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To cite this article: Qingyun Zhu , Purvi Shah & Joseph Sarkis (2020): A paler shade of green: implications of green product deletion on supply chains, International Journal of Production Research, DOI: [10.1080/00207543.2020.1781279](https://doi.org/10.1080/00207543.2020.1781279)

To link to this article: <https://doi.org/10.1080/00207543.2020.1781279>



Published online: 25 Jun 2020.



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A paler shade of green: implications of green product deletion on supply chains

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ABSTRACT

Product management activities by operations, marketing, and finance functions have typically focused on the innovation, acquisition, growth, and management of product lines and products. The same is true when considering product management for green products. The latter stages of critical strategic decisions related to product deletion or discontinuation have received less emphasis. In this conceptual paper, the focus is on green product deletion implications for supply chain management and operations. Organisations may view green product deletion as evolving from a deep green to a paler shade of green in their product offerings. A proposed strategic framework pays particular attention to the implications of the green product deletion decision for supply chain processes and operational competencies. In this situation, lessened organisational greenness needs to be weighed against other organisational and operational competencies. The strategic and inter-organisational relationships associated with this decision help set the stage for future research on this critical, yet neglected, organisational and operational supply chain issue.

ARTICLE HISTORY

Received 11 February 2020
Accepted 26 May 2020

KEYWORDS

Product deletion; supply chain management; supply chain competencies; supply chain processes; sustainability; green marketing

1. Introduction

Supply chains are designed around products; decisions related to sourcing, operations and manufacturing, distribution and logistics, as well as product usage and service depend largely on the characteristics of the product. Cost, quality, flexibility, and time are important strategic operational competencies that influence the planning, design, implementation, and management of supply chains. These supply chain dimensions and decisions become even more complex when the product is designed to be green or environmentally friendly. In this research, green products are defined as products with pro-ecological characteristics or environmental attributes, not only addressing environmental issues but also minimising their impact on the environment at each phase of their life cycle.

Organisations have been under pressure from various stakeholders to green their products and processes (Yu and Ramanathan 2015). Stakeholder pressure can derive from at least four key stakeholder groups (Fine-man and Clarke 1996). The first stakeholder group is represented by organisations whose mission is to protect the planet – serve as surrogates to the environment (Zhu, Sarkis, and Lai 2013). Examples include national or local pro-environmental groups pressuring companies to introduce products that reduce environmental

degradation and may provide environmental benefits (Yu and Ramanathan 2015). The second stakeholder group includes regulators. Regulatory pressures involve legislative requirements that will result in industrial compliance to maintain green processes such as reduction of damaging effluents (Zhu and Sarkis 2007). A third group comprise consuming individuals or organisations that enjoy the rewards of green products or processes when they fit their needs or economic gains. For example, green consumers demand green products to meet their green values (Groening, Sarkis, and Zhu 2018; Zhang, Zhao, and Zhao 2019). Lastly, internal stakeholders, top management teams, and employees might hold pro-environmental beliefs or views (Sarkis and Zhu 2018; Graves, Sarkis, and Zhu 2013).

Some research concerns do arise in this literature. For example, internal versus external stakeholder pressures for green product management vary with studies finding different levels of pressures (Polonsky and Ottman 1998; Awan 2019). The question of whether internal – who have the capacity and resources to implement changes – or external stakeholders – such as customer needs – play a larger role. This issue may also require some aspects of product, industry, and location in supply chain. Another controversy would be the conflicting needs and roles of stakeholders in green product management (Biddle 2013;

González-Benito and González-Benito 2006). When a firm decides to delete a product from its portfolio, several stakeholders and business functions influence or are influenced by this strategic cross-functional decision. These and other issues are discussed as potential theoretical issues from a contingency perspective.

Green products, with their additional environmental characteristics, may require higher environmental standards in materials selection, design and manufacturing, processing, transportation, service, and end-of-life management. For a manufacturing organisation, green products may require greater scrutiny for ensuring environmental characteristics increasing cost more when selecting resources (Kumar, Teichman, and Timpernagel 2012). For example, products that are designed for environmental needs to reduce the usage of hazardous materials may require special search and development increasing costs. Though additional resources may be needed, green products also emphasise resource efficiency (Sarkis and Zhu 2018) which means minimising impacts on the environment with less operational input and costs (Chun and Bidanda 2013). Despite these challenges, green products can be viewed as sources of competitive advantage for an organisation (Pujari, Wright, and Peattie 2003).

Researchers have studied various aspects of green supply chain management, such as green design (Li et al. 2016; Pujari, Wright, and Peattie 2003), green purchasing (Moser 2015; Yen and Yen 2012), production planning and control for remanufacturing (Guide 2000; Kwak and Kim 2017), reverse logistics (Saghiri et al. 2017), and green marketing (Zhu and Sarkis 2016). These supply chain and operations-oriented studies have focused on either introducing new green products or greening existing products. An important question remains unexplored – what is the impact of green product deletion on an organisation's supply chain? Considerations of green product deletion may come from its declining life cycle (Heidrich and Tiwary 2013), operational disruptions (Jabbarzadeh, Fahimnia, and Sabouhi 2018), capacity and resources constraints (Tsai et al. 2012), or social issues (Guo et al. 2015). Little is known about the strategic and operational supply chain processes, competencies, outcomes, or managerial implications related to green product deletion. A systematic review of green product deletion from supply chain and operational theoretical lenses is needed.

Product deletion – elimination, rationalisation or pruning – means discontinuing or removing a product from a firm's product portfolio (Avlonitis and Argouslidis 2012). Although designing, developing, and introducing new products is strategically and financially important for organisations, considering strategic product deletion is also vital because (1) too many products,

especially weak and poorly fitting products, may overburden organisations causing them to be less agile and make them ineffective in addressing shifts in competitive pressures; (2) bulky portfolios comprised of weak products consume valuable firm resources and complicate internal processes across functional areas (Putsis Jr and Bayus 2001; Thonemann and Brandeau 2000); (3) deleting unnecessary products can lower hidden costs and boost organisational profits (Bayus and Putsis Jr 1999); (4) customer confusion can be reduced by ensuring high level of product parity in product lines (Argouslidis and McLean 2001); (5) deleting redundant products can also control cannibalisation effects (Argouslidis and McLean 2001); and (6) saved resources from product deletions can be redeployed to more strategic products in the portfolio. Thus, deleting certain products may have numerous operational, financial, and strategic advantages for firms (Homburg, Fürst, and Prigge 2010; Pourhejazy, Sarkis, and Zhu 2020; Zhu and Sarkis 2020). With better understanding of strategic product deletion, deleting products has become more commonplace. Some examples include General Motors discontinuing several automobile models over the past decade, and several personal care product and electronics companies discontinuing many of their products each year.

Firms also delete green products from their product portfolio. For example, Nike discontinued its environmentally friendly forest dweller shoe launched in 2005 under the brand name Nike Considered because of its poor sales. General Motors deleted the EV1 electric car and Whirlpool discontinued its CFC-free refrigerator, both citing limited demand. Though adding green products is beneficial to firm, social, and environmental sustainability, deleting green products may be beneficial for economical sustainability and has some interplay – potentially negative and positive – with social and environmental concerns. Although, to the authors' knowledge, there is no report providing industry statistics showing the widespread nature of green product deletion, many companies producing green products have a section of their websites dedicated to discontinued or deleted green products. These webpages, though not as strong an evidence as industry statistics or reports, provide some evidence that green product deletion is commonplace in the industry.

Given that green products are introduced for varying reasons when compared with regular products, their deletion may have unforeseen consequences to an organisation's operations and supply chains, some beneficial, some disadvantageous. Firms delete products for several financial, operational, and strategic reasons such as dipping sales and market share, declining profits, redundancy in the product portfolio, cannibalisation amongst

similar products, and rising costs (Avlonitis and Argouslidis 2012; Shah 2017b). In contrast, green products might become candidates for deletions because of (1) customers unwilling to pay a green price premium, (2) misunderstanding consumers and the market, (3) green claims outpacing outcomes, (4) ignoring stakeholders, (5) unexpected and unintended consequences, and (6) expensive technology and inputs that consumers may not fully value (Esty and Winston 2006). Companies have to make challenging trade-offs and deal with side effects when managing green products. For example, Sun Chips deleted their SKU (stock keeping unit) with bioplastic packaging because the bag was so noisy that there was a customer backlash, negative publicity, and dip in market share (Brokaw 2014). Another example is compact fluorescent light bulbs that save energy, but also contain mercury that could harm consumers if they break. The fact is that all products have some impact on the environment. Therefore, making a 100% green product is extremely difficult. Instead, marketers could focus on ways to improve sustainability throughout operations to decrease its negative environmental footprint (Pride and Ferrell 2014).

In such situations, if firms decide to delete a green product, the firm and its management will benefit from understanding what happens to the various aspects of the green product's supply chain i.e. what role does green product deletion play in supply chain management? This research and knowledge gap in supply chain management and product deletion literature needs to be recognised and addressed. Despite a flurry of attention during the early 1980s and occasional publications thereafter, the topic of product deletion still suffers from research neglect. Table 1 identifies the literature gap and contribution of our study. The relationship between product deletion and supply chains has been investigated to some extent through research on product rationalisation and lean management of operations (Song and Kusiak 2009; Zhu, Johnson, and Sarkis 2018). However, issues and concerns around green product deletion have not received attention. The aim of this study is to understand this phenomenon from a conceptual perspective building from literature and theory. The relationship between product deletion and supply chain has been investigated to some extent through research on product rationalisation and lean management of operations (Sadeghi, Alem-Tabriz, and Zandieh 2011; Yao, Shi, and Liu 2020; Zhu, Johnson, and Sarkis 2018). However, issues and concerns around green product deletion have not received attention. The aim of this study is to understand this phenomenon from a conceptual perspective based on literature and theory.

This paper contributes in the context of discovery by synthesising existing ideas and combining unconnected

bodies of knowledge (Yadav 2010). The integrative conceptual framework presented in this paper attempts to combine green marketing, supply chain management, and product deletion literatures by explicating the influence of green product deletion on supply chain management competencies and processes. Competencies are defined as organisational capabilities to manage costs, flexibility, quality, and time. Competencies relate closely to organisational competitiveness and operations and supply chain functional strategies (Halley and Beaulieu 2009). The processes are categorised along supply chain life cycle functions including upstream sourcing, internal operations and manufacturing, downstream distribution and reverse logistics, and product usage and service (Zhu and Shah 2018).

In summary, we observe that green product deletion is not studied in the literature, we seek to address this gap. Its linkage to supply chain and operations concerns is missing in studies. It is an important strategic practical issue to organisations and their supply chains since the corporate reputation, goodwill, competitiveness, and operational and financial performance are tied to this decision. The basic research question we ask is – What influence and relationship exists from green product deletion on supply chains and their performance?

This paper is structured as follows. In the next section, the theoretical background of the proposed conceptual framework is introduced. This discussion is followed by a detailed investigation of how green product deletion influences operations and supply chain management competencies and processes. The paper concludes with theoretical and practical implications of this research, and directions for future research.

2. Theoretical background

A number of topics are reviewed to set the foundation for evaluating the implications of green product deletion on supply chains. These topics include a brief overview of green marketing and green products, product deletion, supply chain management and its processes, strategic supply chain performance competencies, and supply chain management for green products.

2.1. Green marketing and green products

Increasing attention has been afforded by organisations to the natural environment due to a number of competitive and social pressures. In response, research on green issues has grown in various academic disciplines, including marketing (Polonsky 1994). Green marketing, also related to and conceptualised as ecological marketing, environmental marketing, or responsible marketing,

incorporates a range of organisational activities that are green product oriented (Groening, Sarkis, and Zhu 2018) and operationally related to supply chains (Sarkis and Zhu 2018). These activities include product management and processes (Polonsky 1994), pricing, promotion, and distribution of products (Fuller 1999; Zhu and Sarkis 2016). A number of additional green product organisational-level initiatives may include packaging (Rokka and Uusitalo 2008), resource use (Ji, Magnus, and Wang 2014; Mohanty, Misra, and Drzal 2002), and branding (Hartmann and Ibanez 2006; Hartmann, Apaolaza Ibáñez, and Forcada Sainz 2005). Overall, green marketing and products are introduced to address factors, such as (1) satisfying customer needs; (2) meeting organisational goals and objectives; (3) limiting natural environmental burdens; or (4) contributing to societal expectations and norms (Fuller 1999; Violeta and Gheorghe 2009).

