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Circular business models in high value manufacturing: Five industry cases to bridge theory and practice

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Abstract
The transition to a circular economy (CE) requires companies to evaluate their resource flows, supply chains, and business models and to question the ways in which value is created. In the high value manufacturing (HVM) sector, this evaluation is critical, as HVM enables value in nonconventional forms, beyond profit, including unique production processes, brand recognition, rapid delivery times, and highly customized services. We investigate the role of value, cost, and other factors of influence in the selection of a circular business model (CBM) for HVM. Explored through five case studies using a qualitative evaluation of circularity, we then contribute to the emerging field of CBMs by modifying the CBM canvas that can capture the nontraditional value, traditional value, cost, and other influencing factors enabled via CBM adoption in HVM. Finally, the important role of digital technologies for incentivizing and enabling CBM adoption, is clarified.

KEYWORDS
circular business models, circular economy, digital technology, factors of influence, high value manufacturing, value creation

1 | INTRODUCTION

Circular business models (CBMs) have received increasing attention from industry practitioners and academic researchers alike (as evidenced on SCOPUS and Web of Science databases), as they constitute a key enabler in the advancement of circular economy (CE) research as a way for the industry to profitably achieve a radical increase in resource productivity (Linder & Willander, 2017). In addition, CBMs are being proposed to address economic challenges originating from the dominant linear economic model (Circle Economy, 2018; Jackson, 2009; Sachs, 2015). These risks include volatile market prices, problematic ownership structures, and the availability of resources. Other issues associated with the linear economic model include environmental impacts (e.g., water, air and soil pollution, biodiversity, and land resource depletion) (Jackson, 2009; Meadows, Randers, & Meadows, 2004; Rockström et al., 2009), and societal impacts (e.g., soaring unemployment and broadening inequalities) (Prahalad, 2004). Thus, the CE, while not entirely new (Geissdoerfer, Savaget, Bocken, & Hultink, 2017), has seen a significant increase in research in recent years (Okorie et al., 2018).

The CE concept proposes a circular system where the value of products, materials, and resources is retained in the economy for as long as possible (Merli, Preziosi, & Acampora, 2018). Although value is a key theme within CE literature, value is also an important theme within business models (BMs) literature (De Angelis, 2018).
Several authors base their definitions and frameworks for BMs on the concept of value (Amit, Massa, & Zott, 2011; Osterwalder & Pigneur, 2010; Richardson, 2008; Teece, 2010). For instance, Osterwalder and Pigneur (2010) argue a BM to be the rationale of how an organization creates, delivers, and captures value, while Amit, Massa, and Zott (2011) definition can be summarized as the means to create and capture value. When placed within the context of a CE, De Angelis (2018) argues that CBM implementation will affect all the elements of the framework.

Although there have been several studies on CBMs in literature, none have clearly positioned the adoption of CBMs within manufacturing. Manufacturing, including high value manufacturing, none have clearly positioned the adoption of CBMs within manufacturing. Manufacturing, including high value manufacturing (hereafter “HVM”) (MacBryde, Paton, & Mendibil, 2011), plays a central role in the realization of CE, and yet CBM research by Linder and Willander (2017, p. 186) noted, “… the adoption of CBM within manufacturing is not widespread …” (Linder & Willander, 2017). In the absence of a clear framework for transforming existing manufacturing BMs into CBMs, organizations willing to become circular must still figure out how to adapt their existing BMs or create new ones (Urbaninati, Chiaroni, & Chiesa, 2017). Further, given that the risk of pursuing CBMs is typically tied to perceptions of potential high uncertainty and unknown associated costs, business leaders may be reluctant to arbitrarily implement CBMs (Linder & Willander, 2017; Mendoza, Gallego-Schmid, & Azapagic, 2019).

We seek to test and evaluate the relationship and alignment of CBM theory with actual CBM adoption and practice in the HVM sector. Drawing from the work by Jensen, Prendeville, Bocken, and Peck (2019) and Bocken, Schuit, and Kraaijenhagen (2018), we evaluate five HVM industry cases to explore the value, cost component, and factors of influence (FOIs) elements that most significantly affect the CBM that is ultimately selected by organizations seeking to engage in CE. In doing this, we identify whether and how tools such as the CBM canvas can be refined to support and facilitate CBM adoption specifically for underrepresented HVM organizations. Through these cases, we clarify and extend the CBM literature (Linder & Willander, 2017; MacBryde, Paton, & Mendibil, 2011), by identifying the primary barriers to adoption of CBMs by manufacturers and HVMs. Further, we discuss the role and opportunity for a modified circular business model canvas (CBMC) framework (Osterwalder & Pigneur, 2010) to enable barriers mitigation and provide structure for CBM adoption by manufacturers and HVMs.

The rest of the paper is structured as follows: Section 2 presents a review of relevant literature in which the key concepts of CBMs, and CBM selection, are identified. Section 3 describes the case study companies, including characteristics and rationale for inclusion in our study. Section 4 describes the rationale for using CBMs as a conceptual classification matrix and case study results. Section 5 presents a discussion of the findings and insights from both the literature and industry case studies, as well as limitations of this work. Finally, in Section 6, the implications of our research, and future research paths, are highlighted.

2 | LITERATURE REVIEW

The keywords relevant to this research (“Circular Business Models,” “high value manufacturing,” “Cost” and “Value”) have been described as lacking an accepted definition (Livesey, 2006; Sminia, Ates, Paton, & Smith, 2018) and as lacking a common understanding of the concept (Nußholz, 2017). As an example of differing terminology, what is referred to as “high value manufacturing” in UK policy, is, in the United States, South Korea, and European policy referred to as “advanced manufacturing partnership,” “manufacturing 3.0,” and “factories of the future,” respectively. The same challenge exists for the term “circular business models” (CBMs), which is often used interchangeably with “sustainable business models” and “business models for sustainability” (cf. Bocken, Short, Rana, & Evans, 2013; Bocken, Short, Rana, & Evans, 2014; Bocken, Rana, & Short, 2015; Boons, Montalvo, Quist, & Wagner, 2013; Lüdeke-Freund & Boons, 2013). Of key interest here is that CBMs possess qualities and characteristics that are distinct from BMs that are simply oriented toward “sustainability” outcomes (Bocken, Rana, & Short, 2015). Our review adopts a similar approach to that by Nußholz (2017), with a search strategy limited to academic studies with explicit reference to the concept of “circular business model” (Table 1).

2.1 | CBMs in HVM

This section examines the question, “what are CBMs and how are they relevant for HVM?” According to Björkdahl (2009) and Osterwalder and Pigneur (2010), the term business model (BM) refers to the conceptual logic of how a firm creates and appropriates economic value across three value dimensions: (1) value proposition, (2) value creation and delivery, and (3) value capture. Several detailed ontological frameworks exist for BMs, often organized according to the key activities and resources controlled by the firm, customer needs and segments, cost structure, and revenue model (Osterwalder, 2004). During the BM innovation process, an iterative approach is used by firms to devise, refine, test, and realize new ways to create and appropriate value after studying the relevant market conditions (Blank, 2005; McGrath, 2010) (Govindarajan & Trimble, 2010; Ries, 2011; Sarasvathy, 2001). Once key assumptions have been validated, firms typically proceed to heavily invest in scaling the innovative model (Linder & Willander, 2017).

In recent years, and through this iterative process, the related concept of “circular” BMs (hereafter CBMs) has emerged (De Angelis, 2016) as a BM innovation in the context of the CE. This paper adopts the definition of CBM from (Linder & Willander, 2017, p. 183), as a “… business model in which the conceptual logic for value creation is based on utilizing economic value retained in products after...”

