

THE TOTAL PRODUCT DESIGN CONCEPT AND AN APPLICATION TO THE AUTO MARKET

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ABSTRACT

As traditional sources of competitive advantage shrink, firms seek new ones. One such source of competitive advantage is product design because of its effects on customer experience. To understand the role and impact of product design on customer experience, we propose an integrated, customer-based framework for product design that we call the Total Product design concept (TPDC). We define a product's TPDC as consisting of three elements, namely, functionality, aesthetics, and meaning, each of which arises from more elemental product characteristics. We elaborate on the structure of a product's TPDC, its three elements, and the links between those elements and customers' experience with a product. We provide an illustrative application of the TPDC using data from the US auto market. The findings from that application support the proposed three dimensional view of the TPDC, and demonstrate heterogeneity both in the TPDC's structure and its effects on customer satisfaction. For all three segments, functionality enhances customer satisfaction. For the largest segment of customers, functionality is the most important factor, followed by aesthetics. For the other two segments, customer satisfaction is most influenced by the meaning element of TPDC. We discuss the implications of these findings for the auto industry in particular and the potential use of the TPDC more generally.

Keywords: customer experience, product design, customer satisfaction, aesthetics, functionality,

INTRODUCTION

Design can unlock the technological performance we build into a product and help the consumer see it, touch it. Good design is serious business. --- Alan G. Lafley, Chief Executive Office, Procter and Gamble, 2002.

We keep reminding ourselves that almost every vehicle out there -- old, new, big, small, passenger cars, sports utility, roadster, minivan -- fulfills the basic transportation function, and they all fulfill it roughly equally well. Yet people go for the new. They go for the good-looking vehicle. That's why advanced product design is the core of our business strategy. --- Bob Lutz, Vice-Chairman, Daimler-Chrysler-Benz, 2002.

Design DNA is all the rage as car makers try to make their vehicles stand for something --- Money magazine, Jan 13, 2006.

For companies worldwide, design has become strategic, the very core of their efforts to differentiate what they make and do. --- Business Week, July 10, 2006.

Firms operating in competitive and mature markets that increasingly characterize most industries face several challenges including commoditization of products, fragmentation of markets and declining profit margins. Nusbaum (2006) has touted superior product design as an important source of sustainable advantage for firms operating in such environments. But what is "superior product design?" In this paper, we propose the total product design concept (TPDC) to provide an integrated view of product design with implications for new product development practice and theory.

Insights on the strategic role of product design in product management have the potential to contribute to the new product design and development literature. Given the long-standing recognition of the potential of design for generating innovation rents, such work has been a research priority of the Marketing Science Institute (MSI) which sponsored a special issue of the *Journal of Product Innovation Management* featuring articles on such topics as the role of marketing and design in discontinuous product development (Veryzer 2005), links between marketing and engineering on product design (Michalek, Feinberg, and Papalambros 2005), the effect of product appearance on customer choice (Creusen and Schoormans 2005) and the

financial rewards to superior industrial designs (Hertenstein, Platt, and Veryzer 2005). Indeed, recent work (Chiva and Alegre 2009) reports that design investments enhance firm performance.

As consumers do not buy products for merely utilitarian reasons, functionality, by itself, is often not sufficient for successful differentiation in today's competitive markets (Bloch 1995). As Veryzer (1995; p. 642) noted, "it is important for consumer researchers to adopt a conceptualization of design that acknowledges the different aspects of product design (i.e., functional, communicative, and aesthetics)," a perspective we adopt in this paper.

Our customer-centric perspective of product design, (the Total Product Design concept), consists of three design elements: (1) functionality, which arises from the product's features and related benefits, (2) aesthetics, the product's sensorial characteristics, including, its appearance, touch, smell, taste and sound, and (3) meaning, the associations of the product in the minds of its customers. We propose that a product's characteristics map onto the TPDC's three design elements. We also propose, and show via an empirical study, that customers differ in how their perceptions of product characteristics map onto the three design elements and in how those design elements affect their experiences with a product.

We proceed as follows. We first review the related literature on product design, leading to our conceptualization of the TPDC and its three elements. Then we discuss the effects of the TPDC's design elements on customer experience. Next we demonstrate the validity of the proposed TPDC, its design elements and their effects on customer experience, using data on product ratings and customer satisfaction from 47,885 new vehicle owners in the U.S. Our empirical findings both support the TPDC's three-design element structure and show heterogeneity in perceptions of, and preferences for, product design. We conclude with a

discussion of the TPDC's implications for product management theory and practice and opportunities for further research.

PRODUCT DESIGN: AN OVERVIEW

Scholars in several disciplines have defined product design differently, in part, because of their diverse research goals. Studies in cognitive science, human factors research, and marketing, focused primarily on customer perceptions and benefits, define product design using a demand perspective (i.e. the customers' perspective). These definitions focus on product characteristics that enhance usability and user satisfaction. For example, Urban and Hauser (1978; p. 155) define "design as the designation of the key benefits the product is to provide, the psychological positioning of these benefits versus competitive products, and the fulfillment of the product promises by physical features."

Scholars in production and operations management, focusing on the goal of decreasing a firm's costs (i.e. product development, manufacturing and distribution) define product design from a supply side perspective (i.e. the firm's perspective). For example, Krishnan and Ulrich (2001, p. 9) define product design as "the detailed *design* phase which constitutes the specification of design parameters, the determinance of precedence relations in the assembly, and the detail *design* of the components including materials and process selection."

Others (Kotler and Rath 1984; Ulrich and Eppinger 2004) integrate supply and demand side perspectives in defining product design. These definitions incorporate product features and related benefits (e.g., performance, durability) with product costs (e.g. manufacturing and marketing costs), and offer a strategic perspective.

There is also a long tradition of research in the new product development literature using conjoint analysis methods, which has viewed a product as a bundle of product attributes in a multi-attribute framework (e.g., Keeney and Lilien 1987). Using an attribute decomposition approach, conjoint analysis techniques focus on the identification of set of product attributes that maximize consumer utility (See Green, Krieger, and Wind 2001 for a review).

Consumer behavior scholars have examined customers' responses to product characteristics beyond their features and benefits (Bloch 1995; Bloch, Brunel and Arnold 2003; Chitturi, Raghunathan and Mahajan 2007; 2008; Veryzer and Hutchinson 1998). The dominant theme from these studies is that, in addition to product attributes, various aspects of product appearance (e.g., aesthetics, symmetry in appearance) influence customers' evaluations and choice. Developments in experiential marketing (Schmitt and Simonson 1997) suggest that marketers must not only focus on products' (or services') features, but also on the sensorial characteristics of the products to enhance the customer experience. In a similar vein, Berry, Carbone and Haeckel (2002) recommended a focus on 'total customer experience' that includes both experience clues and emotions evoked by a product (e.g., smells, sounds, and sights).

This brief literature review indicates that product characteristics beyond physical features affect customer response. The past literature does not, however, provide an integrated way to view and measure both the physical and non-physical aspects of product design, our focus here.

THE TOTAL PRODUCT DESIGN CONCEPT (TPDC)

The TPDC Defined

We propose that an appropriate representation of a product's design, the TPDC is *not* limited to a product's functionality, but also includes its aesthetics, and meaning, which we

describe below. Second, we argue that customers' perceptions of product design are central to customers' experiences with the product. We first outline the three constituent elements of the TPDC:

Functionality arises from a product's features which deliver the specific benefits that customers realize from using the product.

Aesthetics arise from the product's sensorial characteristics, including its appearance, sound, touch, smell, and feel. Some (e.g., Santayana 1896) have argued that beauty is an inherent property of objects and that certain proportions, shapes, and colors are universally attractive. However, there is widespread recognition that socio-cultural factors (e.g., Berlyne 1971) and individual characteristics (Bloch, Brunel, and Arnold 2003) also influence customers' perceptions of a product's sensorial characteristics. Thus, our conceptualization of aesthetics as customer perceptions acknowledges the interaction between the product and the perceiver (or user).