Some green products, an important element of green marketing, have emerged from the demand-pull of customers with evolved pro-environmental values and purchasing attitudes (Moser 2015; Simon 1992). Green products can be defined based on a number of characteristics such as whether they were designed using green design systems (eco-design), using clean manufacturing processes, or audited using third party verified eco-labels (Baumann, Boons, and Bragd 2002).

Green product development is environmentally proactive. It incorporates environmental issues by emphasising product pro-environmental design and green technology innovations in the product development process (Chen 2001; Pujari, Wright, and Peattie 2003). In addition to organisational and competitive requirements, green products may also be driven by various forms of environmental legislation imposed by governmental authorities across the globe (Nielsen et al. 2019). Organisations that adopt environmental management systems, such as ISO 14000, may also have specific green product definitions (Albino, Balice, and Dangelico 2009). Green products are extensively integrated in organisations seeking an ecological sustainability strategy. Eliminating green products is a multi-layered strategic organisational concern. Before focusing on green product deletion dimension, it is beneficial to provide some underlying principles of general product deletion as discussed in Section 2.2 below.

2.2. Product deletion

Product deletion or elimination is the strategic choice of a firm to discontinue, remove, or withdraw a product from its product line (Avlonitis and Argouslidis 2012). This

field of product management gained research attention in the 1960s when firms resorted to product proliferation without considering its negative consequences such as, rising costs, consuming disproportionate share of management time and effort, and inefficient use of resources (Kotler 1965; Eckles 1971). Firms soon realised that proliferation was draining their valuable resources and they needed to shift their focus from proliferation to rationalisation by deleting weak products from their product lines (Johnson 1975).

Built upon product lifecycle theory (Stark 2015), most of the earlier studies on product deletion have indicated that product deletion is a strategic decision for mature products (Hart 1988; Avlonitis, Hart, and Tzokas 2000). Thus, product deletion decisions often occur in the decline stage of a product life cycle. However, a decline in market demand or saturation of market penetration doesn't necessarily mean that the product has left its maturity stage or is about to reach the decline stage (Ayres and Steger 1985; Day 1981). The correlation between product deletion and its decline position at the product life cycle is misleading (Avlonitis 1985). A product could be deleted in any product lifecycle stage. Concerning the uniqueness of green products, they may be deleted before the arrival of a decline stage. The resource-based view emphasises adaptation and change in building, integrating, or reconfiguring resources and capabilities (Peteraf 1993; Barney 2001). Product deletion might help to enhance competitiveness through scarce resources rearrangement. Resources that are freed from product deletion can be reorganised to produce superior market offerings that are more economically and/or can better satisfy customer demand.

Many companies have deleted products from their product portfolios. For example, Sony (Sanchanta 2007), P&G (Caldwell 2016; Ng 2014), Unilever (Kumar 2003), and Shiseido have trimmed their product lines by deleting products that reduced their firm's profitability and financial performance, did not serve a strategic purpose, or did not meet changing market needs. Product deletion is a multi-stage process that typically involve four steps: (1) identification of candidates for elimination, (2) analysis and product revitalisation, (3) evaluation and decision-making, and (4) implementation of product deletion (Avlonitis and Argouslidis 2012). Consumer and industrial product deletion decisions are empirically classified into a broad typology based on strategic and tactical factors (Avlonitis, Hart, and Tzokas 2000). These factors include deletion due to coercion from external forces, deletion as a part of variety reduction policy to decrease product portfolio complexity, deletion of unsuccessful new products, deletion of a product facing competitive pressures and declining demand, and deletion of

a poorly designed product hurting the company's image (Zhu, Shah, and Sarkis 2018; Zhu and Kouhizadeh 2019; Kouhizadeh, Sarkis, and Zhu 2019).

Product deletion, a well-planned formalised process in many firms, is triggered by consumer needs, and is led by the research and development and/or the product management function (Shah, Laverie, and Davis 2016-17). However, product deletion not only affects the product management function but also influences several aspects of manufacturing, operations, and distribution as well as external stakeholders such as customers, distributors, suppliers, and competitors (Shah 2015; Bai et al. 2018; Zhu, Johnson, and Sarkis 2018). Any elimination from the product line affects the variable costs involved in manufacturing, reactions from channel partners (retailers and distributors), production runs (Alexander 1964; Hamelman and Mazze 1972), distribution compatibility with other products of the firm (Banville and Pletcher 1974), and capacity utilisation (Avlonitis 1993). When green products are deleted, firms encounter changes in the way they source materials, manufacture and distribute products, and offer service as several constraints imposed by the greening aspects of these processes are eliminated. It is therefore proposed that green product deletion affects the firm's sourcing, production, distribution, and service activities as well as flexibility, cost, quality, and time competencies.

2.3. Supply chain management and its processes

Supply chain and operations management has a long history (Sarkis and Zhu 2018). To be able to produce products or provide services, having the necessary resources, processes, and materials is necessary. The term, supply chain management, involves both external, upstream and downstream, and internal, operations practices. Supply chain principles can also be traced to the value chain concept (Porter and Millar 1985). The elements of the value chain include core processes of inbound logistics, operations, outbound logistics, marketing and sales, and service, supported with various non-core organisational functions.

A broader perspective of supply chain activities may include upstream vendor and supplier management, manufacturing and operations, distribution and logistics, and product after-life and closing the loop. Although many definitions exist, our definition of supply chain includes all activities managing the flow and transformation of goods from raw materials and information through the end user. Material and information may flow both up and down the supply chain (Handfield and Nichols 1999).

The supply chain operations reference (SCOR) model (Huan, Sheoran, and Wang 2004), which relates to the value chain, is a popular supply chain process reference model. The SCOR model, activities include four supply chain processes, (1) sourcing, (2) operations and manufacturing, (3) distribution and logistics, and (4) usage and service. The conceptual framework proposed in this paper is based on these SCOR processes.

The supply chain includes these processes and involves a number of organisational functions that participate vertically across, and horizontally within, organisations. Supply chain management will result in inter-organisational relationships with suppliers and customers. There will also be a need to incorporate cross-functional participation such as engineering, manufacturing, purchasing, logistics, and marketing functions within the organisation. The supply chain, by design and definition, is complex, and decisions affecting products or materials will reverberate throughout the supply chain. Although managing processes is one aspect of supply chain management, another important dimension is supply chain planning and control, which requires considerations of performance competencies.

2.4. Strategic supply chain performance competencies

Flexibility, cost, quality, and time strategic performance competencies, are important when planning, designing, implementing, and managing the supply chain. Acknowledging that other dimensions of performance competencies exist, these four (flexibility, cost, quality, and time) are the most commonly identified within the literature (Boyer and Lewis 2002). These operational strategic performance dimensions can help organisations identify ways to differentiate themselves and build operational competitive advantages. They are also critical to organisational decision making across the supply chain (Halley and Beaulieu 2009).

Flexibility represents the ability to incur uncertainties with little penalty in time and cost (Upton 1994). Flexibility is associated with dynamic market environments and risks as well as the firm's capability to identify, respond, and conform to those changes. Cost competency occurs when firms build their organisational competitiveness by committing to cost reduction as an operating principle (Porter 1985). Cost competencies and savings can be achieved through efficient use of technology, process, labour, materials, facilities, and sourcing decisions (Lado, Boyd, and Wright 1992). Quality can be defined as the features and characteristics of a product or service that satisfy customers' expectations consistently

(Rauyruen and Miller 2007). Firms obtain quality competencies when they distinguish their market offerings to be quality competitive in order to satisfy customer demand (Garvin 1987). Time competency is a firm's ability to reduce cycle time in processes of operations, including product design (Li et al. 2020), material purchasing, manufacturing, distribution and delivery, as well as offering highly responsive service to customers (Stalk Jr 1988). Time-based competency, with responsiveness as the key measurement, is instrumental in improving both production efficiencies and customer satisfaction (Richins and Bloch 1991).

2.5. Supply chain management for green products

Competitive and stakeholder forces have evolved, increasing pressures on organisations to green their supply chains and improve their environmental performance (Sarkis and Zhu 2018). That is, organisations are under greater scrutiny to explicitly consider and integrate natural ecological dimensions into managing supply chains (Sarkis 2003; Wagner 2015). Numerous activities and additional motivations for greening supply chains have also evolved. Organisations may wish to green their supply chains for reactive reasons such as meeting compliance and regulatory coercive pressures. Organisations have also sought to be proactive and build competitive advantages by greening their supply chains, products, and services (Pujari, Wright, and Peattie 2003). Some of these competitive reasons include increased revenue generation, building business continuity and resiliency, image and reputation building, and maintaining a license to operate.

Greening of supply chains can occur in all supply chain processes and may closely relate to whether a product, service, or material is considered green. From a *sourcing* perspective, selecting green suppliers, those suppliers whose materials and processes are environmentally friendly, is an important sourcing managerial issue. If organisations aim to make their supply chain greener, they may collaborate with suppliers through supplier development programmes to deepen their greening further (Yen and Yen 2012). Auditing of suppliers, performance measurement, sharing expertise, investment in technologies, and building green networks are approaches that can help suppliers improve their environmental performance (Govindan et al. 2015; Zhu, Geng, and Sarkis 2016). Involving suppliers in design and management of products and processes within a focal company are additional activities when pursuing green supply chain strategies. Greening of inbound logistics may also be a sourcing issue.

Internal greening practices also relate to *operational and manufacturing* activities. Some of these activities involve processes and technologies that could produce greener products and services. Technology may include less environmentally burdensome manufacturing principles and practices, for example, lean manufacturing and elimination of waste, machinery and equipment that may utilise less hazardous materials, or more energy conservation (Shen, Cao, and Xu 2020; Sarkis et al. 2016). Internal activities may include the adoption of environmental policies and systems that influence operations. In addition, the design of products, materials, and processes, internally may incorporate ecological principles (Dey, Roy, and Saha 2019).

Distribution and outbound logistics functions can also be greened (McKinnon et al. 2015). These activities, such as packaging and materials management in the delivery of products, may require evaluation from an environmental perspective (Kuiti et al. 2019). The delivery of products, similar to inbound activities within sourcing, could include green transportation practices. In addition, distribution networks with their warehousing and logistics operations can be made green through more efficient facility design and greener and leaner network schemes. An important functional element of greening distribution and logistics is the development of reverse logistics networks (Öberg, Hüge-Brodin, and Björklund 2012). This downstream set of functions includes methods to manage the end-of-life of products and materials to return them into the forward supply chain. Reverse logistics have complexities in their operations that are commensurate with forward supply chains. Reverse logistics activities are necessary for a critical greening philosophy within supply chains, the 'closing-of-the-loop' for supply chains.

The green and traditional supply chain's product *usage and disposal* phases need to be managed from a perspective of product, materials, and service life cycle (Schenkel et al. 2015). Product usage is typically positioned in a product's supply chain life cycle between forward and reverse supply chain activities. Product usage is an important supply chain activity since usage causes a major portion of a product's environmental burden. Usage is closely related to how products are marketed and managed through the service stages of the supply chain.

This section provided a conceptual background about green products, product deletion, supply chain processes, performance competencies, and supply chain management for green products. Further details on the relationship between green product deletion and supply chain management is now presented in Section 3.

