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Technology versus Design Innovation's Effects on Sales and Tobin's Q: The Moderating Role of Branding Strategy

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This research investigates the impacts on firm performance of (1) technology versus design innovation and (2) their potentially synergistic interaction. Synergies could arise from complementarities, in particular the utilization of technology innovation as a platform for design innovations. Both sales and Tobin's q are examined as dependent performance variables, with sales tapping consumer responses and Tobin's q reflecting investor responses. Moderation by branding strategy (i.e., Corporate Branding versus Mixed Branding versus House of Brands) is analyzed because innovation may impact performance differently depending on branding strategy. Advertising effects, the number of new product introductions, their interaction, R&D expenditures, operating margins, and firm size are also modeled as covariates. The results show that all main and interaction effects are significant in at least one of the branding groups, and that moderation of model paths by branding strategy was pervasive.

Overall, except for technology innovation → Tobin's q, Corporate Branding coefficients for technology innovation, design innovation, and their interaction were almost always significantly different *from Mixed Branding and House of Brands coefficients,* which were not significantly different from each other. *Since Mixed Branding and House of Brands proved very similar, these groups were combined under "Non-Corporate." First,* for technology innovation*, the impact on both sales and Tobin's q for Corporate Branding was less than or equal to Noncorporate. Noteworthy was that the technology innovation → Tobin's q relationship was* equal across all branding strategies*; technology innovation appears to be key for investors. Second,* for design innovation*, the impact for Corporate Branding was positive while for Noncorporate it was null; the same pattern was observed for sales and Tobin's q. Third,* for the interaction*, the impact for Corporate Branding was significantly less than the positive impacts for Noncorporate. For Noncorporate, the* marginal *impact of design innovation on sales or Tobin's q* increased with the level of technology innovation*. For Corporate Branding however, there was no interaction in the case of sales and a negative interaction for Tobin's q. Thus, the* marginal *impact of design innovation on Tobin's q* decreased with increasing levels of technology innovation*. These decreasing marginal effects could reflect limits to corporate brand name extensions, as perceived by investors.*

Introduction

Firms can create new products in two broad ways: technology innovation or design innovation (Verganti, 2006). A design innovation is one in which novel external appearance prevails over novel functionality or technology (Eisenman, 2009; Rindova and Petkova, 2007; Talke, Salomo, Wieringa, and Lutz, 2009). Some analysts have declared the 21st century "the age of aesthetics" (Postrel, 2003), but innovation research still mostly focuses on "technology" innovation (Verganti, 2006). Only recently has the importance of product form beyond function been recognized (Chitturi, Raghunathan, and Mahajan, 2007, 2008; Orth and Malkewitz, 2008) and the issue of design innovation addressed (Talke et al., 2009). The current research addresses this gap in the literature by focusing on the following important questions: What is the impact of design innovation versus technology innovation on firm performance? What is the impact of their potentially synergistic interaction?

These questions have managerial relevance not only because resource allocation should be guided by firm performance impact but also because synergistic interaction could arise from the utilization of technology innovation *as a platform* for design innovations and because design innovations can be used to create multiple layers of design patents *to protect the core function intellectual property*. Also, design innovations can be used to help consumers realize the benefits of technology. Thus, the complementarities of technology and design innovations could have marginal impact in enhancing firm perfor-

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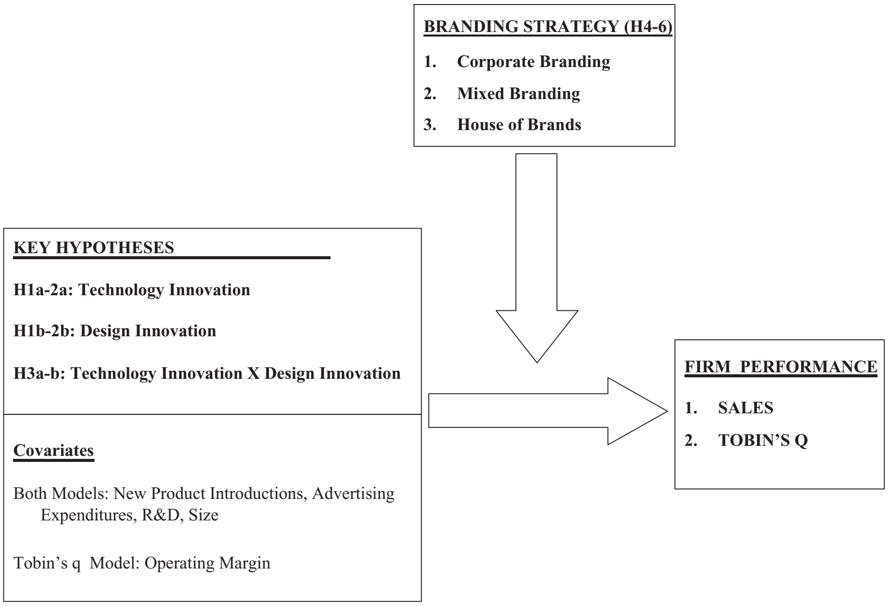

Figure 1. Research Framework for the Investigation of Firm Performance in Sales versus Tobin's Q

mance *in addition to* the value of technology versus design innovation separately; i.e., design and technology synergistically interact.

This article tests the main and interaction effects of technology versus design innovations on sales and Tobin's q, which measure firm performance by tapping consumer and investor responses, respectively. Thus, two models are examined separately, one with sales and one with Tobin's q as dependent variable; both models have the hypothesized main and interaction effects of technology versus design innovations as independent variables; and both models include relevant covariates such as advertising expenditures, R&D expenditures, and firm size.