Meaning refers to the significance and memorial associations about a product that is shared by its customers. A product's meaning is co-produced by the firm (through its product, marketing and communications programs) and its customers (through their interpretations of the product and its related marketing programs within the user community). A product's meaning is not universal, since the concept is based on "me and my tribe" versus others which may include outside reference groups (Fournier 1998).

We note three properties of the proposed TPDC. First, the unit of analysis is a specific product (e.g., Apple iPod, Logitech track ball mouse) and not the product category (e.g., multimedia players, mice). Second, we conceptualize the TPDC's three design elements as latent factors that are functions of specific product characteristics. Third, the TPDC merges the

firm's various activities beyond those specific to new product development activities (e.g., advertising to enhance the positioning of the product in the marketplace). The words of the notable industrial designer (Coates 2003) are pertinent here: "... it is impossible, in fact, to design a watch that only tells time. Knowing nothing more, the design of a watch alone – or any other product – can suggest assumptions about the age, gender, and outlook of the person who wears it."

We illustrate our conceptualization of TPDC's using the Herman Miller's Aeron Chair (Figure 1) (Vogel, Cagan, and Boatwright 2005).

---- Insert Figure 1 here ----

Herman Miller Inc. introduced its Aeron office chair in 1994. The chair's *functionality* is derived from several features that provide a superior seating experience. Dymetrol, the Du Pont's synthetic material used in the Aeron chair's back and seat pan, provides a breathable mesh interface between the user's body and the chair. Its steel, gray frame creates a smooth transition from the open mesh to the frame, strongly supporting the user's body and enabling the user to shift positions comfortably for different tasks. The Aeron chair's spring-cushioned seat enables kinesthetic motion, lowering spinal compression and lowering stress injuries. The Aeron chair's dark gray frame and black open, woven synthetic material of its seat, create an elegant, skeletal and yet a welcoming, comfortable look, its *aesthetics*. The natural finish of its materials and its light, open design create a post-modern visual sensibility. The Aeron chair's *meaning* shifts the traditional emphasis in organizations, on hierarchy, to users' comfort. While most office chairs are designed based only on organizational hierarchy, with senior managers getting larger chairs, Aeron chairs are offered in three sizes corresponding to the physical sizes of users, not to their

organizational ranks, indirectly, suggesting that the Aeron chair supports a flat, democratic organization.

RELATING TPDC TO CUSTOMER EXPERIENCE

We propose a conceptual framework to articulate the structure for the TPDC and its effects on customer experience (Figure 2). The proposed framework allows for heterogeneity across customers in the mapping of product characteristics on to the TPDC's three design elements, and in their effects on customer experience.

---- Insert Figure 2 here ----

Product Characteristics and Design Elements

Accounting for heterogeneity in customers' tastes, needs, and preferences is a basic marketing principle (e.g., Frank, Massey and Wind 1972). Customer heterogeneity requires firms to develop distinctive products, and associated marketing strategies to serve the needs of different customers. For example, Toyota Motor Corporation sells numerous brands and numerous models within brands (e.g., Lexus LS460, Lexus IS 250, Camry, and Scion xA). Each of these brands has distinctive product characteristics and appeals to different customer segments. These products, each with different marketing programs, induce differences in customers' search process for product information (Beatty and Smith 1987; Punj and Stewart), information processing and purchase behaviors (Bettman, Johnson and Payne 1991), and in post-purchase and consumption behaviors (Churchill and Surprenant 1982). Thus, *we expect heterogeneity among customers in how they map product characteristics onto the TPDC's three design elements.*

Design Elements and Customer Experience

When a product's functionality is enhanced, it has a positive effect on customer experience, which results in higher satisfaction (Churchill and Surprenant 1982). Thus, we expect to see an overall positive relationship between product functionality and customer experience. There is also evidence for heterogeneity in customers' perceptions of a product's aesthetics (Creusen and Schoormans 2005). Thus, we expect individual differences with respect to the effects of functionality and aesthetics on customer experience.

A product's meaning, which is both imbued in it by the firm, and is also co-produced by customers, also varies across different customer communities (e.g., Kozinets 2001; Richins and Dawson 1992). A given product may have multiple meanings created in distinct interpretive communities, so that the effects of meaning on customers' experiences with the product are heterogeneous across customers (Fournier 1998).

Thus, for some customers, functionality may have the highest influence (compared to aesthetics and meaning) on customer experience, while for others, aesthetics may be the most important influencer, and for yet others, meaning may be most important design element driving customer experience. Taken together, the above arguments suggest *that the effects of a product's three design elements on customer experience will vary across customers.*

In the following section, we describe an illustrative empirical application of the TPDC, and its three design elements and their effects on customer experience in the US auto market.

AN APPLICATION OF TPDC TO THE US AUTO MARKET

The Data

Consistent with the TPDC's framework, we sought a data set that contains both customers' ratings of a product's characteristics and their experiences with the product. We obtained access to one such source: customer experience data collected by J.D. Power and Associates (JDPA) in their Vehicle Quality Survey (VQS) in the US auto market in 2006. We provide an overview of the VQS methodology in Appendix A1.

The VQS includes customers' ratings of vehicles' product characteristics and satisfaction with their vehicles, within 90 days of their purchase of a new vehicle. Our VQS data covers 47,885 vehicle owners, who purchased new vehicles in 2006. The data includes vehicles from 15 corporations (e.g., American Honda Motor Company, Volkswagen of America, Inc.), 35 makes (e.g., Acura, Honda, Subaru) and 263 make-models (e.g., Nissan Xterra, Buick Lacrosse). The average list price of the vehicle is \$ 31,173 (standard deviation = \$13,216; minimum = \$12,703; maximum = \$103,373).

Measures

The VQS measures that ask customers to rate the vehicle's tangible product characteristics (e.g., fuel efficiency), intangible product characteristics (e.g., appearance) and communicative aspects (e.g., sturdiness, distinctiveness), correspond roughly to functionality, aesthetics and meaning design elements respectively. We provide the measures in the VQS survey in Appendix A2.

Given the large number of product characteristics (over 60) in the VQS survey, the JDPA methodology aggregates customers' ratings of product characteristics using sub-categories (e.g.,

Storage and space, Fuel Efficiency, Exterior) to reduce the dimensionality of product characteristics, which we used to map onto the three design elements. We mapped the following manifest indicators (i.e. sub-categories) corresponding to product characteristics onto the *functionality* design element:

1. Storage and space: storage and space usage, including ease of getting in and out of the vehicle, leg and head room, storage spaces in the vehicle and in the trunk area.
2. Driving dynamics: driving dynamics including ride smoothness, responsiveness of steering and braking system, handling and stability.
3. Fuel efficiency: fuel economy and the driving range between stops.
4. Engineering/transmission: engineering and transmission including the performance during rapid acceleration from stop, passing power at high speed and smoothness of gear shift operations.
5. Seating: seats including seat belt comfort and adjustability, flexibility of seat configurations, and quality of seating materials.
6. Safety: visibility and driving safety including visibility from driver's seat, effectiveness of headlights, ease of controls, displays while driving.
7. Heating, ventilation, air conditioning: heating and air conditioning including ability to maintain desired temperature, controls and ability to defrost/defog the interior glass.
8. Audio system: overall quality of audio system including sound clarity, and ease of controls.

We mapped the following two indicators of the product's sensorial characteristics onto the *aesthetics* design element:

1. Exterior: the vehicle's exterior's attractiveness including the styling of the front, side and rear profiles, and appearance of paint and wheels.
2. Interior: the vehicle's interior's attractiveness including the attractiveness of the instrument panel and dashboard, look and feel of steering wheel, ability to rest arms, smell of vehicle interior.

For the *meaning* design element, we used data on seven communicative characteristics of the vehicle's image (see Appendix A2). As with functionality and aesthetics, we reduced the dimensionality of the meaning data. Using factor analysis, we identified two factors using the

eigenvalue criterion (Eigen value > 1). We designate these factors as *Distinctiveness* and *Sturdiness*.

