A REVIEW OF MARKETING RESEARCH ON PRODUCT DESIGN AND DIRECTIONS FOR FUTURE RESEARCH

Michael G. Luchs
Assistant Professor of Marketing & Design
The College of William and Mary
P.O. Box 8795
Williamsburg, VA 23187-8795
michael.luchs@mason.wm.edu
(757) 221-2906

K. Scott Swan
Professor of Intl. Bus., Design, & Marketing
The College of William and Mary
P.O. Box 8795
Williamsburg, VA 23187-8795
Scott.Swan@mason.wm.edu
(757) 221-2860

M.E.H. Creusen
Assistant Professor of Product Innovation
Delft University of Technology
Landbergstraat 15
2628 CE Delft
The Netherlands
M.E.H.Creusen@tudelft.nl
+31 (0)15 27 85566

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A REVIEW OF MARKETING RESEARCH ON PRODUCT DESIGN

Introduction

The increasing attention given to product design in business practice (e.g., Apple, Puma, Dyson), by the business press (e.g., BusinessWeek, Fast Company, and New York Times best seller list), as well as in education (e.g., Stanford's d.school) has been complemented by academic research on product design in a variety of disciplines given the inherently interdisciplinary nature of product design itself. In this paper, we review academic research on product design published in top marketing oriented journals over the last 17 years. Luchs and Swan (2011) conducted a related review that covered a 12 year period from 1995-2008. Their focus, however, was on developing a conceptual framework for product design, describing research on product design relative to other related marketing topics, and describing publication trends. The current project is instead focused on describing in greater detail what has been collectively learned from this prior research on product design within each of the topic categories identified by Luchs and Swan (2011), as illustrated in Figure 1, along with identifying research directions for marketing scholars to consider.

INSERT FIGURE 1 ABOUT HERE

Methodology

Our approach for selecting articles to include within this review parallels the approach used by Luchs and Swan (2011), albeit for a longer time period. Specifically, we analyze eight of the most influential marketing journals[1] identified by Baumgartner and Pieters (2000) who incorporate both the journal's level of influence and span of influence in their rankings. This latter measure is especially important in the current context given the interdisciplinary nature of product design. Within these journals, we identified articles for our analysis by searching within the EBSCOhost database "Business Source Complete" for articles that contain the term "product design" within their abstracts (AB), subject terms (SU) and/or author supplied keywords (KW). The time period addressed begins in January 1995, coinciding with Bloch's (1995) seminal article on product design, and continues through December 2013. The search yielded 299 articles, although 65 did not sufficiently address product design or were otherwise inconsistent with our focus (e.g., we excluded articles focused on design education), yielding a focal set of 234 articles. Next, we provide an integrated summary of research on product design conducted during this time period, organized within each of the 10 product design topic categories based on Luchs and Swan (2011). We further organize our summary by identifying sub-topics within each topic where possible.

INSERT TABLE 1 ABOUT HERE

Product Design Context and Strategy

[1] In alphabetical order: *Journal of the Academy of Marketing Science, Journal of Business Research, Journal of Consumer Research, Journal of Marketing, Journal of Marketing Research, Journal of Product Innovation Management, Management Science, and Marketing Science*. See Luchs and Swan (2011) for details about journal selection.

Bloch’s (1995) influential model of the design process begins with the identification of design objectives and constraints: performance, ergonomic, production/cost, regulatory/legal, marketing program and designer. Subsequent research expands the definition of design to address both the form and the function of a product, their interaction, the strategic role of design, and its context within academic research (see Luchs and Swan 2011; Ulrich 2011). The role of design in the firm’s strategy development process is not universally acknowledged but has increasing acceptance. Broadly, topics in these top journals concerning product design context and strategy are classified into three areas: the external context; firm strategy, objectives, and capabilities; and interfirm engagement. Our review begins by addressing the best sources for information and the best methods for eliciting this information with respect to external sources (e.g., customers, suppliers). Next, the competitive context, as well as a variety of sources within the firm are addressed. Finally, we examine product design and interfirm engagement to address complexity and interfirm modularity’s influence on supply chain management, contract manufacturing, and design outsourcing.