3. Green product deletion and its impact on supply chains

Firms introduce green products to improve their ecological footprint and achieve environmental benefits. Introducing green products into the marketplace has become more common as firms increasingly seek competitive market advantages associated with a focus on improving environmental performance and ecologically sustainable supply chains. Part of these ecological performance and practice improvements across the supply chain derive from the anticipation of evolving environmental performance requirements by stakeholders. Green products are one of the more proactive reasons for greening supply chains. Green product influences on greening supply chains is well documented (Kuiti et al. 2019; Li et al. 2020; Shen, Cao, and Xu 2020). However, how a green product deletion decision influences an organisation is not well understood or studied. Therefore, the aim of this paper is to propose a conceptual framework that explicates the impact of green product deletion on its supply chain. The next subsection defines the scope of the proposed conceptual framework.

3.1. Scope of the research

First, it is acknowledged that with a green product deletion, the associated green benefits will disappear, i.e. the firm will move from a darker shade of green to a paler one. This is intuitive and therefore not presented as a proposition. For example, despite the many potential business benefits of moving efforts away from environmental programmes and practices, such as higher flexibility in supplier development, transportation methods, and resource allocation, drawbacks also exist. These downsides include (1) managing risks, such as liabilities and fines; (2) waste management cost increases; (3) low resource efficiency measures; (4) high transportation costs; and (5) poor organisational and supply chain social reputation. In addition, there could be an impact on the brand portfolio, other products in the product portfolio, image/reputation of the organisation, and on several stakeholders. However, this research, in the interest of parsimony and coherence, focuses on consequences of green product deletion specifically on a supply chain's processes and competencies.

Second, the stakeholders considered in this framework are the members of a supply chain including all firms with whom the focal firm interacts directly or indirectly, from the point of origin to the point of consumption (Kazadi, Lievens, and Mahr 2016). The stakeholders involved in the focal firm's supply chain are suppliers,

distributors, retailers, logistics firms, and end consumers. The focal firm is the organisation, which manufactures the green product and is planning to discontinue it for business and/or strategic reasons. In the proposed conceptual framework, the implications of green product deletion on its supply chain stakeholders are from the focal firm's perspective.

A firm can delete a product completely with or without replacement. If a firm deletes a green product and replaces it with another green product, there would be a few adjustments but not a great impact on the supply chain processes and competencies. However, if the firm completely deletes the product and does not replace it with any other product, there could be significant changes in that product's supply chain. The focus of this framework is complete green product deletion without replacement and its impact on the deleted green product's supply chain. In addition, it is assumed that the firm has an existing green product, which is being deleted. This is different from a firm that does not have any green products in the portfolio.

3.2. The conceptual framework

This research proposes a conceptual framework (Figure 1) to set the foundation for understanding and studying the relationship between green product deletion and supply chain processes and competencies. The core of the framework is green product deletion. This phenomenon is expected to impact four supply chain processes, which include sourcing, operations and manufacturing, distribution and logistics, and usage and service, based on the SCOR model (Huan, Sheoran, and Wang 2004). These supply chain processes typically follow a cycle, which is depicted in the framework with dotted arrows. It is also proposed that the four major strategic operational competencies within each process are also affected by green product deletion. These competencies, based on the operations strategy literature (Flynn, Schroeder, and Flynn 1999) include costs, flexibility, quality, and time.

The consequences of green product deletion on supply chain processes and competencies, other than negative environmental outcomes, are introduced and discussed in the following sub-sections. After discussion in each subsection, a research proposition is introduced.

3.3. Sourcing

Important sourcing activities include supplier selection, monitoring, and development (Monczka et al. 2015; Nair, Jayaram, and Das 2015). *Selecting* green suppliers requires a consideration of capabilities and competencies related to green practices (Govindan et al. 2015). For

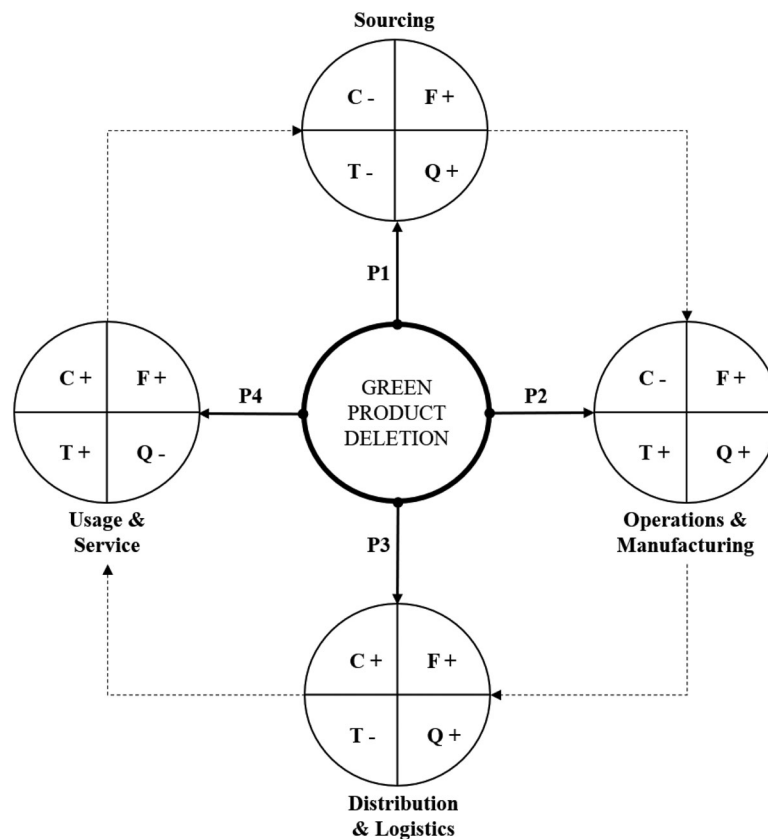


Figure 1. A conceptual framework of green product deletion's influence on supply chain processes and competencies.

Note: The four circles surrounding the central circle represent supply chain management processes, which are impacted by green product deletion. Four supply chain competencies play an important role within each supply chain management process. Green product deletion also affects each of these four competencies. These supply chain competencies are C = Costs; F = Flexibility; Q = Quality; T = Time. P1, P2, P3, and P4 represent the four propositions posited by the conceptual framework. The positive (+) and negative (–) signs depict the directionality of the relationships between green product deletion and the supply chain processes and competencies. For example, P1 represents that green product deletion will likely result in greater flexibility (F +), lower cost (C –), higher quality (Q +), and shorter time (T –) in sourcing activities.

example, certain environmentally based supplier selection criteria are the ability to supply recycled material and components, having green manufacturing processes, using certified environmentally sound materials, or having environmental certifications (Bai and Sarkis 2010a; Genovese et al. 2013). Supplier *monitoring* involves supplier performance evaluation based on operational and strategic criteria. Green supplier monitoring considers environmental factors as fundamental performance indicators (Govindan et al. 2015). Another strategic sourcing activity, supplier *development*, helps to build knowledge and expertise in suppliers. Green supplier development would include green knowledge transfer and communication, investment and resource transfer, and management and organisational practices (Bai and Sarkis 2010b). However, if a green product is no longer a priority for the focal firm due to its deletion, there might be advantages and/or disadvantages associated with sourcing activities (Hwang, Wen, and Chen 2010). These are further discussed in detail with respect to four competencies

(flexibility, cost, quality, and time) that play an important role in sourcing processes.

Flexibility: If a sourced product or material is meant to have certain green characteristics, these characteristics will no longer be required if the green product is deleted. Minimal carbon footprint is an example of a green product characteristic (Onozaka, Hu, and Thilmany 2016). In some regions of the world, the carbon footprints of products are labelled on the packaging. To lower the carbon footprint, companies may practice a buy-local sourcing model, or may have their products delivered through low carbon delivery modes. These deliveries may be completed through alternative energy or electric vehicles that do not emit significant carbon and thus help reduce transportation emissions. If a company is discontinuing certain green products, then they can choose from a broader set of delivery modes and locations for sourcing their materials and product components improving supplier network flexibility (Thun and Müller 2010). However, given too much flexibility in sourcing alternatives,

loss of knowledge related to green materials or suppliers may limit the understanding of sourcing activities causing difficulty in alternative evaluation (Vyas 1993). Overall, there is a greater likelihood of improvement in sourcing flexibility due to green product deletion.

Cost: With green product deletion, there is less need for organisations to integrate environmental performance or capabilities in the supplier selection process for that product. Therefore, potentially lower costs are possible due to increased negotiating power with a broader supplier choice set and greater competition among suppliers. Green materials and components are usually premium priced due to lack of economies of scale and hidden cost inclusion (e.g. social cost) (Ayres 1997; Baumers et al. 2016). Thus, purchasing non-green counterparts reduces material cost. However, source materials and suppliers that perform poorly on environmental aspects, may result in potentially greater risks and associated sourcing costs. Green materials and green suppliers enhance supplier resiliency, implying long-term cost reductions (Rauer and Kaufmann 2015). So overall, there is a greater likelihood of sourcing cost reductions due to green product deletion.

Quality: When certain green products are deleted, emphasis on quality initiatives in supplier selection and monitoring may be greater due to the shift from green to general supply chain competencies (Roehrich et al. 2017). In addition, reallocation of supplier development resources away from environmental programmes to other development programmes might lead to quality improvement in the overall product portfolio. Alternatively, firms might also sacrifice quality due to fewer green activities (Narasimhan and Schoenherr 2012). However, overall, sourcing quality improvement is more likely in the event of green product deletion.

Time: If an organisation outsources some of its processes to gain green expertise, it no longer needs that external green expertise when a green product is deleted (Wang and Song 2017). The organisation can then insource the material or the product if certain green aspects are no longer essential. Insourcing, similar to vertical integration, allows for greater control and more efficient, timely processing (Foerstl et al. 2016). However, more time might be required to switch supplier resources and build supplier expertise from deleted products to other dissimilar products, especially if no green products are to be considered as replacement alternatives (Argouslidis, Baltas, and Mavrommatis 2014; Fisch and Ross 2014). Overall, there is a greater likelihood of saving time in sourcing activities due to green product deletion.

Hence, after considering the pros and cons of green product deletion on its sourcing activities and competencies, in general, it is proposed that,

P1: Green product deletion will likely result in (a) greater flexibility, (b) lower cost, (c) higher quality, and (d) shorter time in sourcing activities.

3.4. Operations and manufacturing

Internal operations of an organisation's manufacturing and service processes may also be green (Sangwan and Mittal 2015). The environmental aspects of internal operations range from internal environmental policies and systems to technology choices and product design (Campatelli and Scippa 2016; Zhu, Sarkis, and Lai 2013). Certified environmental management systems such as ISO 14000 are usually adopted by organisations to signal their greenness to the market (Castka and Prajogo 2013). However, if a green product is deleted, there might be positive and/or negative influences on the focal firm's operations and manufacturing activities. These influences are depicted next with respect to four competencies (flexibility, cost, quality, and time) that play an important role in operations and manufacturing.

Flexibility: The substitution of environmentally damaging materials and processes with less damaging materials is a critical aspect of eco-design. One of the popular design-for-the-environment systems is 'cradle-to-cradle', which charges companies to find alternatives and complete testing of chemicals and materials (McDonough et al. 2003). Deleting green products eliminates such restrictions allowing for a wider range of product design alternatives. Sometimes for just one dimension of a product, significant testing may be required (Lee and Bony 2007). If the firm is deleting the environmental systems required for manufacturing the deleted green product, the production line can become more standardised due to less product variety resulting in less 'green flexibility' (Bai and Sarkis 2017), despite the improvement in the overall flexibility in manufacturing and operations. Overall, there is a greater likelihood of improvement in flexibility of manufacturing and operations activities due to green product deletion.