VQS measures *Customer Satisfaction* with the vehicle as the owners' overall rating of the vehicle on a 10-point scale (mean = 8.24 standard deviation = 1.63), which we used to measure the customer's experience with the vehicles.

We also obtained a set of covariates which may affect customers' experiences with their vehicles, which we discuss next. We measured *Problems encountered* as a count of the total number of problems encountered since the purchase of the vehicle. We measured *the Vehicle's price* as its national list price obtained from the Power Information Network, a J.D. Power and Associates unit that specializes in tracking real-time dealer transactions as owners of high-priced vehicles are more satisfied with their vehicles than owners of low-priced vehicles (Forbes 2006).

As customer satisfaction research in the automotive industry (Devaraj, Matta, and Conlon 2001) suggests that demographics of vehicle owners affect customer satisfaction, we also obtained data on customers' demographics. We measured the vehicle owner's *Age* in years, *Gender* as a dummy variable (1 if male customer, else equal to 0) and *Income* by total household annual income using an ordered 16-category measure increasing in income. We measured the vehicle owner's *Education* as a dummy variable (1 if the customer had college education, zero otherwise).

Finally, we used a set of psychographic variables to profile the segments. The first set of psychographic variables measured customers' general vehicle preferences (12 items), which we factor analyzed using the minimum eigenvalue criterion. We identified four factors, which we labeled the vehicle's image, economy, reliability, and American centrality. The second set of psychographic variables covered owners' motivations (16 items) to purchase the vehicle. Again,

we factor analyzed these 16 items and identified five factors—*Self image, Reliability, Large vehicle, Environmental responsibility, and Value*. Appendix A2 provides details of these items.

Empirical Approach

Our overall approach to analysis can be described as a finite mixture structural equation model in which the factor structure (measurement model) is allowed to vary across the latent classes. For determining factor structure, we use exploratory factor analysis. As described in the previous section, the fundamental thesis underlying our conceptualization is that the structure of the factor loadings (i.e. the way that the car's features load onto the three design elements) will be heterogeneous across customers. Hence, we expect the factor means and factor loadings to vary across different customer groups (latent classes), i.e., the design elements may be interpreted in different ways in different segments.

Our interest is in understanding how the design elements influence satisfaction with a car (make-model) within each latent segment, e.g., whether functionality has greater impact than aesthetics on satisfaction in a particular segment. Thus, we do not wish to make cross-segment comparisons, either in terms of how each segment defines the three design elements, or in terms of how the design aspects of a car influence customer satisfaction. Thus, consistent with past work in the area,¹ we do not need to impose measurement invariance across our latent classes.²

¹ There has been considerable prior research that has used the factor mixture models in which factor structure varies across groups. Measurement invariance is essential only when the researcher's goals are to compare the structural models across groups (Muthén 2008). Indeed, structural models that allow for measurement variance across groups (or latent segments as is the case in our studies) have been implemented in many studies reported in the literature (e.g., Blafield 1980; McLachlan and Peel 2000; Ying 1997). For a marketing application, see Jedidi, Jagpal, and DeSarbo (1997), who use this approach to identify market segments that differ in terms of the importance they attach to various dimensions of satisfaction.

² We subsequently tested whether there was measurement invariance by imposing restrictions across latent classes in terms of equality of factor means, factor variances, factor loadings, and number of factors (Muthén 2008). We only found support for equality in the number of factors across the three latent classes. This is not surprising because the items included by J. D. Power & Associates has been pre-screened over many years to capture specific aspects of product designs, such as aesthetics or functionality.

Thus, in our empirical model, product characteristics determine the three product design elements (latent factors), which, in turn, are related to customer satisfaction. To account for unobserved heterogeneity in how the design elements relate to satisfaction, we specify a finite mixture structural equation model (Jedidi, Jagpal, and DeSarbo 1997) that identifies latent segments on the basis of the inferred relationship between the response variable (i.e., customer satisfaction) and the set of explanatory variables (i.e., the latent factors of functionality, aesthetics, and meaning) within each latent segment. We also account for unobserved mean differences in satisfaction within a segment for different make-models of cars via a random effects formulation. See Appendix A3 and Figure 3 for a mathematical outline of the estimation approach.

Establishing the Three Factor Structure of the TPDC

We examined the appropriateness of the proposed TPDC's 3-element conceptualization by using a multi-step approach to establish the construct validity of the Functionality, Aesthetics, and Meaning constructs. For identification purposes, we set the coefficient for one product characteristic for each design element (driving dynamics for functionality, exterior for aesthetics and distinctiveness for meaning) equal to 1.

First, we establish the unidimensionality of the three design elements. To establish the unidimensionality of the functionality construct, we randomly divided the sample into two parts. We used the data in the first subsample to fit the 8-indicator functionality model and examined the model fit. The model fit was unsatisfactory, with the root mean square error of approximation (RMSEA) = 0.14, and Comparative Fit Index (CFI) = .87. Following an examination of the standardized residuals, we eliminated three product characteristics (Audio systems, Storage and Space, and Safety) with the highest negative standardized residuals, which

indicated over-fitting. Using this revised model specification, we obtained a superior fit of the model for the functionality construct in both sub-samples (the root mean square error of approximation (RMSEA) was 0.06 and 0.07, and Comparative Fit Indices (CFI) was 0.93 and 0.94 in the two subsamples).

As the aesthetics and meaning constructs are measured using only two manifest indicators, we established their construct validity using an alternative approach. We first combined the functionality and the aesthetics constructs in one model as follows: we again divided the sample into two random subsamples, and re-estimated a model that included the functionality and aesthetics constructs. We estimated an exploratory factor analysis model where we fixed the non-target loadings of one reference indicator (whose loading is set to one) -- Driving Dynamics and Exterior for functionality and aesthetics constructs respectively--for these constructs. We then set the non-target loadings of these reference indicators to zero, but allowed all other non-target cross loadings to be freely estimated. This model had good fit of model for both the randomly-divided sub-samples (i.e. the root mean square error of approximation (RMSEA) was 0.05 and 0.04, and Comparative Fit Indices (CFI) was 0.92 and 0.94 in the two sub-samples). The composite reliability (CR) and average variance extracted (AVE) for functionality and aesthetics constructs are as follows: functionality: CR = 0.93, AVE = 0.62; aesthetics: CR = 0.92; AVE = 0.65; in addition, the average variance extracted of functionality (0.62), and aesthetics (0.65) exceeded the squared correlations between them. Thus, following Fornell and Larcker (1981), the two constructs of functionality and aesthetics appear internally consistent and distinct from each other.

Following a similar procedure, we established the construct validity of meaning and functionality, and meaning and aesthetics using exploratory factor analysis with additionally

randomly selected subsamples of observations. The composite reliability (CR) and average variance extracted (AVE) for meaning and functionality constructs are as follows: meaning: CR = 0.94, AVE = 0.66; functionality: CR = 0.88; AVE = 0.63; in addition, the average variance extracted of meaning (0.66) and functionality (0.63) exceeded the squared correlations between them. We obtain a similar pattern of results using confirmatory factor analysis using meaning and aesthetics constructs (results not reported here in the interest of brevity).

We then estimated an exploratory factor analysis model with all three constructs, functionality, aesthetics, and meaning. Again, we fixed the non-target loadings of one reference indicator (whose loading is set to one) for the functionality, aesthetics and meaning constructs: driving dynamics for functionality, exterior for aesthetics, and distinctiveness for meaning. Again, we randomly divided the sample into two parts. The Composite Reliability (CR) and Average Variance Extracted (AVE) for the Functionality, Aesthetics, and Meaning constructs are as follows: functionality: CR = 0.92, AVE = 0.64; aesthetics: CR = 0.91; AVE = 0.63; meaning: CR = 0.93, AVE = 0.62. We established discriminant validity by first noting that the 95 percent confidence intervals of the correlation between the constructs are well below 1.00 ($p < 0.05$), and, second, observing the AVE for functionality (0.57), aesthetics (0.59) and meaning (0.55) exceeded the squared correlations between them, suggesting the convergent validity and discriminant validity of the three constructs (Fornell and Larcker 1981). This model had good model fits in both sub-samples (i.e. the root mean square error of approximation (RMSEA) was 0.07 and 0.06, and Comparative Fit Indices (CFI) was 0.93 and 0.92 in the two sub-samples). Thus, our data correspond quite well to the three-factor structure of functionality, aesthetics, and meaning proposed in the TPDC framework.

