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Product-service systems and circular supply chain practices in UK SMEs: The moderating effect of internal environmental orientation

Carl Kühl, Michael Bourlakis, Emel Aktas *, Heather Skipworth

[a] Cranfield University, Cranfield School of Management, College Road, Cranfield MK43 0AL, United Kingdom

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ABSTRACT

Many studies uphold product-service systems (PSSs) as key factors for the implementation of circular supply chain (CSC) practices. This paper explores this assumption by testing the links between product-, use- and result-oriented PSSs and slowing, closing, and narrowing CSC practices. It develops and validates survey items that can be used to benchmark CSC practice implementation. In addition, it tests a model that recognises the positive moderating role of internal environmental orientation. A survey is conducted with 114 manufacturing small and medium-sized enterprises (SMEs) in the United Kingdom (UK). Partial least squares structural equation modelling is conducted to evaluate two models. The results show that product-oriented PSSs positively affect the slowing, use-oriented positively affects the closing, and result-oriented positively affects the slowing and the narrowing of resource loops. Internal environmental orientation does not moderate the PSS – CSC relationship, suggesting that less internally environmentally oriented firms are not at a disadvantage.

1. Introduction

The circular economy (CE) concept provides a framework for moving from the current linear take-make-dispose economy to a restorative and regenerative system that keeps products and materials at their highest utility and value at all times (Ellen MacArthur Foundation, 2013). In recent years, the CE concept has been integrated into the supply chain management literature owing to the critical role that coordinated forward and reverse supply chains play in operationalising CE principles of circulating products and materials at their highest value and eliminating waste, for example, by extending product life-cycles or recycling wastes (Batista et al., 2018; De Angelis et al., 2018; Ellen MacArthur Foundation, 2013; Farooque et al., 2019). Circular supply chains (CSC) slow, close, and narrow resource loops to increase competitive advantage as well as economic, environmental, and operational performance (Geissdoerfer et al., 2018). The transition from linear to CSCs is a key policy concern in the European Union (EU) and the UK, as demonstrated by recent Circular Economy Policy Packages (DEFRA UK, 2020; European Commission, 2020). One particular focus area is the manufacturing sector.

The CE concept proposes that one of the key ways in which CE principles can be implemented in manufacturing firms is by innovating business models from selling products to delivering services (Hofmann, 2019; Kjaer et al., 2019; Tukker, 2015). It is argued that delivering a mix of tangible products and intangible services, so-called product-service systems (PSSs) will incentivise manufacturers to assume a product stewardship role and to implement CSC practices (Hofmann, 2019; Tukker, 2004, 2015). Especially PSSs, in which the manufacturer only delivers the service and retains product ownership, are considered to have the highest potential for CSC practice implementation since products become capital assets rather than consumables. As a result, manufacturers are incentivised to optimise resource utilisation to improve profit margins by extending product lifetimes, maximising value recovery at end-of-life, and minimising the use of consumables during the use-phase (Hofmann, 2019; Tukker, 2004, 2015).

The link between PSSs and CSC practice implementation is based on the logic of the natural resource-based view (NRBV) (Hart, 1995). According to this theory, firms are able to gain a competitive advantage from implementing pro-environmental practices. From the perspective of the NRBV, companies implement CSC practices to create value, for

Abbreviations: PSS, Product Service System; CSC, Circular Supply Chain; SME, Small and Medium-sized Enterprise; CE, Circular Economy; NRBV, Natural Resource Based View.

* Corresponding author.
E-mail addresses: c.kuhl@cranfield.ac.uk (C. Kühl), m.bourlakis@cranfield.ac.uk (M. Bourlakis), emel.aktas@cranfield.ac.uk (E. Aktas), heather.skipworth@cranfield.ac.uk (H. Skipworth).

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example, through cost reduction or differentiation (Hart, 1995; Rosa et al., 2019). In the case of PSSs, manufacturers are able to implement CSC practices, because they take responsibility for more activities that were previously handled by the customer, such as maintenance and repair (Yang et al., 2018).

Given the key role that PSSs are expected to play in the transition to a CE in the UK and the EU, it is necessary to understand the potential of PSSs to contribute to CSC practice implementation. The relationship between PSSs and CSC practice implementation has been the subject of much research (Hofmann, 2019; Kühl et al., 2019; Tukker, 2015). To date, however, this literature and the argument of the contribution of PSSs to CSC practice implementation is mainly theoretical with only little and exclusively case study-based empirical evidence (Matschewsky, 2019; Tukker, 2015; Yang et al., 2018). Crucially, the existing empirical studies do not address the specific context of CSC practice implementation in SMEs. Compared to larger firms, SMEs may face significant barriers in their transition to CSCs, due to their limited resources, such as a lack of capital, a lack of knowledge, and a lack of support from their supply and demand network (Dey et al., 2020; Rizos et al., 2016). In addition, there are significant economic costs and risks associated with implementing CSC practices in PSSs (Linder & Williander, 2017). There is a risk that SMEs are not maximising the economic and environmental potential of CSC practice implementation in existing PSSs. Investigating the impact of PSSs on CSC practice implementation in the SME context is crucial, since UK and EU manufacturing SMEs play a critical role in implementing PSS business models and CSC practices (Dey et al., 2019, 2020; Poel et al., 2018; Rizos et al., 2016).

Secondly, there is a gap around the conceptual development of CSCs. There is no clear understanding of the practices included in CSCs, especially in regard to the slowing, closing, and narrowing of resource loops, which are key conceptual elements of CSCs (Geissdoerfer et al., 2017, 2018). Particularly for surveys, there are no previously developed and validated measurement scales or items specifically for CSC practices (Masi et al., 2018). While constructs exist for related narratives, such as sustainable supply chains (Abdul-Rashid et al., 2017) or green supply chains (Zhu & Sarkis, 2004), none exist for CSC practices. This is a barrier for both academics and practitioners to assess the progress in CSC implementation: a vital component to the successful transition to a CE.

Thirdly, the role of company culture and firms' commitment to environmental protection needs to be examined more closely. Corporate environmental culture is a key firm-level enabler in the successful transition of SMEs to CE (Kirchherr et al., 2018; Rizos et al., 2016). Most manufacturing firms pursue services for strategic and commercial, not environmental reasons (Baines & Shi, 2015). Compared to firms who pursue PSSs for economic reasons, environmentally-oriented firms may be more aware of circular best practices in PSS design (Matschewsky, 2019). In sum, it is vital to better understand the effect of PSSs on CSC practice implementation as well as the role of internal environmental orientation, to encourage the diffusion of CE throughout the entire manufacturing sector.

