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Published in:
Business Strategy and the Environment

DOI:
10.1002/bse.2881

Received: 18 December 2019 | Revised: 21 July 2021 | Accepted: 3 August 2021

DOI: 10.1002/bse.2881

RESEARCH ARTICLE

Business Strategy and the Environment WILEY

Strategic ambidexterity in green product innovation: Obstacles and implications

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Funding information
Innovation-Oriented Research Program "Integral Product Creation and Realization (IOP IPCR)" of the Netherlands Ministry of Economic Affairs

Abstract

Scholars and managers routinely point to various uncertainties in explaining why manufacturing firms struggle with green product innovation and why green product innovation is different from conventional product innovation. This explanation is yet unsatisfactory as a thorough understanding of how a firm deals with uncertainty exists in conventional innovation literature. At the same time, there is a lack of agreement and understanding how a firm's capabilities shape its green product innovation practices, which could contribute to this gap. Based on a case study at five multinational manufacturers, this paper sets out to contribute to the capability perspective on green product innovation by understanding how manufacturing firms learn and innovate in order to make and sell greener products. A powerful and favored way for firms to learn and innovate under uncertainty is through strategic ambidexterity. With this learning strategy, firms rely on existing competences in one area (exploitation) while they simultaneously explore new competences in another area (exploration). However, our results show that strategic ambidexterity is oftentimes unachievable due to several factors, and as result, firms are forced to choose between a highly uncertain and risky alternative strategy and a more conservative but also less green strategy based on exploitation only, which is often the preferred option. In addition, our findings shed a new light on the role of uncertainty in green product innovation as we conclude that uncertainties firms face in green product innovation are indeed abundant, but are fundamentally not new nor caused by external sources only.

KEYWORDS
case study, green product innovation, strategic ambidexterity, uncertainty

1 | INTRODUCTION

Green product innovation (GPI) has become a critical activity for manufacturing firms due to global pressures toward less polluting and less resource-intensive production systems (Bansal & Hoffman, 2011; Figueres et al., 2017). Through GPI, firms develop new, or significantly improved, products that lead to environmental improvements compared to relevant alternatives (OECD, 2009). Despite this increasing attention and the fact that much is known about the antecedents, practices, and success factors of GPI (Adams et al., 2016;

Dangelico, 2016; Tsai et al., 2019), studies report that manufacturing firms are still struggling with making products significantly greener (Souto & Rodriguez, 2015).

One of the principal explanations for this struggle offered in literature is that manufacturing firms face many uncertainties in GPI. Several factors contributing to this uncertainty have been identified in previous studies, such as ambiguous market signals (Alblas et al., 2014; Foster & Green, 2000; Rehfeld et al., 2007), lacking customer demand for green products (Driessen et al., 2013; Rehfeld et al., 2007), or lack of other investment (Sander, 2016; Souto & Rodriguez, 2015). Also stakeholder pressure and regulations are found to be too unstable and unclear for firms (Dangelico et al., 2013; Dangelico & Pontrandolfo, 2015; Driessen & Hillebrand, 2013). It is argued that addressing these uncertainties—most of which are caused externally—is more complex and sophisticated than conventional product innovation, rendering GPI essentially unique (Cainelli et al., 2015; Mousavi et al., 2019; Wicki & Hansen, 2019). This adds to the anxiety and doubts in firms, which may inhibit actions necessary for innovation (Schmitt et al., 2018).

Conventional innovation literature, on the other hand, offers a different perspective on the impact of uncertainty on innovation. In classic innovation theory, uncertainty boosts innovation and is a necessary ingredient for renewal or improvement (Boisot & MacMillan, 2004; Schumpeter, 1934). Moreover, many uncertainties identified in previous studies of GPI can also be found in conventional, nongreen innovation contexts. For instance, with the introduction of radically new products or technologies, similar conditions of uncertainty exist (Alvarez et al., 2012; Alvarez & Barney, 2007). From dynamic capabilities and organizational learning theory, we know how firms learn and innovate in highly uncertain settings (Blindenbach-Driessen & van den Ende, 2014; Gupta et al., 2006). And even though learning under uncertainty can be challenging organizationally (Hansen et al., 2019; O'Reilly & Tushman, 2008), there are proven methods to mitigate the associated risks while still keeping an innovative edge (Hansen et al., 2019; Voss & Voss, 2013).

The insights from these established theories in conventional innovation literature give rise to the question as to why uncertainty is claimed to have such a hampering and arguably unique effect on the development of greener products. A possible explanation for the obscurity surrounding the notion of uncertainty in GPI is that still little is known about firm's capabilities that facilitate the adoption of GPI practices (Arranz et al., 2020; Demirel & Kesidou, 2019; Hofmann et al., 2012). In particular, insights into how firms learn to make and sell greener products are sparse (Hansen et al., 2019; Wicki & Hansen, 2019). As a result, it is yet unclear whether the uncertainties that firms face are truly unique and make GPI fundamentally different from conventional innovation. Owing to this gap in knowledge, this paper sets out to explore how manufacturers employ organizational learning strategies to shape GPI and how through such strategies firms address the many uncertainties associated with developing greener products.

Within the broader organizational learning theory, this paper focuses specifically on ambidextrous learning. We build on the two classic organizational learning mechanisms of exploitation and exploration (Levinthal & March, 1993; March, 1991) and various ambidextrous learning strategies that combine exploitation and exploration within or across different functional areas in product innovation (Danneels, 2002; O'Reilly & Tushman, 2008; Voss & Voss, 2013; Zhang et al., 2017). Subsequently, we present the results of a multicase study in which we studied the learning strategies in GPI at five established multinational firms, each with a long record of innovation in the manufacturing industry.

This paper has several important implications for managers and policy makers and intends to contribute to the rapidly growing body of literature on GPI in several ways. Firstly, it contributes to the capability perspective on GPI (Arranz et al., 2020; Demirel & Kesidou, 2019; Hofmann et al., 2012) by offering insights into how manufacturing firms learn to innovate in order to make and sell greener products. More specifically, this study provides new explanations for the observed struggle of firms with GPI. Our results show that a powerful and favored ambidextrous learning strategy, referred to as strategic ambidexterity, can be hard to reach for manufacturing firms due to several factors. As a result, firms feel compelled to choose between a highly risky learning strategy as alternative and a more conservative but also less green strategy based on exploitation alone, which is the alternative firms often end up choosing. Secondly, our findings shed a new light on the role of uncertainty in GPI. Our results challenge the dominant view that uncertainty is primarily caused externally and that it is fundamentally different from uncertainty in conventional innovation (Cainelli et al., 2015; Mousavi et al., 2019; Wicki & Hansen, 2019). Instead, we posit that firms are actively contributing to uncertainty as well—albeit often inadvertently. While manufacturing firms may indeed experience an abundance of complicated uncertainties in GPI, especially in the market area, our results suggest that firms can address these uncertainties in ways that are well understood in existing innovation and ambidexterity literature.

2 | THEORETICAL BACKGROUND

2.1 | GPI

In a systematic review of literature on innovation published over a 27-year period, Crossan and Apaydin (2010, p. 1155) define innovation as the "production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems. This definition stresses that innovation is both a process and an outcome." In defining GPI, we therefore further specify its processes and outcomes. With regard to the processes, we acknowledge that firms do not only draw on their existing technological, marketing, and/or organizational resources to develop new products (Hart, 1995; Verona, 1999) but, if necessary, also expand or renew these resources through learning and experimentation (Hansen et al., 2019; Schmitt et al., 2018; Wicki & Hansen, 2019). Although the focus of this paper is on the innovation of products, we do take into account that other types of innovation processes may be involved too, such as developing new production methods, seeking new business models for green products, and adjusting organizational structures and routines.

With regard to the outcomes of GPI, this paper focuses on eco-innovation of products. Eco-innovation can be regarded as a subset of sustainability-oriented innovation, which involves the creation of ecological, social, and economic value through innovation (Adams et al., 2016). Eco-innovation is defined as defined as "the implementation of new, or significantly improved, products (goods and services), processes, marketing methods, organizational structures and institutional arrangements which, with or without intent, lead to environmental improvements compared to relevant alternatives." (OECD, 2009, p. 40). Environmental improvements can range from an incremental improvement within an existing product to a radically new product which does no harm to the environment in any way (Carrillo-Hermosilla et al., 2010; Driessen et al., 2013). Finally, we acknowledge that alongside creating environmental value, firms aim to create economic value through GPI as well, a combination also known as shared value (Porter & Kramer, 2006, 2011).

There is vast body of literature that focuses on identifying antecedents and management practices that help firms create both environmental and economic value through GPI (Adams et al., 2016; Arranz et al., 2020; Dangelico, 2016). Most of the antecedents and management practices identified are closely related to those needed for successful product innovation in general, such as top management commitment, market pull, and cross-functional coordination (Dangelico, 2016; Demirel & Kesidou, 2019), while others are specific to developing green products, such as eco-design (e.g., Katsikeas et al., 2016), and nonmarket stakeholder involvement and integration (e.g., Dangelico et al., 2013; Dangelico & Pontrandolfo, 2015). Although empirical evidence regarding the effect of environmental practices on economic performance is mixed across individual studies, a recent meta-analysis by Tsai et al. (2019) shows that environmental practices, including GPI, indeed have the predicted positive effect on economic performance (Hart, 1995; Porter & van der Linde, 1995).