1Authors utilized SCOPUS and Web of Science for review of existing literature. Using "Circular Business Models" as search words, 62 articles were found for the period between 2014 and 2018 on SCOPUS. While there were 4 articles for 2018, there were 17 articles for 2017 and 40 articles for 2018. Web of Science showed similar increase. The search was performed in October 2019.
use in production of new offerings.” In a CE, the concept of value is distinguished and differentiated on the basis of the inherent material and economic value that is retained in products through life extension and other CE activities, enabled by CBMs. In other words, CBM literature suggests that central motives and dimensions of organizations making the transition to CBMs involve moving beyond the conventional model, expending on stakeholders, flows, influence, and conceptions of what value and cost actually consist of.

CE is described as an industrial system “... that is restorative or regenerative by intention and design. It replaces the ‘end-of-life’ concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models” (Ellen MacArthur Foundation, 2013, p. 7). Accordingly, CBMs are derived from the main principles and elements of CE (De Angelis, 2018; Mathews & Tan, 2011; Urbinatì, Chiaroni, & Chiesa, 2017; S. Yang & Feng, 2008) and are often described via the ReSOLVE framework (Ellen MacArthur Foundation, 2013, 2015), which clarifies the roles of Regenerate, Share, Optimize, Loop, Virtualize, Exchange, as CBM options. Application of the ReSOLVE framework to contemporary BMs requires consideration of circular value creation (Lewandowski, 2016); and what types of value are relevant for CE and CBM landscape requires that manufacturers shift from a firm-centric to a network-centric operational logic (Bocken, de Pauw, Bakker, & van der Grinten, 2016; Ranta, Aarikka-Stenroos, & Mäkinen, 2018).

CBMs take a variety of formats, some of which are included in our HVM case studies, including but not limited to product life extension (De los Ríos & Charnley, 2015; Nußholz, 2017; Ranta, Aarikka-Stenroos, & Mäkinen, 2018); recycle, reduce, and reuse (3Rs) (Ranta, Aarikka-Stenroos, & Mäkinen, 2018); product-service systems (PSS) (De los Ríos & Charnley, 2015; Rosa, Sassanelli, & Terzi, 2019a; Upadhyay, Akter, Adams, Kumar, & Varma, 2019); next-life sales, product modification and renovation, recycling, and consumption collaboration (Upadhyay, Akter, Adams, Kumar, & Varma, 2019); access, performance, and hybrid models (Nußholz, 2017); slowing and closing of resource loops (Moreno, de los Ríos, & Charnley, 2016); and sharing platforms (De los Ríos & Charnley, 2015).

In our review, we noted that BM literature tends to frame costs and value in very conventional ways that to not appropriately account for the system of stakeholders and flows that are enabled via CBMs. Further, utilizing the conventional structure of the BM canvas format inherently subjected innovative CBMs to “fit” within conventional priorities and perceptions. Iterations of the “CBM canvas” have predominately worked within the original BM framework; this may have served to overemphasize elements of perceived cost and risk associated with the CBM and to underemphasize the nonconventional value enabled and captured by the CBM. We argue that an adjusted canvas that is able to meaningfully account for these nonconventional forms of costs, value, and FOI is needed.

### 2.2 Value creation in CBMs

This section examines the question, “how is value understood in the context of BMs and CBMs, and what types of value are relevant for
| Author, year | Paper | CBM | Value component | Sub-components |
|--------------|-------|-----|----------------|---------------|
| Ranta, Aarikka-Stenroos, and Mäkinen (2018) | Creating value in the circular economy: A structured multiple-case analysis of business models | Product life extension strategies: recycle, reuse, and reduce (3Rs) | Value proposition | Value creation |
| Upadhyay, Akter, Adams, Kumar, and Varma (2019) | Investigating “circular business models” in the manufacturing and service sectors | PSS; next life sales; product modification and renovation; recycling; and consumption collaboration | Value proposition | Value creation and delivery |
| Nußholz (2017) | Circular business models: Defining a concept and framing an emerging research field | Product life extension; access and performance model; and hybrid model. (16 different CBMs were captured in the review) | Value proposition | Value capture |
| Moreno, de los Rios, and Charnley (2016) | A conceptual framework for circular design | CBM categorization: CBM focused on closing loops; PSS; CBMs to slow and close resource loops; and BMs for circular advantage | Value proposition | Financial aspects |

(Continues)
| Author, year                  | Paper                                                                 | CBM                      | Value component                        | Sub-components                                                                 |
|------------------------------|----------------------------------------------------------------------|--------------------------|----------------------------------------|--------------------------------------------------------------------------------|
| Rosa, Sassanelli, and Terzi (2019a) | Circular business models versus circular benefits: An assessment in the waste from electrical and electronic equipment sector | PSS                      | Economic value                         | Economic value: Reduction of overall costs, reducing business risks, opening new revenue streams, reducing product/process complexity, and improving competitive advantage |
|                              |                                                                      |                          | Environmental-industrial value         |                                                                                   |
|                              |                                                                      |                          | Social-industrial value                |                                                                                   |
| Lewandowski (2016)           | Designing the business models for circular economy-toward the conceptual framework | 26 CBMs identified across the regenerate, share, optimize, loop, virtualize, and exchange classification criteria | Value propositions                   | Value prop: Ownership based, traditional form of service to virtual form, cost savings, customer bespoke services, and incentives |
|                              |                                                                      |                          | Channels                               |                                                                                   |
|                              |                                                                      |                          | Customer relationships                 |                                                                                   |
|                              |                                                                      |                          | Revenue streams                        |                                                                                   |
|                              |                                                                      |                          | Key resources                          |                                                                                   |
|                              |                                                                      |                          | offering, value creation, value delivery (key resources) |                                                                                   |
| De los Rios and Charnley (2015) | Skills and capabilities for a sustainable and circular economy: The changing role of design | Product life extension, product as a service, and sharing platforms | Economic value                         | Economic value: Material efficiency, product life extension activities for goods, value from sharing platforms, Environmental value: Initiatives such as car sharing help reduce the number of cars on the road and consequently fewer CO₂ emissions from cars, Social value: CE models allow manufacturers to obtain benefits while reducing the amount of materials going to landfill. |
|                              |                                                                      |                          | Environmental value                   |                                                                                   |
|                              |                                                                      |                          | Social value                           |                                                                                   |

Note: Based on Ranta, Aarikka-Stenroos, and Mäkinen (2018).
HVM?" Numerous studies have investigated value within conventional BMs; however, few studies have investigated value in the context of CBMs. As summarized in Table 2, relevant research worth noting includes theoretical perspectives on CBM value creation (Lahti, Wincent, & Parida, 2018), the reconfiguring of CBM elements to capitalize on associated economic, customer, and environmental value (Nußholz, 2017), and a structured multiple explorative case analysis of CBMs, in which the authors argue that value can be created through five different research propositions (Ranta, Aarikka-Stenroos, & Mäkinen, 2018).

As inferred in Table 2, the existing literature broadly approaches the concept of value within the context of BMs as value proposition, value created, and delivered; and value captured, across economic, social, and environmental dimensions. The addition of social and environmental dimensions to the original BM canvas developed by Osterwalder and Pigneur (2010) has been proposed as a way to clarify and demonstrate a framework for the evolving and expanding dimensions and constructs that are needed within a CE (Joyce & Paquin, 2016). Notably, a detailed adaptation of the eco-canvas for CBMs has been proposed by Daou et al. (2020), adding new dimensions for social and environmental foresight and impact, as well as CBM innovation.

However, when organized around the principles of circularity, HVM firms in particular have been noted to extract new forms of value from the CBM that are not adequately captured by just the addition of social and environmental dimensions, that is, the use of Industry 4.0 tools within the construct of the ReSOLVE framework strategies (Huaccho Huatuco, Martinez, Burgess, & Shaw, 2019; Luiz et al., 2018; Sminia, Ates, Paton, & Smith, 2018).