This study aims to address the following research gaps that the prior literature has until now failed to cover: 1) the assessment of the state of CSC practice implementation in manufacturing SMEs that offer PSSs; 2) the development of measurement items and constructs for assessing CSC practice implementation in SMEs.; 3) the investigation of the role of critical success factors in CSC practice implementation in SMEs, in this case, internal environmental orientation. Therefore, this paper proposes a theoretical model that includes PSSs, CSC practices, as well as the critical success factor internal environmental orientation as moderator. This work aims to answer the following questions:

(1) What impact do PSSs have on the implementation of CSC practices in SMEs?
(2) Does internal environmental orientation moderate the relationship between PSSs and CSC practice implementation in SMEs?

This paper has five sections. The next section lays out the conceptual framework of this research, proposing the hypotheses and the conceptual model. The third section explains the research methodology, the sample information, and the data analysis. The fourth section presents the results. The fifth section presents the main conclusions, managerial implications, and limitations of the study, as well as potential opportunities for further research.

2. Literature review and hypotheses development

In the current context of rising environmental ambitions and requirements, there is a need for the industry to conceptualise an economically, environmentally, and socially sustainable industrial model. As a result, researchers and practitioners increasingly focus on the conceptualisation, design, and delivery of sustainable products and services (Caputo, 2021; Caputo et al., 2021; Smart et al., 2017). Both of the two key concepts involved in this research, PSSs and CSC practices, share the same unifying dialogue in the industrial sustainability literature and focus on creating sustainable value through innovation (Smart et al., 2017).

PSSs emerged in the 1990s, and they are part of a wider literature and domain of servitization research that was recognised as a paradigm to change business models from selling products to selling services to increase the competitiveness of manufacturing firms (Kowalkowski et al., 2017; Luoto et al., 2017; Rabetino et al., 2018). The PSS literature is an element of this literature that is specifically focused on sustainability (Rabetino et al., 2018). It builds on the idea that transitioning away from selling products to selling functionality incentivises manufacturers to dematerialise the offering (Rabetino et al., 2018; Tukker, 2004). There are three types of PSSs, which are classified as moving from a product focus to a service focus: product-oriented, use-oriented, and result-oriented (Tukker, 2004).

Similar to the PSS concept, CSCs are also an approach to sustainability that focuses on making better use of resources and waste to create economic and environmental value (Geissdoerfer et al., 2017, 2018; Genovese et al., 2017; Hussain & Malik, 2020). CSCs integrate the supply chain and the surrounding business ecosystem to slow, close, and narrow resource flows to ultimately create economic and environmental value (Batista et al., 2018; Geissdoerfer et al., 2018). Practices associated with slowing of resource use focus on the length of time for which a product is retained in a product system (Bocken et al., 2016). This can be achieved through designing long-life products and through product life extensions, such as maintenance, repair or refurbishing (Bocken et al., 2016). Closing resource loops focuses on closing flows between post-use and production, for example, through recycling or cascading by-products (Bocken et al., 2016). Narrowing the resource impact focuses on reducing the use of resources per product (Bocken et al., 2016). It focuses on reducing resource use per unit of value, for example, through more efficient product use phases (Bocken et al., 2016).

The underlying theoretical framework builds on the natural resource-based view of the firm (NRBV) (Hart, 1995). The NRBV argues that the original Resource-based View (Barney, 1991) did not consider the impact of the natural environment on the firm. To build a sustainable competitive advantage, firms would need to innovate beyond current economic and organisational practices. CSC practices closely resemble the product stewardship strategy outlined by Hart (1995), which espouses that firms can differentiate themselves by minimising the life-cycle impacts of their products across the entire value chain. One of the strategies for creating sustainable competitive advantage is through product stewardship (Hart, 1995). Product stewardship aims to minimise a product's environmental impacts across the life-cycle and is closely related to CSCs or other comparable sustainable supply chain narratives, such as reverse logistics or closed-loop supply chains (Vachon & Klassen, 2008). According to Hart (1995), creating sustainable competitive advantage through product stewardship relies on a firm's stakeholder integration resources. Stakeholder integration is the organisational ability to collaborate with stakeholders to solve environmental issues (Sharma & Vredenburg, 1998). Its role in supporting product stewardship is based on the fact that practices, such as recycling, are socially complex and rely on information and knowledge exchange between stakeholders (Hart, 1995; Vachon & Klassen, 2008).

The development of the hypotheses on the relationship between PSSs and CSC practice implementation follows this logic. The PSS types contribute differently to CSC practice implementation due to varying degrees of stakeholder integration in these business models. As PSS business models become more advanced, there is a closer integration of manufacturers and customers across the product life cycle and the ability for the manufacturer to implement CSC practices that create economic and environmental benefits. There are two ways in which the increased stakeholder integration manifests itself in PSSs. Firstly, in the responsibility that manufacturers take on for conducting product life cycle management activities, such as maintenance and repairs, that would otherwise be carried out by the customer in a traditional product sales business model (Gaiardelli et al., 2014; Tukker, 2015). Due to these increased contractual requirements, the manufacturer has more information about the location, quality, and usage of the product, which facilitates the implementation of CSC practices that create economic and environmental benefits, such as repairs, refurbishment or recycling (Baines & Lightfoot, 2013; Östlin et al., 2008).

Secondly, stakeholder integration manifests itself in an increased focus on meeting specific customer needs (Gaiardelli et al., 2014; Tukker, 2004, 2015). The more service-oriented the PSSs are, the more they are focused on meeting specific customer needs, for example, by delivering outcomes or results, instead of supporting pre-determined products (Gaiardelli et al., 2014; Tukker, 2004, 2015). Since manufacturer and customer only agree on the result that needs to be delivered instead of specifying the products involved, the manufacturer has more opportunities to find innovative ways of meeting customer needs while optimising resource utilisation (Reim et al., 2015). This relationship between PSSs and CSC practice implementation is not exclusive to large businesses but also occurs in SMEs (Manninen et al., 2018; Sousa-Zomer et al., 2018). The link between PSSs and CSC practices associated with the slowing, closing, and narrowing of resource loops is elaborated more closely in the next section.