Despite these insights, several studies report that firms are still struggling with GPI (Souto & Rodriguez, 2015). Market demand for green products are perceived to be ambiguous (Alblas et al., 2014; Rehfeld et al., 2007) or even unfavorable (Driessen et al., 2013; Rehfeld et al., 2007), resulting in a lack of economic certainty for investing in risky green innovation projects (Sander, 2016; Souto & Rodriguez, 2015). Driessen et al. (2013), for example, show that firms with several key environmental practices in place had problems to develop economically viable products with significant environmental improvements due to lacking market demand, whereas firms that developed products with limited environmental improvements had more economic success. Moreover, pressures to address the environmental impact of products from a wide variety of stakeholders, including governments, are often in conflict with each other, which results in even more uncertainty for firms (Dangelico et al., 2013; Dangelico & Pontrandolfo, 2015; Driessen & Hillebrand, 2013). Indeed, there is even uncertainty about what "greener" actually means in practice (Foster & Green, 2000).

It is argued that these factors add to uncertainty involved with GPI, which inhibits the actions necessary for innovation, and that this uncertainty is inherently more complex and sophisticated than the uncertainties encountered in conventional product innovation (Cainelli et al., 2015; Mousavi et al., 2019; Wicki & Hansen, 2019). Most factors contributing to uncertainty in GPI as reported in literature are attributed to external sources, such as issues related to customer demand, eco-regulations, and stakeholder pressure. Yet, there is evidence to suggest that the uncertainty increases with the level of ambition in terms of environmental improvements (Driessen et al., 2013). As uncertainty is a subjective and perceptual phenomenon in terms of firm's perceived inability to predict changes in the environment (Schmitt et al., 2018), it can thus be expected that firms also contribute to uncertainty in GPI themselves, when their innovation competences proof ineffective to address current market circumstances. This is normal when market conditions change, and firms can adapt to these changes by relying on a specific set of competences known as dynamic capabilities (Crossan & Apaydin, 2010; O'Reilly & Tushman, 2008). A dynamic capabilities perspective, which seems crucial in understanding why firms struggle with GPI, is largely missing in the debate about GPI so far.

Dynamic capabilities are organizational routines geared toward creating, extending, and modifying the ways in which firms innovate and operate under conditions of change and uncertainty (Helfat et al., 2007; Teece et al., 1997). Only recently scholars have begun to study these capabilities in relation to how firms shape their GPI practices in order to make and sell green products (Arranz et al., 2020). For instance, studies have confirmed that the three core dynamic capabilities (i.e., sensing, seizing, and transforming) have a significant influence on a firm's sustainability-oriented innovation processes (Inigo et al., 2017; Mousavi et al., 2018, 2019). Dynamic capabilities that are specifically relevant in sustainability-oriented innovation have been identified too, such as sensing capabilities for recognizing green innovation opportunities (Demirel & Kesidou, 2019; Mousavi et al., 2018), path-dependent learning and logics (Arranz et al., 2020; Inigo & Albareda, 2019; Wu et al., 2016), and creating and maintaining external linkages with key stakeholders (Hofmann et al., 2012; Mousavi et al., 2018).

Insights related to the question as to why uncertainty seems to have such a hampering and unique effect in the context of GPI are notably lacking in the literature. For this, we deem it necessary to append the dynamic capabilities perspective on GPI by introducing ambidextrous learning theory. In particular, it seems relevant to account for the distinction between exploitative and explorative learning and their interactions (Crossan & Apaydin, 2010; O'Reilly & Tushman, 2008).

2.2 | Exploitation, exploration, and ambidexterity

Exploitation and exploration are two fundamentally different mechanisms related to how organizations learn and adapt. With exploitation, firms focus on refining and extending existing processes and technologies (Lavie et al., 2010). It is aimed at integration, efficiency, and short-term profitability (Gupta et al., 2006; Levinthal & March, 1993). Exploitation in product innovation means that firms try to make new linkages within their *existing* competences, technologies, and products to learn how to make their products better, cheaper, or, of interest our study, greener. Conversely, with exploration, firms engage in discovery, experimentation, and variation to create *new* competences usually geared to adapting to external changes (Lavie et al., 2010; March, 1991), for instance, innovation competences to develop new green products and/or to create a new market for those products. A new product can be used as a "tool" to discover and experiment with new competences (Danneels, 2002, p. 1105).

Organizational learning theory and in particular the distinction between exploitation and exploration have only been used sparsely in studies on the development of green products, services, and production processes. Jakhar et al. (2020) found that firms with a strong tradition in exploitative innovation tend to respond to stakeholder pressures with sustainability practices that are more short-term oriented, whereas firms with a long-standing tradition with explorative innovation implement more long-term sustainability practices. To our knowledge, Wicki and Hansen (2019) were the first to use the exploitation–exploration distinction in a case study of GPI in a technology-oriented firm. They find that GPI is "a very different process from the incremental innovation typically observed in established firms with focus on performance" (Wicki & Hansen, 2019, p. 980). Instead of short-term exploitation, Wicki and Hansen (2019) conclude that developing green products and technologies involves long-term exploration with a high likelihood of failures.

Engaging in long-term explorative learning is considered an extremely challenging, "high-risk" learning strategy (Ansoff, 1957; Danneels, 2002). Therefore, ideally, firms not only explore but also exploit or alternate between exploration and exploitation in order to perform well in the present while being resilient for the future—a concept known as ambidextrous learning (Andriopoulos & Lewis, 2009; Tushman & O'Reilly, 1996; Zimmermann et al., 2018). Whether and how ambidextrous learning can facilitate the development of green products in manufacturing firms appears a promising new perspective to this field.

2.3 | Strategic ambidexterity

In the context of GPI, *strategic ambidexterity* appears a fruitful starting point for our study. Strategic ambidexterity enables firms to facilitate cross-fertilization between exploitation and exploration *within* and *across* organizational functions, that is, within-function ambidexterity and cross-functional ambidexterity (Hansen et al., 2019; Voss & Voss, 2013). Strategic ambidexterity is based on the principle of leveraging (Danneels, 2002; Zhang et al., 2017). A firm can leverage the relative certainty, existing knowledge, and competences that come with exploitation in one area of product innovation with the uncertainties and lack of experience that come with exploration in one area of product innovation (Voss & Voss, 2013; Zhang et al., 2017). The two primary functional areas discerned in product innovation are the technology and market areas (Verona, 1999). With respect to cross-functional ambidexterity, for example, assessing the market potential for a radical new product is relatively less difficult when a firm can leverage and exploit its existing market competences. Similarly, assessing the technological feasibility of a product is relatively less difficult when a firm can leverage and exploit its existing technology competences when exploring radically new market competences. The same principles hold for within-function ambidexterity where a part of the existing technological (or market) competences can be exploited while another part of the technological (or market) competences can be renewed through exploration. For instance, a firm can explore new competences and technologies for an entirely new set of functions or a new type of material that will be implemented in an existing product platform while selling it in an existing market. Alternatively, a firm may explore competences related to a new business model to sell an existing product as a service to an existing group of customers.

Strategic ambidexterity thus offers firms a relatively less uncertain way to grow and renew itself (Levinthal & March, 1993; Voss & Voss, 2013), and it is oftentimes the preferred strategy for firms to engage in more radical types of innovation while reducing the risks of a "pure" exploration strategy (Danneels, 2002; Zhang et al., 2017).

2.4 | Ambidextrous learning strategies framework

Several learning strategies can be discerned based on the distinction between exploitation and exploration and the distinction between the technology and market areas (Ansoff, 1957; Danneels, 2002; Voss & Voss, 2013; Zhang et al., 2017). We present an overview of those strategies in Figure 1. We start with the two "pure" strategies: (1) *pure exploitation*, where a firm engages in exploitative learning in both functional areas, that is, technology and market, and (2) *pure exploration*, where a firm engages in explorative learning in both functional areas. Subsequently, we recognize two cross-functional ambidextrous learning strategies: (3) *technology development*, where a firm engages in explorative learning in the technology area, but relies on exploitative learning in the market area, and (4) *market development*, where a firm engages in explorative learning in the market area, but relies on exploitative learning in the technology area. There are two within-function strategies: (5) With *technology ambidexterity*, a firm simultaneously explores new technological competences and exploits some of its existing ones, and (6) with *market ambidexterity*, a firm simultaneously explores new market competences and exploits existing ones. Finally (7a trough 7f), there is a set of hybrid strategies with different combinations of pure exploitation and exploration (1 and 2), technology and market development (3 and 4), and technology and market ambidexterity (5 and 6).