Our exploratory factor analyses to determine the three-factor structure of functionality, aesthetics, and meaning was based on treating the entire data set as coming from a single segment of consumers. After performing the latent class analysis, we examined the factor structure in each of the three latent segments (not reported here in the interest of brevity) that emerged from the empirical analyses (which we discuss next). In these additional analyses, we also found support for the three-factor structure of functionality, aesthetics and meaning. Specifically we found that the CRs (between .85 and .92) and AVEs (between .53 and 0.63) of the factors were acceptable and the model fits were good (CFIs [between .90 and .93] and RMSEAs [between .05 and .09]).

TPDC's Structure and its Effects on Customer Satisfaction

We first estimate an unconstrained structural equation model in which the measurement model (i.e., the factor structure) and structural equation (i.e., the effects of each factor on the dependent variable, customer satisfaction) is allowed to vary across the latent classes. We expect that the structure of the factor loadings (i.e. the way in which a car's various observed features load onto the three design elements) would differ across the latent classes. Recall that such heterogeneity is a fundamental thesis of our framework. To test whether the measurement models are identical across the latent classes, we also estimated nested constrained models (Muthén 2008), where we checked for: i) configural invariance (equality of covariance matrices across the latent classes), ii) metric invariance (equality of factor loadings of the same items across the latent classes), and iii) scalar invariance (equality of the intercepts across the latent classes).

For all estimated models, we included two covariates (the number of problems encountered and the vehicle's price) and four customer demographics (age, gender, household

income and education) in the model relating the TPDC's design elements to customer satisfaction.

With respect to the unconstrained model (i.e., allowing for measurement variance across the latent segments), the 3-segment model (with entropy = .942) outperformed the models with 1, 2, and 4 segments based on the Bayesian Information Criterion. BIC is 2,456,654 for the 1-segment model, 1,800,375 for the 2-segment model, 1,777,307 for the 3-segment model, and 1,799,612 for the 4-segment model respectively. This support for the model indicates configural invariance of the measurement model. Segment 1 has 33,835 respondents (71% of the population), Segment 2 has 11,564 respondents (24%), and Segment 3 has 2,486 respondents (5%). We summarize the results of the 3-segment structural equation model in Table 1.

Next, for the selected 3-segment model, we estimated two constrained models. First, we examined metric invariance and found that the difference in model fit for the constrained model (equality of factor loadings of the same items across the latent classes) and unconstrained model was significant, and thus the null hypothesis that the regression slopes relating the latent factors to the observed variables were equal for each group can be rejected ($\Delta\chi^2_{(12)} = 23.013, p < .028$). Second, we examined scalar invariance (equality of intercepts across the latent classes and equality of factor loading). Again, the difference in Chi-square between the constrained and unconstrained models was marginally statistically significant ($\Delta\chi^2_{(24)} = 35.908, p < .056$), suggesting the lack of scalar invariance. Collectively, our results imply that the three-factor structure holds across the three latent classes (i.e., all three segments view design as consisting of three elements). However, with metric and scalar variance across the groups, the factor means and loadings differ across the latent segments.

Overall, the results support our expectation of heterogeneity in the mapping of the product characteristics on to the three design elements (Measurement Model) and in the effects of the three design elements on customer satisfaction (Structure Model), which we next discuss.

---- Insert Table 1 here ----

The Mapping of Product Characteristics onto Design Elements (Measurement Model).

Based on Wald tests of comparisons of the parameter estimates (which compares the standardized coefficient estimates) of the relative loadings of product characteristics on the design elements, for customers in Segment 1 (Column 2 of Table 1), the vehicle's driving dynamics, engineering transmission, seating, and air-conditioning mapped more strongly to the functionality design element than its fuel efficiency (all statistically significant at $p < .01$). The vehicle's distinctiveness mapped more strongly on to the meaning design element than did its sturdiness ($p < .01$).

For customers in Segment 2 (Column 3 of Table 1), the vehicle's driving dynamics, engineering transmission, seating, and air-conditioning mapped more strongly on to functionality than its fuel efficiency ($p < .01$). With respect to aesthetics, the vehicle's interior loaded more strongly onto the aesthetics design element than the vehicle's exterior ($p < .01$), while the vehicle's sturdiness mapped more strongly on to the meaning design element than its distinctiveness ($p < .01$).

For customers in Segment 3 (Column 4 of Table 1), the vehicle's fuel efficiency, engineering transmission, seating, and air-conditioning, and audio system, mapped more strongly on to functionality than its driving dynamics ($p < .01$). With respect to aesthetics, as in segment 2, the vehicle's interior again more strongly loaded onto aesthetics than on to its exterior ($p < .01$). Unlike Segment 1, however, sturdiness of the vehicle mapped more strongly on to

meaning than its distinctiveness ($p < .01$). Collectively, the results from the three segments suggest significant heterogeneity in the mapping of product characteristics onto the design elements.

The Effects of Design Elements on Customer Satisfaction (Structure Model). With respect to the effects of design elements on customer satisfaction, functionality is the most important design element for customers in Segment 1 ($b = 0.455$, $p < .01$ compared to $b = 0.383$, $p < .01$ for aesthetics and $b = 0.162$, $p < .01$ for meaning), which are all significantly different from each other at $p < .01$. Meaning is the most important design element for customers in Segment 2 ($b = 1.641$ compared to $b = 0.982$ for functionality and $b = -0.516$ for aesthetics) and for customers in Segment 3 ($b = 0.593$ for meaning compared to $b = 0.265$ for functionality and $b = 0.235$ for aesthetics). We discuss the negative coefficient for the effect of aesthetics on customer satisfaction for customers in Segment 2 below, where we integrate these results with the profiles of customers in the three segments.

Profiling the Three Customer Segments. Next, we integrate segment profiles (Table 2) with the factor loading model and regression results (Table 1). Customers in Segment 1 (71%), have somewhat higher average incomes compared to segments 2 and 3, were generally satisfied with their vehicles (mean = 8.76) and had experienced the fewest problems with their vehicles (mean = 1.02). These customers seek reliable, and aesthetically-pleasing, non-American vehicles.

---- Insert Table 2 here ----

With respect to the relationships between the three design elements and customer satisfaction, aesthetics is positively related to customer satisfaction for customers in Segment 1. However, the effects of functionality on satisfaction are higher than the effects of aesthetics ($p <$

.01) and meaning ($p < .01$), although aesthetics still has a relatively strong influence on satisfaction (compared to functionality) in Segment 1 when compared to the other two segments. Thus, for this large group of customers (71%), excellent functionality and aesthetics are important.

Customers in Segment 2 (24%), who had somewhat lower average incomes than customers in Segment 1, were less satisfied with their vehicles (mean rating = 6.68 on a 10-point scale) and reported the most number of problems with their vehicles (mean = 2.24). These customers seek lower-priced vehicles, which may, post facto, explain their lower satisfaction with their vehicles. Note the strong impact of meaning ($b = 1.641$) relative to functionality and meaning for customers in this segment. The negative effect of the vehicle's aesthetics on customer satisfaction in Segment 2 is surprising. We conjecture that customers in this segment who prefer traditional style, sturdy vehicles may view aesthetics in their vehicles as an unnecessary frill that only increases the price of the vehicle.