As proposed by Bocken, Short, Rana, and Evans (2013), effective differentiation and competition of CBMs on the basis of cost require a fundamental rethinking of the value proposition, particularly for HVMs. This is because CBMs expand traditional stakeholders to include (1) customers, (2) investors and shareholders, (3) employees, (4) the environment, and (5) society. There is general consensus in the literature that the use of CBMs in the context of HVM creates opportunities for new forms of value (Livesey, 2006; Luiz et al., 2018; MacBryde, Paton, & Clegg, 2013; Martinez, Neely, Ren, & Smart, 2008; Sminia, Ates, Paton, & Smith, 2018; Upadhyay, Akter, Adams, Kumar, & Varma, 2019). Per Sminia et al. (2018, p.522): “... there seems to be more to HVM than manufacturing firms simply exploiting their manufacturing core capabilities and pursuing a focus or differentiation strategy to avoid competition on price” (Sminia, Ates, Paton, & Smith, 2018).

However, the current literature regarding original and adapted BM canvases does not adequately clarify what new forms of value may be possible for HVMs through the adoption of CBMs. As this has not been fully explored, we posit that the FOIs affecting design and implementation of CBMs, and the potential reframing of what constitutes value and cost for HVM CBMs, can also provide valuable insights for the continued evolution of CBM canvases.

2Using SCOPUS and keeping the time period as undefined, the authors found there to be 348 articles when “business models” and “value” were used as search words. The search words were restricted to article titles only.

2.3 Costs factors associated with CBMs for HVMs

This section examines the question, “what are the associated costs that high value manufacturers would face in adopting circular business models?” BM ontology refers to “costs” and “cost structure” as an inclusive term generally defined as “all costs incurred to operate a business model” (Osterwalder et al., 2014). Given that costs are incurred as a necessity of value creation, delivery, and capture, there is a clear link between value and cost structure, suggesting that costs and revenue are sub-components of the value capture mechanisms (De Angelis, 2018; J. Vogtlander, Mestre, Scheepens, & Weaver, 2013).

For example, Schröder, Falk, and Schmitt (2015) identify the cost factors in the adoption of additive manufacturing activities as including fixed costs (machine costs and software and hardware costs) and variable costs (production, material, labor, maintenance, and printing costs). Alternately, cost factors are identified and distinguished as “production costs” versus “product costs” for more general CBM adoption (Bressanelli, Perona, & Saccani, 2017; Giannetti, Risso, & Cinquini, 2016). A sample of cost factors identified from available literature is presented in Table 3.

From our sample of literature, it is clear that cost factors are clearly tied to the type of CBM being adopted. Thus, related to, and influencing CBM cost structure decisions, manufacturers face significant and distinct cost-related challenges that must be overcome for CBM adoption. Among these, the perceived higher investment risk, and therefore cost, of CBMs (Linder & Williander, 2017), the risk of sales cannibalization by circular product offerings (Daniel, Guide, & Li, 2010), the challenge of operating cost-efficient return flow and reverse logistics (Raci & Shankar, 2005), the inherent operational risks tied to inventory management and evolving asset ownership models (Kuo, Ma, Huang, Hu, & Huang, 2010; Linder & Williander, 2017), and tax disadvantages tied to labor-intensive CBM activities (Stahel, 2010). Often not addressed within the literature is the associated traditional and nontraditional value creation that accompanies these additional risks, uncertainties, and costs.

2.4 Other FOIs

This section addresses the question “what other factors, besides costs and value, should high value manufacturers consider before adopting any circular business model?” According to Upadhyay, Akter, Adams, Kumar, and Varma (2019) and Huang, Tan, and Ding (2015), manufacturers are motivated to adopt CBMs for a variety of reasons that include but are not limited to increasing environmental regulations, access to reverse supply chains, utilization of product residuals at the end of product-life, and pressure from customers and suppliers. Unrelated to cost and traditional measures of value, these constitute FOIs that can motivate a decision for an HVM to adopt a CBM and affect the design of the CBM. In some cases, CBM innovation and adoption may present a pathway to competitive advantage for a firm, if the CBM is distinctly differentiated and difficult to replicate (Teece, 2010). However, despite their relevance
| Author, year | Paper | CBM | Industry | Cost component |
|-------------|-------|-----|----------|----------------|
| Schröder, Falk, and Schmitt (2015) | Evaluation of cost structures of additive manufacturing processes using a new business model | Product service system | Additive manufacturing | Cost of machine, production cost, material costs, labor costs, maintenance, software, hardware, and printing |
| J. G. Vogtlander, Scheepens, Bocken, and Peck (2017) | Combined analyses of costs, market value and eco-costs in circular business models: Eco-efficient value creation in remanufacturing | Remanufacturing is identified as a CBM, product service system. | Remanufacturing for mainstream consumer markets | Eco-efficient value creation method (J. Vogtlander, Mestre, Scheepens, & Wever, 2013) is used to identify “Eco-costs,” a cost component that expresses the amount of environmental burden of a product on the basis of prevention of that burden. Other costs identified include R&D costs, marketing costs, and production costs. |
| Lee, Suckling, Lilley, and Wilson (2016) | Reshaping the washing machine industry through circular economy and product-service system business models | Product service system | Manufacturing (washing machine manufacturing) | Material cost and connected inventory costs |
| Giannetti, Risso, and Cinquini (2016) | Managing costs by business model: issues emerging from the case of E-Car | SDL, where goods are seen as merely a means or delivery mechanism for service provision | E-car industry | Cost structure, described as cost drivers. These include cost of items (insurance premiums, maintenance, or materials); labor and over-head costs; scale and learning; and production costs |
| Susarla, Barua, and Whinston (2009) | A transaction cost perspective of the “software as a service” business model | “Software as a service,” a variant of PSS | Computing/information technology | Adaptation and monitoring costs, described as transaction costs; contracts costs (haggling, dispute resolution, bargaining, and renegotiation); product costs |

Note: Based on Ranta, Aarikka-Stenroos, and Mäkinen (2018).
Abbreviations: SDL = Service-dominant logic.
*Eco-costs have been introduced in the International Journal of LCA, which was last updated in 2012. Mathematically, it is defined as the sum of the “midpoints” (12 environmental and 5 social) (van der Velden & Vogtländer, 2017).
and importance, our literature search revealed no papers that clearly identified and delineated the FOI for CBM adoption in HVM firms. At best, where identified, these factors are typically lumped together within general cost or value dimensions.

The rapid spread of CBMs as a business strategy has given rise to the need for standardized understanding of the contextual elements that are necessary for identifying and implementing CBM practices (Chen, Hung, & Ma, 2020). A clear framework for connecting CBM theory to CBM practice is following our review of existing literature, there is a clear need to establish relevant and common understanding of value and cost factors for ontological, normative and operational aspects of CBMs for HVM (Chen, Hung, & Ma, 2020). Further, there is a need to systematically account for important FOI that affect different dimensions of the CBM and that cannot be sufficiently addressed within conventional value or cost perspectives (Frishammar & Parida, 2019; Sarasini & Linder, 2018).

3 RESEARCH DESIGN AND METHODOLOGY

In accordance with existing CBM research, we assume a qualitative case study methodology (Bocken, Schuit, & Kraaijenhagen, 2018; De Angelis, 2016; Jensen, Prendeville, Bocken, & Peck, 2019). Given emerging nature of research into CBMs and HVM, the use of multiple case studies facilitates a wider exploration of relevant research questions and thus a more convincing theory (vs. single-case studies) (Gustafsson, 2017). Case studies are considered as one of the most important methods for inductive research and have been utilized in several studies investigating firm value (Bititci, Garengo, Ates, & Nudurupati, 2015; Eisenhardt, 1989; Huacho Huatuco, Martinez, Burgess, & Shaw, 2019). We capture this case study protocol in Figure 1 below.