Strategic ambidexterity offers a powerful way to pursue explorative learning and more radical innovation while leveraging existing competences through exploitative learning, but it also poses various

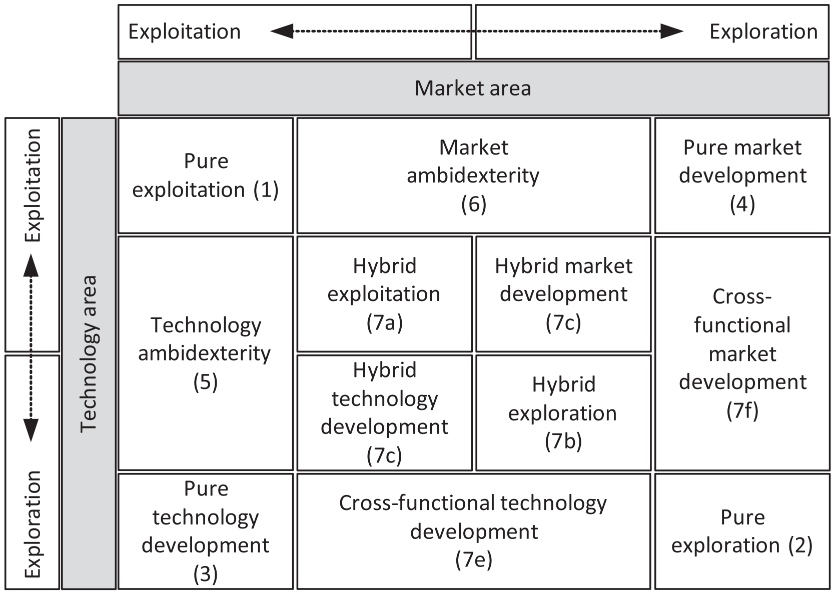


FIGURE 1 Strategic ambidexterity framework adapted from Voss and Voss (2013), Danneels (2002), Zhang et al. (2017), and Ansoff (1957)

challenges for firms. Exploitation and exploration do not only differ based on their goals, outcomes, and time horizons but also entail fundamental contradictions related to management, structure, and monitoring, and for this reason, they are often structurally separated in differentiated business units (Blindenbach-Driessen & van den Ende, 2014; Zimmermann et al., 2018), which comes with other challenges and uncertainties, such as integration issues (Hansen et al., 2019) and the need for abundant resources (Voss & Voss, 2013). In addition, taking advantage of cross-fertilization and leveraging in ambidextrous learning means that firms face the risk of cross-contamination, also dubbed as the "capability–rigidity paradox" (Leonard-Barton, 1992; O'Connor, 2008). Cross-contamination occurs in strategic ambidexterity when the exploitative learning component, which relies on a firm's existing competences, determines a lower degree of innovativeness or a lower level of ambition pursued during the overall innovation process (Gassmann et al., 2012; Hansen et al., 2019).

Based on what we know from previous studies of GPI regarding the negative impact of uncertainty on a firm's efforts on greening their products, it is critical to understand whether and how these strategic ambidextrous learning strategies are employed in the context of GPI. With such strategies, firms can focus on exploration in a certain area (i.e., technology or market) while exploiting another area, hereby creating a way to realize more radical innovation without having to adopt the risky pure exploration strategy. As manufacturing firms are mostly technology oriented, we expect they will feel most comfortable with exploration in the technology area and less comfortable with exploration in the market area. This suggests that manufacturing firms will prefer to stay to the left half of Figure 1 when engaging in GPI.

3 | METHODS AND DATA

In order to understand how manufacturers employ ambidextrous learning strategies in GPI, we used a qualitative research approach, including multiple cases and several sources of rich empirical data. Where theory is nascent and the understanding of a phenomenon ambiguous, a qualitative approach is most suitable (Yin, 1989). A qualitative approach enables an open inquiry into the phenomenon (Strauss & Corbin, 1990) building on multiple complementary data sources (Eisenhardt & Graebner, 2007; Yin, 1989) but also on existing theory (Miles & Huberman, 1994; Yin, 1989), which in our study is the strategic ambidexterity research framework as presented in Figure 1. We opted for a multiple case study as it allowed us to compare cases through a literal replication logic, which is considered to lead to more robust results than in comparison to a single case study (Yin, 1989).

This study was part of a large 3-year research program on sustainable product development within the manufacturing industry. Among its participants were five multinational manufacturing firms, all located in the Netherlands. All efforts and results of these firms in terms of GPI—including the projects, practices, policies, successes, and failures related to making and selling green products—served as the unit of analysis in our study.

The selected cases all have a proven track record with developing innovate products (i.e., the cases have been an industry leader for several decades, and each of them has introduced one or more market-changing product innovations in the past) and aspire to be industry leaders in sustainability. We use these two properties to justify our sampling logic based on literal replication; that is, we expect to find similar results across the cases (Eisenhardt & Graebner, 2007; Yin, 1989). We acknowledge that the firms vary in terms of their business size, type of industry, type of customers (i.e., B2C or B2B), and type of products (see Table 1), yet, prior to our study, there were no reasons to expect differences in the efforts and results in terms of GPI.

3.1 | Data collection

Empirical data were collected between June 2012 and November 2015. Three rounds of semi-structured interviews (28 in total) formed

TABLE 1 Case company details

	Cases				
	Domestic Appliances	Document Systems	Switchgear	Centrifugal Pumps	Thermal Systems
Industry	Domestic appliances	Document handling and management systems	Electrical components and systems	Flow technology	Thermo-technology applications
Example products	Coffee machines, MP3 players, vacuum cleaners	Postage meters and mailroom equipment	Low- and medium-voltage switchgear	Centrifugal pumps	Condensing boilers
Primary type business	B2C	B2B	B2B	B2B	B2B
Market/typical customers	Consumer households	Large mailing companies, governmental organizations	Power suppliers, large industrial firms	Large industrial firms, shipbuilding, marine, and automotive	Households, building corporations, housing corporations
Production process	Make to stock	Assemble to order	Make to stock	Assemble to order	Make to stock
R&D/NPD workforce of selected case	600 FTE	70 FTE	60 FTE	10 FTE	120 FTE
Company size	2000 FTE (local, selected as case—17,000 FTE global)	250 FTE (local, selected as case—6000 FTE global)	900 FTE (local, selected as case—102,000 FTE global)	95 FTE (local, selected as case—15,000 FTE global)	600 FTE (local, selected as case—350,000 FTE global)
ISO 140001 certified	Yes	Yes	Yes	Yes	Yes

the main source of data (see Table 2). All the interviews were conducted by two or three researchers and lasted between 1 and 2 hours. The first round consisted of five interviews, one with each firm's product innovation manager, and were conducted in July 2012. The second round of interviews took place with the same interviewees, in January and February 2013, to follow up on the insights gained from the first round. The third round consisted of 18 interviews, which were conducted between July 2013 and January 2014. In this round, not only the firms' product innovation managers were interviewed, but also managers from other organizational functions such as operations, supply chain management, purchasing, sales, and marketing. The first and third rounds were audio-recorded and transcribed verbatim, and detailed notes were kept during the second round of interviews, resulting in 502 pages of interview data.

We used an interview protocol that evolved over the interview rounds. All interviews started with a series of questions about the interviewee's background, current function, and perceptions of sustainability. In the first round of interviews, we then focused on gaining an overview of the firms' strategic sustainability intentions and their practices to improve sustainability, followed by more in-depth questions about the firm's GPI policies and competences as well as the environmental and economic performance of the firm's green products. The second round of interviews was aimed at corroborating our insights from the first round of interviews. In the third round of interviews, we discussed those insights with interviewees from different organizational functions. We also assessed the relevance of the various dimensions of green products (i.e., energy, materials, and pollution), why these dimensions were relevant (and, if not, why not), how each firm dealt with these dimensions, and whether their actions were successful.

We triangulated our interview data with several other sources of empirical data. First, we organized six workshops during which preliminary findings were presented and corroborated (see Table 3). All five firms participated in each of those workshops, and each firm (except Thermal Systems) hosted a site visit during one of the workshops. Second, as part of the overall research program, we supervised at least one MSc thesis student in four of the five companies (it was not possible to initiate such a project at Domestic Appliances) in the period between April 2013 and September 2014 (see Table 2). These were 9-month graduation projects for the MSc Industrial Engineering and Management at the University of Groningen of which the students spend 6 months on average embedded in the firm. The aim of these projects was to do a diagnosis on sustainability-related issues in each firm and to design a proposal for a solution or improvement for the firm. For the purposes of this study, we used the MSc thesis students that were embedded in those projects as informants. They were oftentimes in a position to clarify the situation regarding questions that remained unanswered after the interviews and to enhance the primarily retrospective interview data with a forward-looking perspective to guard against post hoc rationalization. On average, we spent approximately 20 hours with each embedded informant. Finally, we studied several secondary data sources such as annual reports,

TABLE 2 Interviews and informants

Case	Person	1st round July 2012	2nd round Jan to Feb 2013	3nd round Jul to Jan 2014	Research project 2013–2014
Domestic Appliances	NPD manager	1			
	NPD team member		1[a]		
	Sustainability officer			1	
Document Systems	NPD manager	1	1[a]	1	
	Project manager remanufacturing			1	
	R&D manager			1	
	Domain manager			1	
	Embedded MSc thesis student				1
Switchgear	NPD manager	1	1[a]	1[a]	
	NPD team member				
	R&D manager			1	
	Supply chain manager			1	
	Marketing manager			1	
	Embedded MSc student				1
Centrifugal Pumps	NPD manager	1	1[a]	2	
	Procurement/supply chain manager			1	
	Marketing manager			1	
	Sales manager			1	
	Embedded MSc thesis student				2
Thermal Systems	NPD manager	1	1[a]	1	
	Sales manager			1	
	Marketing manager			1	
	Supply chain manager			1	
	Embedded MSc thesis student				1
	Total	5	5	18	5

[a]These interviews were not recorded but detailed notes were taken.

TABLE 3 Workshops with participating cases

Workshop #	Date	Meeting organizer
1	April 2012	External party
2	November 2012	Domestic Appliances
3	March 2013	University
4	January 2014	Switchgear
5	October 2014	Centrifugal Pumps
6	November 2015	Document Systems

corporate social responsibility documents, and innovation process descriptions.

3.2 | Data analysis

Our study is based on a combination of inductive and deductive reasoning with an iterative data analysis process that oscillated between empirical data and related theory (Gioia et al., 2012). In the first stage of the analysis, the transcripts and notes from all the interviews were coded by the first author, following an open coding approach (Flick, 2006; Gioia et al., 2012) using Atlas.ti software. Important properties, events, routines, and examples of outcomes of each firm's GPI efforts, as well as the various opinions about going green, were coded into first-order categories while adhering to interviewee terms as much as possible (Gioia et al., 2012). The resulting coding scheme consisted of 481 distinct codes that were linked to 1932 statements by the various interviewees.