Customers in Segment 3 (5%), who had the lowest average incomes among the three segments, were very satisfied with their vehicles (mean rating = 9.31 on a 10-point scale). Thus, customers in Segment 3 who seek reliable, mainstream, middle of the road vehicles, appear to value meaning most followed by functionality and aesthetics.

Robustness of Results to Sample. To test the robustness and sensitivity of our results to the specific sample of customers and products, we randomly removed 10% of the data and re-estimated the model; following that procedure we obtained results consistent with those reported in Table 1.

Then we eliminated brands whose price exceeded \$40,000 and re-estimated the model (there are a several small and expensive vehicles that could be outliers and might influence the

segment structure). We obtained essentially the same segment structure reported in Table 1, suggesting that the results are robust to sample variations.

Overall, the results of this empirical illustration in the US auto industry provide support for the TPDC. Our test of the dimensionality of the framework supports the existence of three design elements. Our demonstration of the three customer segments solution demonstrates customer heterogeneity in the mapping of product characteristics on to the three design elements as well as their differential effects on customer satisfaction.

DISCUSSION

We develop a useful framework to understand the role and effects of an integrated product design template. The empirical application of the TPDC to the US auto market supported the three-design element conceptualization, and heterogeneity in its structure and effects on customer satisfaction.

Theoretical Contributions

Although there has been recognition of the potential for product design to generate innovation rents, there has been little research that has explored the strategic implications of integrated design decisions in new product development. Consumers do not buy products purely for utilitarian reasons; thus, functionality, by itself, is often not sufficient for successful differentiation in today's competitive markets (Bloch 1995). Our research answers Veryzer's (1995; p. 642) call to adopt a conceptualization of design that acknowledges the different aspects of product design (i.e., functional, communicative, and aesthetics) by introducing and empirically testing the Total Product Design Concept (TPDC). Below, we discuss this paper's contributions to the new product design and development literature.

An expanded view of product design to include functionality, aesthetics and meaning. Our three dimensional conceptualization of the TPDC incorporates functionality, aesthetics, and meaning and our empirical findings from the US automotive industry support the TPDC's conceptualization. We show that a product's aesthetics and meaning play a central role in affecting customer satisfaction with the product. Our identification of the design element of meaning (arising from the product's various marketing mix elements e.g., branding and advertising strategies) represents a departure from past work (e.g., Bloch, Brunel and Arnold 2003; Chitturi, Raghunathan and Mahajan 2007; 2008) which have focused on functionality and aesthetics.

An expanded view of product design to include customers and competition. Our customer-centric conceptualization suggests that the firm's marketing mix strategy (e.g., pricing, communications) is integral to product design, at least through the TPDC's meaning dimension. In addition, our framework implicitly includes a product's competitive position. Given the dynamic nature of customers and competition, an implication of our work is that a product's TPDC is fluid may evolve over time.

Heterogeneity in how product design influences customer experience. In our illustrative application, we find that the effects of product characteristics on a design element and the effects of the three design elements on customer satisfaction vary across customer-segments. Indeed, we find that even the importance of various product characteristics (e.g., fuel efficiency, driving dynamics) in defining a design element (e.g., functionality) varies across segments. These findings extend past research on product design, which has not explored such heterogeneity.

Managerial Implications

Product design means different things to different consumers. Our finding of three latent segments suggests heterogeneity in terms of how different groups of consumers interpret product design, and its effects on customer satisfaction. Note, however, that all three segments perceive design in terms of the three design elements, namely, functionality, aesthetics, and meaning. At the same time, we find that the effects of product design on customer satisfaction differ across the three “design” segments. Indeed, in some segments, meaning has a stronger effect than functionality on customer satisfaction, showing that there is no hierarchy or dominance in the effect of either one of TPDC’s three elements on customer experience. Customer heterogeneity in the structure of product design and its effects on customer satisfaction suggest that the effects of product design are beyond the control of firms, who must view themselves, at best, as co-owners of the product design process.

Product design should involve both the firm’s new product developers and marketers. In most firms, each TPDC element is developed, owned, and managed by a different organizational unit or function. A product’s functionality may be the engineering function’s domain, while aesthetics belongs to the industrial design function, and meaning is managed by the marketing function. Moreover, the three design elements are often developed at different times in the product’s evolution: the development of a product’s functionality and aesthetics typically preceding the development of its meaning. Hence, there is an opportunity for firms to look beyond functionality and incorporate aesthetics and meaning in their products.

Product design involves customers and is co-created by the firm and its customers. The customer-based perspective underlying the TPDC suggests that product design emerges from the firm’s new product development efforts and marketing activities (i.e., packaging, advertising,

distribution, etc.) *and* the tastes, preferences, and actions of its customers. This perspective underscores the importance of recognizing heterogeneity in the effects of product design on customer experience.

The important role of customers in the creation of a product's total design, suggests both opportunities and constraints for firms in the design of products. Firms that actively engage their customers in the design of products could potentially increase their differentiation from competitors and realize design innovation rents, relative to when they are excluded from this process. However, such deeper engagements would also result in a loss of control (Prahalad and Ramaswamy 2004), which must be vigilantly managed.

Product design is a source of innovation rents. The TPDC suggests that in addition to functionality, a product's aesthetics and meaning, differentiate a firm's offerings, and influence customer satisfaction, hence providing opportunities for appropriation of economic rents via design decisions. Unlike differentiation based on functionality, differentiation based on aesthetic or meaning design elements may be less imitable by competitors.

For example, while other multimedia players share the Apple iPod's functionality, the iPod's distinctive design, combining its outstanding functionality with aesthetics and meaning, is resistant to competitive imitation, increasing revenues, price premiums, and customer loyalty (Business Week, March 21, 2005). Companies that conceptualize and execute product design programs that follow the proposed TPDC approach (i.e., paying attention to all three design elements, and recognizing that customers in distinct segments value the design elements differently), can expect their products to appeal to customers and generate superior rents and/or create higher barriers to imitation.

Firms should consider the benefit of a TPDC Audit. A dynamic view of the TPDC underscores the importance of continuous product development, extending beyond the product's introduction. Careful monitoring systems, flexible and functionally integrated product development teams, and ongoing product management processes are needed not only to manage the dynamics in product design across consumers and over time, but also to capitalize on those dynamics as sources of innovation rents.

The TPDC can generate new marketing insights and implications. Our empirical application suggested that some premium cars like BMW, Porsche and Audi appeal to the majority, possibly a key to their success—although premium priced, they generate profitable sales volume by appealing to a majority. Others (Hummer and Chevy Monte Carlo e.g.) sell in small volumes to all segments. It seems that these latter cars rate sufficiently highly for a small number of customers in each of the design segments. Hence, the TPDC approach can provide insight into multiple design success paths in the market.

Also, study of product design in the US automotive market is worthy of empirical investigation in its own right as the US automotive industry is a significant, vital force in the U.S. economy with downstream and upstream effects on several industries. The Big Three US automotive companies (General Motors, Ford and Chrysler) face special challenges with declining sales over several decades. Our framework and the specific findings for each of the three segments should be useful for automakers seeking to develop better marketing programs for their existing vehicles.

Research Opportunities

Our TPDC concept suggests various research opportunities.

Mapping Product Characteristics onto Design Elements. The TPDC adopts an integrated approach to product design, incorporating aesthetics and meaning in addition to the traditional focus on products' functionality. From a firm's perspective, an important question that emerges from this extended conceptualization of product design is: How do the product characteristics in different products map onto the design elements of functionality, aesthetics, and meaning?

A firm that adopts the integrated TPDC approach might have to change its new product management processes. But such a change is risky if the performance implications of the adoption of an integrated TPDC approach are unknown. What are the magnitudes of the performance rewards for a product developed using a TPDC approach? Are the rewards for a TPDC approach different across product categories, or across segments in a product category, or across firms, or over time for a given product? Are some organizational or product management team characteristics more or less likely to result in a TPDC approach to product development? An interesting question is how marketing mix elements (e.g., price, promotion, and place) affect the rewards accruing to a TPDC approach to product design. What are the benefits of a firm's integrated TPDC approach for all its products on firm performance outcomes, including sales growth, profitability, and shareholder value?