2.1. The effect of product-service systems on CSC practice implementation

In product-oriented PSSs, the product is sold to the customer and enhanced by stand-alone additional services, such as maintenance or extended warranty agreements (Gaiardelli et al., 2014; Tukker, 2004). This creates economic value for both the manufacturer and the customer since manufacturers are able to create additional revenues, while the customer does not need to develop individual servicing capabilities (Yang et al., 2018). Product-oriented PSSs contribute to a slowing of resource loops since these services are focused on preserving and extending product functionality. From the perspective of the NRBV, the fact that product-oriented PSSs only contribute to a slowing of resource loops can be attributed to the fact that there is limited integration of manufacturer and customer. The PSSs are limited only to the specified activities required to extend the product lifetime, such as conducting maintenance or repair activities and not to a wider scope of activities (Gaiardelli et al., 2014; Reim et al., 2015; Yang et al., 2018). In addition, since the products and services that the manufacturer delivers to the customer are highly specified and contractually defined, there are few opportunities for the manufacturer to innovate products and services to deliver specific customer needs (Gaiardelli et al., 2014; Reim et al., 2015). As a result, the manufacturer can only implement incremental innovations to products to support PSSs service delivery, such as designing products for ease of maintenance or repairs (Reim et al., 2015). This argument leads to the following hypothesis:

Hypothesis 1. The provision of product-oriented PSSs in SMEs positively affects the implementation of CSC practices that slow resource loops.

Use-oriented PSSs provide functionality or access, for example, through leasing, renting, or sharing instead of selling products (Gaiardelli et al., 2014; Tukker, 2004). Compared to product-oriented PSSs, use-oriented PSSs have a closer integration of manufacturer and customer since the manufacturer becomes the product fleet manager, internalising the risks of product breakdowns in the offering (Gaiardelli et al., 2014). To successfully deliver the offering and to manage these risks, there is more information exchange between manufacturer and customer, and manufacturer involvement across the product life-cycle (Gaiardelli et al., 2014; Reim et al., 2015). In regard to the slowing of resource loops, the manufacturer is also responsible for supporting the customer's use of the product, which results in the implementation of practices that slow resource loops, such as maintenance and repairs as well as refurbishment (Matschewsky, 2019; Yang et al., 2018). The implementation of CSC practices that slow resource loops is enabled by the exchange of information on product status and usage between manufacturer and customer, for example, to optimise maintenance and repair services (Matschewsky, 2019). From the perspective of the NRBV, the implementation of practices that slow resource loops help reduce the risks of product breakdowns and prolong the customer's use of the product, thereby reducing the resources required to deliver the service to the customer (Reim et al., 2015).

However, in addition to product-oriented PSSs, the manufacturer also retains product ownership in use-oriented PSSs, resulting in a fixed responsibility for products to return to the manufacturer at the end-of-use or end-of-life (Gaiardelli et al., 2014; Tukker, 2004). The implementation of such a responsibility requires information exchange between the manufacturer and the customer on the timing, location, quantity, and quality of product returns, which facilities the implementation of practices that close resource loops (Östlin et al., 2008). According to the logic of the NRBV, manufacturers can use this information and knowledge to create economic and environmental benefits, by maximising value recovery at end-of-life, for example through recycling. The implementation of practices that close resource loops, in particular component reuse or recycling were identified across several existing case studies of use-oriented PSSs (Matschewsky, 2019; Sousa-Zomer et al., 2018; Yang et al., 2018). This argument leads to the following hypothesis:

Hypothesis 2. The provision of use-oriented PSSs in SMEs positively affects the implementation of CSC practices that slow (H2a) and close (H2b) resource loops.

Result-oriented PSSs are the most complex and service-oriented types of PSSs and deliver not a pre-determined product but instead a specific customer need, result, or outcome (Gaiardelli et al., 2014; Tukker, 2015). These business models have the highest degree of manufacturer-customer integration, since offerings are customised to the specific needs and processes of customers and because the manufacturer takes over the most responsibility for product life-cycle activities to deliver the contractually specified performance outcomes (Gaiardelli et al., 2014; Reim et al., 2015). Since manufacturers and customers only agree on the results that need to be delivered, without specifying a particular product or service, this provides more flexibility and opportunities for the manufacturer to find innovative ways to deliver the service while optimising resource utilisation (Reim et al., 2015). From the perspective of the NRBV, the manufacturer will implement CSC practices in result-oriented PSSs to maximise value creation and minimise costs, since all products and parts used to deliver the results become cost centres (Tukker, 2015; Yang & Evans, 2019).

Similar to use-oriented PSS, result-oriented PSSs are considered to result in a slowing and closing of resource loops, since the manufacturer takes on risks associated with the product, by providing performance guarantees and retains product ownership. In regard to the implementation of CSC practices associated with the slowing of resource loops, this can include for example, optimising product design for ease of maintenance and repair, as well as conducting maintenance, repair, or refurbishment activities to maximise product lifetimes (Baines & Lightfoot, 2013; Yang et al., 2018). Since the manufacturer retains product ownership, there is a fixed responsibility for products to return to the manufacturer at the end-of-use or end-of-life. To maximise value creation, the manufacturer also implements practices that close resource loops, such as recycling (Yang et al., 2018).

The biggest difference to the other two types of PSSs in regard to the implementation of CSC practices, is that result-oriented PSSs also can contribute to a narrowing of resource loops. Since manufacturers are responsible for delivering pre-determined outcomes or results, they take more control over the product use phase compared to use-oriented PSSs, either by directly controlling the use of the product or by closely collaborating with the customer (Gaiardelli et al., 2014). Since all products and parts used to deliver the results become cost centres (Tukker, 2015; Yang & Evans, 2019), the manufacturer is incentivised to optimise resource utilisation to deliver the PSSs. This may include innovating to use more resource-efficient products to deliver the service or encouraging the customer to use the product more efficiently, through the provision of trainings or by setting pain and gain sharing incentives that encourage a resource efficient use of the product by the customer (Datta & Roy, 2011; Kjaer et al., 2019). This argument leads to the following hypotheses:

Hypothesis 3. The provision of result-oriented PSSs in SMEs positively affects the implementation of CSC practices that slow (H3a), close (H3b), and narrow (H3c) resource loops.

2.2. *The moderating effect of internal environmental orientation*

Internal environmental orientation refers to managers' and employees' values and ethical standards in regard to environmental protection (Banerjee, 2002). It can be conceptualised as a "pro-environmental culture" (Chan et al., 2012, p. 623) that manifests itself in a firm's mission statements, policies, procedures, and the training of employees. From the perspective of the resource-based view, a firm's strategic orientation, such as environmental orientation, can guide the decision-making to implement specific business practices (Chan et al., 2012; Grant, 1991). Since internal environmental orientation refers to the environmentalist culture of a firm, these values and beliefs become embedded in the firm and dissipate through it. From an organisational learning perspective, the environmental values and beliefs of the corporate leaders will eventually dissipate through the company, its organisational systems, and people (Chan et al., 2012; Egri & Herman, 2000). As a result, a strong environmental culture will motivate employees to seek ways to innovate more environmentally friendly products and processes (Chan et al., 2012).