In the second stage of analysis, the first author refined and differentiated the first-order categories into second-order themes using axial coding (Miles & Huberman, 1994; Strauss & Corbin, 1990). During this stage, a more theory-driven approach was adopted, identifying relevant theoretical concepts from existing streams of literature (e.g., exploitation, exploration and strategic ambidexterity) and crafting new theoretical concepts and categories. The second author ensured the reliability of the second-order themes through coding a sample of 203 quotes from the interviews

(Miles & Huberman, 1994). The inter-rater reliability was 87.2%, and the few remaining disagreements over the coding scheme were resolved, and resulting data structures updated accordingly. Subsequently, the authors iteratively established a set of overarching dimensions (Gioia et al., 2012). The resulting data structures are presented in Figures 2 and 3, and an overview of illustrative interviewee quotes associated with the higher order concepts is presented in the Supporting Information.

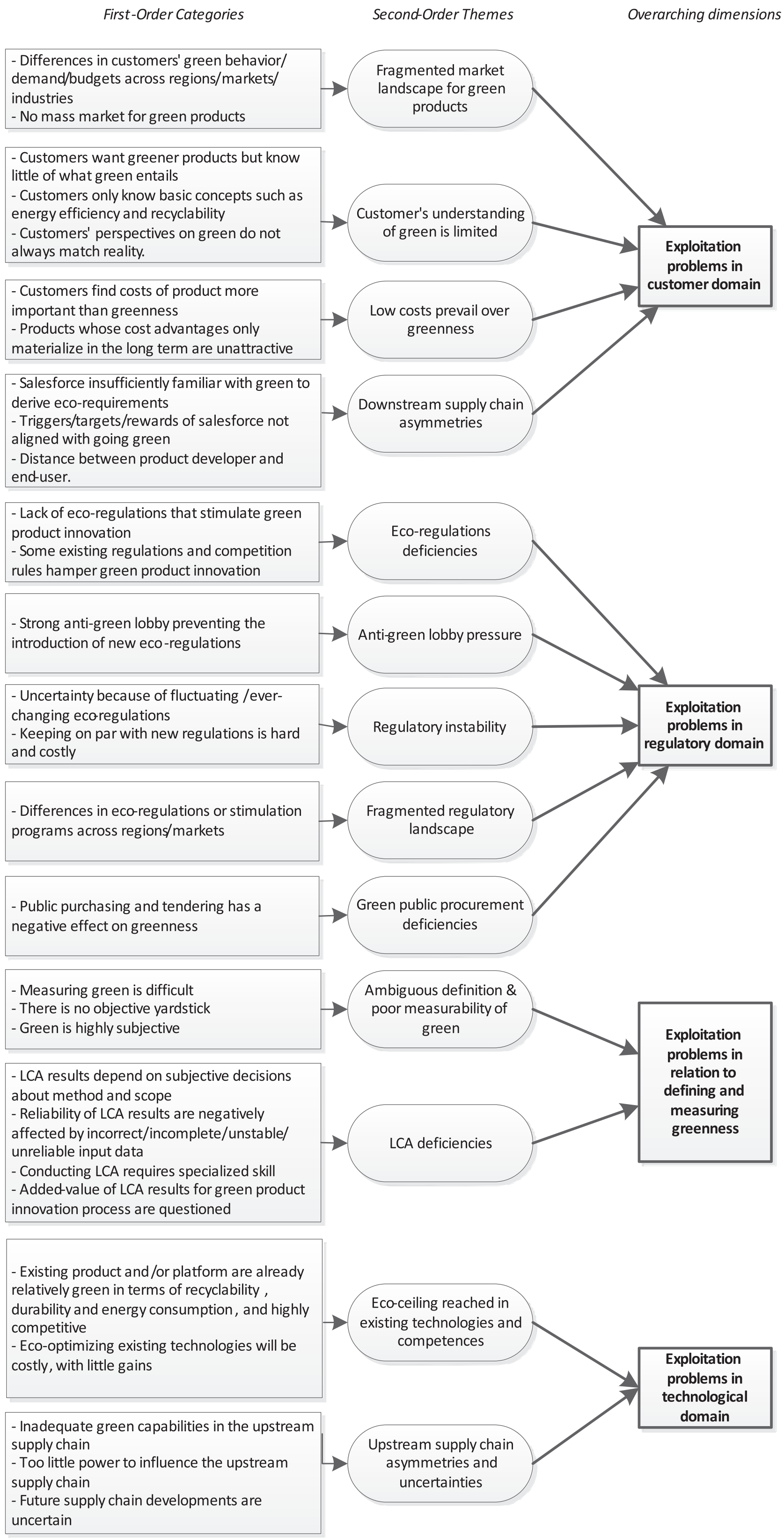
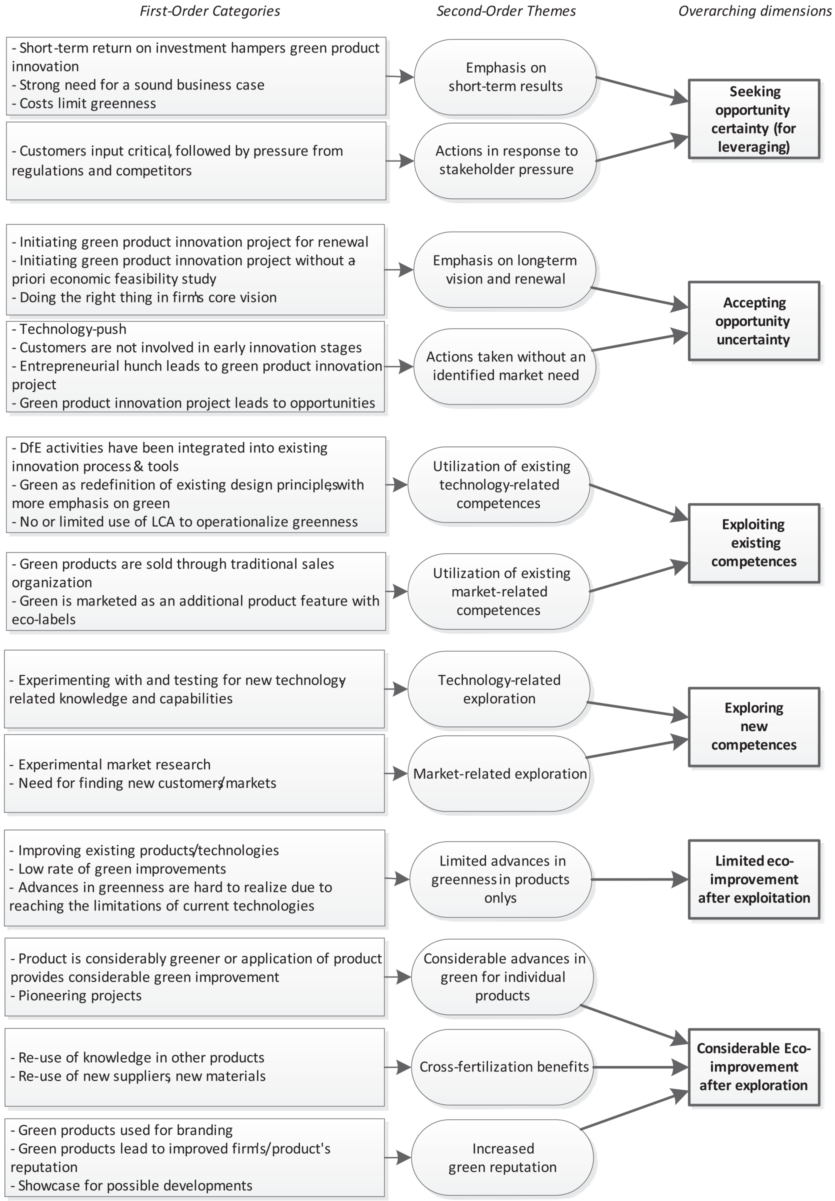


FIGURE 2 Data structure: exploitation problems

FIGURE 3 Data structure: opportunity stances, learning modes and outcomes



4 | FINDINGS

The results section is structured as follows. Firstly, we show how our cases aim to employ strategic ambidexterity to develop greener products. Secondly, we explain why our cases cannot employ this learning strategy in GPI. Thirdly, we explain how our cases react on these problems and circumstances.

4.1 | The requirement for ambidextrous learning

All five cases have the ambition to start GPI initiatives that will yield greener products driven by corporate strategies in which sustainability has explicitly become an important goal. Also, all cases have a strong track record in innovation for conventional product development, and they believe they can utilize their existing technology-oriented innovation competences in GPI. Furthermore, it became clear that, in principle, the green ambitions of our cases exceed only small and incremental eco-improvements in products. For instance,

> Our ambition is, well, to put one of the most environmentally friendly products in the market within our segment. (Document Systems NPD Manager)

But our cases' ambitions, strategy, and potential to innovate alone have shown to be insufficient to trigger radical and far-reaching new GPI initiatives. The default condition for starting almost every new GPI initiative remains that there is demand and that a business case can be formulated up front.

> There must be a demand from the market that results in added value from our activities. Otherwise, it is

> simply a waste of our time. (Switchgear NPD team member)

In discussing business case opportunities for new GPI initiatives, the product development and R&D departments closely collaborate with their marketing and sales departments. The learning mode in the market area of product innovation is exploitative of nature. The firms' existing competences are used to sense signals from the existing customer base to review the business opportunities for new green products and to react to new eco-regulation and legislature. In addition, the existing business models of selling products and distributing them are used as starting point in these discussions. There were no signs of explorative actions in stage, such as business model innovation or opportunity and market creation in our data. Interviewees explicitly pointed out that pushing new (green) technology to customers is out of the question. Rather, they closely listen what either legislators or customers require (i.e., market pull).