We developed the TPDC and the related propositions in the context of physical goods. Does the TPDC concept also apply to services? Exclusive country clubs and living communities are examples of services where many of these concepts may apply directly. We see an opportunity to integrate the TPDC with the idea of "total customer experience" (Berry, Carbone, and Haeckel 2002) for the design and management of services.

Another question is whether the nature of customers' responses to the three design elements differs. For example, does functionality produce cognitive responses, while aesthetics and meaning produce affective responses? Or do the TPDC's elements blend together to produce an integrated customer response? The available data do not permit us to address these questions. Future research that examines the inter-relationships among the design elements and the inter-play of cognitive and affective responses to products will be useful.

Do the effects of the TPDC's design elements change as customers' experiences with the product change? For example, does the domain of the design elements (i.e. the mapping of the different product characteristics onto the design elements) differ when customers initially choose a product versus after they have used the product for some time? Customer panels with data that includes data prior to, during, and post-product purchase of other products would be useful for undertaking such a program of research.

The expanded and integrated approach to new product design processes suggested by our research has implications for a product's market performance: What is the nature and magnitude of performance rewards for a product developed using the proposed TPDC approach? Are the rewards for a TPDC approach different across product categories, or across segments in a product category, or across firms, or over time for a given product? Are some organizational or product management team characteristics more or less likely to result in a TPDC approach to product development?

The data collected by J.D. Power and Associates via the Vehicle Quality Survey (VQS) in the US automotive market provided us an opportunity to illustrate our proposed TPDC framework. However, the data set we use pertains only to the U.S. automobile market. Future research that explores the TPDC with custom-design methods to more accurately capture the

three design elements in other product categories and relates them to different outcome variables, across other products and markets, including in Europe and Asia, will be insightful.

On net, we hope that we have contributed in a meaningful way to product design theory, and that the proposed TPDC approach to product design will help managers reconceive and develop strategies that profitably leverage their investment in products design.

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APPENDIX A1

J.D. Power and Associates Customer Satisfaction Index Methodology

The *J.D. Power and Associates Automotive Performance, Execution and Layout (APEAL)SM* Index is an industry benchmark for measuring the appeal of new vehicles and owner satisfaction and is derived using data from the VQS study. The overall index score measures how much customers like or dislike virtually every aspect of their new vehicle, with the objective of helping vehicle manufacturers identify specific design aspects of the vehicle on which they should focus their efforts.

The VQS study covers 95 characteristics covering power train, exterior and interior design, seats, audio/entertainment/navigation, and convenience features. The J.D. Power and Associates index models assume that the attribute variables predicting overall satisfaction are grouped into sub-categories. These categories were determined based on both J.D. Power and Associates industry-related knowledge of what produces customer satisfaction with new vehicles during the first 90 days of ownership. Factor analysis was used in the early stages of the development of the Index to determine how the characteristics should be grouped into categories and to eliminate items that had a poor fit within the subcategory or were redundant with other items. Based on this technique, the VQS APEAL Index Model is based on 10 subcategories. The 10 subcategories are: Storage and space, Driving dynamics, Fuel efficiency, Engineering/transmission, Seating, Safety, Heating, ventilation, air conditioning, and Audio system, Exterior and Interior.

In the APEAL Index Model, each subcategory includes an overall rating item for that category. Further, the questionnaire is organized so that all items within a category are grouped together and are followed by the overall rating item for that category. For example, the overall rating in the Engine/transmission subcategory, respondents are asked with one question, “Overall rating of the vehicle’s engine/transmission.” At the individual attribute level, the model contains more detailed information related to specific engine and transmission characteristics, such as “Performance during rapid acceleration from a stop.”

APPENDIX A2
Measures: Vehicle Quality Survey (VQS)

Construct (Mean; standard deviation)	Item(s)*
Customer Experience Customer Satisfaction (mean = 8.24, standard deviation (sd) = 1.63)	Taking into consideration all aspects of your vehicle, please rate your overall satisfaction with your new vehicle
Functionality	
Storage and Space (mean = 7.83, sd = 1.85)	Storage and space usage Ease of getting in/out of the vehicle Front seat head room/leg room/foot room Rear passenger head room/leg room/foot room Effectiveness of center console storage Location/arrangement of storage spaces Amount of trunk/cargo area space
Driving Dynamics (mean = 7.98, sd = 1.68)	Ride smoothness in normal driving Quietness over harsh bumps Responsiveness/effort of steering system Braking responsiveness/effort Handling/stability on curves or winding roads Handling/stability in adverse conditions
Fuel Efficiency (mean = 6.72, sd = 2.18)	Fuel economy
Audio system (mean = 7.57, sd = 1.78)	Ease of operating controls while driving Ease to see/read audio systems displays Ability to play the formats I want (CD, MP3, DVD Audio)
Engineering/Transmission (mean = 7.80, sd = 1.80)	Performance during rapid acceleration from stop Sound of engine/exhaust during rapid acceleration Passing power at high speeds Smoothness of gear shift operation Rating of vehicle's fuel economy (mpg) Driving range between fuel stops
Safety (mean = 7.86, sd = 1.98)	Forward visibility from the driver's seat Effectiveness of the sun's visors Effectiveness of headlights How well the front wipers/washers clear the windshield Visibility when changing lanes Ease of judging distances when parking

*(All vehicle related items rated on a 10 point scale from Unacceptable (1) – Truly exceptional (10)

APPENDIX A2
Measures: Vehicle Quality Survey (VQS) (contd.)

Construct (Mean; standard deviation)	Item(s)
Seating (mean = 7.64 standard deviation (sd) = 1.63)	Seat belt comfort and adjustability Styling of the seats Seating material conveys an impression of high quality Ability of seat surfaces to resist soil/lint Flexibility of seating configurations
Heating, Ventilation and Air Conditioning (mean = 7.74, sd = 1.73)	Ability to detect airflow where you want it System's ability to maintain desired temperature Controls convey an impression of high quality Quietness of the Heater/AC fan Ability to seal off interior from outside odors/pollutants Ease of operating heating/AC controls while driving How well the system defrosts/defogs the interior glass
Aesthetics	
Exterior (mean = 8.40, sd = 1.97)	Front-end styling (headlights/grille area) Side-profile appearance and styling Rear-end styling (taillight and trunk area) Appearance of the wheels, rims and tires Appearance of exterior paint (e.g. quality, evenness)
Interior (mean = 7.99, sd = 1.96)	How well the exterior and interior colors are coordinated Attractiveness of instrument panel and dashboard Look and feel of steering wheel Ability to rest arms comfortably when driving Interior materials convey an impression of high quality How well interior colors/materials are coordinated Appearance/illumination of gauges/controls Overall interior quietness Pleasantness of audible signals (e.g. chimes, turn signals) Usefulness of courtesy lights Attractiveness of interior lighting
Meaning	
Distinctiveness (factor score) (semantic differential scale 1- 5)	(factor loadings, all cross factor loadings below .28) Elegant – unrefined (.88) Innovative – conventional (.61) Stands out - Blends in (.56) Luxurious - no frills (.92) Prestigious – common (.91)
Sturdiness (factor score) (semantic differential scale 1- 5)	Rugged – fragile (.81) Reliable – unreliable (.74)

APPENDIX A2
Items Measures: Vehicle Quality Survey (VQS) (contd.)