This logic of internal environmental orientation influencing how firms innovate is also used to explain differences in the way that PSSs contribute to CSC practice implementation. Even though PSSs are inextricably linked to the CSC concept, they are not intrinsically circular or sustainable (Kjaer et al., 2019). Instead, sustainability and circularity best practices need to be integrated into the design and development of PSSs (Kjaer et al., 2019; Pigosso & McAloone, 2016). Empirically, this is supported by the observation that an environmental culture and awareness was an important success factor for the implementation of CSC practices in PSSs, including for SMEs, (Matschewsky, 2019; Rizos et al., 2016) and by the fact that significant amount of evidence for CSC practice implementation in the PSSs of environmentally-oriented firms (Manninen et al., 2018; Sousa-Zomer et al., 2018). Conversely, a lacking awareness understanding of the potential value creation opportunities of CSC practice implementation was shown to inhibit CSC practice implementation in PSSs (Guldmann & Huulgaard, 2020; Yang et al., 2018). As a result, manufacturing firms that offer PSSs with a high internal environmental orientation will likely the necessary systems, processes, and employees in place to successfully implement CSC practices. This argument leads to the following hypotheses:

Hypothesis 4. Internal environmental orientation in SMEs positively moderates the relationship between PSSs and the implementation of CSC practices that slow (H4a), close (H4b), and narrow (H4c) resource loops.

Fig. 1 shows the overall conceptual framework and delineates the proposed relationships between PSSs, CSC practices, firm size, and internal environmental orientation.

3. Methods

3.1. *Data collection and sample*

The hypotheses depicted in Fig. 1 were empirically tested through a sample of UK machinery and equipment manufacturing firms since these sectors are especially prominent in servitization-related research. This is operationalised through the UK Standard Industrial Classification (SIC) codes (Companies House UK, 2018). Respondents were selected through volunteer opt-in panels from Qualtrics. There are typically two main concerns about this method: 1) respondents in non-probabilistic approaches may be fundamentally different from the population; 2) responses may be of lower quality (Zhang et al., 2020). In regard to the first concern, this was deemed acceptable, since this study is of an exploratory nature (Daniel, 2012). Several techniques were employed to identify careless responses, including measuring the response time, reverse worded items, and attention check items (Curran, 2016). In addition, previous studies showed that respondents in opt-in panels take the task of completing surveys more seriously than previously thought (Zhang et al., 2020).

In total, 3089 respondents entered the survey, 2310 did not match the quota, and 573 did not pass the response quality checks. Finally, 114 valid responses were obtained. All of these stemmed from SMEs. Some of the responses were only partially completed. Since these had less than 10 per cent of missing data (i.e. 10 responses in this survey), the mean value replacement technique was used (Tsikriktsis, 2005). The demographic characteristics of the respondents are summarised in Table 1.

3.2. *Measures*

Multiple items were used to measure each of the constructs, as summarised in Table 2. The measurement scales and items were developed in accordance with Churchill's (1979) procedure for

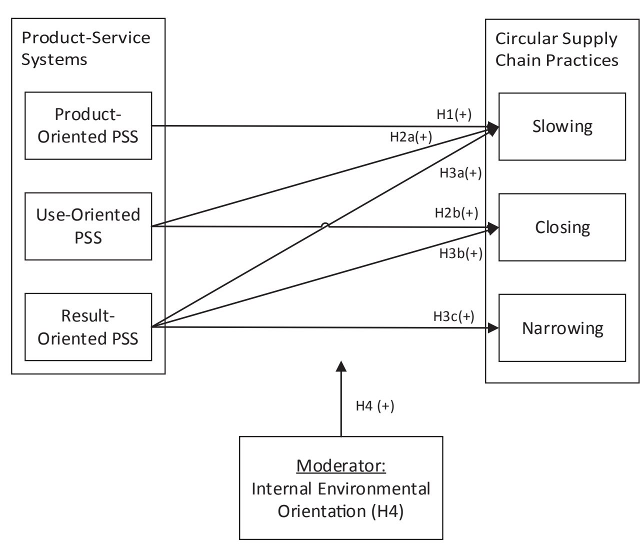

Fig. 1. Conceptual framework for empirical research.

Table 1
Demographic characteristics of respondents.

Demographic variable	Category	Frequency	%
Industry	Manufacture of computer, electronic, and optical equipment	60	52.6
	Manufacture of machinery and equipment	54	47.4
Respondent title	Operations/supply chain manager	43	37.7
	Sales/marketing manager	34	29.8
	Project manager	20	17.5
	Director	11	9.6
	Design/engineering manager	4	3.4
	Sustainability manager	2	1.8
Firm size			
Turnover	Less than £1.8 million	29	25.4
	Between £1.8 and £9 million	50	43.9
	Between £9 and £45 million	35	30.7
Employees	Less than 10	10	8.8
	Between 10 and 49	35	30.7
	Between 50 and 249	69	60.5

developing measures with desirable reliability and validity properties.

In the first step, the domain of the constructs and their definitions were specified through a systematic literature review (Kühl et al., 2019). Based on these, an additional systematic literature review was conducted to identify existing survey items for these constructs. Then, interviews were conducted with six expert academics (from outside the research team) in CSCs and PSSs. The measured items were refined and reworded accordingly. The measurement items for all constructs were defined as reflective indicators since they are a representative sample of a larger possible population of indicators that exist within the conceptual domain of the constructs (Gaiardelli et al., 2014; Kalmykova et al., 2018). Following this phase, the survey was pre-tested with eight executives working for UK machinery and equipment manufacturers. Thus, the face validity of the 30 items was established.

To measure PSSs adoption, the measurement scale of Sousa and da Silveira (2017) was identified as the most suitable. To clarify the option of not offering the service at all, the N/A (not applicable) option was included (Kohtamaki et al., 2015). The final scale is: To what extent are these services offered by your firm? Please mark a number (Five-point scale: select 0 if you do not offer the service at all; 1 = very low; 2 = low; 3 = medium; 4 = high; 5 = very high). The PSSs items were operationalised using existing classifications (Gaiardelli et al., 2014; Tukker, 2004). The product-oriented PSSs items correspond to Sousa and da Silveira's (2017) category of basic services.