> No, sorry, we could believe at Thermal Systems that we have the technology in-house and in fact say that the product is driven from the inside-out, that technologies will at some point surely be launched, but the world is more unmanageable. I represent the market, my role within the company is to continuously hold up a mirror to the organization and say: "just carefully listen to customers" (Thermal Systems Marketing Manager)

These observations confirm our expectation that to initiate a new GPI initiative, manufacturing firms initially look for opportunities in the market area by means of exploiting their existing competences. Furthermore, in this decision-making process, firms have to be convinced that their current market competences can be largely exploited in later stages of the development process, which like conventional product development is expected to take several years, oftentimes even more than 5 years. The relative certainty of a business opportunity while using the firm's existing market competences now and in the future should provide the required leverage for firms to engage in explorative learning in the technology area ambidextrously. Furthermore, they expect to exploit the benefits resulting from cross-fertilization by relying on existing competences partially. Firms thus aim to realize strategic ambidexterity either through the technology ambidexterity learning strategy or through the pure technology development strategy (see Figure 4). However, as we will discuss next, our cases generally fail to meet the requirement of seeing a clear market opportunity.

4.2 | Obstacles to strategic ambidexterity

We identify several domains in which the five manufacturing firms under study are unable to exploit their existing competences, especially in the required market area (also see Figure 2). The most problematic domains within the market area are the customer domain, the regulatory domain, and the measurement domain. Leveraging these competences for more explorative learning in the technology area becomes problematic and, as a result, hinders employing a strategic ambidexterity learning strategy. Also in the technological domain, when firms look for options to partially leverage existing technological competences, similar problems arise.

4.3 | The problem of exploiting existing competences related to the customer domain

Our informants explain that general high-level trends and developments in their markets are moving toward green. But a frequently occurring theme in our interviews was that the market departments

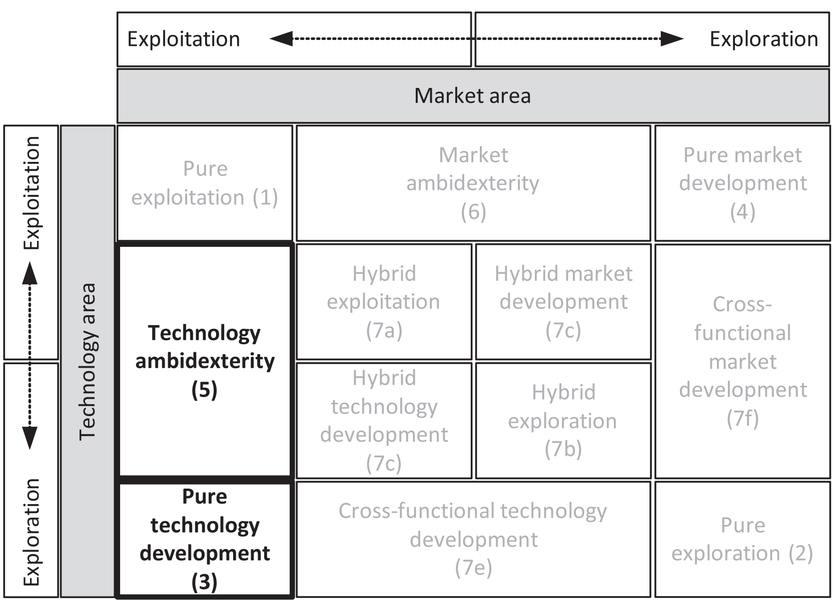


FIGURE 4 Preferred strategic ambidexterity strategies

generally could make little sense of the customers' concrete requirements. They perceived their demands to be conflicting, ambiguous, or even negative, when it comes to the greenness of a product.

Firstly, our cases were unable to deal with the fragmented market landscape for green products. When the marketing departments gauged the demand for green products, or capture eco-requirements from customers, they were confronted with demands, preferences, and budgets for green products that vary widely across customer groups, market segments, and market regions depending on the local state of technology, eco-regulations, industry standards, and customer habits. The lack of a clear set of requirements makes it very difficult to develop a green product that is useful and attractive for the mass markets that our case companies usually serve.

> [...] at least 25 relevant markets, each with their own, well, 25 just to give a round number for now, but 25 relevant markets, each with their own wish list and their own developments and their own specific characteristics. (Thermal Systems Marketing Manager)

Secondly, when it comes to expressing preferences for green products, our informants indicated that their customers generally have little knowledge about what green entails exactly. As a result, our cases have tried reluctantly to educate their customers to some extent, but to little avail. More complex notions of green such as recyclability, possibilities for remanufacturing, or cleaner production methods in the supply chain remain elusive. On occasions, things that are in fact very green were perceived by customers as harmful to the environment, such as the use of wood as a material in domestic apparel.

> So, we have presented several technological sustainability proof points to our customers, such as using wood. Wood is the most sustainable material that one could use, according to the mPt-value [i.e., "Eco-indicator 99" LCA method measured in millipoints]. Customers found wood totally unsustainable because they say, "you are not supposed to cut a tree for a [coffee machine], right?" (Domestic Appliances NPD Team Member)

Furthermore, our cases had difficulties formulating a proper value proposition and selling it to their customers. Green products are usually sold at a price premium because of the costs of development and higher materials and production costs. It is well known, also in literature, that when push comes to shove, most customers still deem the sales price of a product more important than its greenness and they are unwilling to pay the premium. But even if, over its lifespan, a green product also provides significant cost savings for customers, selling it to customers appeared problematic for our cases. The informants suggested that customers are often put off by the high initial investment for green products and deem the return on investment too uncertain given the long payback period. While our cases were unable to convince their customers of this value proposition, they also did not look for alternative solutions, such as offering financing, as they do not believe they have the resources or capabilities for this.

> The problem is there are no companies who can finance this in an attractive way. [...]. Electric grids are very abstract. Expensive to finance. In the past energy companies had their own bank. [...] Then you can pull it off. But [Switchgear Co.] is an operational excellence company and is not interested in financing. (Switchgear Co. Marketing Manager)

Finally, the informants revealed that information asymmetries in their highly specialized and compartmentalized supply chains hamper green innovation. Firms are highly dependent on the green capability of their downstream supply chain partners to identify opportunities and sell green products. Our interviewees perceived their partners' capabilities in that regard as underdeveloped, or at least insufficiently aligned with their own capability, but were also unable to turn this around via their supply chain management competences.

4.4 | The problem of exploiting existing competences related to the regulatory domain

The second domain in which firms experience problems when relying on their existing competences is in the regulatory domain. Although the cases were confronted with increasingly stringent eco-regulations, these regulations were still far from covering the full spectrum of green (i.e., all types and dimensions of environmental impacts caused by products), stable, and globally consistent eco-regulations. At the same time, firms and their suppliers faced substantial uncertainty over the constantly changing and unknown future status of eco-regulations and stimulation programs. Current routines of firms to remain compliant with eco-regulations, such as updating material and product declarations, are deemed costly and time consuming; but these activities need to be regularly repeated due to the volatile nature of current regulations.

Whereas some of these issues in the regulatory domain seem an external factor at the outset, firms can influence eco-regulations through lobby. Although all our cases are part of larger multinational enterprises, our interviewees admitted their organizations lacked the power and competences to engage in lobby effectively to implement more stringent eco-regulations that would make making and selling green products more attractive. On the other hand, major competitors are successful in lobbying *against* stringent environmental regulations (i.e., the anti-green lobby). Relatedly, our cases were unable to introduce more stringent green requirements in public sector tendering through lobbyist. Public sector tendering and purchasing are bound by legislation that aims to ensure and increase fair competition among companies given that winning a public procurement bid can be very lucrative. However, cutting-edge eco-requirements were seldom included in such bids as it would result in only a few companies being able to meet such requirements.

> […] in public procurement bids, we were asked to conduct an LCA study but, ultimately, [green] was never decisive [in winning a public procurement bid]. [The decision] was always based on the sales price, the delivery terms and conditions, delivery times, those kinds of things. [It] actually concerned business-as-usual things. (Switchgear NPD Manager)

4.5 | The problems of exploiting existing competences related to defining and measuring greenness

A third domain in which firms were unable to apply exploitative learning is related to the definition and measurement of the level of greenness. In principle, green is a scientifically verifiable technological concept, yet an objective yardstick to measure greenness that is commonly accepted by other market stakeholders was not available. In addition, accurately defining and measuring green proofed to be highly complex. As a result, firms use simple definitions and measurements, closely in line with customer's limited understanding of green products, which render the notion of green highly subjective.

> I view sustainability as similar to something like happiness: what does happiness mean to you and what does it mean to me? (Domestic Appliances NPD Team Member)

Our cases' existing claims about the greenness of its products were often received with skepticism by customers, and it is expected that this becomes even more problematic with more radically green products. Despite life-cycle assessments (LCAs) being advocated in the literature as a method for objectively assessing greenness, our data revealed that LCA outcomes are perceived as unreliable due to the subjectivity in determining an LCA's scope and the quality of the input data that are used. A Switchgear product developer noted that the results of an LCA had been successfully contested by customers and competitors, even as far as the courts. On top of the LCA's inherent deficiencies, conducting an LCA requires highly specialized skills and considerable resources. Given the limited added value of an LCA, and its high costs, our cases made limited use of this approach.