Cost: The costs of certified environmental management systems can be quite significant (Darnall and Edwards 2006). With the deletion of a green product, such systems and certifications may no longer be needed for that product. The implication would be lower costs due to no requirement of environmental certifications in operations. Furthermore, green materials are no longer

required in manufacturing thereby reducing the material variety requirements. This means the focal firm has to manage a narrow range of materials inventory leading to lessened inventory levels, better control, and thus lower costs (Wan and Sanders 2017; Hvam et al. 2020). However, the initial investments in the manufacturing facilities and operational infrastructure development, which are specifically designed and constructed for green products, will no longer be needed. Therefore, restructuring facilities and infrastructure will burden the firm, especially if moving from green to non-green product development and manufacturing (Saunders and Jobber 1994). However, overall, there is a greater likelihood of cost reduction in manufacturing and operations activities due to green product deletion.

Quality: Quality increase may occur in the product portfolio due to slack resources from the deleted product and focus on non-green quality specifications (Anderson 2001; Avlonitis, Hart, and Tzokas 2000). Furthermore, green product deletion leads to inventory reduction, which also improves overall product quality (Ton and Raman 2010). However, it has been found that quality in general improves when environmental systems are incorporated into operations (Narasimhan and Schoenherr 2012; Pil and Rothenberg 2003). With green product deletion, the need for pro-environmental operations lessens. Thus, firms will likely sacrifice perceived and actual quality due to fewer green activities (Narasimhan and Schoenherr 2012). Overall, green product deletion is expected to improve quality.

Time: Low efficiency, at least in the short run, in the manufacturing and operations processes results in longer time due to shifting product characteristics and worker retraining (Harness and Marr 2004). However, the product manufacturing process might be shortened since fewer environmental auditing activities will occur resulting in fewer delays (Edwards 2003) depending on the occurrence and frequency of environmental auditing for green product operations and processing. In general, green product deletion is likely to result in longer times in manufacturing and operations processes.

Based on the above discussion, in general, it is posited that,

P2: Green product deletion will likely lead to (a) greater flexibility, (b) lower cost, (c) higher quality, and (d) longer time in operations and manufacturing processes.

3.5. Distribution and logistics

Distribution and logistics include managing activities related to distribution channels, warehousing, packaging,

retailing, logistics, transportation, and sorting and collection of end-of-life products (Franchetti, Elahi, and Ghose 2017). These downstream processes can be quite extensive with significant uncertainties. Typical green-focused activities within these processes include green packaging, warehousing, and transportation mode selection. For example, green packaging is one of the most important visible traits of the final product delivery. Reusable or recyclable packaging adds to the green characteristics and support for green products (Zhang and Zhao 2012). However, deleting such a green product might have positive and/or negative effects on the focal firm's distribution and logistics activities. These influences are depicted next with respect to four competencies (flexibility, cost, quality, and time) that play an important role in distribution and logistics.

Flexibility: Packaging eco-design typically limit prohibited materials using checklists (Holdway, Walker, and Hilton 2002). If greening of packaging is no longer a constraint due to green product deletion, more packaging can be associated with aesthetics and marketing, which means more flexibility in packaging alternatives (Lee and Xu 2005). The delivery and transportation selection process after green product deletion will also allow for greater choices of warehouses and transportation modes (Dekker, Bloemhof, and Mallidis 2012). However, loss of knowledge in green packaging designs and green transportation modes may reduce experience and expertise (Holan and Phillips 2004). Overall, there is a greater likelihood of improvement in distribution and logistics flexibility due to green product deletion.

Cost: There is a hierarchy of most to least environmentally efficient delivery modes when it comes to energy usage and emissions per unit. Typically, air transportation has been viewed as the least ecologically efficient, while maritime shipping as the most efficient on a per unit delivery basis (Rondinelli and Berry 2000). With a lessened need to find the most ecologically efficient transportation mode following green product deletion, wider choices of modes may facilitate major cost reduction depending on availability of logistics alternatives. However, the interaction between packaging and transportation might also have cost implications. Green product deletion may result in wasteful packaging for aesthetic purposes. Wasteful packaging leads to greater packaging and transportation cost (Prendergast and Pitt 1996). At this stage, supply chain activities work more closely with both organisational and individual customers, as deleting a green product may risk the company losing customers (retailers) who are loyal to that product (Homburg, Fürst, and Prigge 2010; Vyas 1993). Greater potential cost is

incurred to seek new markets and customers. Therefore, overall, there is a higher likelihood of increase in distribution and logistics cost due to green product deletion.

Quality: With green product deletion, the focal firm has wider alternatives available in packaging, warehousing, distribution, and logistics provider choices (Brady, Cronin, and Brand 2002). Delivery reliability is an important quality measure for this stage. Greater distribution and logistics alternatives can improve scheduling and delivery reliability, thereby the quality. With green product deletion, similar to other supply chain processes, organisations could switch emphasis and slack resources to other quality-oriented factors. Overall, there is a higher likelihood of improvement in distribution and logistics quality due to green product deletion.

Time: If the green product was under regulatory policy, such as Waste Electrical and Electronic Equipment (WEEE) (Ebrahimpour and Johnson 1992), after its deletion, regulatory compliance to that policy is not required. Therefore, shorter lead-time cycle is expected, as compliance to environmental product regulations is no longer required post green product deletion. Reverse logistics and closed-loop supply chain activities are not necessary any more thus saving time resources that can be dedicated to other business processes. Overall, there is a greater likelihood of saving time in distribution and logistics activities due to green product deletion.

This discussion leads to the third research proposition:

P3: Green product deletion, in general, will most likely result in (a) greater flexibility, (b) higher cost, (c) higher quality, and (d) shorter time in distribution and reverse logistics activities.

3.6. Product usage and service

After product delivery, individual end users use and consume the product. Product usage and service activities are downstream supply chain processes and are thus closer to individual consumers and product end-users. Here consumers expect after-sales service from focal firms. *Ceteris paribus*, green product usage is more pronounced amongst environmentally conscious consumers (Young et al. 2010). When the green product is deleted and the perceived green impact is gone, the differentiation offered by the organisation between green and regular non-green product usage will disappear (Gauthier 2017). Green product deletion affects the product usage and service activities with respect to four competencies (flexibility, cost, quality, and time) that are discussed below.

Flexibility: With a green product deletion, it is expected that an organisation's supply chain responsibilities will

end after a consumer's purchase transaction. Organisations may no longer have the responsibility of product recycling and resource reclamation, unless required by law. The implications for the focal firms will be more flexibility within the overall supply chain processes due to additional resources released from discontinued product end-of-life activities that could be redeployed to other supply chain activities. Recycling is an example of product end-of-life activity, which will no longer be required when an associated green product is deleted. One may argue that the focal firm will lose its 'recycling flexibility', however, on the other hand, it is also gaining 'labor flexibility' (Bai and Sarkis 2017). Therefore, overall, usage and service process flexibility improves with green product deletion.

Cost: End-of-life activities are adopted by focal firms to acquire less expensive materials and/or components (Guide et al. 2000). With green product deletion, cost could potentially increase since waste reduction emphasis is lessened, resource reclamation is not required, and close-loop resource reallocation is not necessary for that product. Therefore, overall, there is a higher likelihood of increase in usage and service cost due to green product deletion.

Quality: Extended producer responsibility (EPR)¹ is an important aspect of environmental supply chain designs. When a green product is deleted, organisations may not necessarily need to attach after sales service required by that green product's EPR practices. This lack of service may result in consumers perceiving the product to be of lower quality and may eventually affect consumers' satisfaction levels and perceived brand reputation, both of which are quality measures (Sengupta, Balaji, and Krishnan 2015). In general, the quality of usage and service activities is expected to reduce due to green product deletion.

Time: If focal firms engage in EPR activities, such as offering rebates and deposit-refunds to have consumers return their used products, the product life cycle time is shortened because it is likely that consumers will return products in a relatively shorter time (Souza 2013; Taylor 2000). With the deletion of green products, its associated EPR incentives are no longer needed; resulting in increased product life cycle time. In addition, in the long run, EPR dissolution would potentially hurt firm image and perception (Albino, Balice, and Dangelico 2009); thus, more time would be needed to establish firm market standing and to acquire new customers. In general, green product deletion is likely to result in longer times in usage and service activities.

Taking into consideration, the above discussion, it is proposed that,

Table 2. Propositions depicting the influence of green product deletion on supply chain processes and competencies.

<i>PROPOSITIONS</i>	<i>Flexibility (a)</i>	<i>Cost (b)</i>	<i>Quality (c)</i>	<i>Time (d)</i>
<i>Sourcing (P1)</i>	↑	↓	↑	↓
<i>Operations and Manufacturing (P2)</i>	↑	↓	↑	↑
<i>Distribution and Logistics (P3)</i>	↑	↑	↑	↓
<i>Usage and Service (P4)</i>	↑	↑	↓	↑

Note: The upward facing arrow represents an increase in each competency within a specific supply chain process, and the downward facing arrow represents a decrease. A grey arrow represents a negative impact such as increase in cost or time, or reduction in quality or flexibility. A white arrow represents a positive impact such as decrease in cost or time or increase in quality or flexibility.

Table 3. Conceptual propositions and supporting literature.

	Sourcing	Operations and Manufacturing	Distribution and Logistics	Product Usage and Service
	<i>P1: Green product deletion will likely result in (a) greater flexibility, (b) lower cost, (c) higher quality, and (d) shorter time in sourcing activities.</i>	<i>P2: Green product deletion will likely lead to (a) greater flexibility, (b) lower cost, (c) higher quality, and (d) longer time in operations and manufacturing processes.</i>	<i>P3: Green product deletion, in general, will most likely result in (a) greater flexibility, (b) higher cost, (c) higher quality, and (d) shorter time in distribution and reverse logistics activities.</i>	<i>P4: Green product deletion, in general, will most likely result in (a) greater flexibility, (b) higher cost, (c) lower quality, and (d) longer time in usage and service activities.</i>
Flexibility	Onozaka, Hu, and Thilmany (2016); Thun and Müller (2010); Vyas (1993).	McDonough et al. (2003); Lee and Bony (2007); Bai and Sarkis (2017).	Holdway, Walker, and Hilton (2002); Lee and Xu (2005); Dekker, Bloemhof, and Mallidis (2012); Holan and Phillips (2004).	Gauthier (2017); Bai and Sarkis (2017).
Cost	Ayres (1997); Baumers et al. (2016); Rauer and Kaufmann (2015)	Darnall and Edwards (2006); Wan and Sanders (2017); Hvam et al. (2020); Saunders and Jobber (1994).	Rondinelli and Berry (2000); Prendergast and Pitt (1996); Homburg, Fürst, and Prigge (2010); Vyas (1993).	Guide et al. (2000).
Quality	Roehrich et al. (2017); Narasimhan and Schoenherr (2012)	Anderson (2001); Avlonitis, Hart, and Tzokas (2000); Ton and Raman (2010); Narasimhan and Schoenherr (2012); Pil and Rothenberg (2003); Narasimhan and Schoenherr (2012).	Brady, Cronin, and Brand (2002).	Sengupta, Balaji, and Krishnan (2015).
Time	Wang and Song (2017); Foerstl et al. (2016); Argouslidis, Baltas, and Mavrommatis (2014); Fisch and Ross (2014).	Harness and Marr (2004); Edwards (2003).	Ebrahimpour and Johnson (1992).	Souza (2013); Taylor (2000); Albino, Balice, and Dangelico (2009).

P4: Green product deletion, in general, will most likely result in (a) greater flexibility, (b) higher cost, (c) lower quality, and (d) longer time in usage and service activities.

Table 2 summarises the propositional relationships of green product deletion and potential impact on an

organisation's supply chain processes and competencies; and the supporting literature is abridged in Table 3. Table 2 is a 4 × 4 matrix with columns representing the four strategic supply chain performance competencies (flexibility, cost, quality and time) and rows representing supply chain processes (sourcing, operations

and manufacturing, distribution and reverse logistics, and usage and service). Within each cell, overall consequences of green product deletion are shown for each supply chain process with regard to a specific competency. The upward facing arrow represents an increase in each competency within a specific supply chain process, and the downward facing arrow represents a decrease. A grey arrow represents a negative impact such as increase in cost or time and reduction in quality or flexibility. The general propositional relationships are derived from literature and practice.