Construct (Mean; standard deviation)	Item(s)
Covariates for Customer Satisfaction Model	
Problems Encountered (mean=1.33, standard deviation (sd)=1.97)	Total number of problems in functioning (broken, not working) and in design of feature
Price (\$) (mean = 31,173, sd =13216)	-
Income (mean =8.37, sd = 3.92)	1-16 scaled variable
Age (mean = 50.1, sd=14.66)	-
Education (77% college educated)	0/1 (College educated)
Gender (60% male)	0/1 (Male)
Profiling Variables for Latent Segments	
Preferences for Vehicles (factor score – 4 items from 11 items)	<p>Status and Style (factor loadings)</p> <p>I want a vehicle that stands out from the crowd (.79)</p> <p>When I buy a vehicle, I want the best in its class (.63)</p> <p>Styling and design are very important (.81)</p> <p>Brand name is very important (.64)</p> <p>Economy and Safety</p> <p>Fuel economy is important (.81)</p> <p>I would prefer an environmentally friendly vehicle (.82)</p> <p>To me, safety is more important than styling (.54)</p> <p>Conservativeness</p> <p>I would never buy a vehicle the first year it comes out (.61)</p> <p>I tend to prefer larger vehicles (.69)</p> <p>American-centric</p> <p>I like to buy American (.76)</p> <p>I will tolerate some problems if I get the performance I want (.77)</p>
Motivations to Buy Vehicle (factor score – 5 factors from 11 items)	<p>Comfort</p> <p>Interior comfort (.57)</p> <p>Exterior styling (.78)</p> <p>Reliability</p> <p>Quality of workmanship (.62)</p> <p>Reliability/durability (.77)</p> <p>Large vehicle</p> <p>Passenger capacity (.74)</p> <p>Cargo capacity (.75)</p> <p>Environmental consciousness</p> <p>Environmental impact (.77)</p> <p>Gas mileage (.74)</p> <p>Value consciousness</p> <p>Low price or payment/ability to obtain financing (.72)</p> <p>Safety (.68)</p>

APPENDIX A3

Outline of Finite Mixture Structural Equation Model

Modeling Framework

We specify a finite-mixture structural equation model for estimation. This model allows for unobserved heterogeneity (latent segments) among consumers in terms of how the various car attributes map onto the three design elements and in how the three design elements influence satisfaction with the make-models of their cars. The model incorporates random intercepts to account for unobserved differences in how each make-model is perceived, on average, by consumers within each latent segment.

Let s be an index to denote membership in an unobserved segment ($s = 1, \dots, S$) and ξ^s denote a (3×1) vector of exogenous latent variables (namely, the three design elements of functionality, aesthetics and meaning). Let x_m/s denote a $(p \times 1)$ vector of observable indicator variables measuring ξ^s for car model m and let y_m denote the observed endogenous variable, customer satisfaction with the car. Strictly speaking, m should be further indexed by i to denote that customer i evaluated car model m . However, we suppress i to simplify notation except when we need to make this explicit. Then, following Jedidi, Jagpal, and DeSarbo (1997), we can specify the measurement model for the exogenous latent variable ξ^s as follows:

$$x_m | s = \nu_{x_m}^s + \Lambda_{x_m}^s \xi^s + \varepsilon^s \quad (\text{A3.1})$$

Where $\Lambda_{x_m}^s$ is a $(p \times 3)$ is a coefficient matrix of factor loadings, $\nu_{x_m}^s$ is a $(p \times 1)$ vector of the measurement intercept terms, and ε^s is the vector of measurement error in $x_m | s$. Let

$E(\xi^s) = \tau_{\xi^s}^s$, $E[(\xi^s - \tau_{\xi^s}^s)(\xi^s - \tau_{\xi^s}^s)'] = \Phi^s$, $E(\varepsilon^s \varepsilon^{s'}) = \Theta_{\varepsilon^s}^s$. We assume that $E(\varepsilon^s) = 0$, and that the vectors of measurement errors are uncorrelated with the vector of latent variables. Although our measurement model includes two latent constructs, each measured with just two indicators, the model is nevertheless identified because we allow all latent constructs to be correlated (see Figure 3). Note also that we do not specify a measurement model for y_m because it is measured using a single indicator.

Our structural model defines the hypothesized relationship of customers' satisfaction with their vehicle (the dependent variable) and the exogenous latent variables (the three design elements) and several control variables (Z), defined as:

$$y_m | s, z = \gamma_m^s + (\Gamma^s)' \xi^s + (\Omega^s)' Z + \zeta^s \quad (\text{A3.2})$$

Γ^s is a (3×1) vector of parameters that specify the relationship between the exogenous latent variables and y_m in segment s , and Ω^s is a $(r \times 1)$ vector of parameters that specify the relationship between r observed control variables Z and y_m in segment s , and ζ^s is the error term specified in more detail below. One way to specify the intercepts, γ_m^s , would be as fixed effects (using dummy variables). However, there are too many car models to

make it feasible to estimate a model with many dummy variables. Instead, γ_m^s are random effects that capture mean differences in satisfaction among the car models in each latent segment s – that is, each make-model is assumed to be drawn from a probability distribution for the mean satisfaction levels for a population of make-models.³ There are several ways to specify the probability model for the random effects; we use the non-parametric approach (Henry and Muthén, 2010).

The probability that a consumer who has a specific make-model will belong to a particular latent class is determined by a mixing distribution. Let π_s be the mixing proportions in the structural equation model in A3.1 and A3.2 that specify the probability of a consumer belonging to latent class or market segment s (or, equivalently, π_s is the segment proportion in the population). $\sum_{s=1}^S \pi_s = 1$ and $0 \leq \pi_s \leq 1$. We have suppressed the notation i to represent the customer. We assume that the density of $y, f(y/\pi, \theta)$, is a mixture of S class-specific densities, $f_s(y/\theta_s)$. That is:

$$f(y/\theta) = \sum_{s=1}^S \pi_s f_s(\theta_s) \quad (\text{A3.3})$$

where θ denotes all unknown parameters of the measurement and structural models, and θ_s is the subset of the unknown parameters that apply to segment s . We assume $f_s(\cdot)$ to be multivariate normal with 0 mean conditional on class membership and the covariates, i.e., ζ^s is $N(0, \Psi_s)$. We allow the correlations between the three latent constructs of functionality, aesthetics and meaning to be non-zero.

We estimate the finite mixture SEM model using MPlus software (Version 4.2). Parameter estimates are obtained by maximizing likelihood via the EM algorithm (Muthen 2002). To determine the number of latent segments, we use the Bayesian Information Criterion (BIC) (Schwarz 1978) to compare the model with s segments with a model with $s+1$ segments $\forall s = 1, 2, \dots$ until the model fit stops improving. We also report an entropy measure of separation (ES), the extent of separation of the segments which is calculated as:

$$ES = 1 - \frac{\sum_{i=1}^I \sum_{s=1}^S p_{is} \ln(p_{is})}{N \ln(S)} \quad (\text{A3.4})$$

where p_{is} is the posterior probability of customer i belonging to segment s , which is calculated using the Bayes rule. ES is bounded in the range 0 to 1, such that a value closer to 1 indicates good separation of the latent segments. For purposes of classification, each customer is assigned to the segment to which s/he has the highest posterior probability of belonging.

³ While we could have specified a two-level model where γ_m^s is a function of several make-model covariates and an error term, our structural model (equation A3.2) already includes most of the variables about each make-model, and a second level would add little explanatory value in our model.