External Context

Assessing customer needs. Understanding customers’ needs is a robust emergent theme. Veryzer and Borja de Mozota (2005) discuss the concept of user-oriented design (UOD), also known as user-centered design in the design literature (e.g., Norman, 1986), and describe it as “a process that encourages explicit and deep consideration of customer needs (p. 134).” In addition, firms can achieve greater success by addressing customers’ needs that relate to the entire product-market lifecycle, such as the need for a diversity of options over time (Kahn 1998). This ability to satisfy customers over time requires an understanding of the relationship between innovation, product design, and cross-cultural differences (Moon, Miller, and Kim 2013).

An imperative question is how to obtain information, especially when customers are often unaware of or unable to articulate their needs (Rosenthal and Capper 2006). This has led to a growing interest in research methods such as contextual observation and ethnography. Through a series of case studies, Rosenthal and Capper (2006) describe the process steps and alternative approaches that uncover insights as well as illustrate the benefits and challenges of ethnography.

Marketing must ensure that information they provide about customer requirements satisfies the information processing requirements of the design community (Bailetti and Litva 1995; Michalek, Feinberg, and Papalambros 2005). However, too much customer input can increase time-to-market (Datar et al. 1996), introduce biases (Antioco, Moenaert, and Lindgreen 2008), conflict with the channel structure (Williams, Kanna, and Azarm 2011), and produce disparate perceptions across functional areas (Calantone, Di Benedetto, and Haggblom 1995). Design-driven innovation makes it possible for firms to drive innovation based on new product meanings they envision will ultimately diffuse through society (Verganti 2008). This approach addresses future customers’ needs in addition to those of current customers, as suggested by proponents of “user oriented design” (Veryzer and Borja de Mozota 2005).

Finally, the sociocultural context and other environmental factors complicate and create uncertainty in the product design process (Chao 1998; Giloni, Seshadri, and Tucci 2008). Amaldoss and Jain (2008) note that social forces, such as reference group effects, can lead customers to identify features that are costly to add to a product, yet offer little true value-in-use.

Trends in the environment. Research shows a growing interest in the sustainability attributes of products, where sustainability refers to "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (UN Bruntland Commission 1987). Chen (2001) suggests that while "green product development" is growing in importance, it also presents a challenge given the potential trade-off between traditional product attributes and environmental constraints. Dangelico, Pontrandolfo, and Pujari (2013) find that the acquisition of technical know-how and the creation of collaborative networks are important for integrating environmental issues into product design and that green product development leads to increased opportunities though not necessarily better financial performance of NPD programs. Alternatively, Luchs, Brower, and Chitturi (2012) show how functional performance and aesthetic design trade-offs influence the likelihood of choosing sustainable products. Fuller and Ottman (2004) suggest that while sustainable product design can counter ecosystems degradation, current marketing decision processes generally ignore this important and growing customer need.

Competitors. As technology driven markets mature, customers may reach "satiation" with the performance of existing products (Adner and Levinthal 2001). Thus, subsequent efforts devoted to increasing performance and maintaining price in a competitive market are less productive than addressing unsatisfied customer needs. This observation has important implications for product design as firms attempt to balance user needs with corporate objectives within competitive environments.

Firm Strategy, Objectives and Capabilities

Dynamic Capabilities. Design is increasingly seen as a strategic tool to develop dominant brands with lasting advantages (Bloch 1995; Noble and Kumar 2010; Srinivasan et al. 2012). As such, dynamic capabilities related to design become a powerful source of competitive advantage, renewal, growth, and adaptation as the environment changes (Marsh and Stock 2006). For instance, Cachon and Swinney (2011) identify quick response production capabilities with enhanced product design capabilities that can offer significant value.

There is a strong emphasis on capabilities that drive efficiency, often associated with different modeling approaches (Smith and Eppinger 1997). In the design context, efficiency carries more than process implications. Efficiency goals are connected with strategic planning, functionally integrated decision-making, and core capabilities (Michalek, Feinberg, and Papalambros 2005; Srinivasan, Lovejoy, and Beach 1997; Ulrich and Ellison 1999).