FIGURE 1 Methodological process for HVM case studies and synthesis. CBM = circular business model, FOI = factor of influence, HVM = high value manufacturing

Appropriate candidate companies for the case studies included those reported to be pursuing circularity principles (Zucchella & Previtali, 2019). Several sources for industry case study candidates were identified: (1) HVM companies that had received awards recognizing their CE implementation, (2) search engines\(^3\), (3) companies cited in CE and sustainability reports, (4) companies that had comprehensive case study documents in the Ellen McArthur Foundation database\(^4\), and (5) companies that had comprehensive case study documents in the European Remanufacturing Network database.

As captured in Table 4, we restricted our selection of case studies to five companies, anonymized as following: Company A (a Small or Medium-sized Enterprise automobile manufacturer), Company B (a global leader in transport mobility), Company C (an ICT refurbishment company) Company D (an automobile parts remanufacturer), and Company E (a global lighting company). These case study companies provided representation of diverse sizes, product offerings, and value-chain positions. Further, in addition to pursuing circularity principles, these case study companies are aligned with some of the conditions of HVM, key of which is the continued engagement in manufacturing while avoiding price competition (MacBryde, Paton, & Mendibil, 2011; Sminia, Ates, Paton, & Smith, 2018). All companies accepted our invitation to be included as an industry case study, and each reviewed the final results. An initial review of publicly available documents for each case study was completed, with descriptions highlighting the company’s familiarity with CE and CE concepts, their existing CBMs, and project focus (cf. Bocken, Schuit, & Kraaijenhagen, 2018). After the initial review was completed, requests for additional data were made to all companies to clarify their company-specific perspectives regarding costs, value, and FOI. All five (5) responded, initially providing

\(^3\)Online search for these case studies were made and accessed for research on October. 03. 2019

\(^4\)Ellen MacArthur Foundation case study database can be accessed at https://www.ellennmacarthurfoundation.org/case-studies (Accessed for research October. 03. 2019).
| Company and structure | Industry | Familiarity with implementing the CE | Identified CBM | Project focus | Case study secondary data source |
|-----------------------|----------|-------------------------------------|----------------|--------------|----------------------------------|
| Company A, >21 employees (UK) | Automotive Hydrogen fuel-cell car | Detailed awareness of the circular economy concept. Implements CBM into manufacturing and governance structure | PSS Ownership of car is retained with mobility as a service. | Incentivizing existing supply network | Company website, EMF database |
| Company B division >34,200 employees (global) | Intelligent transport division of Company B | Good awareness of CE concept. Siemens CE position statement. Focused on environmentally focused CE initiatives such as zero waste to landfill. | Product life extension model based on predictive maintenance | Implementing sustainability standards, enabling manufacturing with I4.0 | Company website, PowerPoint presentation |
| Company C, >146 (UK) | Refurbished Servers and Data Centre Equipment | Understands circular economy changes their business model. Involved in a 3-year Interreg-funded research project, “Circular Economy in the Data Centre Industry” | Product life extension model: Refurbishment | Interreg-funded research project, as associate partner. Public sector circular IT frameworks (ongoing) | Company website. Secondary data sources |
| Company D, >100 employees (UK) | Automotive remanufacturers | Excellent awareness of the CE. Part of the ERN. Currently works with academia in CE related initiatives for company. | Product life extension model: remanufacturing | Merging remanufacturing and manufacturing sites | Company website. ERN database. |
| Company E, >1000 employees (global) | Energy (lighting) | Company possesses excellent understanding of CE principles. Involved with academia at TU Delft, Lund University and across Europe. | Selling of light as a service. PSS. | Developing the business model of the “pay per lux” project and the platform that facilitate resource management between manufacturer, supplier and end-user. Integrate the CE in business operations and daily way of working as well as building CE leadership competencies | EMF database, Google Scholar, Science Direct, UNEP study |

Abbreviations: ERN = European Remanufacturing Network, PSS = Product-service systems.
additional public documents that were included in the analysis, as well as addressing follow-up questions by email where needed. Additional data and information from secondary sources were collected to facilitate the triangulation of information and important cross-case comparisons (Saunders, Lewis, & Thornhill, 2012; Urbinati, Chiaroni, & Chiesa, 2017). Finally, the research protocol was concluded with a semi-structured (30–60 minutes) interview with respondents from case companies as well as 3 academics to ensure a measure of triangulation. The case study results were discussed and validated with the respondents. Demographics for the respondents are given in Appendix A and we capture the semi-structured interview questions in Appendix B (Binder & Edwards, 2010; Mäkelä & Turcan, 2007). This facilitated the development of our proposed expanded framework that links CBM theory to circular HVM practice.

4 | RESULTS OF CASE COMPANIES

Although the implementation pattern of CE principles, and the understanding of BMs differed, all case companies possessed a detailed and practical understanding of CE, had a defined CE purpose, and had incorporated CE thinking into their mission and goals (Table 4). The five industry case studies were analyzed on the basis of CBM value (Table 2) and CBM cost (Table 3). Analysis of supplemental documents, secondary research, and interview results was used to assess FOI for HVM company-specific adoption of CBM.

4.1 | Company A case study

| Company: | Company A |
|----------|-----------|
| Description: | SME automobile manufacturer |
| Number of employees: | 21 |
| Year founded: | 2007 |
| Operations: | UK based |

4.1.1 | CBM/evidence of circularity

Company A has sustainability at its core, across manufacturing, design, structure, and governance elements of the business. Specifically, Company A provides the value proposition of mobility at zero cost to the planet via a hydrogen fuel cell vehicle (HFCV). The innovation-driven car has been created for the planet via a hydrogen fuel cell vehicle (HFCV). The innovation-driven car has been created for the planet via a hydrogen fuel cell vehicle (HFCV). The innovation-driven car has been created for the planet via a hydrogen fuel cell vehicle (HFCV).

The BM can be regarded as a PSS model, given its emphasis on "sale of use," rather than "sale of product" (Baines et al., 2007). This value proposition is embedded into a circular value network, that consists of a mining company, a membrane electrode assemblies (MEAs) supplier, a fuel cell manufacturer, and Company A. In the cost structure, the customer pays Company A via a monthly direct debit that accounts for a fixed monthly base rate and a mileage rate; the fuel cell is leased to Company A, who pays for installed kilowatt hours of electricity; the fuel cell manufacturers do not buy the MEA, and instead, have a contractual leasing agreement with the MEA supplier; and the platinum needed in the MEA is leased to the MEA supplier by the mining company. Thus, by Company A’s suppliers maintaining ownership of different components of the HFCV all circular value network stakeholders, and the customer, benefit from a restructuring of the risks, responsibilities and costs normally associated with asset ownership, and a lower environmental impact of the product is expected (Baines et al., 2007; Bech, Niero, McAloune, Kjaer, & Pigosso, 2018; Lindkvist & Sundin, 2016).

For Company A, this CBM is adopted throughout the supply chain by the firm’s suppliers; hence, there is greater alignment of interests across suppliers, Company A, customers, and the environmental goal. To support this CBM, a “distributed manufacturing model” uses small, flexible, and scalable manufacturing units, that are located within distributed production networks (Matt, Rauch, & Dallasega, 2015; Moreno & Charnley, 2014). According to the CEO of Company A, they will “build human-scale, profitable operations near the markets they serve – each will produce around 5,000 cars a year.”