> As an engineer, I believe it [moving away from LCAs] is foolish. Because, in the end, you lack hard, quantifiable data that are made available by industry. […] Rather, you claim "this product contains ten percent recycled plastics." […] That is less scientific, but is in line with what the customer understands. (Domestic Appliances NPD Manager)

4.6 | The problems of exploiting existing competences in the technological domain

It is also possible for firms to be ambidextrous *within* the technology or market areas, for example, the technology ambidexterity and market ambidexterity strategies shown in Figure 1. Especially when it is problematic to engage in exploitation in the market area, as our cases clearly experience, leveraging these difficulties and uncertainties with partial exploitation in the technology area becomes an important requirement for firms to engage in exploration. But also with such strategy, firms experience problems up front.

Firstly, three of our five cases (Switchgear Co., Thermal Systems Co., and Centrifugal Pumps Co., which are all B2B firms) make products that can be characterized as relatively green already in terms of recyclability, durability, and energy consumption. These characteristics were introduced due to cost and efficiency motives in the past, or due to regulations more recently, but have been further improved due to of fierce competition on these characteristics in the market for decades. As a result, there is little left that can be improved in a cost-effective way based on current technology and current product platforms.

> The current product [i.e., high efficiency condensing boilers] that we have now, is not bad in principle. We have extracted everything out of gas, and the machines can now be offered against an absolutely low price. These machines last 15 years. With the other [i.e., new green heating technology] you have such a high initial investment that from a money point of view you cannot do it as an individual buyer. (Thermal Systems NPD Manager)

These technologies and product platforms have (almost) reached a temporary "eco-ceiling" when it comes to further environmental improvements. Adding a bit more greenness will require a huge effort in time and resources by the firm. Moreover, adding this marginal greenness still does not lead to a fully sustainable product. For that, new technology breakthroughs are deemed necessary.

Secondly, existing competences of our cases were insufficient to address technological issues in the supply chain. For instance, when, and at what rate, materials or standard components from suppliers become greener cannot be influenced easily. Similar challenges existed downstream in the supply chain. Our cases are potentially very capable in designing products with even higher recyclability, but this needs to be aligned with the recycler's processes and competences, which were still limited. Which recycling techniques will be used or be allowed by law in the future was also perceived to be very uncertain, especially when products might be usable for more than 20 years before recycling becomes an issue.

The number of problems we identified in the technology area is notably smaller than in the market area, which may give the impression that firms experience less problems with exploitation in the technology area than in the market area. However, our cases initially start with checking for opportunities in the market area, and only if sufficient leverage exists in this area, they move on to explore in the technology area. As we will make clear next, this rarely happens. As a result, firms may have a lot more experience with problems in the market area of GPI and less in the technology area.

4.7 | Addressing the obstacles to strategic ambidexterity in GPI: Two reactions

As expected, our cases first try to employ a technology ambidexterity learning strategy in order to make serious strides with GPI starting by finding opportunities for green products through existing market competences (see Figure 5). The rationale behind this is that by leveraging their existing competences related to the market area, firms are able to accept more risks and uncertainties with exploration in the technology area and they can reap the benefits from cross-fertilization. However, all five cases fail to provide the required leverage for technological exploration because exploitation of their existing market-related competences does not yield success in the current market conditions for green products. Similar difficulties exists when our cases seek to leverage existing products and competences in the technology area, especially when products are relatively green and cost-efficient already. Our cases therefore were unsuccessful in employing the desired strategic ambidexterity strategy (Figure 5, Arrow 0). We observe two responses to this status quo.

4.8 | The pure exploitative learning strategy: The "fallback line"

The first and dominant reaction across *all* cases is to lower green ambitions and retreat to a pure exploitation strategy (see Figure 5, Arrow 1). The pure exploitation strategy seems to be the "fallback line" for firms. With a pure exploitation strategy, firms usually modify their existing technological and marketing competences slightly to make and sell green products while putting the emphasis on short-term market results.

> We have initiated activities aimed at improving the operating efficiency of the pumps, first and foremost from the perspective of competitive advantage. Until recently, we have never considered these activities as sustainability efforts, but in essence they are. Basically, it is a redefinition of existing principles. (Centrifugal Pumps NPD Manager)

Most of our interviews revolved around issues related to realizing short-term cost savings or sales benefits through green products. Costs and profit margins were the dominant criteria when making green product portfolio decisions: Products were selected where the most progress could be made with regard to one or more green aspects with the least amount of "pain" for the company in terms of development costs or investments.

> While you hear people saying that green products have a higher profit margin, we see it as products with a

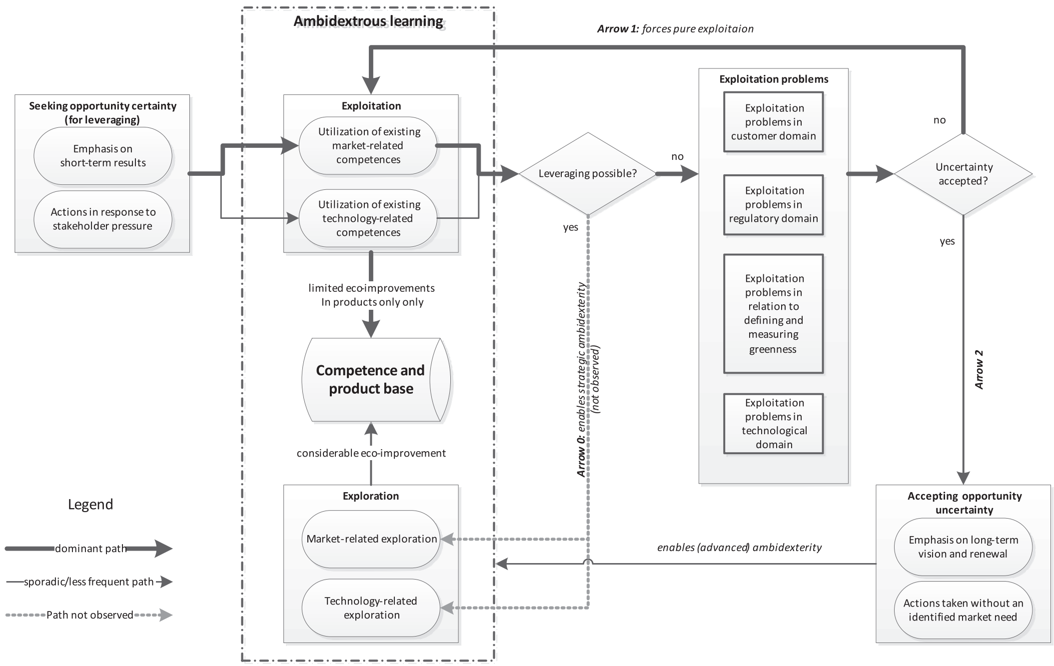


FIGURE 5 Dynamic model of adopting (ambidextrous) learning strategies in GPO

> higher profit margin are more often green. […] Because a product is more profitable, there is more room for investment. By letting a business unit decide the category in which they want to develop greener products, they can effectively choose products where it does not hurt and where there is room for improvement. (Domestic Appliances Sustainability Officer)

Our interviewees perceived very limited demands and pressures for green products from the market, which translated into a set of low eco-requirements to be incorporated in existing products. To implement these eco-requirements, our cases did not treat GPI any differently from developing nongreen products. Product developers could simply modify existing design logic and familiar design parameters such as quality, costs, and look-and-feel. In a similar fashion, our cases relied on their existing sales organization to sell green products: Green was simply marketed as an additional product feature, often communicated via "eco-labels."

> We get Jip and Janneke[1] guidelines. (Domestic Appliances NPD Manager)

In defining the greenness of a product or product group, the cases generally relied on a set of basic green themes, measuring green using simple, familiar methods based on already available data. This elementary notion of green was carefully aligned with what customers understand by green and was communicated in words and pictures that will be perceived as such, even if this perception was known to be too limited, or even wrong.

Economic success with the green products resulting from pure exploitation was mentioned by our interviewees, but only in relation to low-hanging fruit, such as cost savings due to using less materials. The examples of successful GPI amount to small environmental improvements to existing products.

> It really is a step-wise approach. Everything we do, we do in small steps. Our ambition is that, ultimately, green products make up 50% of our total sales, […] but that does not mean we have to lead the pack by a clear mile at this moment. (Domestic Appliances Sustainability Officer)

In general, interviewees were skeptical about the environmental effectiveness of the pure exploitation strategy.

> If I am being very honest. I have studied Industrial Design. While being there, I invested a great amount of time in in sustainable product development. And the way we are incorporating it here is still very marginal. (Document Systems Domain Manager)

The dominant reaction of firms clearly points to the occurrence of cross-contamination in ambidextrous learning, where by relying on existing competences results in a lower degree of innovativeness and greenness to be pursued (Gassmann et al., 2012; Hansen et al., 2019). Yet, despite the clear chasm between the ambition and intentions of our cases in regard to green products and the actual results, which were seen as marginal, the related activities and results were nevertheless promoted as genuine GPI efforts—in the interviews but also in public campaigns and the said eco-labels. Most of the competitors of our cases were not able to do more. On the contrary, according to our interviewees, their competitors were oftentimes lagging behind. Although more progress was hoped for, the general view was that this level of GPI is what the market deems necessary at this moment.

> And what you are able to with the existing products, yes, that can be done with those components I just outlined. Small pieces that can make the world a little bit better. (Document Systems Domain Manager)

4.9 | Advanced ambidextrous learning strategies: The exception that proofs the "rule"

If the leveraging principle in ambidextrous learning—either in the market area of innovation or partially in the technology area—cannot be employed, our cases mostly stick to the more conservative, less risky, and also less green pure exploitation strategy. Yet, our data include three examples where firms did not retreat to this fallback line and moved toward ambidextrous learning strategies that involved exploration both in the technology area and in the market area (Figure 5, Arrow 2).