Team performance. Another significant stream of research addresses team capabilities and their influence on performance (see Dahl 2011 for a review of research opportunities). Organizational and technical practices, such as cross-functional teaming and co-location, are effective for increasing new design integration with other functional areas (Datar, et al. 1996; Liker and Collins 1999; Veryzer and de Mozota 2005) and subsequent commercial success (Ettlie 1995), even across cultures (Souder and Jenssen 1999). Adding new team members increases product enhancements at a faster pace than more intense use of process technology but increases the need for repairs at almost the same rate as enhancements (Barry, Kemerer, and Slaughter 2006). Specifically, Joshi (2010) demonstrated that it is beneficial for salespeople to have design input into the product development process. Micheli et al. (2012) investigated how managers and designers can interact more productively during NPD.

Interfirm Engagement

Co-development. New product development is complex and often leads to partnerships (Muffatto and Panizzolo 1996) but many successful, high-growth firms are having problems moving to concurrent design as well as involving suppliers, dealers, and customers in the design process (Dickson et al. 1995). Cooperative research concerns include supply chain management, contract manufacturing, and design outsourcing (Baiman, Fischer, and Rajan 2001; Carson 2007; Mikkola 2006; Novak and Eppinger 2001; Wasti and Liker 1997). Ineffective relationship management with potential buyers during new product development (NPD) can be an important contributor to new product failure in technology-based, industrial markets. Alternatively, with design and engineering consultants, the ability to develop innovations may be dependent on analogical distance and transfer content (Kalogerakis, Lüthje, and Herstatt 2010). Since there is no relationship approach that is universally desirable, managers may need to engage in a portfolio of relationship approaches with buyers during NPD (Athaide and Klink, 2009). The solutions to these challenges require creative and sometimes counterintuitive wisdom (Staudenmayer, Tripsas, and Tucci 2005) but can lead to further success even in such things as green product development (Dangelico, Pontrandolpho, and Pujari 2013).

Product complexity and the supply chain. The trend has been to outsource more of the parts but to cooperate more closely with fewer partners so as to address increased product complexity. Product complexity rises with the number of product components, the extent of interactions among components, and the degree of product novelty. Using a property rights approach in the auto industry, Novak and Eppinger (2001) argue that in-house production is more attractive when product complexity is high so firms can capture benefits of their investment. Supporting and expanding these findings, Baiman, Fischer, and Rajan (2001) highlight the interaction between performance used for contracting within the supply chain, the architecture of the product produced by the supply chain and the incentive efficiency of the chain.

Positive design outcomes from complex product and complex supply chains require difficult tradeoffs among a host of idiosyncratic characteristics and variables. Black-box products require a highly interactive design process between suppliers and OEMs - firms cannot avoid changes in specifications; rather they should approach it as a learning opportunity (Karlsson, Nellore, and Soderquist 1998). The composition of components, distinctive to a particular product architecture as well as how components are linked to one another, determine the performance and cost benefits of product architectures (Mikkola 2006). For example, in the Italian motorcycle industry, design completely provided by the supplier is used in only a few cases and only by specialist and niche producers, never by volume producers who usually prefer a co-design relationship (Muffatto and Panizzolo 1996).

Product Design Process

Idea generation, screening, creativity, imagery, product concept development, and other product design process activities enable rapid creation, prototyping, and concept testing of products. Tools that have been explored are conjoint analysis, multidimensional scaling, and multi-attribute value analysis. Literature on concept generation focuses less on individual creativity and more on the identification of an ideal concept as well as the integration of activities involved in defining a product concept. One of the major challenges is finding the best fit between market acceptance and factors internal to the firm, such as technical capability and product manufacturability. Ulrich and Ellison (1999) develop a theory of design-select to predict when firms will select an existing component (offering the benefits of minimizing investment, exploiting economies of scale, and preserving organizational focus) versus designing product specific components (allowing the maximization of product performance, minimizing the size/mass, and minimizing true variable costs of production).

Also, there may be limits to aesthetic design. Evidence suggests circumstances under which consumers generate negative inferences regarding the performance and quality of highly attractive products (Hoegg, Alba, and Dahl 2010). Void of external information, such as brand reputation, consumers may doubt the efficacy of products with extremely high levels of visual attractiveness as compared to those of moderate levels of visual attractiveness. Design decisions can even affect the preference for counterfeit brands (Wilcox, Kim, and Sen 2009).

Design is not an easy fix for all problems; it is complex and context specific but offers some exciting opportunities. We now discuss topics in each of the design phases (i.e., idea generation, concept development and evaluation, technical implementation, and manufacturing and commercialization).