4.1.2 | HVM-specific HVM features

Company A qualifies as HVM via the technology of the HFCV car, as well as their CBM in which they compete primarily on different forms of value, not cost. The HFCV car is lightweight, weighing just 580 kg: motors are used as brakes, hence recovering over 50% of kinetic energy when braking; the body of the car is made of lightweight composites; the car is powered by a low-powered hydrogen fuel cell (8.5 kW) with zero tail-pipe emissions. In Table 5, we identify the various value, cost, and FOI considerations for Company A, adapting the conceptual framework from (Ranta, Aarikka-Stenroos, & Mäkinen, 2018) and expanding on the CBM canvas. Company A’s CBM maintains CE principles by ensuring that used products and materials are returned back to the manufacturer. Each manufacturer within the circular value network is responsible for repairs and replacement of worn-out materials, ensuring that minimum amounts of virgin materials are consumed.

4.2 | Company B case study

| Company: | Company B |
|----------|-----------|
| Description: | Global leader in transport mobility |
| Number of employees: | 34, 200 |
| Year founded: | 2018 |
| Operations: | Global |

MEAs are embedded in the fuel cell (Okorie, Salonitis, Charnley, & Turner, 2018).
4.2.1 | CBM/evidence of circularity

The parent company of Company B presents a value proposition that is grounded in CBM mobility services and embedded with Industry 4.0 technologies (Table 6). A separately managed company, dedicated to rail technology, railway electrification, intelligent traffic systems, road solutions, turnkey projects, and electrification and intermodal solutions, was created. These technologies are served by “Portfolios,” which are what Company B describes as “services to support these technologies.” Company B Portfolios for the installed base of mobility equipment include maintenance, spare part, upgrade, and operations services. The customer experience for Company B customers incorporates a three-pronged approach focused on efficiency (increase of efficiency through optimized processes), sustainability (ensuring sustainability through leveraging of experience), and reliability (ensuring high reliability through innovative maintenance concepts).

4.2.2 | HVM-specific CBM features

Company B’s CE position statement focuses on utilizing digital technologies to drive the transition to a CE, and as digital technologies

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**TABLE 5** Value, associated costs, and other factors influencing CBM adoption in Company A

| CBM          | Value prop                                                                 | Value creation and delivery                                                                 | Value capture                                                                 | Cost components                                                                 | Other factors influencing CBM adoption                                                                 |
|--------------|----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| PSS          | Offering: transport mobility through hydrogen fuel-cell car as a service. Ensuring efficiency is profitable. Target customer: stakeholders on circular value network (mining company, MEA supplier, fuel cell manufacturer, and individual customers) | Value creation: Environmental, customer, economic, and information Resource and capabilities: R&D lab, good company structure Organization: Coordinates relationship between mining company, MEA supplier, fuel cell manufacturer, and external stakeholders Position in the value network: base member of the value network | Revenue sources: Government Grant. Crowd funding. Economics of the business: Distributed manufacturing model | Associated costs: labor, material, production, technology, data cost (capture, storage, analysis), information, pricing structure, transportation and logistics costs, and contracting | Customer acceptance, circular value network structure, environmental factors, industry 4.0 technologies, lower economic barriers as being competitive is not dependent on the build cost of the car but its lifetime cost. |

**TABLE 6** Value, associated costs, and other factors influencing CBM adoption in Company B

| CBM          | Value prop                                                                 | Value creation and delivery                                                                 | Value capture                                                                 | Cost components                                                                 | Other factors influencing CBM adoption                                                                 |
|--------------|----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| PSS; resource efficiency through IoT solutions; product life extension using predictive-based maintenance | Offering: rail solutions, road solutions, intermodal solutions, and consulting. Target customer: Government through public transport and infrastructure. | Value creation: Environmental, economic, social, customer, waste, and information and generated data Resources and capabilities: R&D labs, international operations, mobility-focused solutions. Organization: 3 way [Company B customers] Position in the value network: Central | Revenue sources: Customers (mainly government and passengers) Economics of the business: enabled by digitalization (IoT, additive manufacturing, augmented reliability, and data-driven predictive maintenance) | Associated costs: labor, data cost (capture, storage, analysis), repair and maintenance cost, and transportation and logistics costs | Digital technologies, adoption, deployment is the main factor influencing, ability to integrate CBM with government policies, for example rail policies, sustainability policies, CBM model is ideal to product offering. |
become pervasive, this trend is expected across manufacturing companies (Beatriz et al., 2018; Okorie et al., 2018; Rajput & Singh, 2019). For Company B, a PSS is used alongside Internet of things (IoT) solutions, to ensure improved resource and product life extension options via predictive and preventative maintenance. Company B creates value that manifests in environmental (sustainability), economic (optimization), information (product-level, installed-base\(^6\)), and customer (service) forms (Schenkel, Krikke, Caniëls, Laan, & van, 2015). The industry case study analysis revealed two other manifested forms of value creation: resource utilization, that is, solid waste is collected, and utilized as an energy-from-waste input; and generated data (product and system levels and analytics), that is, generated data are used to drive IoT-based CE solutions, including predictive maintenance and digital twinning used to extend product and component life cycles. This is different from information value (see Footnote 6), which includes information about the installed base (Schenkel, Krikke, Caniëls, Laan, & van, 2015). Thus, digital technologies can influence the choice of CBM that HVM companies make and require expanding the dimensions of the existing CBM canvas (Table 6).

### 4.3 Company C case study

| Company: Company C |
|-------------------|
| Description: ICT refurbishment |
| Number of employees: 146 (2019 numbers) |
| Year founded: 2005 |
| Operations: EU, North America, Asia Pacific |

### 4.3.1 CBM/evidence of circularity

Company C began selling new and refurbished ICT equipment in 2005. However, rising demand for refurbished equipment during the 2008 financial crisis enabled the company to pivot into a specialized, comprehensive refurbishment-focused CBM that continues to sell a small amount of new product. The comprehensive refurbishment process at Company C includes several stages: (1) business-to-business (B2B) purchase of redundant ICT equipment, (2) restoration of IT equipment to factory conditions, (3) securely erasing data bearing devices, and (4) shipping components and/or fully configured refurbished servers to new customers. Product quality is signaled and supported via a manufacturer-comparable three-year warranty. Becoming a CBM specialist in a growth sector has benefitted the firm, with staffing levels rising from 48 to 146 between 2016 and 2019, and revenue increasing from £14 m in 2015 to £36 m in September 2018 (Insider Media Limited, 2018). The associated value, cost, and FOI for Company C are described in Table 7.

4Information at the product level, regarding the installed base, includes data regarding product age, technical status, physical location, spare parts consumption, maintenance and service status, and life-cycle performance.

5Secondary data were collected from Company C in August 2019.

### 4.3.2 HVM-specific CBM features

Value creation by Company C can be summarized as both “observable” and “hidden.” Observable value derives from the fact that enterprise ICT equipment continues to be traded in secondary markets long after original owner corporations write it off as zero value after a three-year or “live” accounting period. According to the CEO of Company C, “With a typical corporate, once they have written older kit off, after three years it is no longer on the balance sheet or of any interest and their recycler will charge X pounds to collect it. But there is value in it. We have been saying ‘don’t give it to your recycler, give it to us and we will give you fair market value for it’” (Insider Media Limited, 2018). Hidden value creation manifests in both economic and environmental forms, via a value proposition for Company C’s management team stakeholders (M. Yang, Evans, Vladimirova, & Rana, 2017) that is grounded in dematerialization, for example, the reduction in unit-level and aggregate material use required to generate revenue. In addition to previously identified initiatives (Table 4), Company C is involved in several education efforts targeting the increase of recovery rates for precious materials from ICT using nonmechanical techniques. They describe these initiatives as value-creating initiatives and classify the “education” value among the intangible, hidden value. Unlike “value missed” (Bocken, Short, Rana, & Evans, 2013; M. Yang, Evans, Vladimirova, & Rana, 2017), which posits that “value missed” is value that is not explored or adequately captured by the BM, Company C regards the education/research value and the dematerialization value deriving from their HVM activities as being hidden value. Thus, although these forms of value were “… not envisaged when we first developed the business model …” (Sustainability Manager, Company C), this case company is currently working to integrate these forms of value effectively into their CBM.