At present, there is no dedicated construct developed for assessing CSC practice implementation. This study employed a five-point Likert scale from green supply chain practice implementation (1 = not considering it; 2 = planning to consider it; 3 = considering it currently; 4 = initiating implementation; 5 = implementing successfully) (Zhu & Sarkis, 2004). The slowing of resource loops focused on supply chain practices that extend product lifetimes while closing focused on post-production waste and by-product flows (Bocken et al., 2016). For narrowing, there were a few specific items related to increasing resource efficiency at the level required in this study. In most cases, the aspects related to narrowing were operationalised as multi-item constructs in their own right, such as sustainable manufacturing processes or supply chain collaboration. To keep the number of items to a reasonable number, overarching items were formulated that included resource use reduction across the key focal areas in sustainable supply chain management, namely supplier collaboration, product design, production, and downstream collaboration (Golicic & Smith, 2013). The construct of internal environmental orientation was applied from Banerjee (2002). This scale was chosen because it provided a good summary and overview of the degree to which a firm incorporates environmental concerns into its strategy and decision-making. It was adapted from a seven-point Likert scale to a five-point Likert scale to increase uniformity with the other scales.

3.3. Data analysis

The analysis applied variance-based structural equation modelling (SEM) to test the hypotheses, specifically the partial least squares (PLS) technique. This technique is suitable for this study due to two reasons: 1) the sample is relatively small (n = 114); 2) this study focuses on the prediction of dependent variables. This method was chosen over covariance-based SEM due to the exploratory nature of this research (Hair et al., 2011). SmartPLS software was used to analyse the measurement as well as the structural model (Ringle et al., 2015). Using PLS entails a two-stage approach: 1) the assessment of the reliability and validity of the measurement model and 2) the evaluation of the structural model. The measurement model specifies the indicators and their relationships with the constructs, whereas the structural model includes the latent variables and their relationships which are captured in path coefficients (Hair et al., 2017, p. 321).

4. Results

4.1. First stage: measurement model

Since all constructs are reflective, the measurement model is assessed in four steps: individual item reliability, construct reliability, convergent validity, and discriminant validity (Hair et al., 2017, p. 106) (see Table 2). Individual item reliability is considered adequate when the item loading exceeds 0.7. There were a number of items (PO4, SLOW4-7, CLOS5, NAR2) with indicator loadings below 0.7. Even though this result is not desirable, the decision was made not to remove any indicators to ensure the content validity of the construct (Hair et al., 2017, p. 113). Weaker loadings are often obtained in exploratory research with newly developed scales (Hulland, 1999). Internal consistency reliability is evaluated by Cronbach's α and the composite reliability. All Cronbach's α and composite reliability were between the specified threshold of 0.7 and 0.9, thereby supporting the reliability of the constructs. Convergent validity is assessed using the average variance extracted (AVE) measure. All AVE values exceeded the minimum threshold of 0.5.

The discriminant validity was examined using two methods (see Table 3): the Fornell and Larcker (1981) criterion and the heterotrait-monotrait ratio (HTMT) (Henseler et al., 2015). For the HTMT ratio, all variables were below the required 0.85 threshold value (Henseler et al., 2015). The HTMT ratio was shown to be significantly different from 1 through a bootstrapping procedure with a 95 per cent confidence interval (Hair et al., 2017, p. 119). The comparison of the square root of AVE and correlations for pairs of constructs (Fornell & Larcker, 1981), also suggest that discriminant validity is achieved.

To further validate the measurement model, the potential for common method bias was also addressed in two ways. Firstly, the Harman single-factor test was used to check for this possibility. According to the unrotated factor solution, the first factor accounts for 30.935 per cent of the variance, which indicates that no factor accounts for the majority of covariance among the measures. Due to the potential weakness of the Harman single-factor test in addressing common method variance (Podsakoff et al., 2003), a second test was conducted. A full collinearity assessment was conducted employing the partial least squares method (Kock, 2015). The VIFs for all variables ranged between 1.202 and 2.255, well below the 3.3 threshold. Thus, these two tests imply that the findings have not been affected by the use of the same data source, i.e., common method bias was absent. The results of the quality checks of the measurement model were satisfactory, and the analysis, therefore, continued with the structural model to test the hypotheses developed in Section 2.

Table 2
Measurement model analysis.

Latent Variable	Item	Item Weight	Item Loading	AVE	Cronbach's α	Composite reliability
PO PSS	(Sousa & da Silveira, 2017)			0.615	0.788	0.864
PO1	Installation/commissioning of products	0.341	0.781			
PO2	Provision of spare parts/consumables	0.291	0.792			
PO3	Maintenance and repair of products	0.356	0.873			
PO4	Helpdesk/customer support centre	0.284	0.678			
UO PSS				0.740	0.824	0.895
UO1	Lease of products (with responsibility for product maintenance, repair; long-term agreement; use by a single user) (Gaiardelli et al., 2014)	0.402	0.848			
UO2	Rental/Sharing (with responsibility for product maintenance, repair; short-term agreement; sequential use by different users) (Sousa & da Silveira, 2017)	0.405	0.906			
UO3	Pay-per-use (service provider gives customers access to products; only pays for usage) (Gaiardelli et al., 2014)	0.355	0.824			
RO PSS				0.812	0.769	0.896
RO1	Performance-based contract (service provider is paid for delivering results to customer, not individual products or service) (Gaiardelli et al., 2014)	0.592	0.915			
RO2	Outsourcing (service provider takes full responsibility for customer's operating processes) (Gaiardelli et al., 2014)	0.517	0.887			
Slowing Practices				0.510	0.836	0.878
SLOW1	Design of products for durability (Bocken et al., 2016)	0.172	0.714			
SLOW2	Design of products for maintenance and repair (Lai et al., 2013)	0.230	0.834			
SLOW3	Design of products for future modification (adaptability or upgradability) (Bocken et al., 2016)	0.258	0.811			
SLOW4	Design of products for refurbishment or remanufacturing (Abdul-Rashid et al., 2017)	0.171	0.652			
SLOW5	Collection of used products from customers for reuse or resale (Lai et al., 2013)	0.152	0.663			
SLOW6	Maintenance and repair of products (Abdul-Rashid et al., 2017)	0.186	0.569			
SLOW7	Collection of used products from customers for refurbishment or remanufacturing (Lai et al., 2013)	0.220	0.719			
Closing Practices				0.539	0.785	0.853
CLOS1	Design of products for recycling (Abdul-Rashid et al., 2017)	0.268	0.717			
CLOS2	Use of recycled materials in product designs (Linder et al., 2017)	0.256	0.723			
CLOS3	Collection of used products from customers for recycling Lai, Wu and Wong, 2013)	0.232	0.773			
CLOS4	Recovery of components from used products for reuse in other products (Lai et al., 2013)	0.299	0.817			
CLOS5	Transfer of wastes or by-products for reuse in another process (Masi et al., 2018)	0.208	0.628			
Narrowing Practices				0.620	0.845	0.890
NAR1	Design of products to reduce the consumption of material/energy during the use phase (Abdul-Rashid et al., 2017)	0.295	0.774			
NAR2	Design of products to reduce their weight (Abdul-Rashid et al., 2017)	0.193	0.668			
NAR3	Re-design of production processes to reduce the consumption of material/energy (Abdul-Rashid et al., 2017)	0.216	0.832			
NAR4	Supplier collaboration to reduce the consumption of material/energy (Zhu & Sarkis, 2004)	0.305	0.863			
NAR5	Customer collaboration to reduce the consumption of material/energy (Zhu & Sarkis, 2004)	0.256	0.786			
IEO	(Banerjee, 2002)			0.715	0.867	0.909
IEO1	At our firm, we make a concerted effort to make every employee understand the importance of environmental preservation.	0.336	0.857			
IEO2	Our firm has a clear policy statement urging environmental awareness in every area.	0.319	0.890			
IEO3	Environmental preservation is a high-priority activity in our firm.	0.253	0.836			
IEO4	Preserving the environment is a central corporate value in our firm.	0.273	0.796			