Idea Generation and Screening

Creativity & Ideation. Idea generation requires a high level of integration between external factors, such as user needs, and internal factors, such as technical capabilities (Veryzer and Borja de Mozota 2005). Our review suggests that idea generation is often treated as a creative process based on user requirements or as an engineering design process that seeks to identify the "ideal concept" amongst a large set of possible feature combinations. The former is used more for newer products, while the latter is used more for incremental product improvements or in a later phase of development, when consumers are familiar with the product and its possible attributes.

With respect to idea generation based on user research, a logical question is how to use this information to guide idea and concept generation. Dahl, Chattopadhyay, and Gorn (1999) focus on the technique of visual mental imagery whereby a designer represents knowledge in "quasi-pictorial terms." Dahl and Moreau (2002) demonstrate the value of another creativity technique that, instead of focusing on the customer, uses related product categories as a basis for idea generation.

Concept generation. Other researchers have approached design as an engineering oriented problem-solving task. One approach is to identify an ideal concept, given a large set of possible features, and use genetic algorithms (GA). Balakrishnan and Jacob (1996) describe how GA, based on the principles of natural selection, can be applied to product design problems and compare it to other approaches for generating design solutions. Further, GA can incorporate information about variations in product performance across usage situations and conditions, thereby enabling the generation of "robust designs" (Luo et al. 2005). Another approach is the use of modular architectures, enabling the rapid creation and prototyping of concepts used to ascertain customer preferences (Sanchez 1999).

Concept Development and Evaluation

Attribute-based models of consumer preference. Significant prior research has addressed the difficulties of predicting a product's market acceptance with an emphasis on identifying the optimal product configuration from a set of possible product attributes and attribute levels. Attribute-based techniques include conjoint analysis, multidimensional scaling, and multi-attribute value analysis (Tomkovick and Dobie 1995). Our review suggests that while research on refinements to these models continues, with an emphasis on conjoint analysis, recent research extends beyond the problem of how to optimize initial choice for a single product, as well as how to address some of the limitations inherent in attribute based analytical techniques.

Discrete choice models, estimated using hypothetical choices derived through surveys, are widely used to estimate the importance of product attributes to make product design and marketing mix decisions (Feit, Beltramo, and Feinberg 2010). Current research methods include conjoint methodologies and self-design or customization approaches (Franke, Schreier, and Kaiser 2010; Valenzuela, Dhar, Zettelmeyer 2009; Moreau and Herd 2010). Further, behavior-based personalization of products is popular but exhibits multiple perils (Zhang 2011).

In addition to improving the predictive ability of attribute-based models, a combination of analytical tools can be used to provide greater precision to predict market demand. Liechty, Ramaswamy, and Cohen (2001) propose the use of "choice menus" as an alternative to research tools such as conjoint analysis. The primary purpose is not necessarily to enable mass customization, but instead to learn more about consumer preference. With choice menus, consumers are provided with various scenarios that enable selection of different, yet potentially interdependent, feature levels with associated prices. Hippel and Katz (2002) discuss a related concept, user "toolkits," that allows potential customers to design their own product from a set of pre-defined elements and then iterate and even simulate the product's use in their own environment to test performance.

Integrating user needs and firm capabilities. In addition to identifying product concepts most likely to lead to market success, firms also face the challenge of finding the best fit between market acceptance and factors internal to the firm such as technical capability and product manufacturability. To address this concern, Pullman, Moore, and Wardell (2002) propose the simultaneous use of Quality Function Deployment (QFD) and conjoint analysis. While QFD enables the generation of novel ideas and identification of engineering trade-offs, conjoint analysis is able to forecast market reactions to alternative designs, i.e., complementary, rather than competing, approaches to product design (also see Katz 2004). Luo (2011) proposes a product line optimization method that simultaneously considers marketing and engineering factors, leading to a more profitable product line than when the requirements from these two domains are considered separately. Michalek, Feinberg, and Papalambros (2005) introduce analytical target cascading (ATC) from the engineering community and show how it is iteratively used with traditional marketing methods, such as conjoint analysis, to arrive at an optimal solution.