Across every cell of Table 2, the common drawback of green product deletion is lessened environmental performance and social responsibility. This fact should not be lost when considering the disadvantages of green product deletion decisions that are not replaced by other green products. The strategic concerns include not meeting the needs and expectations of a broader stakeholder community, beyond business partners. Other advantages of greening strategies and greening supply chains include maintaining business continuity in the supply chain, having a license to operate, additional revenue generation, and improved company image (Sarkis 2013). It is likely that some or all of these advantages, known for 'making the business case' and not considered amongst the operational performance competencies and process activities, will be lost. However, the critical positive business consequences of green product deletion on a company adopting a paler shade of green strategy should not be underestimated.

4. Discussion and implications

4.1. Theoretical implications – a contingency theoretic perspective

Research has extensively considered operations and supply chain implications from a new product development perspective (e.g. Lee 2002). These frameworks and theories have focused on product growth strategies, but not on product deletion or discontinuation. Marketing has mainly considered product deletion of unprofitable, obsolete or mature product categories. Green products are still a relatively current and novel phenomenon and overall are at an early stage of the product development life cycle investigation. Deletion of green products may not follow similar contexts of existing findings for regular product deletion. Whether these differences are parlayed to supply chain implications is an open research question. The proposed conceptual framework in this paper, contributes in the context of discovery and justification by creatively synthesising ideas, developing new relationships between established constructs, identifying

and addressing a research gap, and integrating extant theoretical perspectives (Yadav 2010).

The proposed framework is generative in nature and helps to set the foundation and open new doors for future research in this under-explored field of green product deletion. In the future, the relative magnitude and directions of green product deletion influence on processes and competencies, proposed here, need to be empirically investigated. A *contingency theory* in organisational theory stipulates that specific situational factors can affect the direct relationships between independent and dependent variables. For example, if an organisation's operations strategy is focused on customisation and high responsiveness, deleting a green product may be favourable. This is because green product deletion may improve flexibility and enhance time-based competencies or responsiveness. In this example, other dimensions such as cost competency will be of minimal concern.

Operations programmes and philosophies that influence the supply chain, such as just-in-time principles (Golhar and Stamm 1991), the lean management philosophy (Jasti and Kodali 2015), total quality management (Vanichchinchai and Igel 2011), eco-design, and the theory of constraints, are contextual programmes that may influence the green product deletion program and its practical implications. This contingency theoretic perspective results in a series of potential moderating relationships. For example, lean manufacturing focuses on waste elimination. If the goal of green products is to design processes that will utilise the least amount of materials, elimination of the green product may result in minimising emphasis on lean principles. A perception of less emphasis on lean principles may require behavioural investigation of managers to determine whether green product deletion can cause managers and workers to perceive the organisation as being less conscious about waste reduction, in general. This perception may cause lean management programmes to be less effective. Whether this behavioural and perceptual situation – *the contingency* – does occur for this and other general operations and supply chain programmes needs investigation.

It is also acknowledged that there might be broader strategic and positioning issues arising out of green product deletion as well as variations in the relationships between constructs presented in the proposed framework. These issues and variations may be captured by considering additional contingencies. Contingencies include contextual factors that exist and influence the relationship between a green product deletion decision and organisation's strategic supply chain dimensions (processes and competencies). Contingencies may be moderators, mediators, or control variables

that play an important role in the context of green product deletion. Contingencies that could play a role in this framework may relate to external exogenous variables, green product-related variables, or firm-related variables. External exogenous variables may concern government policies and regulations, fluctuation of exchange rates, industrial-level forces, and length of market life. Green product-related variables include strategic positioning of the product, the green dimensions of a product, product portfolio complexity, and product's life cycle stage. Firm-related variables include ownership and governance characteristics, mergers and acquisitions, culture and entrepreneurship issues, mission and value propositions. These contingencies should be carefully considered when applying this framework in theory and practice. Empirical research to investigate these contingencies in the context of green product deletion needs to be pursued.

For instance, research has found that organisations adopt green strategies and practices when they are faced with various external stakeholder and institutional pressures (Zhu, Geng, and Sarkis 2016). These pressures may include compliance (governmental, coercive) or beyond compliance (competitors, mimetic) dimensions. Whether the existence or lack of various external pressures plays a role in green product deletion requires future research investigation. The type of pressure may also play a role in the implications for the supply chain. For example, if the reason for adopting certain green practices in the supply chain activities was due to compliance, green product deletion may not have any influence on competencies or processes as the organisation still needs to comply with regulations.

The framework also unlocks several opportunities of theory application in this under-explored research area. For example, theories can be integrated within the proposed framework to further explain the impact of green product deletion on various facets of supply chain management. Resource-based theory, stakeholder theory, resource dependence theory, service-dominant logic, and innovation diffusion theory are among the promising theories that may invoke additional insights to generate and integrate conceptual ideas within green product deletion and supply chain management literatures. We provide examples for resource-based, role and stakeholder theory here as ways to investigate contingencies – other theories and related questions from a green supply chain management perspective can be found in Sarkis, Zhu, and Lai (2011).

Resource based theory may contingently ask the question on whether resources and dynamic capabilities are enhanced by deletion of a product. It may be that the green product is a differentiator that provides valuable,

inimitable, and rare resources that provide a competitive advantage. If this is the case, then deleting the green product to improve supply chain performance may go against the strategic direction of the organisation. If it frees up resources to provide greater capabilities in competitive dimensions, then green product deletion may be worth it and supply chain performance may or may not contribute to the decision.

Role theory can be a linking theory that grounds the contingencies and impacts of green product deletion on supply chain processes and actors (Biddle 2013). Role theory describes individuals or organisations behavioural patterns by considering associated social positions and expectations. Role theory research includes consensus, conformity, conflicts of role taking characteristics (Markham et al. 2010). Role theory as applied to the supply chain management field can provide significant insight that has yet to be investigated fully. For example, supply chain actors take various social roles in supply chain networks and investigating how they make product and supply chain decisions is an important research direction. Role theory can support insights into role decision making for products, processes, and resources over which the respective role players have influence. For example, a role player takes certain positions in a given relationship; consider the role conflicts associated with marketing and operations when making a green product decision. The roles and expectations of marketing are to keep growing revenue with a wide variety of green products to satisfy multiple niches. Operations and production are concerned with efficiency, their role is to protect the resources and provide the necessary supplies in a cost-efficient way. Deleting these products may improve efficiency. Sustainability directors in their role may find that efficiencies can work well in reducing resource use; but may have conflicts within their group who each see varying levels of importance of efficiency versus greener processes that are less efficient but more environmentally sound. A wide array of role-related expectations may pose different power, perceptions, actions over adding or deleting certain products and supporting processes.

Stakeholders can also play a contingent role on the relative performance outcomes. A product may or may not be deleted depending on the primary stakeholder involved in the decision and may also influence performance. For example, if there are stakeholder pressures from investors to maintain a certain product or delete these stakeholders may focus on cost dimensions. Green customer stakeholders may wish to have flexibility and variety of green quality products – and not care about the supply chain costs – and thus an organisation may not focus on deleting or keeping green products

that may have certain outcomes. Regulatory stakeholders may require green products to be maintained so that outcomes related to environmental quality measures are maintained in the supply chain.

Many such contingencies exist and could be the foundation of many additional research questions and hypotheses.

4.2. Managerial implications

The proposed conceptual framework has implications for practitioners as well. The proposed framework can make the strategic decision of product deletion more manageable within a green context. First, the framework challenges the traditional view that only adding green products is considered beneficial for firm performance and introduces a novel perspective that deleting green products also can be beneficial for firms through potential changes in supply chain processes and competencies. The results caution managers that an unquestionable positive view of expanding the green product portfolio may be simplistic. On the other hand, alternative and critical thinking is needed to determine whether deleting green products can be beneficial to the organisation and its supply chain.

Second, the framework posits that green product deletion influences supply chain processes and competencies. Each supply chain element in the framework can influence managerial decision making in the context of green product deletion. The performance of each element involves various critical factors. This framework helps managers to better understand green product deletion's impact on each supply chain factor; and in return, the identification of each factor can also improve decision making processes on supply chain. Propositions that presented in the framework also may inform broader strategic decision making on supply chains in a post-product deletion stage. Such decisions may include supplier selection, capacity planning, network design, and product end-of life services. For example, supply chain management sourcing decisions include outsourcing of various processes to external suppliers. An outsourcing decision, especially one that is driven by green product requirements, may need to be altered when green requirements are no longer part of the supplier selection criteria. In some cases, unless the current supplier has better overall non-green competencies, a different supplier or insourcing may occur. The framework provides direction for some of these considerations, even if the decision is to outsource or insource one of the general supply chain processes (e.g. production) discussed in this paper.

Third, green product deletion decisions and outcomes presented in the framework are intensively from but not limited to supply chain perspectives. Managers from different departments may utilise the framework in alternative ways. For example, in the event of product deletion, marketing and sales managers are concerned about alienating their customers (Shah 2017a). This framework provides factors they can consider during the green product deletion. For example, knowing from the framework that green product deletion could affect distribution and logistics, they can ensure that their channel partners provide continued service to retain consumers of the deleted green product. Thus, this framework provides an important checklist of factors that managers from cross-functional areas could consider while making the product deletion decision. This framework will enable improved cross-functional integration amongst marketing, operations, finance, supply chain, and environmental management, instead of the decision being made by a single department.

Fourth, the framework sets the stage to help identify key performance indicators (KPIs) for green product deletion mainly from an operations strategy perspective based on cost, flexibility, time, and quality competencies related to various elements of supply chain processes. As an example, when a green product is deleted, there could be reduced after sales service. This may lead to consumers perceiving a lower product quality, which further negatively affects consumers' satisfaction levels and perceived brand reputation. Using this framework while making the green product deletion decision, marketing managers consider the impact on quality competency and thus are able to identify two important KPIs (customer satisfaction and brand reputation). This helps them anticipate and manage the adverse consequences arising from green product deletion related to a key stakeholder (customers). Similarly, if managers also consider time, cost, and flexibility competencies, they will be able to identify more KPIs and manage green product deletion successfully.

5. Conclusion

This study investigates product deletion impact on supply chain management within a green context. The proposed framework demonstrates the linkage between an organisation's strategic-level product deletion decision and supply chain processes in terms of four core competencies (quality, flexibility, time, and cost). Overall, the framework: (1) fills a research gap by integrating green product deletion and supply chain management literatures; (2) facilitates firms' green product deletion decision-making process; and (3) sets both, a conceptual and practical, foundation for further investigation of each

element within the framework as well as the relationships amongst them.

This study opens up new lines of research on an important strategic decision, green product deletion, which deserves more attention in the supply chain management, sustainability, and marketing literature. This topic has not been covered in previous research. Theoretically, the constructs, relationships, and theories that were used to conceptualise the framework may also provide directions in general product deletion context. Directions and strength of relationships might vary for different product categories and characteristics and therefore the framework should be adapted accordingly. The initial relationships listed in the propositions are a theoretical and conceptual perspectives that require further investigation.

Finally, the framework could be extended to product deletion in general and provide implications for firms and their supply chains. This aspect is an important contribution to practice. Practically, we have identified four implications that contribute to providing insights to practitioner and practice – these specific implications include: (1) Care should be taken with keeping green products in a portfolio and raises awareness; (2) Supply chain performance and decision implications should be considered when deleting green products; (3) An interdisciplinary process is needed for green product deletion decisions are to be made and should not be under the purview of a single department; and (4) Organisations can identify key performance indicators that relate to green product deletion and supply chain performance decisions.

This research and literature stream integration is expected to inspire future study related to product deletion in diverse disciplines and within different contexts. It is also meant to build improved practice for green and regular product deletion decisions.

