can be addressed.

Second, we identify the "underlying problems" of each CBM barrier (see Figure 2) by using the literature on problem solving as a method theory (Lukka and Vinnari 2014). By delving into the underlying problems, we underscore the microfoundations for improved problem solving and capability building in the context of CBMs (Nickerson and Zenger 2004). While barriers and their categories remain significant, building capability and knowledge is better achieved by efficiently tackling the fundamental problems associated with each barrier (cf. Nickerson and Zenger 2004; Santa-Maria et al. 2022). In particular, many of the problems underpinning the barriers seem nondecomposable (Hsieh et al. 2007) in that they cannot easily be disassembled into constituent parts nor "solved" by a single actor mobilizing a single knowledge set (Hsieh et al. 2007). For example, issues of interoperability, customers' hesitancy in accepting circular offerings, the inability to communicate sustainable benefits, involving existing partners in creating new circular offerings, deficient trust, and nurturing effective collaboration clearly center on multiple actors (focal firm, customers, ecosystem partners) and multiple knowledge sets (market, customer, technological, and procedural knowledge). Conversely, other problems appear more decomposable. Though still challenging, the decomposability of problems allows groups or individuals with distinct knowledge sets to work independently toward solutions (Nickerson and Zenger 2004; Hsieh et al. 2007). For instance, we find that problems related to value capture barriers—such as high, initial investment costs, access to and recruitment of new talent, and compliance to varying regulatory regimes—appear as internal to the firm, domain specific, and standalone.

For the somewhat simpler, decomposable problems, firms can rely on directional search—namely, solving problems internally through feedback loops or experience from prior attempts. Initial high investment costs can be addressed by drawing on prior experience of managing such costs. For nondecomposable problems, ecosystem collaboration and effective alignment structures among partners are essential. These arrangements facilitate knowledge transfer from diverse actors through heuristic search by evaluating probable consequences rather than solely prior experiences (Dziubaniuk et al. 2024; Nickerson and Zenger 2004). This highlights the importance of an ecosystem perspective where multiple partners collaborate to address CBM barriers (Kanda et al. 2021) with particular reference to nondecomposable problem solving. Acknowledging the challenges inherent in CBMs is crucial to deploying suitable problem-solving strategies (Stumpf et al. 2021; Koistinen et al. 2022). It is critical to match the type of problem (decomposable and nondecomposable) with the appropriate solution search method (Nickerson and Zenger 2004). This illuminates problem solving for CBMs and helps explain why CBMs are advancing so slowly in many industrial firms. Moreover, we invite further research on other possible overarching characteristics of barriers that go beyond the extant categorizations.

Finally, we contribute by showing that many of the identified barriers prohibit scaling rather than the initial development of a CBM. This represents an important contribution to the CBM literature (Geissdoerfer et al. 2020; Salvador et al. 2020), which only recently has begun to recognize that scaling CBMs is a major problem for industrial firms, which demands different steps over time. Not involving customers during co-creation, maintaining an underdeveloped service delivery organization, and failing to conceive risk management strategies are particularly evident during the scaling phase of CBM implementation. We shed light on key management actions to overcome barriers at each step from value creation to delivery and to capture by proposing three key recommendations (see Figure 3). We encourage CBM scholars, who have, thus far, made valuable contributions by proposing CBM typologies (Lüdeke-Freund et al. 2019) and suggested strategies to improve resource efficiency (Nußholz 2017), to devote greater attention to the upscaling of CBMs and its management over time.

5.2 | Managerial Implications

Our study provides numerous implications for managers responsible for driving CBM initiatives in large industrial firms. Awareness of the barriers to each of the CBM dimensions is a first step in analyzing how these barriers can be mitigated, removed, circumvented, or otherwise dealt with.

Three areas require senior managers' closer attention. First, investment in digital technologies, such as AI, IoT, and blockchain, is necessary to optimize customer operations, improve customer experience, and realize circular goals. Being able to utilize IoT sensor data directly from machinery enables industrial firms to improve predictive maintenance, reduce downtime, and enhance productivity. Therefore, such digital capability investment is a prerequisite for successful CBM implementation with the potential to address multiple barriers. Second, forging strategic ecosystem partnerships with innovative startups, research institutions, and new industry players can fast-track the development and commercialization of CBMs, particularly for nondecomposable problems and barriers, which benefit from multiple diverse knowledge sets and input from multiple actors. For example, by combining academic research with startup agility, industrial firms, such as Volvo Group, are rapidly prototyping and commercializing remanufactured parts, leading to reduced waste and extended product lifecycles (Volvo Group 2021). Third, experimenting closely with early-adopter lead customers of circular solutions facilitates the co-creation of innovative products and services tailored to market needs. It enables testing and validating new revenue models, such as subscription-based or outcome-based pricing, and it may help mitigate risks and adapt to emerging customer needs. An additional advantage of involving lead customers in CBM development is that it serves as a "success story" and reduces customer resistance to accepting CBM offerings in traditional industries. A relevant example to cite here is Siemens who worked closely with industrial manufacturing companies, such as KUKA Robotics, to co-develop subscription-based services for robotics maintenance (Siemens 2023). By collaborating directly with early adopters, Siemens was able to test outcome-based pricing models while refining predictive maintenance solutions that enhance uptime and performance that helps reduce resistance to circular offerings in the broader industrial sector.

5.3 | Limitations

Our research comes with a few important limitations to keep in mind. First, our analysis draws on the secondary data in the academic and gray literature that has already been published. First-hand empirical evidence from practice could have facilitated a more in-depth and fine-grained analysis. Second, our study is focused on a single country, Sweden. So, the results may not replicate perfectly in other countries and regions that operate under different institutional and industrial prerequisites. Third, our focus on industrial firms and the B2B setting places boundaries on the type of CBMs studied—namely, firms seeking improved resource efficiency through advanced services. Barriers and problems, for example, may look very different in a B2C setting.

5.4 | Conclusions

We show that barriers can be directly tied to the CBM dimensions of value creation, value delivery, and value capture, and that each CBM dimension is underpinned by a unique set of barriers. The analysis also demonstrates that each barrier is underpinned by a unique set of problems, many of which seem complex and nondecomposable. This underscores the need for ecosystem collaboration and effective alignment structures among partners. These problems, first and foremost, seem to make the scaling of a CBM challenging, and they presuppose that diverse actors come together and mobilize different knowledge sets. Altogether, these findings are synthesized into a framework that adds a time sequence for addressing barriers and problems. By tying barriers directly to the CBM dimensions in the framework, our results move beyond identifying mere barrier classifications to uncovering how the dominance of different barriers, underpinned by varying nondecomposable and decomposable problems, varies over time during the scaling of CBMs. Although CBM development is essentially experimental and iterative, barriers and problems underpinning value creation should be the first to be addressed, followed by those pertaining to value delivery, and then those concerning value capture when the other types have been mitigated, removed, circumvented, or otherwise dealt with.

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Conflicts of Interest

The authors declare no conflicts of interest.

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