Also important to the issue of concept selection is the context of the choice (Arora, Allenby, and Ginter 1998). Likewise, there are factors within the firm's context that could influence concept selection decisions. While conjoint analysis is traditionally used to optimize the design of a single product, it can address the problem of optimal product line and product platform design (Chen and Hausman 2000; Moore, Louviere, and Verma 1999). Within the context of green product development, for example, Chen (2001) shows how firms can jointly consider the interactions of consumer preferences and environmental standards in an effort to optimize their product design decisions.

Beyond discrete attributes. While integrating marketing and engineering/manufacturing demands in concept generation may offer benefits, traditional methods for doing so may be inadequate. Srinivasan, Lovejoy, and Beach (1997) point out that even though attribute-based predictions of both market acceptance and product costs are significant, substantial, and successful; they leave too much variance unaddressed. They do not consider product aesthetics and product usability, nor do they adequately predict manufacturing costs due to the integrative effects of design decisions. Simply put, a product is more than the sum of its parts. Subjective attributes also need to be incorporated into the evaluation of product concepts (Luo, Kannan, and Ratchford 2008). A benefit of using prototypes during concept selection allows the collection of information on products in a variety of usage situations. Subsequently, firms better understand which designs are robust, producing lower variations in product performance and consumer preferences across usage situations (Luo et al. 2005) but concerns abound (Dickinson and Wilby 1997; Vriens et al. 1998). Recent developments in 3D printing may make the development of representative models less costly and, therefore, make it easier to obtain early customer feedback.

From consumer research to mass customization. A noteworthy trend in the review is the prevalence of research on mass customization. Fueled in part by the interactive capabilities of the internet, mass customization addresses many of the elements depicted in Figure 1 from the identification of customer needs, through idea generation and concept selection. Indeed, mass customization outsources many of these tasks to consumers. Research addresses this phenomenon from a variety of perspectives including how firms can benefit from this approach, when it is most likely to succeed, its limitations, and ways to overcome these limitations.

Several researchers examine when mass customization is likely to succeed. Simonson (2005) argues that firms must carefully consider a variety of consumer individual differences such as the customer's knowledge and stability of their preferences as well as the type of purchase and presentation format. Further, Ghosh, Dutta, and Stremersch (2006) contend that the firm must consider the limits of what the customer should and can customize. Relatedly, Franke, Keinz, and Steger (2009) show that the benefit gained from customization is higher when consumers have better insight into their own preferences, are better able to express their preferences, and have greater product involvement. Kaplan, Schoder, and Haenlein (2007) indicate that a customer's base category consumption frequency and need satisfaction positively influence their intention to adopt a mass-customized product. In addition, Valenzuela, Dhar, and Zettelmeyer (2009), Franke, Schreier, and Kaiser (2010), Moreau and Herd (2010), as well as Moreau, Bonney, and Herd (2011) investigate the influence of self-customization procedures and toolkits on self-design evaluations.

A related stream of research seeks to overcome the limits of customer knowledge. Randall, Terwiesch, and Ulrich (2007) describe the advantages of needs-based systems over traditional feature-based systems. With this approach, the user is able to specify the relative importance of their needs – while the firm retains control over how these needs are met. In yet another way, Franke, Keinz, and Schreier (2008) promote the benefits of mass customization user communities. Within these virtual communities, customers benefit from information provided by other users with respect to both preliminary ideas as well as design solutions.

Technical Implementation

Platforms and modularity. One of the most researched concepts within product design is that of sharing parts, components, platforms, processes, or resources across products. Meyer, Tertzakian, and Utterback (1997) discuss how individual products can be efficiently constructed on successive generations of underlying product architectures, referred to as product platform renewal and derivative product generations. The use of modular architecture techniques enables a firm to better leverage investments in product design and development (Krishnan and Gupta 2001) and creates advantages on a number of performance dimensions (Meyer and Dalal 2002). Sanchez (1999) argues that using modular architectures can lead to greater product variety and lower time-to-market while decreasing the cost of developing new product designs. Kim and Chahajed (2001) develop the idea that through properly selecting the features that are identical, a firm may achieve a valuation premium without sacrificing consumer valuation and, therefore, enjoy the economies of scale in manufacturing and logistics due to commonality.