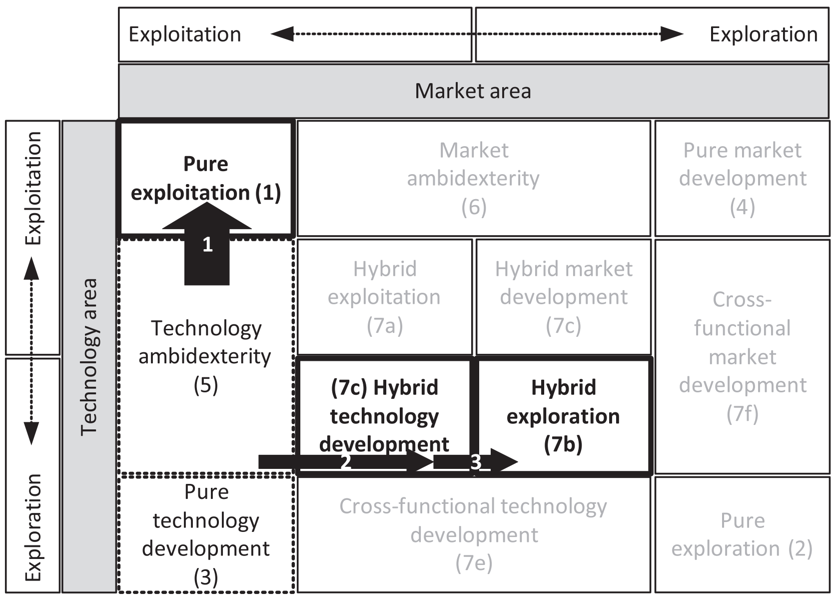
Each of these examples involves a GPI project observed in a different company where the development of a product or system included a breakthrough green improvement or a unique-to-the-industry green feature (see Table 4 for details). Although several existing competences are still used in the development of these radically new and greener products, many new competences have been developed or still need to be developed. The projects slightly differ from each other to the level of market exploration required and fall under the hybrid technology development (7c) and hybrid exploration (7b) strategies (see Figure 6, Arrows 2 and 3).

From the market perspective, in none of these three examples was there a clear regulatory pressure or a strong business case demanded by the firm at the outset of the innovation project. Indeed, economic feasibility studies, which are applied in the early stages of product innovation projects virtually by default, were deliberately postponed in sharp contrast to the firms' routines that usually lead to the pure exploitation strategy. Firms thus created conditions that prevented cross-contamination in the early stages of their ambidextrous learning processes. Further, the voice of the customer played a less important role in deriving requirements for the new product or system. Instead, the firms themselves determined the green requirements for the new products, which is in contrast to the market pull logic that our firms generally apply in GPI. The lack of existing and effective market competences, for instance, to market or sell the new

TABLE 4 Examples of ambidextrous GPI projects

Centrifugal Pumps "Green water pump"	In a joint venture with a system engineering company, Centrifugal Pumps designed and built a green pump system to meet the requirements of a water purification company. Instead of using freshwater sources, which is common in such systems, wastewater was used. Enabling the use of wastewater involved designing a highly sophisticated and robust pump system. Further, the pump systems also had to be highly energy efficient to comply with the customer's long-term eco-requirements and to reduce operational costs over a period of 25 years. The new pump system includes parts that required a new sandblasting production technique, for which Centrifugal Pumps sought collaboration with a new supplier. The project is considered a success in terms of greenness, reputation, and profit
Document Systems "Green packaging solution"	The head of R&D at Document Systems came up with the idea for an entirely new green product when he received parcels with gifts for his children. Besides the gifts, the parcels contained mostly air, which makes shipping highly inefficient and thus environmentally unfriendly. He immediately saw an opportunity for the development of a fit-to-size packaging machine that sizes, constructs, tapes, weighs, and labels each custom order. Six months later, the head of R&D had found a customer to launch this new system, which gave the company's top management reason to further invest in its development. Several systems have since been built for multiple customers, resulting in greener packaging and higher transportation efficiency. The machine reflects a significant strategic and organizational change for the company (from the envelope to the parcel business)
Domestic Appliances "Green coffee machine"	A flagship project by Domestic Appliances resulted in a green coffee machine consisting of 50% recycled plastics, which is considered unique for that market sector. Recycled plastics require a fundamentally different approach to the design, production, and quality management of food-processing domestic appliances because they have properties that are very different from "virgin" plastics (in terms of shaping, look-and-feel, and health and safety requirements). Another challenge was to make and advertise this green coffee machine in such a way that customers were not put off by the inclusion of previously used materials. In addition to developing new technological competences, Domestic Appliances had to manage its supply chain differently. It started collaborating with a recycling company that adopted the role of a first-tier component and materials supplier, which is a highly unusual relationship in most current fast moving consumer goods supply chains. The project is considered a major success in terms of greenness, reputation, and lessons learned

FIGURE 6 Reactions to the status quo



product, became an explicit part of the innovation task. As a result, business opportunities were created or identified by proactively engaging in exploration.

> The opportunities were not clear before [engaging with the customer] [...] If we would not have carried out the project, we probably would not have seen the opportunities and the chance would have been denied to us. (Centrifugal Pumps NPD Manager)

Various interviewees mentioned "testing," "test sites," or "exercises" to experimentally learn how to make unique green products, how to sell them, to whom, and how to organize their green innovation activities. For instance, the aims of Domestic Appliances' Green Coffee Machine project were not only to set a great green example within the firm and for the public but also particularly to take a leap in terms of technological green knowledge and competences for long-term firm renewal. Addressing the various uncertainties required firms to continue with explorative learning alongside the exploitation of the new knowledge and competences.

> We still do not get it fully because the materials [i.e., recycled plastics] work fine in one factory, but completely fail in another factory. […] We are still testing new materials to find out why it works sometimes and at other times not. Innovation continues to be necessary. (Domestic Appliances Sustainability Officer)

Across all our cases, we saw that existing routines and organizational structures were often geared toward short-term goals, making both the initiation and continuation of the explorative projects a challenge. However, the lessons learned after exploring new avenues for making and selling green products could be exploited (i.e., cross-fertilization).

> We can re-use the things we learnt for the [Green Coffee Machine] in making other products. [Such as] the suppliers we identified and the materials. Also, outside coffee [product categories]. We feel we need such projects, where we take the next step, a leap forward, to raise the bar for the rest. (Domestic Appliances Sustainability Officer)

The firms also set up new collaborations with suppliers and end users to mitigate upstream and downstream supply chain asymmetries. Domestic Appliances, for example, initiated a collaboration with a recycling company, which became a first-tier parts and materials supplier for the Green Coffee Machine.

Finally, we see that the green products developed when adopting pure exploration result in considerably more environmental value than created under the exploitative strategy. As such, these flagship projects function as a showcase of a firm's technological expertise and innovativeness, leading not only to an enhanced reputation but also to new orders and customers, sometimes irrespective of the green credentials.

> You can show yourself as a company doing a good job, not so much in terms of the sustainability of the materials used, but more in terms of overall performance. […] Look, we are a team of knowledgeable people with a thorough know-how of the pumps themselves […] and together with you we can work towards the best solution for you. (Centrifugal Pumps, Marketing Manager)

The three exceptions proof the "rule" established within our study; that is, it can be very difficult for manufacturing firms to make more significant strides with GPI because the preferred way of ambidextrous learning (i.e., based on strategic ambidexterity) is unavailable. The three exceptions highlight the unique conditions that need to be created and the risks that need to be accepted to enable more advanced ambidextrous learning in GPI.

5 | DISCUSSION AND CONCLUSIONS

While the academic literature reveals a growing understanding of GPI, still several gaps exist that are in need of further scrutinizing. This paper focused on two related research gaps, namely, a lack in knowledge on how manufacturing firms learn to shape their GPI practices to make and sell greener products and what role uncertainty plays in this learning process.

Firstly, the majority of studies in GPI so far have focused on antecedents and success factors of GPI, while only recently more attention has been paid to the capabilities that shape a firm's GPI practices (Arranz et al., 2020; Demirel & Kesidou, 2019; Hofmann et al., 2012). Our study contributes to this growing body of literature by offering insights on how firms learn when they aim to make and sell green products. Starting from Wicki and Hansen's (2019) observation that developing green products and technologies involves long-term explorative learning with a high likelihood of failures, we zoomed in on whether and how firms might combine exploitative learning with explorative learning within and across the technology area and market areas—a concept better known as strategic ambidexterity (Voss & Voss, 2013). The expectation was that learning based on strategic ambidexterity gives firms less uncertainty than employing a "pure" explorative learning strategy as they can exploit an existing set of competences that has proven itself over time and that can be used to cross-fertilize the exploration of new competences and innovative products (Danneels, 2002; Zhang et al., 2017).

Our results confirm that firms regard strategic ambidexterity as the preferred learning strategy to innovate for making and selling greener products. The primary condition for this strategy to work is that a significant part of the firms' existing competences can in fact be exploited effectively while exploring others, but that appears problematic. Especially existing market competences proof to be inadequate for addressing current and future market and regulatory conditions for green products, and as a result, they cannot be exploited nor leveraged for cross-functional ambidexterity. Furthermore, we found that partially leveraging a firm's existing technology competences (i.e., within-function ambidexterity) can be problematic too. Paradoxically, this occurs when a firm's current generation product platforms and technologies are relative green already, which we refer to as a temporary "eco-ceiling." In reaction to these problems, firms either stick to more risk-averse "pure" exploitation learning strategies with limited progress in terms of greenness, by strongly relying on their existing technological and market competences in innovation, or they move toward more advanced ambidextrous strategies, involving explorative learning in *both* the technological and market areas simultaneously. As the latter strategies are deemed as inherently uncertain and high risk (Ansoff, 1957; Danneels, 2002; Wicki & Hansen, 2019), firms adopt them sporadically.