Note

1. EPR is defined as an organisation's responsibility for a product that emphasises the post-use stage of a product's life cycle. Two primary dimensions of EPR include the producing organisation: (1) being at least partially responsible for a product's end-of-life, physically and economically; and (2) incorporating environmental considerations in product design (Lifset, Atasu, and Tojo 2013).

Disclosure statement

No potential conflict of interest was reported by the author(s).

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References

- Albino, V., A. Balice, and R. M. Dangelico. 2009. "Environmental Strategies and Green Product Development: An Overview on Sustainability-Driven Companies." *Business Strategy and the Environment* 18 (2): 83–96.
- Alexander, R. S. 1964. "The Death and Burial of 'Sick' Products." *The Journal of Marketing* 28 (2): 1–7.
- Anderson, S. W. 2001. "Direct and Indirect Effects of Product Mix Characteristics on Capacity Management Decisions and Operating Performance." *International Journal of Flexible Manufacturing Systems* 13 (3): 241–265.
- Argouslidis, P. C., G. Baltas, and A. Mavrommatis. 2014. "Outcomes of Decision Speed: An Empirical Study in Product Elimination Decision-Making Processes." *European Journal of Marketing* 48 (5/6): 982–1008.
- Argouslidis, P. C., and F. McLean. 2001. "Financial Service Elimination: Objectives and Problem Situations." *Journal of Financial Services Marketing* 5 (3): 227–237.
- Ashayeri, J., N. Ma, and R. Sotirov. 2015. "Supply Chain Network Downsizing with Product Line Pruning Using a New Demand Substitution." *Journal of the Operational Research Society* 66 (10): 1699–1716.
- Avlonitis, G. J. 1983a. "The Product-Elimination Decision and Strategies." *Industrial Marketing Management* 12 (1): 31–43.
- Avlonitis, G. J. 1983b. "Improving Product Elimination in Engineering Companies." *Journal of General Management* 9 (2): 42–56.
- Avlonitis, G. J. 1984. "Industrial Product Elimination: Major Factors to Consider." *Industrial Marketing Management* 13 (2): 77–85.
- Avlonitis, G. J. 1985. "Product Elimination Decision Making: Does Formality Matter?" *Journal of Marketing* 49 (1): 41–52.
- Avlonitis, G. J. 1987. "Linking Different Types of Product Elimination Decisions to Their Performance Outcome: 'Project Dropstrat.'" *International Journal of Research in Marketing* 4 (1): 43–57.
- Avlonitis, G. J. 1993. "Project Dropstrat: What Factors Do Managers Consider in Deciding Whether to Drop a Product?" *European Journal of Marketing* 27 (4): 35–57.
- Avlonitis, G. J., and P. C. Argouslidis. 2012. "Tracking the Evolution of Theory on Product Elimination: Past, Present, and Future." *The Marketing Review* 12 (4): 345–379.
- Avlonitis, G. J., S. J. Hart, and N. X. Tzokas. 2000. "An Analysis of Product Deletion Scenarios." *Journal of Product Innovation Management* 17 (1): 41–56.
- Awan, U. 2019. "Industrial Ecology in Support of Sustainable Development Goals." *Responsible Consumption and Production. Encyclopedia of the UN Sustainable Development Goals*.
- Ayres, R. U. 1997. "Metals Recycling: Economic and Environmental Implications." *Resources, Conservation and Recycling* 21 (3): 145–173.
- Ayres, R. U., and W. A. Steger. 1985. "Rejuvenating the Life Cycle Concept." *The Journal of Business Strategy* 6 (1): 66–76.
- Bai, C., and J. Sarkis. 2010a. "Integrating Sustainability Into Supplier Selection with Grey System and Rough Set Methodologies." *International Journal of Production Economics* 124 (1): 252–264.
- Bai, C., and J. Sarkis. 2010b. "Green Supplier Development: Analytical Evaluation Using Rough Set Theory." *Journal of Cleaner Production* 18 (12): 1200–1210.

- Bai, C., and J. Sarkis. 2017. "Improving Green Flexibility Through Advanced Manufacturing Technology Investment: Modeling the Decision Process." *International Journal of Production Economics* 188: 86–104.
- Bai, C., P. Shah, Q. Zhu, and J. Sarkis. 2018. "Green Product Deletion Decisions: An Integrated Sustainable Production and Consumption Approach." *Industrial Management and Data Systems* 118 (2): 349–389.
- Banville, G. R., and B. Pletcher. 1974. "The Product Elimination Function." *Journal of the Academy of Marketing Science* 2 (3): 432–446.
- Barney, J. B. 2001. "Resource-based Theories of Competitive Advantage: A Ten-Year Retrospective on the Resource-Based View." *Journal of Management* 27 (6): 643–650.
- Baumann, H., F. Boons, and A. Bragd. 2002. "Mapping the Green Product Development Field: Engineering, Policy and Business Perspectives." *Journal of Cleaner Production* 10 (5): 409–425.
- Baumers, M., P. Dickens, C. Tuck, and R. Hague. 2016. "The Cost of Additive Manufacturing: Machine Productivity, Economies of Scale and Technology-Push." *Technological Forecasting and Social Change* 102: 193–201.
- Bayus, B. L., and W. P. Putsis Jr. 1999. "Product Proliferation: An Empirical Analysis of Product Line Determinants and Market Outcomes." *Marketing Science* 18 (2): 137–153.
- Biddle, B. J. 2013. *Role Theory: Expectations, Identities, and Behaviors*. New York: Academic Press.
- Boyer, K. K., and M. W. Lewis. 2002. "Competitive Priorities: Investigating the Need for Trade-Offs in Operations Strategy." *Production and Operations Management* 11 (1): 9–20.
- Brady, M. K., J. J. Cronin, and R. R. Brand. 2002. "Performance-only Measurement of Service Quality: A Replication and Extension." *Journal of Business Research* 55 (1): 17–31.
- Brokaw, L. 2014. "Pepsi's Biodegradable Backlash: The Snack Bag that was too Noisy." March 18. Accessed June 13, 2017. <https://www.greenbiz.com/blog/2014/03/18/pepsi-biodegradable-backlash-snack-bag-was-too-noisy>.
- Caldwell, G. 2016. "Less is more: P&G Culls a Sixth of Olay Line." *Global Cosmetics News*, January 5. Accessed January 30, 2017. <https://globalcosmeticsnews.com/north-america/2190/less-is-more-p-g-culls-a-sixth-of-olay-line>.
- Campatelli, G., and A. Scippa. 2016. "Environmental Impact Reduction for a Turning Process: Comparative Analysis of Lubrication and Cutting Inserts Substitution Strategies." *Procedia CIRP* 55: 200–205.
- Castka, P., and D. Prajogo. 2013. "The Effect of Pressure From Secondary Stakeholders on the Internalization of ISO 14001." *Journal of Cleaner Production* 47 (2): 245–252.
- Chen, C. 2001. "Design for the Environment: A Quality-Based Model for Green Product Development." *Management Science* 47 (2): 250–263.
- Chun, Y., and B. Bidanda. 2013. "Sustainable Manufacturing and the Role of the International Journal of Production Research." *International Journal of Production Research* 51 (23–24): 7448–7455.
- Darnall, N., and D. Edwards. 2006. "Predicting the Cost of Environmental Management System Adoption: the Role of Capabilities, Resources and Ownership Structure." *Strategic Management Journal* 27 (4): 301–320.
- Day, G. S. 1981. "The Product Life Cycle: Analysis and Applications Issues." *Journal of Marketing* 45 (4): 60–67.
- Dekker, R., J. Bloemhof, and I. Mallidis. 2012. "Operations Research for Green Logistics—An Overview of Aspects, Issues, Contributions and Challenges." *European Journal of Operational Research* 219 (3): 671–679.
- Dey, K., S. Roy, and S. Saha. 2019. "The Impact of Strategic Inventory and Procurement Strategies on Green Product Design in a Two-Period Supply Chain." *International Journal of Production Research* 57 (7): 1915–1948.
- Ebrahimipour, M., and J. L. Johnson. 1992. "Quality, Vendor Evaluation and Organizational Performance: A Comparison of US and Japanese Firms." *Journal of Business Research* 25 (2): 129–142.
- Eckles, R. W. 1971. "Product Line Deletion and Simplification: Tough but Necessary Decisions." *Business Horizons* 14 (5): 71–74.
- Edwards, A. J. 2003. *ISO 14001 Environmental Certification Step by Step*. Revised e. Oxford: Butterworth-Heinemann.
- Esty, D., and A. Winston. 2006. *Green to Gold: How Smart Companies Use Environmental Strategy to Innovate, Create Value, and Build Competitive Advantage*. Hoboken, NJ: John Wiley & Sons Inc.
- Evans, R. H. 1977. "Add Soft Data to Product Elimination Decisions." *Industrial Marketing Management* 6 (2): 91–94.
- Fineman, S., and K. Clarke. 1996. "Green Stakeholders: Industry Interpretations and Response." *Journal of Management Studies* 33 (6): 715–730.
- Fisch, J. H., and J. M. Ross. 2014. "Timing Product Replacements Under Uncertainty—The Importance of Material–Price Fluctuations for the Success of Products That Are Based on New Materials." *Journal of Product Innovation Management* 31 (5): 1076–1088.
- Flynn, B. B., R. G. Schroeder, and E. J. Flynn. 1999. "World Class Manufacturing: an Investigation of Hayes and Wheelwright's Foundation." *Journal of Operations Management* 17 (3): 249–269.
- Foerstl, K., J. F. Kirchoff, L. Bals, and A. Ellinger. 2016. "Reshoring and Insourcing: Drivers and Future Research Directions." *International Journal of Physical Distribution & Logistics Management* 46 (5): 492–515.
- Franchetti, M. J., B. Elahi, and S. Ghose. 2017. "Green Supply Chain, Logistics, and Transportation." In *Green and Lean Management*, edited by C. Machado and J. Paulo Davim, 1–16. Cham: Springer International Publishing.
- Fuller, D. A. 1999. *Sustainable Marketing: Managerial-Ecological Issues*. Thousand Oaks, CA: Sage Publications, Inc.
- Garvin, D. A. 1987. "Competing on the 8 Dimensions of Quality." *Harvard Business Review* 65 (6): 101–109.
- Gauthier, J. 2017. "Sustainable Business Strategies: Typologies and Future Directions." *Society and Business Review* 12: 77–93.
- Genovese, A., S. C. Lenny Koh, G. Bruno, and E. Esposito. 2013. "Greener Supplier Selection: State of the Art and Some Empirical Evidence." *International Journal of Production Research* 51 (10): 2868–2886.
- Golhar, D. Y., and C. L. Stamm. 1991. "The Just-in-Time Philosophy: a Literature Review." *International Journal of Production Research* 29 (4): 657–676.
- González-Benito, J., and Ó González-Benito. 2006. "The Role of Stakeholder Pressure and Managerial Values in the Implementation of Environmental Logistics Practices." *International Journal of Production Research* 44 (7): 1353–1373.