### 4.4 Company D Case study

| Company: Company D |
|-------------------|
| Description: Automobile parts remanufacturer |
| Company size: 55 |
| Year founded: 1971 |
| Operations: UK based |

### 4.4.1 CBM/evidence of circularity

Company D is a UK-based independent remanufacturing firm serving customers across the United Kingdom, Europe, and North America since 1971. Their remanufacturing vehicle fleet includes off-highway, heavy goods vehicles (HGVs), and trucks, buses and coaches, vans and light commercial trucks, and automotive cars. As a remanufacturer of steering boxes, pumps, racks, and original equipment manufacturer (OEM) steering columns, Company D’s value proposition stems from
the definition of remanufacturing, in which a core\textsuperscript{8} or product is returned to performance and quality that meets or exceeds that of a new version of the product (International Resource Panel, 2018; Paterson, Ijomah, & Windmill, 2017). The CBM network effectively connects Company D, vehicle OEMs, customers (end-users), and the independent aftermarket/secondary market. Company D’s remanufactured products are supplied through two CBM schemes: (1) service exchange (independent market) and (2) return and remanufacture (OEMs) (Figure 2).

Under the service exchange scheme, a customer pays Company D for a remanufactured product from their stock, and Company D applies a surcharge to the transaction that acts as a deposit. When the worn-out product needs to be replaced, the customer returns it to Company D and receives the surcharge credit (deposit) back, in exchange. Thus, the customer is incentivized to return the product/core, and Company D uses the old product/core to replenish their service exchange scheme inventory stock. The return and remanufacture dimension of the BM primarily applies to vehicle manufacturers who collect old parts/units from their customer/end-users and send these units in bulk to Company D. Once the remanufacturing process is complete, the company returns the remanufactured units to the manufacturers. For Company D and its stakeholders, the value manifests in economic, environmental, and social forms (Table 8). Relative to a newly manufactured version, Company D estimates that the remanufactured product is 50%–65% less expensive, consistent with remanufacturing literature (Adrian, 2010; APSRG & APMG, 2014; Lund & Mundial, 1984). Price discounting for remanufactured products creates economic value for customers, without compromising the profit margins of the remanufacturers (International Resource Panel, 2018). This is because the CBM enables a significant reduction in unit-level operating costs as a result of reduced material use and energy consumption requirements (International Resource Panel, 2018).

### HVM-specific CBM features

Through its HVM approach and remanufacturing CBM, which includes the maintenance of remanufactured product inventory, Company D additionally creates a time-based form of value. That is, Company D is able to significantly reduce the lead time for providing HVM replacement vehicle parts to its customers (Table 8). Further, they can reduce the amount of time required to return the same core back to the original customer. Thus, Company D’s CBM incorporates an additional value-proposition grounded in minimizing the out-of-service time for fleet vehicles that complements the more conventional economic, environmental and social value creation.

### Company E Case company

| Company: | Company E |
|----------|-----------|
| Description: | Global lighting company |
| Company size: | 32,000 |
| Year founded: | 2013 |
| Operations: | Global |
4.5.1 CBM/evidence of circularity

The “performance economy” model (Stahel, 2008) emphasizes the importance of selling services rather than products, and inspired Company E’s decision to develop the bespoke “pay-per-lux” intelligent lighting system. This CBM incorporates the design of the “pay-per-lux” system to fit the requirement of the customer's space (installed location) and budget while also ensuring design for durability and ease of maintenance and repair. As a circular design strategy of the “light-as-a-service” model, Company E retains ownership and responsibility for the lighting installation, including any necessary maintenance and repair during the life of the arrangement, and the customer pays for the light that is actually used (e.g., per lumen). By enabling the optimized dimming or brightening of the lighting system in response to motion, or the presence of daylight, a combined sensor and controller system helps to keep energy consumption at a minimum. Thus, the value created, delivered, and captured in the “pay-per-lux” model is the full life-cycle management of energy-efficient lighting, including preventive maintenance and system optimization (Mendoza, Gallego-Schmid, & Azapagic, 2019). For Company E, the intentional design for longevity and recyclability into their products leads to nontraditional forms of value-creation (Schulte, 2013). Overall, this CBM enables value to manifest in environmental and economic value for the customer and for Philips (Table 9).

### Table 8: Value, associated costs, and other factors influencing CBM adoption in Company D

| CBM | Value prop | Value creation and delivery | Value capture | Cost components | Other factors influencing CBM adoption |
|-----|------------|-----------------------------|---------------|----------------|----------------------------------------|
| Product life extension via remanufacturing consisting of “returned and remanufactured scheme” and “service exchange scheme” | Offering: remanufactured OEM steering systems, steering, hydraulics and military engineering. Target customer: OEMs, government bodies, and agencies | Value creation: economic, environmental, and social (job opportunities), customer relationship as a value. Resources and capabilities: 45 years' experience in remanufacturing, an integrated manufacturing and remanufacturing site Resources and capabilities: integrated remanufacturing and manufacturing hub Organization: Primarily B2B Position in the value network: Central | Resources sources: customers (OEMs and government departments) Economics of the business: remanufacturing primarily driven by cheaper cost of remanufactured products in comparison to newly manufactured products. | Associated costs: training, warehouse space, labor and personnel cost, and logistics cost | Policies and legislation factors supporting remanufacturing and CE transition in the United Kingdom. Policy-implementing bodies such as European Remanufacturing Network, Conseil European de Remanufacture |

**FIGURE 2** Company D business model (sourced from Company D business model case study description)
4.5.2 | HVM-specific CBM features

HVMs, especially when adopting CBMs, often require major upfront financing and longer payback periods, which highlights a need and opportunity for HVM to strategically shift away from more conventional expectations regarding return on investment (ROI) and payback periods (Schulte, 2013) (Table 9). Recognizing this particular HVM-CBM challenge, Company E collaborated with a consultancy, who served as an intermediary within the system by retaining ownership of the material content (asset-base) of the lighting system and selling it back to Company E at end-of-life.

5 | ANALYSIS AND DISCUSSION

5.1 | CBMs analysis

As our industry case studies indicate, HVMs employ a range of different CBMs, including PSS, product-as-a-service (PaaS), predictive maintenance, remanufacturing, and refurbishment. This suggests the clear applicability of a variety of CBMs to HVM, specifically: share (focused on [i] sharing assets such as PSS and [ii] prolonging product life); optimize (focused on [i] increasing performance/efficiency of products via predictive maintenance practices, and [ii] leveraging big data, automation, and remote sensing; loop (focused on [i] enabling multiple product service lives) (Rosa, Sassanelli, & Terzi, 2019b). Further, there is evidence of CBMs tending toward “supplying service solutions rather than products,” or “service based manufacturing,” particularly in the context of HVM (MacBryde, Paton, & Clegg, 2013). Given the nature of HVM, it is reasonable to expect that “service” should be a component of the overall value proposition made to customers. Through the integration of “looping” and “optimizing” CBMs, such as remanufacturing, refurbishment, and data-driven predictive maintenance, firms can deliver value through a broadened range of activities, that offers a more balanced and complementary value proposition package (MacBryde, Paton, & Clegg, 2013; Martinez, Neely, Ren, & Smart, 2008). Although each industry case differed in terms of the product offering, size, geographic location, and industries, we noted that there were recurring themes of value considerations for CBM adoption that emerged across these HVMs.

As identified previously, the currently proposed CBM canvas options in the literature may not adequately reflect the unique opportunities for reframed value, cost, and other FOI associated with HVM. Further, the CBM canvas, as predominately evaluated in the literature may not provide sufficient insight or context to support HVM organizations as they attempt to transition from linear to circular BMs.