Notes: PO: Product-oriented PSS; UO: Use-oriented; RO: Result-oriented; SLO: Slowing; CLO: Closing; NAR: Narrowing; IEO: Internal Environmental Orientation.

4.2. Structural model

To establish the validity of the structural model, we followed Hair et al. (2011) and estimated the R^2 values for endogenous variables in the structural model where we used the recommended thresholds of 0.75, 0.50, and 0.25 for substantial, moderate, and weak explanatory power. We used bootstrapping to establish the significance of the path coefficients (Hair et al., 20211) and used blindfolding to obtain cross-validated redundancy measures for each construct. Our interpretations followed that Q^2 values larger than zero indicated predictive relevance. Table 4 presents descriptive statistics. The structural model was evaluated based on the collinearity assessment, the significance and relevance of the structural path coefficients, the R^2 value (the percentage of variance explained); the f^2 effect size, and the Q^2 (cross-validated redundancy) test for predictive relevance (Hair et al., 2017, p. 191). Table 5 shows the explained variance (R^2) in the endogenous variables, the cross-validated redundancy values (Q^2), the effect size (f^2), and the path coefficients for the models under study. The statistical significance for the path coefficients is evaluated by using the *p*-values.

Bootstrapping (5,000 samples) was used to generate standard errors and *p*-values to determine the statistical significance of the path coefficients. To check for collinearity issues, the variance inflation factors (VIFs) were generated for all latent variables in the software. As previously mentioned, all VIF values were below the 3.3 threshold method (Kock, 2015). Therefore, collinearity among the constructs was not a critical issue in the structural model. The explanatory power of the structural model was examined through the coefficient of determination (R^2). The results showed that slowing and closing had substantial R^2 values of 0.346 and 0.145, whereas the prediction of narrowing was significantly weaker ($R^2 = 0.057$) (Hair et al., 2017, p. 199). Blindfolding was used to evaluate the model with the cross-validated redundancy index Q^2 for the endogenous variables. Q^2 values greater than 0.02 imply that the model has predictive relevance (Chin et al., 2003). Slowing had the highest (0.168) followed by closing (0.072) and finally narrowing (0.027). The results confirm that the structural model has satisfactory predictive relevance, especially for slowing and closing.

Table 3
Discriminant validity.

Heterotrait-monotrait ratio (HTMT)

	Closing	IEO	Narrowing	PO PSS	RO PSS	Slowing	UO PSS
Closing							
IEO	0.427						
Narrowing	0.470	0.475					
PO PSS	0.329	0.407	0.607				
RO PSS	0.432	0.209	0.282	0.299			
Slowing	0.623	0.496	0.697	0.681	0.408		
UO PSS	0.444	0.099	0.314	0.398	0.798	0.383	

Fornell-Larcker Criterion

	Closing	IEO	Narrowing	PO PSS	RO PSS	Slowing	UO PSS
Closing	0.734						
IEO	0.357	0.845					
Narrowing	0.392	0.419	0.787				
PO PSS	0.265	0.337	0.493	0.784			
RO PSS	0.342	0.175	0.240	0.238	0.901		
Slowing	0.512	0.439	0.602	0.563	0.339	0.714	
UO PSS	0.358	0.074	0.271	0.330	0.642	0.323	0.860

Table 4
Descriptive statistics.

Variable	Mean	S.D.	Min	Max
PO PSS	2.999	1.122	0	5
UO PSS	1.763	1.380	0	5
RO PSS	2.026	1.531	0	5
Slowing	3.368	0.988	1	5
Closing	2.865	1.060	1	5
Narrowing	3.044	1.101	1	5
IEO	3.292	0.694	1	5

Model 1 includes the main direct paths between the different PSSs and the three dimensions of CSC practices. In this scenario, the results support H1, H2b, H3a, H3c, but not H2a and H3b. Model 2 introduces the assumed moderating effect of internal environmental orientation. As in regression analysis, the predictor and moderator variables are multiplied to obtain the interaction terms. The evaluation of H4 employs the two-stage technique, which is generally recommended for modelling the interaction term (Hair et al., 2017, p. 255). In Table 5, Model 2 includes internal environmental orientation, along with the interaction terms. The results of the path coefficients show that internal environmental orientation is not a significant moderating variable. Consequently, H4 is not supported.

5. Discussion and conclusions

5.1. Main findings

Rooted in the natural resource-based view (NRBV) of the firm (Hart, 1995), this study reveals whether and how PSSs impact the implementation of CSC practices in UK SMEs.

The findings show that: 1) PSSs contribute positively to CSC implementation in SMEs; 2) Internal environmental orientation does not moderate the relationship between PSSs and CSC practice implementation; 3) Testing the newly developed scales for CSC practices refines and validates a data collection tool for measuring this emerging concept. These results offer a series of theoretical and managerial implications that are analysed below. The findings from the hypothesis testing are summarised in Table 6.