- Govindan, K., S. Rajendran, J. Sarkis, and P. Murugesan. 2015. "Multi Criteria Decision Making Approaches for Green Supplier Evaluation and Selection: A Literature Review." *Journal of Cleaner Production* 98 (3): 66–83.
- Graves, L. M., J. Sarkis, and Q. Zhu. 2013. "How Transformational Leadership and Employee Motivation Combine to Predict Employee Proenvironmental Behaviors in China." *Journal of Environmental Psychology* 35: 81–91.
- Groening, C., J. Sarkis, and Q. Zhu. 2018. "Green Marketing Consumer-Level Theory Review: A Compendium of Applied Theories and Further Research Directions." *Journal of Cleaner Production* 172: 1848–1866.
- Guide, V. D. R. 2000. "Production Planning and Control for Remanufacturing: Industry Practice and Research Needs." *Journal of Operations Management* 18 (4): 467–483.
- Guide, V. D. R., V. Jayaraman, R. Srivastava, and W. C. Benton. 2000. "Supply-chain Management for Recoverable Manufacturing Systems." *Interfaces* 30 (3): 125–142.
- Guo, W. F., J. Zhou, C. L. Yu, S. B. Tsai, Y. Z. Xue, Q. Chen, J.-j. Guo, P.-Y. Huang, and C. H. Wu. 2015. "Evaluating the Green Corporate Social Responsibility of Manufacturing Corporations From a Green Industry Law Perspective." *International Journal of Production Research* 53 (2): 665–674.
- Halley, A., and M. Beaulieu. 2009. "Mastery of Operational Competencies in the Context of Supply Chain Management." *Supply Chain Management: An International Journal* 14 (1): 49–63.
- Hamelman, P. W., and E. M. Mazze. 1972. "Improving Product Abandonment Decisions." *The Journal of Marketing* 36 (2): 20–26.
- Handfield, R. B., and E. L. Nichols Jr. 1999. *Introduction to Supply Chain Management*. Englewood Cliffs, NJ: Prentice Hall.
- Harness, D. R., and N. E. Marr. 2004. "A Comparison of Product Elimination Success Factors in the UK Banking, Building Society and Insurance Sectors." *International Journal of Bank Marketing* 22 (2): 126–143.
- Hart, S. J. 1988. "The Causes of Product Deletion in British Manufacturing Companies." *Journal of Marketing Management* 3 (3): 328–343.
- Hartmann, P., V. Apaolaza Ibáñez, and F. J. Forcada Sainz. 2005. "Green Branding Effects on Attitude: Functional Versus Emotional Positioning Strategies." *Marketing Intelligence & Planning* 23 (1): 9–29.
- Hartmann, P., and V. A. Ibanez. 2006. "Green Value Added." *Marketing Intelligence & Planning* 24 (7): 673–680.
- Heidrich, O., and A. Tiwary. 2013. "Environmental Appraisal of Green Production Systems: Challenges Faced by Small Companies Using Life Cycle Assessment." *International Journal of Production Research* 51 (19): 5884–5896.
- Holan, P. M. D., and N. Phillips. 2004. "Remembrance of Things Past? The Dynamics of Organizational Forgetting." *Management Science* 50 (11): 1603–1613.
- Holdway, R., D. Walker, and M. Hilton. 2002. "Eco-design and Successful Packaging." *Design Management Review* 13 (4): 45–53.
- Homburg, C., A. Fürst, and J.-K. Prigge. 2010. "A Customer Perspective on Product Eliminations: How the Removal of Products Affects Customers and Business Relationships." *Journal of the Academy of Marketing Science* 38 (5): 531–549.
- Huan, S. H., S. K. Sheoran, and G. Wang. 2004. "A Review and Analysis of Supply Chain Operations Reference (SCOR) Model." *Supply Chain Management: An International Journal* 9 (1): 23–29.
- Hvam, L., C. L. Hansen, C. Forza, N. H. Mortensen, and A. Haug. 2020. "The Reduction of Product and Process Complexity Based on the Quantification of Product Complexity Costs." *International Journal of Production Research* 58 (2): 350–366.
- Hwang, Y. D., Y. F. Wen, and M. C. Chen. 2010. "A Study on the Relationship Between the PDSA Cycle of Green Purchasing and the Performance of the SCOR Model." *Total Quality Management & Business Excellence* 21 (12): 1261–1278.
- Jabbarzadeh, A., B. Fahimnia, and F. Sabouhi. 2018. "Resilient and Sustainable Supply Chain Design: Sustainability Analysis Under Disruption Risks." *International Journal of Production Research* 56 (17): 5945–5968.
- Jasti, N. V. K., and R. Kodali. 2015. "Lean Production: Literature Review and Trends." *International Journal of Production Research* 53 (3): 867–885.
- Ji, K., J. R. Magnus, and W. Wang. 2014. "Natural Resources, Institutional Quality, and Economic Growth in China." *Environmental and Resource Economics* 57 (3): 323–343.
- Johnson, M. L. 1975. "End of the Line for Weak Products?" *Industry Week* Sep-15: 25–29.
- Kazadi, K., A. Lievens, and D. Mahr. 2016. "Stakeholder co-Creation During the Innovation Process: Identifying Capabilities for Knowledge Creation among Multiple Stakeholders." *Journal of Business Research* 69 (2): 525–540.
- Kent, R. A., and P. C. Argouslidis. 2005. "Shaping Business Decisions Using Fuzzy-Set Analysis: Service Elimination Decisions." *Journal of Marketing Management* 21 (5–6): 641–658.
- Kotler, P. 1965. "Phasing out Weak Products." *Harvard Business Review* 43 (2): 107–118.
- Kouhizadeh, M., J. Sarkis, and Q. Zhu. 2019. "At the Nexus of Blockchain Technology, the Circular Economy, and Product Deletion." *Applied Sciences* 9 (8): 1712.
- Kuiti, M. R., D. Ghosh, S. Gouda, S. Swami, and R. Shankar. 2019. "Integrated Product Design, Shelf-Space Allocation and Transportation Decisions in Green Supply Chains." *International Journal of Production Research* 57 (19): 6181–6201.
- Kumar, N. 2003. "Kill a Brand, Keep a Customer." *Harvard Business Review* 81 (12): 86–95.
- Kumar, S., S. Teichman, and T. Timpernagel. 2012. "A Green Supply Chain is a Requirement for Profitability." *International Journal of Production Research* 50 (5): 1278–1296.
- Kwak, M., and H. Kim. 2017. "Green Profit Maximization Through Integrated Pricing and Production Planning for a Line of new and Remanufactured Products." *Journal of Cleaner Production* 142 (4): 3454–3470.
- Lado, A. A., N. G. Boyd, and P. Wright. 1992. "A Competency-Based Model of Sustainable Competitive Advantage: Toward a Conceptual Integration." *Journal of Management* 18 (1): 77–91.
- Lee, H. L. 2002. "Aligning Supply Chain Strategies with Product Uncertainties." *California Management Review* 44 (3): 105–119.
- Lee, D., and L. Bony. 2007. "Cradle-to-Cradle Design at Herman Miller: Moving Toward Environmental Sustainability." Harvard Business School Case 607-003, Cambridge, MA.
- Lee, S. G., and X. Xu. 2005. "Design for the Environment: Life Cycle Assessment and Sustainable Packaging Issues."

- International Journal of Environmental Technology and Management* 5 (1): 14–41.
- Li, Q., X. Guan, T. Shi, and W. Jiao. 2020. “Green Product Design with Competition and Fairness Concerns in the Circular Economy Era.” *International Journal of Production Research* 58 (1): 165–179.
- Li, S., V. Jayaraman, A. Paulraj, and K.-c. Shang. 2016. “Proactive Environmental Strategies and Performance: Role of Green Supply Chain Processes and Green Product Design in the Chinese High-Tech Industry.” *International Journal of Production Research* 54 (7): 2136–2151.
- Lifset, R., A. Atasu, and N. Tojo. 2013. “Extended Producer Responsibility.” *Journal of Industrial Ecology* 17 (2): 162–166.
- Markham, S. K., S. J. Ward, L. Aiman-Smith, and A. I. Kingon. 2010. “The Valley of Death as Context for Role Theory in Product Innovation.” *Journal of Product Innovation Management* 27 (3): 402–417.
- McDonough, W., M. Braungart, P. T. Anastas, and J. B. Zimmerman. 2003. “Peer Reviewed: Applying the Principles of Green Engineering to Cradle-to-Cradle Design.” *Environmental Science & Technology* 37 (23): 434A–441A.
- McKinnon, A., M. Browne, A. Whiteing, and M. Piecyk. 2015. *Green Logistics: Improving the Environmental Sustainability of Logistics*. London: Kogan Page Publishers.
- Mitchell, M., R. Taylor, and F. Tanyel. 1997. “Product Elimination Decisions: A Comparison of Consumer and Industrial Products.” *Journal of Marketing Management (10711988)* 7 (2).
- Mitchell, M. A., R. D. Taylor, and F. Tanyel. 1998. “Product Elimination Decisions: A Comparison of American and British Manufacturing Firms.” *International Journal of Commerce and Management*.
- Mohanty, A., M. Misra, and L. Drzal. 2002. “Sustainable bio-Composites From Renewable Resources: Opportunities and Challenges in the Green Materials World.” *Journal of Polymers and the Environment* 10 (1-2): 19–26.
- Monczka, R. M., R. B. Handfield, L. C. Giunipero, and J. L. Patterson. 2015. *Purchasing and Supply Chain Management*. New York: Cengage Learning.
- Moser, A. K. 2015. “Thinking Green, Buying Green? Drivers of pro-Environmental Purchasing Behavior.” *Journal of Consumer Marketing* 32 (3): 167–175.
- Muir, J., and N. Reynolds. 2011. “Product Deletion: A Critical Overview and Empirical Insight into This Process.” *Journal of General Management* 37 (1): 5–30.
- Nair, A., J. Jayaram, and A. Das. 2015. “Strategic Purchasing Participation, Supplier Selection, Supplier Evaluation and Purchasing Performance.” *International Journal of Production Research* 53 (20): 6263–6278.
- Narasimhan, R., and T. Schoenherr. 2012. “The Effects of Integrated Supply Management Practices and Environmental Management Practices on Relative Competitive Quality Advantage.” *International Journal of Production Research* 50 (4): 1185–1201.
- Ng, S. 2014. “P&G to Shed more than Half its Brands: Company to Focus on 70 to 80 Products, Including Tide and Pampers.” *The Wall Street Journal*, August 1. Accessed January 30, 2017. <http://online.wsj.com/articles/procter-gamble-posts-higher-profit-on-cost-cutting-1406892304>.
- Nielsen, I. E., S. Majumder, S. S. Sana, and S. Saha. 2019. “Comparative Analysis of Government Incentives and Game Structures on Single and two-Period Green Supply Chain.” *Journal of Cleaner Production* 235: 1371–1398.
- Öberg, C., M. Hüge-Brodin, and M. Björklund. 2012. “Applying a Network Level in Environmental Impact Assessments.” *Journal of Business Research* 65 (2): 247–255.
- Onozaka, Y., W. Hu, and D. D. Thilmany. 2016. “Can eco-Labels Reduce Carbon Emissions? Market-Wide Analysis of Carbon Labeling and Locally Grown Fresh Apples.” *Renewable Agriculture and Food Systems* 31 (02): 122–138.
- Peteraf, M. A. 1993. “The Cornerstones of Competitive Advantage: A Resource-Based View.” *Strategic Management Journal* 14 (3): 179–191.
- Pil, F. K., and S. Rothenberg. 2003. “Environmental Performance as a Driver of Superior Quality.” *Production and Operations Management* 12 (3): 404–415.
- Polonsky, M. J. 1994. “An Introduction to Green Marketing.” *Electronic Green Journal* 1 (2). <http://egj.lib.uidaho.edu/egj02/polon01.html>.
- Polonsky, M. J., and J. A. Ottman. 1998. “Exploratory Examination of Whether Marketers Include Stakeholders in the Green new Product Development Process.” *Journal of Cleaner Production* 6 (3-4): 269–275.
- Porter, M. E. 1985. *Competitive Advantage: Creating and Sustaining Superior Performance*. New York: FreePress.
- Porter, M. E., and V. E. Millar. “How Information Gives You Competitive Advantage.” *Harvard Business Review*.
- Pourhejazy, P., J. Sarkis, and Q. Zhu. 2020. “Product Deletion as an Operational Strategic Decision: Exploring the Sequential Effect of Prominent Criteria on Decision-Making.” *Computers & Industrial Engineering* 140: 106274.
- Prendergast, G., and L. Pitt. 1996. “Packaging, Marketing, Logistics and the Environment: Are There Trade-Offs?” *International Journal of Physical Distribution & Logistics Management* 26 (6): 60–72.
- Pride, W. M., and O. C. Ferrell. 2014. *Foundations of Marketing*. Stamford, CT: Cengage Learning.
- Pujari, D., G. Wright, and K. Peattie. 2003. “Green and Competitive: Influences on Environmental new Product Development Performance.” *Journal of Business Research* 56 (8): 657–671.
- Putsis Jr, W. P., and B. L. Bayus. 2001. “An Empirical Analysis of Firms’ Product Line Decisions.” *Journal of Marketing Research* 38 (1): 110–118.
- Rauer, J., and L. Kaufmann. 2015. “Mitigating External Barriers to Implementing Green Supply Chain Management: A Grounded Theory Investigation of Green-Tech Companies’ Rare Earth Metals Supply Chains.” *Journal of Supply Chain Management* 51 (2): 65–88.
- Rauyruen, P., and K. E. Miller. 2007. “Relationship Quality as a Predictor of B2B Customer Loyalty.” *Journal of Business Research* 60 (1): 21–31.
- Richins, M. L., and P. H. Bloch. 1991. “Post-purchase Product Satisfaction: Incorporating the Effects of Involvement and Time.” *Journal of Business Research* 23 (2): 145–158.
- Roehrich, J. K., J. K. Roehrich, S. U. Hojmoose, S. U. Hojmoose, V. Overland, and V. Overland. 2017. “Driving Green Supply Chain Management Performance Through Supplier Selection and Value Internalisation: a Self-Determination Theory Perspective.” *International Journal of Operations & Production Management* 37 (4): 489–509.
- Rokka, J., and L. Uusitalo. 2008. “Preference for Green Packaging in Consumer Product Choices – do Consumers