Krishnan and Gupta (2001) indicate that platforms are not appropriate, however, for extreme levels of market diversity or high levels of non-platform scale economies. Ethiraj and Levinthal (2004) develop a model that points to the trade-off between the destabilizing effects of overly refined modularization, modest levels of search, and a premature fixation on inferior designs that can result from excessive levels of integration. John, Weiss, and Dutta (1999) find that 1) the dominance of unit-one costs favor platform designs over optimized designs; 2) greater diversity of technologies favors modular designs over optimized designs; and 3) greater tacitness favors optimized designs over modular designs. Finally, modular upgradable architecture alleviates concerns with product obsolescence but introduces new challenges such as design inconsistency (Krishnan and Ramachandran 2011) and speed of improvements (Ülkü, Dimofte, and Schmidt 2012).

Efficiency and Optimality. Technical engineering design approaches offer many other tactical suggestions to improve efficiency and optimization (Bhuiyan, Gerwin, and Thomson 2004; Erat and Kavadias 2008; Ha and Porteus 1995; Loch, Terwiesch, and Thomke 2001; Michalek, Feinberg, and Papalambros 2005; Nair, Thakur, and Wen 1995; Netessine and Taylor 2007; Smith and Eppinger 1997; Ulrich and Ellison 1999).

Commercialization

Product Design and Commercialization. Veryzer and Borja de Mozota (2005) develop the idea that user-oriented design plays a major role in facilitating product appropriateness, acting as interface among the firm, the customer, and society, along with playing an important role in technology transfer as well as adoption. In attribute-based models of consumer preference, commercialization aspects such as price sensitivities can be taken into account during concept optimization. For example, Tomkovick and Dobie (1995) combine hedonic pricing models and factorial surveys to allow product designers to more accurately gauge price sensitivity and market receptivity to new product designs. In addition, market simulation can include competitive reactions (Giloni, Seshadri and Tucci, 2008). Competition offers interesting implications for mass customized products. Syam, Ruan, and Hess (2005) argue that firms need to carefully consider which features to customize with respect to competitors' customized offerings. An implication of mass customization is that consumers show greater willingness to pay for self-designed products (Franke and Piller 2004), because such products offer increased functionality, uniqueness, pride of authorship, and joy of performing a creative act.

Package Design. Package design incorporates engineered functional attributes (e.g., ergonomics, durability, recyclability) and a package's visual attributes (Bloch 1995). Orth and Malkewitz (2008) prescribe that package designs are of five holistic types and can be matched with brand types. Raghubir and Greenleaf (2006) find that the ratio of the sides of a rectangular product or package can influence purchase intentions and its impact seems to depend on the relative seriousness of the context in which the product is used.

Product Design Consequences

Consequences, or outcomes, of product design include both consumer responses, such as consumer evaluation, choice and post consumer choice, as well as firm performance and product level success variables. With regard to consumer response to product design, we make a distinction between product form and product function, and describe their interrelations. For example, product form influences consumer perception of product function (e.g., Hoegg and Alba 2011) and product function can be accentuated by product form.

Consumer Evaluation and Choice

Product Form. Product form represents a variety of elements "chosen and blended into a whole… to achieve a particular sensory effect…including shape, scale, tempo, proportion, materials, color, reflectiveness, ornamentation and texture (Bloch 1995 p. 17; see also Davis 1987; Kellaris and Kent 1993). Bloch's (1995) seminal article on product form identifies several ways in which the form of a product can contribute to a product's success. First, the form can help a product gain attention so that consumers invest in evaluating the product. Second, the form of a product can have an inherent aesthetic value that affects consumers' evaluations and is consequential throughout the ownership of the product. Third, the form can communicate functional, experiential, and symbolic information to consumers. Finally, the form of a product can enable categorization of the product. Creusen and Schoormans (2005) give an overview and qualitative insight into the roles of product appearance for consumers.

Veryzer and Hutchinson (1998) demonstrate that both the perceived unity and prototypicality of a product design have a positive effect on consumer aesthetic responses to products. Raghubir and Greenleaf (2006) state that consumer's evaluations of rectangular shaped products depend upon the ratios of the length of the sides of the product and context. Concerning the symbolic value of product form, , Orth and Malkewitz (2008) define a taxonomy of design types within a given product category (e.g., bottles of wine) where each design type conveys a specific symbolic meaning, Karjalainen and Snelders (2010) show that meaning is created by design in a three-way relationship among design features, brand values, and the interpretation by a potential customer.