Our findings are in line with Salo et al.'s (2020) observation that "companies made significantly fewer functional innovations than other innovation mechanisms, revealing a trend to focus on more traditional mechanisms more typical of eco-design" (p. 2662) and we can further explain this trend of technology-oriented exploitation. Manufacturing firms with a strong and long-standing track record in technological innovation are likely to prefer exploring new competences and green products in the technology area while exploiting as much of their existing competences as possible in the market area. When firms cannot leverage these existing market competences, they usually choose for incremental eco-innovation in the technology area based on pure exploitation. Previous innovation activities foster future innovation activities. Hence, a firm's response to certain conditions during the learning process is path dependent and a function of its innovative capabilities developed over time (Danneels, 2002; Leonard-Barton, 1992; O'Connor, 2008). This explanation has been found to be relevant in the context of eco-innovation on the firm level already (Arranz et al., 2020; Jakhar et al., 2020).

Secondly, our findings provide an explanation as to why firms are struggling with the many uncertainties involved in GPI. In contrast to several studies that have concluded these struggles are mainly caused by external forces (Alblas et al., 2014; Driessen et al., 2013; Ketata et al., 2015; Rehfeld et al., 2007), we posit that the struggles are the results of internal forces as well. In addition to some of the well-known uncertainties that are purely caused by external factors (e.g., by customers, other market stakeholders, or regulators), we identify two internal causes that help explain why firms experience so many uncertainties in GPI. The first cause occurs when firms stick to trying to exploit existing competences that are ineffective in addressing current market conditions or when they are trying to partially exploit ineffective competences as is necessary in certain cross-functional or with-function ambidexterity strategies. Under those circumstances, firms will be insufficiently able to understand or predict external conditions or plan effective actions related to making and selling new green products, and as a result, they will experience an abundance of uncertainty in GPI.

A second but fundamentally different type of internal uncertainty can be linked to the advanced ambidextrous learning strategies that appear necessary to make significant progress with GPI. Here, our findings confirm prior expectations that traditional exploitation–exploration tensions are amplified in GPI because firms have to "bridge conventional technology innovation directed at customer and business growth with innovations generating broader societal benefits" (Hansen et al., 2019, p. 504). Firms that can make significant progress with green products and develop more advanced GPI competences are likely to operate highly ambidextrously as the three exceptional examples in our case study demonstrate. This means a firm learns exploratively in both preferred and less preferred domains simultaneously while still being engaged in their conventional operations and innovation domain. Besides the inherent risks of explorative learning, this leads to tensions and challenges and thus uncertainty, for instance, because an ambidextrous organization is known to be inherently contradictory (Smith & Tushman, 2005; Zimmermann et al., 2018) and highly path dependent (Danneels, 2002; Leonard-Barton, 1992; O'Connor, 2008).

Moreover, we expect that the level of ambidexterity required and the associated challenges and uncertainty increase with the level of environmental improvements added (or intended to be added) to products (Driessen et al., 2013). The uncertainties firms experience, as found in our study, are expected to become even stronger when the level greenness required increases, asking more ambidextrous learning in several areas. For example, a very green product (e.g., one causing no environmental harm at all) will be even more difficult to make as it required radically new green technologies and production methods and also more difficult to sell as it is likely to be more expensive, unfamiliar to customers, requiring new sales channels, and possibly in conflict with current regulations.

These findings also shed a different light on existing notions that the uncertainties experienced by firms are more complex and sophisticated than conventional product innovation, making GPI essentially unique (Cainelli et al., 2015; Mousavi et al., 2019; Wicki & Hansen, 2019). We posit that the uncertainties firms face are not fundamentally new or different from uncertainties that occur with the introduction of radically new products or technologies in conventional innovation. As uncertainty is a subjective and perceptual phenomenon (Schmitt et al., 2018), we argue that the combination of conditions surrounding GPI—both inside (existing competences and learning strategies) and outside (demand, pressure and regulations) the firm—causes firms to experience more uncertainty than they are used to. Yet, the learning and innovation strategies and other associated factors to address these uncertainties are similar to conventional product innovation and theoretically well known and well understood. Therefore, in our view, distinguishing between these two different internal causes of uncertainty in GPI—one due to sticking to exploitation and the other due to engaging in ambidextrous learning and exploration—is crucial in building a better understanding of how firms learn and innovate to make and sell green products in future research.

5.1 | Managerial implications

This study offers insights that are valuable to both managers and policy makers. Our data show that managers tend to see green uncertainty as largely externally to their firm's strategy and practices. This study shows that firms also co-create and cultivate some uncertainties by leaning heavily on existing competences. For manufacturing firms, as in our case study, learning about less familiar aspects of innovation in the market and other nontechnical domains—such as relevant business models, the implications for the supply chain, or communicating its value proposition to customers—can be critical in developing, making, and selling green products (Chesbrough, 2010; Claudy et al., 2016; Visnjic et al., 2014). Managers working for firms with strong sustainability ambitions are advised to stimulate and enable innovation projects with fewer, and ideally no, short-term financial objectives in order to engage in explorative learning, and they may have to involve other personnel, departments, and external partners than they usually would in order to learn more ambidextrously (Levinthal & March, 1993; Zimmermann et al., 2018).

Our study also provides important insights for sustainability-oriented stakeholders and policy makers, who are traditionally seen as key sources of incentives and pressure for greener products and production processes (Gao & Bansal, 2013). The pure exploitation learning strategies will most likely remain dominant in the majority of manufacturing firms as most firms in general are risk-averse and undervalue the future in favor of short-term profits (O'Connor & Rice, 2013; Shevchenko et al., 2016; Slawinski et al., 2017). Also, engaging in advanced forms of ambidextrous learning successfully can be extremely challenging for firms (Smith & Tushman, 2005; Zimmermann et al., 2018). Alleviating market uncertainty through external pressures, for instance, by introducing stringent and far-reaching eco-regulations and ensuring that these are permanent and strictly enforced, is therefore important element in accelerating the rate of learning, innovation, and greening of firms. This insight is closely related to the strand of literature that urges governments and other stakeholders to decrease green uncertainty in order to stimulate green innovation (Porter & van der Linde, 1995), and, as Howard-Grenville, Buckle, Hoskins, and George (2014, p. 618) observed, "The policy uncertainty may, in many cases, be of greater concern than uncertainties over future climate projections."

5.2 | Limitations and future work

Our research has several limitations to consider when interpreting its outcomes, and these may also provide fertile ground for future research. While our interview data consistently point to the impeding role that exploitative learning plays in developing green products, we certainly do not mean to imply that this approach is never effective, nor that adopting an ambidextrous strategy is a panacea for all sustainability issues. Rather, our findings emphasize the relevance of understanding the various learning strategies and their interconnectedness (Di Stefano et al., 2014; e.g., O'Reilly & Tushman, 2008; Tushman & O'Reilly, 1996). Due the limited number of instances of pure exploration projects in our study, and the relatively early stage of the corresponding innovation projects, it was impractical to assess how managers achieve cross-fertilization, nor how they cope with the challenges of realizing ambidexterity. Rigorously exploring these aspects using the full depth and scope of insights available in the ambidexterity literature would be a valuable direction for future research and could lead to a better understanding of GPI.

This study shows that GPI can require significant changes to a firm's familiar innovation and learning strategy and that firms can also contribute to the uncertainty they face in the context of GPI—especially when they fail to change. It seems existing innovation and organizational learning theory have oftentimes remained in the background in previous research (Mousavi et al., 2019; Wicki & Hansen, 2019). The observation that GPI and the associated uncertainties are more complex and sophisticated than conventional innovation may be the result of inductive bottom-up approaches in extant research without theoretical frameworks rooted in existing theory. Our study's findings imply that existing innovation and learning theories are highly relevant in studies of GPI. In particular, taking into account that firms can employ their innovation capabilities in different "modes"—be it exploitation or exploration or incremental or radical—as is well known in conventional innovation theory appears important. Whereas different strategies toward eco-innovation and GPI have been conceptualized previously (Adams et al., 2016; Buysse & Verbeke, 2003; Hart, 1995), more research is needed that studies how multiple or hybrid types of strategies are employed in practice.

Finally, the market-related aspects of green innovation were frequently mentioned in our interviews as a major challenge to making progress. Although these market-related aspects are known to be as important as the aspects in the technology area of innovation (Kim & Atuahene-Gima, 2010; Voss & Voss, 2013), the technology-oriented nature of the cases we studied were less appropriate for studying the intricacies of green marketing. Here, future green innovation research could, for instance, borrow and integrate insights from the growing body of literature on sustainability-oriented business models (Boons & Lüdeke-Freund, 2013; Lüdeke-Freund, 2019) and include theories on marketing capabilities (Day, 2011; O'Connor & Rice, 2013) and business model innovation (Chesbrough, 2010; Teece, 2010; Zott et al., 2011).

ACKNOWLEDGMENTS

The authors are thankful to the editor and the three anonymous reviewers for numerous constructive comments and advice. The authors also gratefully acknowledge the support of the Innovation-Oriented Research Program "Integral Product Creation and Realization (IOP IPCR)" of the Netherlands Ministry of Economic Affairs. Finally, the authors would like to thank Alex Alblas and Hans Wortmann for their cooperation in earlier stages of the research.

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ENDNOTE

[1] Jip and Janneke are characters from a famous series of Dutch books for children.

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How to cite this article: Peters, K., & Buijs, P. (2022). Strategic ambidexterity in green product innovation: Obstacles and implications. *Business Strategy and the Environment*, *31*(1), 173–193. https://doi.org/10.1002/bse.2881