- Care?" *International Journal of Consumer Studies* 32 (5): 516–525.
- Rondinelli, D., and M. Berry. 2000. "Multimodal Transportation, Logistics, and the Environment: Managing Interactions in a Global Economy." *European Management Journal* 18 (4): 398–410.
- Rothe, J. T. 1970. "Product Elimination Decision." *MSU Business Topics-Michigan State University* 18 (4): 45–52.
- Sadeghi, A., A. Alem-Tabriz, and M. Zandieh. 2011. "Product Portfolio Planning: A Metaheuristic-Based Simulated Annealing Algorithm." *International Journal of Production Research* 49 (8): 2327–2350.
- Saghiri, S., R. Wilding, C. Mena, and M. Bourlakis. 2017. "Toward a Three-Dimensional Framework for Omni-Channel." *Journal of Business Research* 77: 53–67.
- Sanchanta, M. 2007. "Sony Under Fire Over 60Gb PS3 Phase-out Plans." *Financial Times*, July 17. Accessed January 30, 2017. http://www.ft.com/cms/s/0/4b984278-34c7-11dc-8c78-0000779fd2ac.html?ft_site=falcon&desktop=true#axzz4Pu92OIqe.
- Sangwan, K. S., and V. K. Mittal. 2015. "A Bibliometric Analysis of Green Manufacturing and Similar Frameworks." *Management of Environmental Quality: An International Journal* 26 (4): 566–587.
- Sarkis, J. 2003. "A Strategic Decision Framework for Green Supply Chain Management." *Journal of Cleaner Production* 11 (4): 397–409.
- Sarkis, J. 2013. *Green Supply Chain Management*. New York, NJ: Momentum Press, ASME.
- Sarkis, J., C. Bai, A. B. L. d. S. Jabbour, C. J. C. Jabbour, and V. A. Sobreiro. 2016. "Connecting the Pieces of the Puzzle Toward Sustainable Organizations: A Framework Integrating OM Principles with GSCM." *Benchmarking: An International Journal* 23 (6): 1605–1623.
- Sarkis, J., and Q. Zhu. 2018. "Environmental Sustainability and Production: Taking the Road Less Travelled." *International Journal of Production Research* 56 (1-2): 743–759.
- Sarkis, J., Q. Zhu, and K. H. Lai. 2011. "An Organizational Theoretic Review of Green Supply Chain Management Literature." *International Journal of Production Economics* 130 (1): 1–15.
- Saunders, J., and D. Jobber. 1994. "Product Replacement: Strategies for Simultaneous Product Deletion and Launch." *Journal of Product Innovation Management* 11 (5): 433–450.
- Schenkel, M., H. Krikke, M. C. Caniëls, and E. van der Laan. 2015. "Creating Integral Value for Stakeholders in Closed Loop Supply Chains." *Journal of Purchasing and Supply Management* 21 (3): 155–166.
- Sengupta, A. S., M. S. Balaji, and B. C. Krishnan. 2015. "How Customers Cope with Service Failure? A Study of Brand Reputation and Customer Satisfaction." *Journal of Business Research* 68 (3): 665–674.
- Shah, P. 2015. "Kill it or Keep it?: The Weak Brand Retain-or-Discard Decision in Brand Portfolio Management." *Journal of Brand Management* 22 (2): 154–172.
- Shah, P. 2017a. "Culling the Brand Portfolio: Brand Deletion Outcomes and Success Factors." *Management Research Review* 40 (4): 370–377.
- Shah, P. 2017b. "Why do Firms Delete Brands?: Insights From a Qualitative Study." *Journal of Marketing Management* 33 (5-6): 446–463.
- Shah, P., D. A. Laverie, and D. F. Davis. 2016-17. "Brand Deletion." *Journal of Brand Strategy* 5 (4): 434–452.
- Shen, B., Y. Cao, and X. Xu. 2020. "Product Line Design and Quality Differentiation for Green and non-Green Products in a Supply Chain." *International Journal of Production Research* 58 (1): 148–164.
- Simon, F. L. 1992. "Marketing Green Products in the Triad." *Columbia Journal of World Business* 27 (3-4): 268–285.
- Song, Z., and A. Kusiak. 2009. "Optimising Product Configurations with a Data-Mining Approach." *International Journal of Production Research* 47 (7): 1733–1751.
- Souza, G. C. 2013. "Closed-Loop Supply Chains: A Critical Review, and Future Research." *Decision Sciences* 44 (1): 7–38.
- Stalk Jr, G. 1988. "Time – The Next Source of Competitive Advantage." *Harvard Business Review* 41: 42–52.
- Stark, J. 2015. "Product Lifecycle Management." In *Product Lifecycle Management. Decision Engineering*. Vol. 1, 1–29. Cham: Springer.
- Taylor, D. C. 2000. "Policy Incentives to Minimize Generation of Municipal Solid Waste." *Waste Management and Research* 18 (5): 406–419.
- Thonemann, U. W., and M. L. Brandeau. 2000. "Optimal Commonality in Component Design." *Operations Research* 48 (1): 1–19.
- Thun, J. H., and A. Müller. 2010. "An Empirical Analysis of Green Supply Chain Management in the German Automotive Industry." *Business Strategy and the Environment* 19 (2): 119–132.
- Ton, Z., and A. Raman. 2010. "The Effect of Product Variety and Inventory Levels on Retail Store Sales: A Longitudinal Study." *Production and Operations Management* 19 (5): 546–560.
- Tsai, W. H., W. R. Lin, Y. W. Fan, P. L. Lee, S. J. Lin, and J. L. Hsu. 2012. "Applying a Mathematical Programming Approach for a Green Product mix Decision." *International Journal of Production Research* 50 (4): 1171–1184.
- Upton, D. M. 1994. "The Management of Manufacturing Flexibility." *California Management Review* 36 (2): 72–89.
- Vanichchinchai, A., and B. Igel. 2011. "The Impact of Total Quality Management on Supply Chain Management and Firm's Supply Performance." *International Journal of Production Research* 49 (11): 3405–3424.
- Violeta, S., and I. Gheorghe. 2009. "The Green Strategy Mix – A New Marketing Approach." *Knowledge Management and Innovation in Advancing Economics–Analysis and Solutions*, 1-3, 1344-1347.
- Vyas, N. M. 1993. "Industrial Product Elimination Decisions: Some Complex Issues." *European Journal of Marketing* 27 (4): 58–76.
- Wagner, M. 2015. "The Link of Environmental and Economic Performance: Drivers and Limitations of Sustainability Integration." *Journal of Business Research* 68 (6): 1306–1317.
- Wan, X., and N. R. Sanders. 2017. "The Negative Impact of Product Variety: Forecast Bias, Inventory Levels, and the Role of Vertical Integration." *International Journal of Production Economics* 186: 123–131.
- Wang, S., and M. Song. 2017. "Influences of Reverse Outsourcing on Green Technological Progress From the Perspective of a Global Supply Chain." *Science of The Total Environment* 595: 201–208.

- Weckles, R. 1971. "Product Line Deletion and Simplification: Tough But Necessary Decisions." *Business Horizons* 14 (5): 71–74.
- Yadav, M. S. 2010. "The Decline of Conceptual Articles and Implications for Knowledge Development." *Journal of Marketing* 74 (1): 1–19.
- Yao, J., H. Shi, and C. Liu. 2020. "Optimising the Configuration of Green Supply Chains Under Mass Personalisation." *International Journal of Production Research* 58: 1–19.
- Yen, Y. X., and S. Y. Yen. 2012. "Top-management's Role in Adopting Green Purchasing Standards in High-Tech Industrial Firms." *Journal of Business Research* 65 (7): 951–959.
- Young, W., K. Hwang, S. McDonald, and C. J. Oates. 2010. "Sustainable Consumption: Green Consumer Behaviour When Purchasing Products." *Sustainable Development* 18 (1): 20–31.
- Yu, W., and R. Ramanathan. 2015. "An Empirical Examination of Stakeholder Pressures, Green Operations Practices and Environmental Performance." *International Journal of Production Research* 53 (21): 6390–6407.
- Zhang, G., and Z. Zhao. 2012. "Green Packaging Management of Logistics Enterprises." *Physics Procedia* 24 (1): 900–905.
- Zhang, Q., Q. Zhao, and X. Zhao. 2019. "Manufacturer's Product Choice in the Presence of Environment-Conscious Consumers: Brown Product or Green Product." *International Journal of Production Research* 57 (23): 7423–7438.
- Zhu, Q., Y. Geng, and J. Sarkis. 2016. "Shifting Chinese Organizational Responses to Evolving Greening Pressures." *Eco-logical Economics* 121 (1): 65–74.
- Zhu, Q., S. Johnson, and J. Sarkis. 2018. "Lean Six Sigma and Environmental Sustainability: A Hospital Perspective." *Supply Chain Forum: An International Journal* 19 (1): 25–41.
- Zhu, Q., and M. Kouhizadeh. 2019. "Blockchain Technology, Supply Chain Information, and Strategic Product Deletion Management." *IEEE Engineering Management Review* 47 (1): 36–44.
- Zhu, Q., and J. Sarkis. 2007. "The Moderating Effects of Institutional Pressures on Emergent Green Supply Chain Practices and Performance." *International Journal of Production Research* 45 (18-19): 4333–4355.
- Zhu, Q., and J. Sarkis. 2016. "Green Marketing and Consumerism as Social Change in China: Analyzing the Literature." *International Journal of Production Economics* 181 (4): 289–302.
- Zhu, Q., and J. Sarkis. 2020. "Product Deletion and Sustainable Supply Chains." In *Global Perspectives on Green Business Administration and Sustainable Supply Chain Management*, edited by Syed Abdul Rehman Khan, 1–15. Hershey, PA: IGI Global.
- Zhu, Q., J. Sarkis, and K. H. Lai. 2013. "Institutional-based Antecedents and Performance Outcomes of Internal and External Green Supply Chain Management Practices." *Journal of Purchasing and Supply Management* 19 (2): 106–117.
- Zhu, Q., and P. Shah. 2018. "Product Deletion and its Impact on Supply Chain Environmental Sustainability." *Resources, Conservation and Recycling* 132 (January): 1–2.
- Zhu, Q., P. Shah, and J. Sarkis. 2018. "Addition by Subtraction: Integrating Product Deletion with Lean and Sustainable Supply Chain Management." *International Journal of Production Economics* 205: 201–214.