Given this, we integrate and model a summary of elements possible via the implementation of CBMs for HVM using a modified canvas.
5.2 | Value and cost element analysis

There were observed differences between value and cost components of BMs and CBMs, across HVM industries (Tables 5–9), and these were modeled using the CSBMC (Figure 3).

5.2.1 | Value creation

In accordance with the original BM canvas (Osterwalder & Pigneur, 2010), dimensions of value creation typically include key partners and/or stakeholders, key activities, and key resources of the CBM (Bocken, Short, Rana, & Evans, 2014). Although a number of reviewed papers suggest that value creation is fully captured within these three categories, it is also clear that the collaborative and networked nature of innovation for CBMs can lead to many new concepts, value, and uncertainties that are affected by key FOI (Antikainen & Valkokari, 2016). In the context of HVM, value drivers such as commoditization, specialization, globalization, sustainability, and the use of digital technology (Martinez, Neely, Ren, & Smart, 2008) can be integrated to deliver new forms of value for stakeholders. Some value creation components identified across the CBM case studies stood-out as distinct; for example, the value created through research and development (R&D) related to a PaaS model by Company E differs meaningfully from the value that R&D creates in non-HVM models. Thus, for HVMs with CBMs, in particular, R&D is very important and can provide a competitive advantage. This aligns with the resource-based theory of the firm (RBT) in which the organization as is framed as a “bundle of value” embedded in resources (Bowman & Ambrosini, 2000; Wernerfelt, 1984). As Richardson (2008) argues, value creation and delivery describe the firm’s sources competitive advantage states. In contrast to linear BMs, CBMs require a systems view of the product and product-system (Bakker et al., 2014).

5.2.2 | Value proposition

Based on the five industry case studies, we also posit that CBMs enable an expanded scope for the value proposition for HVMs, that includes the amplified value created for a broad set of stakeholders (e.g., society and the environment), in addition to the firm and its customers. Thus, the value proposition may explicitly include environmentally and socially oriented outcomes that appeal to the target customer and/or other stakeholders as a central driver of the CBM. Value proposition components of CBMs for HVMs thus include, but are not limited to the following:

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**FIGURE 3** The circular business model canvas for high-value manufacturing, provides a summary of CSBMC elements of value possible via the implementation of CBMs (*) within HVM (**) organizations, above-and-beyond conventional economic, environmental, and social dimensions of business model value (Source: adapted from Osterwalder & Pigneur, 2010)
- Economic value: Financial, cost reduction, risk reduction, and other monetary benefits that can accrue to the company and its stakeholders (Schenkel, Caniëls, Krikke, & Van Der Laan, 2015; Subramoniam, Huisingh, & Chinnam, 2010)
- Social responsibility value: Pursing environmental sustainability and CE BMs, such as value retention processes (VRPs), can enhance environmental performance and social well-being.
- Environmental value: The direct environmental value that can accrue by adopting CBMs (Schenkel, Caniëls, Krikke, & Van Der Laan, 2015), that is, GHG emissions reduction of between 79% and 99%, and significant material savings by adopting VRPs (UNEP, 2018).
- Educational/research value: HVMs can engage in collaboration with universities and research councils, enabling the advancement of qualitative and quantitative data.
- Organizational value: Value in the form of institutional knowledge and improving work conditions that can be gained via the process of developing and scaling CBM solutions (e.g., Company A’s localized approach, and options for flexible working conditions) (Bocken, Short, Rana, & Evans, 2014).
- Dematerialization and material-use offsets: The inherent value, beyond cost avoidance, of the product’s physical form and materials which are retained via use of VRPs, such as refurbishment and remanufacturing.
- Generated data: Product- and systems-level (predictive) data that can be generated via the use of digital technology within HVMs, and which can inform optimized product maintenance and end-of-life management decisions.
- Information value: Value of asset information and process knowledge that can be used to improve product design/quality/safety, life cycle information, and/or improved reverse supply chain (Ferré & Whybark, 2000; Frank, 2000; Schenkel, Caniëls, Krikke, & Van Der Laan, 2015)
- Circular value: The value that is generated through use of a network model that accuress to the HVMs, their parts suppliers, their raw material providers, and their customers.

These industry case studies demonstrate that the scope of value proposition can be extended beyond conventional dimensions of economic, environmental, and social value through the adoption of CBMs by HVMs. This more comprehensive understanding of extended and amplified CBM value propositions can provide HVMs with strategic clarity regarding the creation/modification of circular product or service offerings (Bocken, Schuit, & Kraaijenhagen, 2018; Breuer & Lüdeke-Freund, 2017; Ries, 2011).

5.2.3 Value delivery

Based on the industry case study insights, HVMs deliver value to a diverse and large number of beneficiaries, via interconnected global value systems (Martinez, Neely, Ren, & Smart, 2008) of communication, physical distribution and recovery, and sales channels. For certain types of CBMs, particularly those engaged in looping (e.g., Company C and Company D) and exchange (e.g., Company E), value delivery is achieved through both the physical forward distribution of products, and the physical recovery and reverse logistics systems that are maintained to manage end-of-use and end-of-life products and cores. Reverse logistics can represent a significant cost component for CBMs; however, this is typically managed effectively through pricing strategy and complementary revenue streams (e.g., Company D’s core deposit). The extent, complexity, and cost of asset management, recovery, and reverse-logistics systems can vary based on whether the channels are B2B (e.g., Company D’s OEM “Returned & Remanufactured” scheme) or business-to-consumer (B2C) (e.g., Company C). Some HVMs (e.g., Company D) may leverage diverse distribution channels by maintaining and managing separate B2B and B2C channels; this approach can lead to increased access to diverse market segments, while mitigating distinct associated asset management risks (EMF, 2015).

Communication channels remain an important element for HVMs wishing to engage and communicate with their customer segments about new and nonconventional value propositions enabled via the CBMs. As an example, in addition to conventional passive channels (e.g., publications and websites) and active channels (e.g., public events, networking events, and feedback forms) (Mendoza, Gallego-Schimid, & Azapagic, 2019), Company A utilizes an “experimentation” model of communication and engagement in which the public is invited to view a test trial of a product. This innovative engagement mechanism is possible largely through the integration of a CBM for HVM. Diversity in communication channels is also an important mechanism for building effective relationships with customers, enabling bidirectional feedback loops that guide the creation of novel CBM value propositions. The case studies demonstrate this diversity; that is, Company A uses social media to inform the public about product development and new launches; Company C’s social media information focuses on its work in reuse and refurbishment; Company B’s social media channel focuses on the sustainability agenda of the parent company; and so forth. Thus, as demonstrated, HVMs in particular have an opportunity to increasing use active channels to reframe opportunities for CBMs with a focus on new forms of value and new forms of delivering value to their customers.