5.2. Theoretical implications

This study makes three key contributions to the literature: Firstly, in

Table 5
Structural model.

Relationships	Model 1		Model 2		f2	Support
	R^2 (adj.)	Q^2	R^2 (adj.)	Q^2		
	$R^2_{Slow} = 0.346$ moderate	$Q^2_{Slow} = 0.168$	$R^2_{Slow} = 0.400$ moderate	$Q^2_{Slow} = 0.200$		
	$R^2_{Clos} = 0.145$ weak	$Q^2_{Clos} = 0.072$	$R^2_{Clos} = 0.245$ moderate	$Q^2_{Clos} = 0.132$		
	$R^2_{Narr} = 0.057$ weak	$Q^2_{Narr} = 0.027$	$R^2_{Narr} = 0.183$ weak	$Q^2_{Narr} = 0.108$		
	Path Coeff.	*Conf. Interval*	*Path Coeff.*	*Conf. Interval*		
H1: PO-SLO	0.509***	(0.36; 0.65)	0.414***	(0.23; 0.59)		Yes
H2a: UO-SLO	0.028^{ns}	(-0.15; 0.20)	0.057^{ns}	(-0.12; 0.28)		No
H2b: UO-CLO	0.239*	(0.05; 0.47)	0.262**	(0.11; 0.49)		Yes
H3a: RO-SLO	0.198*	(0.01; 0.37)	0.178^{ns}	(-0.05; 0.36)		Yes
H3b: RO-CLO	0.202^{ns}	(-0.05; 0.44)	0.130^{ns}	(-0.12; 0.33)		No
H3c: RO-NAR	0.256*	(0.14; 0.43)	0.173^{ns}	(0.03; 0.34)		Yes
H4: IEO						No
IEOxPO-SLO			-0.032^{ns}	(-0.19; 0.16)	0.002	
IEOxUO-SLO			0.021^{ns}	(-0.23; 0.20)	0.007	
IEOxUO-CLO			-0.140^{ns}	(-0.37; 0.04)	0.016	
IEOxRO-SLO			-0.117^{ns}	(-0.33; 0.14)	0.013	
IEOxRO-CLO			-0.052^{ns}	(-0.20; 0.17)	0.002	
IEOxRO-NAR			-0.011^{ns}	(-0.20; 0.17)	0.000	

Notes: PO: Product-oriented PSS; UO: Use-oriented; RO: Result-oriented; SLO: Slowing; CLO: Closing; NAR: Narrowing; IEO: Internal Environmental Orientation. ***$p < 0.001$; **$p < 0.01$: *$p < 0.05$; ^{ns}: not significant.

Table 6
Hypothesis test results.

Hypothesis	Relationship	Coefficient	*p*-value	Result
H1	PO PSS → Slowing	0.509	0	Supported
H2a	UO PSS → Slowing	0.028	0.766	Not supported
H2b	UO PSS → Closing	0.239	0.024	Supported
H3a	RO PSS → Slowing	0.198	0.03	Supported
H3b	RO PSS → Closing	0.202	0.097	Not supported
H3c	RO PSS → Narrowing	0.256	0.002	Supported
H4a	IEOxPO PSS → Slowing	−0.032	0.716	Not supported
	IEOxUO PSS → Slowing	0.021	0.847	Not supported
	IEOxRO PSS → Slowing	−0.14	0.173	Not supported
H4b	IEOxUO PSS → Closing	−0.117	0.34	Not supported
	IEOxRO PSS → Closing	−0.052	0.599	Not supported
H4c	IEOxRO PSS → Narrowing	−0.011	0.906	Not supported

Notes: PO: Product-oriented PSS; UO: Use-oriented; RO: Result-oriented; SLO: Slowing; CLO: Closing; NAR: Narrowing; IEO: Internal Environmental Orientation.

regard to the first research question ("What impact do PSSs have on the implementation of CSC practices in SMEs?") it shows that the assumed contribution also holds in SMEs . This is relevant because prior studies have dedicated little attention to the contribution of PSSs to CSC implementation in SMEs (Matschewsky, 2019; Yang et al., 2018), even though SMEs are facing unique difficulties and challenges in the transition to CSCs (Dey et al., 2020; Rizos et al., 2016). The findings show a positive relationship for the contribution of product-oriented PSSs to a slowing of resource loops (H1), use-oriented PSSs to a closing of resource loops (H2b) as well as the contribution of result-oriented PSSs to the slowing (H3a) and narrowing of resource loops (H3c). The high path coefficient of product-oriented PSSs compared to use- and result-oriented PSSs contradict the theory and previous empirical evidence (Hofmann, 2019; Kühl et al., 2019; Tukker, 2015; Yang et al., 2018). This surprising finding can be explained by the fact that these services had higher implementation rates compared to use- and result-oriented PSSs (see Table 4). In servitization, manufacturers typically start with offering product-oriented PSSs to build and improve their service capabilities before they expand into offering more complex service offerings, such as use- and result-oriented PSSs (Palo et al., 2019; Sousa & da Silveira, 2017).

Secondly, the findings provide empirical evidence for an emerging theoretical argument on the fallacy of PSSs to contribute to the transition from linear to CSCs (Hofmann, 2019; Mayers et al., 2021). The unsupported hypothesis H2a shows in practice, that use-oriented PSSs are often merely financing mechanisms that are not designed to slow resource loops through product life extension (Hofmann, 2019; Mayers et al., 2021). In addition, hypothesis H3b on the contribution of result-oriented PSSs to a closing of resource loops was not supported. This can be explained by the fact that managers do not see the value from such activities, since they are not part of the core business (Yang et al., 2018). Overall, the findings suggest that PSS design and implementation is currently not optimised for CSC potential and that more design or policy support is needed (e.g., incentive setting through carbon or resource tax) (Calisto Friant et al., 2020; Matschewsky, 2019; Zeeuw van der Laan & Aurisicchio, 2020).

Thirdly, the study contributes to the conceptual understanding of CSCs by developing a measurement scale and items based on the classification of slowing, closing, and narrowing of resource loops (Bocken et al., 2016; Geissdoerfer et al., 2017). It extends previous conceptualisations (Masi et al., 2018; Zhu et al., 2010) in two ways. Firstly, it aligns the construct with the theoretical dimensions of CSCs instead of adopting dimensions and items that were developed for other sustainable supply chain narratives. This is important for the content validity of the construct since these narratives are related, but different (Batista et al., 2018). Secondly, it provides a more robust classification of practices than Masi et al. (2018), by establishing the construct's validity and reliability. The results indicate good indicator loadings for the practices associated with narrowing but suggest that adapting the items associated with slowing and closing may help improve some of the weaker outer loadings (<0.70). These dimensions and measurement items contribute to theory by providing a better understanding of CSC practice implementation in organisations, in particular, in SMEs.