Hoegg and Alba (2011) examine how the form of a product can alter judgments about feature function. Page and Herr (2002) found that the aesthetic attractiveness heightens perceived product quality. However, Hoegg, Alba, and Dahl (2010) show that when aesthetics and feature performance information conflict, attractive aesthetics lower perceived functionality. Krishna and Morrin (2008) address the influence of haptic cues, i.e., touch, in influencing perceptions of product performance. The design of a product also communicates impressions about ease of use that may influence consumer perceptions in the purchase situation (Creusen and Schoormans 2005).

The form or appearance of a product influences the way consumers categorize the product (Bloch, 1995; Creusen and Schoormans, 2005). Prior research has suggested that visual "goodness-of-fit" with a category, or prototypicality, can enhance product evaluations (Veryzer and Hutchinson 1998). Landwehr, Labroo, and Herrmann (2011) show that including measures of prototypicality and complexity of frontal car designs significantly improves sales forecasting. Kreuzbauer and Malter (2005) show how designers can alter specific elements of a product's form to support line-extension strategies. Talke et al. (2009) show that design newness (i.e., a unique visual product appearance) positively impacts car sales, while Radford and Bloch (2011) show that products that are high in visual newness engender more affective consumer reactions.

Bloch, Brunel, and Arnold (2003) demonstrate that consumers also vary with respect to the degree to which they are influenced by visual product aesthetics. Cox and Cox (2002) demonstrate the value in studying consumers' product evaluations over time. Specifically, they study the effects of repeated exposure on consumers' liking of visually complex and simple product forms. They show that preferences for visually complex forms increase with repeated exposure.

Product Function. As evident in our review thus far, a significant amount of research approaches product design as the process of determining which function/performance attributes to embody in a product and focuses on function (vs. form) aspects of product design. However, while much of this prior research helps companies with the process of selecting attributes to include in a product, other research has focused instead on developing our understanding of consumers' responses to the aggregate outcomes of these discrete attribute decisions. As demonstrated by Thompson, Hamilton, and Rust (2005), rather than bundle a large set of attributes in a single product, companies interested in maximizing consumer satisfaction and long-term sales are better off designing a larger set of more specialized products.

Choosing within product lines. Consistent with offering a larger set of specialized products, Kahn (1998) argues that companies will be more effective by offering a high-variety product line that makes it more likely that consumers will find the option they desire as well as allow consumers to enjoy a diversity of options over time. Others have shown that consumers' evaluations of products are influenced by the presence of related products within the same product line. Kim and Chhajed (2001) demonstrate that when products share similar features within a product line, the valuation of the low-end product can increase while the valuation of the high-end product can decrease. Thus, while designers can consider the benefits of offering a line of related products, they must also consider the effect that this context has on consumers' valuations of the individual products.

Post Consumer Choice

Product use. In addition to changes in preference for design and features across time (e.g., Cox and Cox 2002; Thompson et al. 2005), several researchers have addressed product design effects beyond initial product choice. Chitturi, Raghunathan, and Mahajan (2008) show that a product's hedonic (i.e., product form) and utilitarian (i.e., product function) benefits differentially affect the post consumption feelings. Specifically, they demonstrate that products that exceed customers' utilitarian needs enhance satisfaction whereas products that exceed hedonic wants enhance customer delight. Further, they provide evidence suggesting that delighting customers improves customer loyalty (e.g., word-of-mouth and repurchase intentions) beyond that derived from satisfying them. Srinivasan et al. (2012) relate the design elements functionality, aesthetics and meaning to customer satisfaction and define customer segments that place different importance on these elements.

Product disposal and sustainability. Attention to sustainability issues in the design community has emerged as a significant interest (Eppinger 2011). Beyond considering the effect of design decisions on consumers after initial product choice, research has begun to address other long-term effects (see also the section *Trends in the environment*). "Green product development" is becoming increasingly important to customers (Chen, 2001), although current marketing decision processes generally ignore this growing customer preference (Fuller and Ottman, 2004). Thus, in addition to considering the effects of design decisions on the individuals consuming specific products, there are significant opportunities to consider the indirect effects on the environment and, hence, on the sustainability of a consumption-oriented economy. Fuller and Ottman (2004) demonstrate how sustainable product design can counter ecosystems degradation. Design challenges such as "cradle-to-cradle" responsibility (i.e., production, recycling, and subsequent production of products from post consumption materials) and 'product life-cycle analysis' are being increasingly accepted as part of the standard design process.