5.2.4 Value capture

The aggregated costs and revenues for HVMs operating under CBMs are presented in Figure 4. Fourteen (14) costs components and eight (8) revenue streams were identified from across our five HVM case studies for different customer segments and sources. Importantly, the nature and magnitude of cost components relate to the nature of the business and the type of CBM adopted, that is, where Company C experiences a relatively greater inventory warehousing cost component, Company A and Company B experience a relatively greater data
### TABLE 10  Framework for connecting CBM theory to CBM practice—Example of linear-to-circular BM implementation plan for an HVM company

| Value proposition to customer | Current state | Example: CBM objective | Example: transition priorities | Example: metric of measurement | Example: key strategies | Factors of influence |
|-------------------------------|---------------|-------------------------|--------------------------------|--------------------------------|------------------------|---------------------|
| Value creation                | Key activities | Product sales           | Product service system and leasing | Evaluate servitization/leasing options (by product) | Quantify material savings, cost savings, and profit margin differential | Pilot CBM with a specific product/line to explore requirements and opportunities | • access to circular value network; • low barriers to entry; • digital technologies and industry 4.0; • skilled/trained workforce; • legislation and policies supporting CBMs and CE |
| Key resources                 | Sales team    | Customer-relationship specialists and product support | Training; data collection and utilization for predictive maintenance | Maintenance frequency and scheduling | • access to circular value network; • low barriers to entry; • digital technologies and industry 4.0; • skilled/trained workforce; • legislation and policies supporting CBMs and CE |
| Key partners                  | Forward-logistics specialists | Circular value network, circular insurance, and circular finance | Establish preventative maintenance and reverse-logistics | Product life cycle extension/ # service lives | Offer easy and accessible circular financing plan to cover entire life-cycle management |
| Value delivery                | Customer relationships | Sales and marketing | Social media and community outreach | Communicate value proposition impact for potential new customers | Repeat business/longevity of relationship | Use digital, social platforms to communicate new CBM narrative |
| Key channels                  | Targeted B2B | Experimentation and take-back programs | Coordinate and collaborate with partners for take-back | Asset/core recovery rate and reuse rate | Leverage existing reverse-logistics specialists to get started |
| Target customers              | B2B SME, B2P, and B2C | Expand scope of target customers and stakeholders and classify stakeholders | Customer/stakeholder growth rate | Conduct market analysis to identify new target segments for CBM value-proposition |
| Value capture                 | Revenue streams | Single-transaction sale | Monthly lease/subscription payment | Explore alternative circular finance models/options | Leasing/subscriptions as % of total revenue | Partner with circular finance organizations |
| Cost components               | Production, operation and R&D | Production, reverse-logistics, R&D, operations, and customer engagement | Develop cost models to account for expected cost decreases and increases from CBM | CBM profit margin (long-term) vs. current state profit margin (long-term) | Collaborate with partners to minimize/streamline reverse-logistics requirements |

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management cost component. The nature and magnitude of revenue streams is also tied to the nature of the business and the type of CBM; that is, Company E’s revenue streams are substantially large relative to the other case studies, whereas Company A’s is noted for the flexibility achieved through its use of crowdfunding. As for any business, HVMs adopting CBMs must manage and balance their specific set of cost components and revenue streams, that is, Company D must manage “core deposits” as both a revenue and cost component within their unique remanufacturing CBM. A strategic approach to value capture within CBMs can enable the reduction and/or prioritizing of costs and activities, that is, the development of a corporate CE procurement strategy can reduce costs of “maintenance, waste management, energy and carbon emission tax” (Mendoza, Gallego-Schmid, & Azapagic, 2019).

5.3 | FOIs analysis

Numerous FOIs were identified across different dimensions of the HVM CBM case studies, including technological factors (Industry 4.0 technologies, digital technologies), policy factors (supporting legislation and government policies), and availability of resources and support (e.g., the presence of nongovernmental organizations engaged in CE). Relevant FOIs are closely tied to the extended scope of the value proposition that is enabled by CBM: For example, HVMs are often drawn to the idea of a CBM because of the inherent environmental benefits may be yielded. HVMs are also drawn toward CBMs for strategic reasons. For example, when an HVM firm already possess remanufacturing capability (e.g., product knowledge and skilled labor), the adoption of a CBM presents lower relative barriers to entry for the firm and reinforces high entry barriers for potential competitors. The presence of nongovernmental organizations engaged in CE initiatives also appears to serve as a FOI in the adoption of CBMs by HVMs: To support their decision-making and CBM transition, HVMs may look to these nongovernmental organizations for research partnerships, policy leadership, and technical advice that relates to their CBM of choice.

Our findings from CBM practice in HVM are analyzed with respect to CBM theory in an effort to further clarify areas of alignment and disparity and identify opportunities for enhanced value in HVMs interested in adopting CBMs. Using a framework to integrate CBM theory and CBM practice, per the example populated in Table 10, it is clear that a systems perspective able to account for all dimensions of the CBM, and the FOI that affect distinct elements of the CBM, is critical for any HVM organization intending to transition to a CBM.

6 | CONCLUSIONS

This work clarifies and differentiates the value, costs, and FOI associated with the adoption of CBMs by HVM organizations and extends thinking regarding the nature and form of value and cost. Using a qualitative approach, we map value creation, value proposition, value delivery, and value capture elements of the CSBMC for five industry case studies. First, we find that, irrespective of firm size, digital technologies can help in the process of value creation and capture as well as are critical enablers of FOIs, useful in the process of CBM implementation. In addition to the conventional social, economic, and environmental dimensions of value identified in CBM literature, we find that HVMs can access CBM-specific value propositions that include nonconventional forms of value that influence and motivate the adoption of CBMs: educational/research value, organizational value, generated data, customer value, and information value. Further, value capture, by means of balancing revenue and cost components, was observed to be specific to the unique nature of each HVM business and the type of CBM adopted. Thus, for HVMs to remain competitive in the adoption of a CBM, a clear understanding of the connections between required cost components, revenue opportunities, and the extended value proposition is needed. This must be clearly communicated to customers and extended value system stakeholders. Business leaders must understand what the opportunities for value creation and capture are in a CE and what is a CBM. This element must come prior to the development and adoption of potential CBMs for HVM. Future research is needed to understand the magnitude of CBM value creation versus cost, specific to HVMs, particularly the requirements for intensive upfront capital investments and financing. Given that cost reduction is a fundamental objective for HVMs, it would be important to understand the degree and influence of cost components for different types of CBMs, and how that relates to revenue potential in the same CBM context. Useful to this future research, will be a deeper investigation into measurement metrics for CBMs in HVM. This will be crucial in assessing the success or otherwise of CBMs implementation in HVM.

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APPENDIX A: Details of respondents

| S/N | Role in company/institution | Industry | Number of employees in company/institution | Total work experience (years) | Educational qualification | Location |
|-----|-----------------------------|----------|--------------------------------------------|-----------------------------|--------------------------|----------|
| 1   | Founder/Chief Engineer      | SME Automobile Manufacturer | 21                                         | 36                          | MBA                      | UK       |
| 2   | Commercial Manager          | SME Automobile Manufacturer | 21                                         | 15                          | MBA                      | UK       |
| 3   | Head of Production Excellence at Siemens | Transport Mobility | 34,200                                     | 14                          | Postgraduate             | Germany (Global) |
| 4   | Sustainability Manager      | ICT Refurbishment | 146                                        | 17                          | BA                       | UK       |
| 5   | CEO                         | Automobile parts remanufacturer | 55                                         | 24                          | BSc                      | UK (Europe) |
| 6   | Senior Director Sustainability | Lighting Company | 32,000                                     | 33                          | MBA                      | The Netherlands (Global) |
| 7   | Academic                    | University | 6,600                                      | 7                           | PhD                      | UK       |
| 8   | Academic                    | University | 3,812                                      | 9                           | PhD                      | The Netherlands |
| 9   | Academic                    | University | 4,200                                      | 16                          | PhD                      | Sweden    |

APPENDIX B: Semi-Interview Discussion Questions

1. Thinking about the CBM tool that we present in this paper, do you think that this could help support and deepen more sustainable initiatives or programmes in your/a business? If you think it could be helpful, do you think that the CBM tool would support full-scale change, incremental change, or both?

2. Thinking about how the CBM tool and its strategic organization of the five dimensions (value creation, value proposition, value delivery, value capture, and factors of influence), do you have any suggestions for how this tool could be improved to better support and enable your/an organisation?

3. Thinking about the use of digital technologies in your/an organisation (e.g. mobile devices, Big Data, remote sensors, modelling), do you think that the combined use of digital technologies and the CMB tool could help to improve Circular Business Model adoption in your/any company?

4. If you were to use the CBM tool within your/an organization to support your adoption of Circular Business Models, do you have any suggestions for how to better integrate and connect the different components of the CBM? E.g., Could value delivery elements and value capture elements be effectively aligned, and how would you go about doing so?