Fourthly, it also elaborates on critical success factors for CSC implementation in manufacturing SMEs (Dey et al., 2020). Regarding the second research question ("Does internal environmental orientation moderate the relationship between PSSs and CSC practice implementation in SMEs?), the research shows that internal environmental orientation does not moderate the relationship between PSSs and CSC practice implementation (H4). This counters previous results that highlighted the importance of a pro-environmental corporate culture in enabling CSC practice implementation in SMEs (Rizos et al., 2016). This can be explained by that fact that CSC practice implementation in SMEs is likely to be ultimately determined by more pragmatic reasons, such as cost reduction or competitiveness benefits (Dey et al., 2019, 2020). In particular, SMEs implement these practices if they result in economic benefits, such as cost reduction (Dey et al., 2019, 2020).

5.3. *Managerial and policy implications*

Firstly, the findings suggest that current versions of PSSs do not maximise the CSC potential. This study contributes to the CE literature, by developing and testing a benchmarking tool that can be used by practitioners with a conceptual framework of a 17-item measurement scale, evaluating the different elements of CSC practices implementation. Managers in manufacturing SMEs can use this validated scale as a self-diagnostic tool to assess their current performance in the transition from linear to CSCs and to identify specific areas for improvement.

Secondly, this study provides practitioners as well as policy-makers relevant empirical evidence about the limitations of PSSs. It highlights the potential limitations of use-oriented PSSs in the slowing of resource loops as well as result-oriented in the closing of resource loops. For practitioners, it shows that design guides are needed to support the circular design and implementation of business models. This study highlights these efforts with the previously mentioned benchmarking tool. For policymakers, it shows that enabling business models by itself will not necessarily lead to the desired economic and environmental win-wins (Calisto Friant et al., 2020), but that deeper reforms are needed to support CSC practice implementation, such as reduced taxes on services or the introduction of ambitious resource or carbon taxes.

5.4. *Limitations and further research directions*

This study has several limitations, which suggest opportunities for further research. Firstly, it relies on the perceptions of survey respondents. To elicit their insights, the survey methodology employs a single method. Future research could adopt a longitudinal data analysis method to spot potential developments in the CSC practice implementation, particularly as firms innovate their PSSs. This could be supported by the development of objective measures for PSSs and CSC practice implementation to supplement the subjective assessment of the relevant constructs. Secondly, due to the exploratory nature of this study, the data was acquired using a volunteer opt-in panel. Future research should adopt probability sampling techniques to increase the generalisability of the findings. Thirdly, this research is focused on SMEs and a specific set of industries (equipment and machinery manufacturing) in a set geographical context (UK). As a result, care must be taken when generalising the results to other contexts and geographic locations. As we provide both the measurement items and the survey sample selection rationale along with methodological choices in modelling, we deem other researchers can easily replicate our findings with new data. For example, further studies might be carried out with larger samples to explore differences between groups of firms, for example, among micro-, small-, and medium-sized firms or include additional control variables (e.g. industry sector) to help rule out confounding effects and to further improve the robustness of the results. The findings from this study also point to the potential shortcomings of use-oriented PSSs in slowing resource loops and result-oriented PSSs in closing resource loops. The literature on the potential limitations of PSSs is just emerging and to date, it is primarily based on theoretical arguments (Hofmann, 2019). Case study research is needed to explore the shortcomings of PSSs in more detail.

CRediT authorship contribution statement

Carl Kühl: Writing – original draft, Visualization, Project administration, Investigation, Formal analysis, Data curation, Conceptualization. **Michael Bourlakis:** Writing – review & editing, Supervision, Funding acquisition. **Emel Aktas:** Writing – review & editing, Validation, Supervision. **Heather Skipworth:** Writing – review & editing, Supervision, Methodology.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Dr. Carl Kühl is a Visiting Lecturer at the Centre for Logistics, Procurement and Supply Chain Management at Cranfield School of Management, Cranfield University, UK. His research interests focus around circular economy, PSS and supply chain management. He is Marie Skłodowska Curie Fellow and part of Circ€uit, the Circular European Economy Innovative Training Network. It is an action funded by the European Commission under the Horizon 2020 Marie Skłodowska Curie Action 2016.

Professor Michael Bourlakis holds the Chair in Logistics and Supply Chain Management at Cranfield School of Management (UK). He is also Head of the Logistics, Procurement and Supply Chain Management Group, the Director of the Centre for Logistics and Supply Chain Management and Director of Research for the School. He has won more than 28 research and consulting projects from various bodies (EPSRC, Food Standards Agency, Technology Strategy Board, EU (FPVI, FPVII), Horizon 2020, Marie Skłodowska-Curie), local Regional Development Agencies and private companies. Michael Bourlakis has generated more than 260 publications including 67 journal papers and three edited books. He sits on the Editorial Board of 17 journals including most leading logistics, supply chain and operations management journals. He has an applied, industry-led research perspective examining logistics and supply chain management issues via multi- and inter-disciplinary lenses.

Professor Emel Aktas holds the Chair of Supply Chain Analytics at Cranfield School of Management. She specialises in supply chain analytics; using mathematical modelling, simulation, decision support systems and statistical analysis in transport, retail and manufacturing sectors. Her recent research focusses on food supply chain management, with one project (SAFE-Q) on minimising the waste in food supply chains and another (U-TURN) on logistics collaboration practises for distribution of food in the cities. Her work has appeared in European Journal of Operational Research, Interfaces, International Journal of Production Economics and Computers and Human Behaviour.

Dr. Heather Skipworth is an Associate Professor in the Centre for Logistics, Procurement, and Supply Chain Management at Cranfield School of Management. She works on a variety of research projects and has published in a number of international scholarly journals. Her particular areas of research interest include: agile and responsive supply chains; supply chain strategy and alignment; supply chain relationships; and supply chain risk. She is Director of the Agile Supply Chain Research Club, which provides a collaborative forum where member companies can share promising supply chain practices and participate in Cranfield University research. She also teaches on the MSc in Logistics and Supply Chain Management leading modules on Supply Chain Strategy and Sales and Operations Planning and is the lead Author on a key logistics text influencing academics and practitioners entitled Logistics Management and Strategy (edition 5, 2014).