TABLE 1
TWO-STAGE MODEL OF PRODUCT CHARACTERISTICS, TPDC'S DESIGN
ELEMENTS AND CUSTOMER SATISFACTION (N=47, 885)

Variable	Aggregate Column 1	Segment 1 Column 2	Segment 2 Column 3	Segment 3 Column 4
Mapping of Product Characteristics on Design Elements (Measurement Model)				
Functionality				
Dynamics	1.000	1.000	1.000	1.000
Fuel efficiency	.953***	.956***	.923***	1.284***
Engineering transmission	1.051***	1.012***	1.138***	1.432***
Seating	1.022***	.993***	1.045***	1.454***
Air-conditioning	1.058***	1.037**	1.142***	1.590***
Aesthetics				
Exterior	1.000	1.000	1.000	1.000
Interior	1.148***	1.083***	1.352***	1.787***
Meaning				
Distinctiveness	1.000	1.000	1.000	1.000
Sturdiness	.734***	0.554***	1.018***	3.712***
Satisfaction: Effects of Design Elements (Structural Model)				
Functionality	.532***	.455***	.982***	.265***
Aesthetics	.341***	.383***	-.516***	.235***
Meaning	.299***	.162***	1.641***	.593***
Covariates				
Problems Encountered	-.034***	-.029***	-.053***	-.028***
Vehicle Price (\$)	-.002 (ns)	-.001*	-.002***	.000 (ns)
Income	.002(ns)	.002*	-.004*	-.014***
Age	-.004 (ns)	-.006***	-.008***	.001 (ns)
Gender	-.009 (ns)	.004 (ns)	.006 (ns)	-.118***
Education	.003 (ns)	.058***	-.023 (ns)	-.148***
Segment Size (No, of respondents)	-	33,835	11,564	2,486
Segment Size (Proportion)		(.71)	(.24)	(.05)
Entropy of separation for 3-segment model			0.942	

*** denotes $p < .01$, ** $p < .05$ and * $p < .10$.

TABLE 2
TPDC AND CUSTOMER SATISFACTION

Profile	Segment 1	Segment 2	Segment 3
Size	Majority (71%)	One-fourth of customers (24%)	Very few (5%)
Make-models that have disproportionately higher number of purchases in the segment (compared to other segments)	Infiniti M Series, Acura TL, Honda Odyssey, Audi 4 Door Sedan, Porsche Cayman, BMW 3 Series	Ford Ranger, Kia Optima, Mercury Grand Marquis, Hyundai Elantra Sedan, Kia Spectra Sedan, Chrysler Sebring Sedan, Chevy Uplander, Pontiac Montana SV6, GMC Savana Cargo	Toyota Tacoma, Toyota Corolla, Volkswagen Jetta, Volkswagen Passat, Volkswagen Beetle, Scion XB, Subaru Outback, Chevy Impala, Pontiac G6 Sedan, Pontiac Torrent
Make-models that have disproportionately fewer purchases in the segment (compared to other segments)	Suzuki Aero SX, Suzuki Forenza, Suzuki Grand Vitara, Saab 9, Dodge Durango, Dodge Dakota, Pontiac Vibe, Scion XA, Jeep Wrangler	Toyota Tacoma, Lincoln Zephyr, Mazda 5, Toyota Prius	Ford Freestyle, Mercury Milan, Infiniti G35 Coupe, Ford Escape, Nissan Quest, Toyota Camry
How satisfied are they with their vehicle?	Moderate (8.76)	Low (6.68)	High (9.31)
Problems with their vehicle	1.02	2.24	1.15
Average vehicle price	31,912	28,746	29,632
Average income	High	Average	Low
Average age	49.9	50.1	55.2
% with College education	78	75	61
% with Children	68	72	61
What they look for in vehicles?	Aesthetically pleasing non-American vehicles	Traditional style, sturdy vehicles	Mainstream, middle-of-the-road vehicles

Notes: Make models that had roughly equal penetration in all three segments include the following: Honda Civic Sedan, Mazda 6 Sedan, Nissan Titan, Ford Tundra, Hyundai Sonata, Chevy Monte Carlo, Hummer.

FIGURE 1
ILLUSTRATING THE TPDC: HERMAN MILLER'S AERON CHAIR

Functionality

- Synthetic, breathable weave of Dymetrol for greater comfort.
- Metal frame and adjustable hand rest strongly supports body.
- Controls to move chair easily placed
- All features aimed to increase comfort and lower work-related injuries.



Aesthetics

- Transparent weave of seat pan and backrest provides light, simple look.
- Frame in dark gray provides elegant, skeletal look.

Meaning

- Different size chairs based on size of person, not hierarchy – supporting a flat, horizontal organization
- The informal, sleek look emphasizes individual comfort over conformity and rigidity associated with work-life, in general and other office furniture, more particularly.

FIGURE 2
CONCEPTUAL FRAMEWORK: TPDC AND CUSTOMER EXPERIENCE

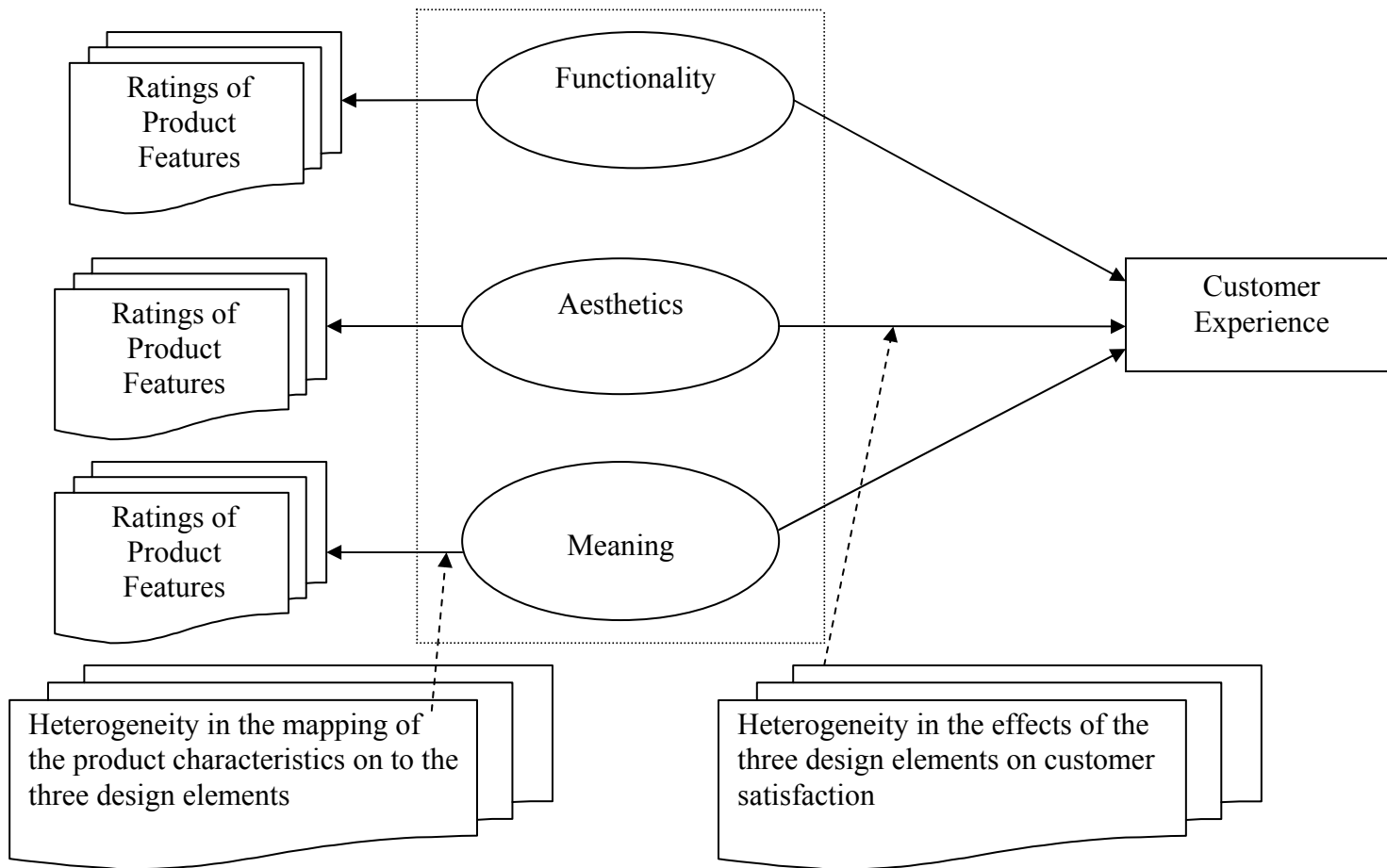


FIGURE 3
MODEL SPECIFICATION