Product/Firm Performance

Product Success. Product success and firm success are intimately connected. Firms attempt to balance short-term individual product success against the longer-term firm level success required to reinvest in future differential advantages for product success. The strategic significance of dominant designs, the balance of risks, investments and success rates feed into the desire to increase profits, sales and develop strong brands **(**Srinivasan, Lilien, and Rangaswamy 2006). There are a number of firm incentives to offer customized products in addition to standard products in a competitive environment (Syam and Kumar 2006). Products customized on the basis of expressed preferences bring about significantly higher benefits for customers in terms of willingness to pay, purchase intention, and attitude toward the product than standard products (Franke, Keinz, and Steger 2009).

Firm Performance. Product success measures are often tied together with firm performance variables like market share, sales, quality, brand development, innovativeness, speed-to-market, and profit (Amaldoss and Jain 2008; Dell'Era and Verganti 2007; Moore, Louviere, and Verma 1999; Novak and Eppinger 2001; Smith 1999; Swan et al. 2005). Gemser and Leenders (2001) explicitly show increasing company performance by integrating industrial design into product development. In addition, Chiva and Alegre (2009) show that investment in design and design management enhance firm performance, while Hertenstein et al. (2005) show that effective industrial design relates to increased corporate financial and stock market performance.

Managerial relevance of research

There is a very practical application of design for business. Jaguar and Ford executives have both talked about how important the look of their cars: styling, paint colors, contrast stitching on leather seats. Which fits nicely with the research, as Landwehr, Labroo, and Herrmann (2011) show that including measures of prototypicality and complexity of frontal car designs significantly improves sales forecasting. Further, Talke, Salomo, Wieringa, and Lutz (2009) show that aesthetic design newness has a positive impact right after the product introduction and persists in strength over time, while technical newness drives sales with a lagged effect and decreases toward the end of the life cycle. Other important firm level metrics relevant to product design include market dominance (Giloni, Seshadri, and Tucci 2008), modular design and buyer-supplier relationships (Hoetker, Swaminathan, and Mitchell 2007), marketing flexibility through product modularity, a coordinated supply chain, information technology (Sanchez 1999), moderating pollution (Fuller and Ottman 2004), firm competitiveness (Dickson et al. 1995), and customer lifetime value (Thompson, Hamilton, and Rust 2005). Finally, design can be employed to create visual recognition of a brands' core values (Karjalainen and Snelders 2010). These managerially important outcomes highlight the criticality of design-related research.

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TABLE 1 (Luchs and Swan 2011)

TOPICS ADDRESSED WITHIN EACH CATEGORY OF THE

PRODUCT DESIGN CONCEPTUAL MODEL

<table>
<tr><th>General Category</th><th>Topic Category</th><th>Subcategories</th></tr>
<tr><td rowspan="3">Context and Strategy</td><td>External Context</td><td>• Assessing customer needs
• Trends in the environment
• Competitors</td></tr>
<tr><td>Firm Strategy, Objectives and Capabilities</td><td>• Dynamic capabilities
• Team performance</td></tr>
<tr><td>Interfirm Engagement</td><td>• Co-development
• Product complexity and the supply chain</td></tr>
<tr><td rowspan="4">Product Design Process</td><td>Idea Generation and Screening</td><td>• Creativity and ideation
• Concept generation</td></tr>
<tr><td>Concept Development and Evaluation</td><td>• Attribute based models of consumer preference
• Integrating user needs and firm capabilities
• Beyond discrete attributes
• From consumer research to mass customization</td></tr>
<tr><td>Technical Implementation</td><td>• Platforms and modularity
• Efficiency and optimality</td></tr>
<tr><td>Commercialization</td><td>• Product design and commercialization
• Package design</td></tr>
<tr><td rowspan="3">Product Design Consequences</td><td>Consumer Evaluation and Choice</td><td>• Product form
• Product function
• Choosing within product lines</td></tr>
<tr><td>Post Consumer Choice</td><td>• Product use
• Product disposal and sustainability</td></tr>
<tr><td>Product/firm performance</td><td>• Product success
• Firm Performance</td></tr>
</table>

FIGURE 1 (Luchs and Swan 2011)

CONCEPTUAL MODEL OF PRODUCT DESIGN RESEARCH