BIOGRAPHICAL SKETCHES

Dr. Gaia Rubera is Associate Professor of Marketing at Bocconi University. Her research interests focus on design innovation, creativity, new product development, and marketing strategy. Her work has been published in various academic journals including *Journal of Marketing*, *Journal of Business Studies*, *Journal of Product Innovation Management*, *Journal of Service Research*, and others.

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This article also explores moderation of model paths contingent on branding strategy as originally defined by Laforet and Saunders (1994; see also Rao, Agarwal, and Dahlhoff, 2004): Corporate Branding versus Mixed Branding versus House of Brands. Strategic decisions about type of branding strategy may determine the economic value of innovations (Rao et al., 2004); i.e., branding strategies may yield differential impacts of technology versus design innovation and their interaction. Thus, this article explores how one key strategic marketing decision influences the degree of impact of technology versus design innovations on consumer versus investor response.

Determinants of Firm Performance: The Role of Innovation

An Overview of the Firm Performance Models: Sales versus Tobin's q

This research investigates separate models of sales and Tobin's q, both indicators of firm performance (Figure 1). Traditionally, much marketing literature focuses on consumer responses; sales represent the firm performance variable that reflects consumer response in this article. In the last decade, researchers have also investigated investor responses, which are generally motivated by cash flow expectations (see Special Issue of *Journal of Marketing*, 2009; Rao et al., 2004; Srinivasan and Hanssens, 2009; Srinivasan, Pauwels, Silva-Risso, and Hanssens, 2009; Srivastava, Shervani, and Fahey, 1998). Investors evaluate factors related to firm operations and to future growth in order to assess future cash flows, associated risks, and future stock performance. Tobin's q represents the performance variable that reflects investor response in this research.

Firm performance is modeled as depending on two sets of constructs (as in Figure 1): (1) technology innovation, design innovation, and their interaction (H1–H6); and (2) covariates, which include new product introductions, advertising expenditures, expenditures for R&D, size, and operating margins. The research also explores moderation of all model paths by branding strategy; Rao et al. (2004) tabled characteristics of three branding strategies but studied investor response only. This article examines both sales and Tobin's q as dependent variables.

Technology Innovation versus Design Innovation

A product is a combination of two main elements: form and function (Bloch, 1995; Chitturi et al., 2007). Product form determines how colors, shapes, proportions, and materials are blended to create the specific object that customers perceive and experience (Rindova and Petkova, 2007). Firms can thus innovate in two basic ways: technology innovation, which modifies product function; or design innovation, which modifies product form (Verganti, 2006). Design innovation is one in which novel external appearance (aesthetics) prevails over novel technology (Rindova and Petkova, 2007; Talke et al., 2009). Design innovation, focusing on novel blending of design elements, may be independent of technology innovation (Rindova and Petkova, 2007).

In the last few years, the role of design innovation has received increasing attention (e.g., "stylistic innovation" in Cappetta, Cillo, and Ponti, 2006; "aesthetic innovation" in Eisenman, 2009). The number of worldwide design patents has steadily increased (Worldwide Intellectual Property Organization Statistics Database, November 2008). However, innovation is still mostly conceptualized as "technological," producing changes in function but not necessarily (or not primarily) in form (Verganti, 2006). Recently, form, independent of function, has been addressed (Chitturi et al., 2007, 2008; Orth and Malkewitz, 2008), but design innovation research is in its infancy (Luchs and Swan, 2011).

Design innovations alter the affective responses triggered, but the core technology of the product remains invariant (Bloch, 1995; Eisenman, 2009). Social meanings are manipulated, and existing customers' tastes for new, design-related product dimensions are cultivated (Djelic and Ainamo, 2005; Lieberson, 2000); e.g., Eisenman (2009) found that computer producers in 1999–2003 strategically decided on developing design to make up for scant technology innovation.

Hypotheses H1–H3: The Effects of Technology and Design Innovations

Technology and design innovations: main effects. Previous research suggests that either technology or design innovation separately should enhance firm performance (Srinivasan et al., 2009; Talke et al., 2009). Consider the sales impact first. Consumers interpret technology innovation as a signal that the new product offers advantages over existing alternatives (Mukherjee and Hoyer, 2001). New functions can also improve product positioning, creating differentiation from competitors (Talke et al., 2009). Recent evidence supports technology innovation's positive effect on sales (Pauwels, Silva-Risso, Srinivasan, and Hanssens, 2004; Talke et al., 2009). Similarly, consumers react favorably to novel product forms (Csikszentmihalyi and Robinson, 1990). Design innovation stimulates consumers' interest and curiosity (e.g., Krippendorff, 2005; Rindova and Petkova, 2007), which in turn stimulates active information search, opinion exchange, or product trials (Talke et al., 2009). Thus:

> *H1: (a) Technology innovation and (b) design innovation have positive effects on sales.*

Investors also value innovation: new products are a promise of future profit generation, and thus investors are motivated to hold the stock of firms having high-innovation activity (Pauwels et al., 2004). While Srinivasan et al. (2009) report a positive effect of technology innovation on investors, the effects of design innovation have not been empirically investigated. Because technology and design innovations signal the competitiveness of the firm and the ability to expand product portfolios in the future (Sood and Tellis, 2009), both types of innovation should have positive impacts on investor response; both create platforms to sustain future growth. Thus:

> *H2: (a) Technology innovation and (b) design innovation have positive effects on Tobin's q.*

Technology and design innovations: interaction effect. With the exception of Talke et al. (2009), the interaction effect between the two types of innovation, reflecting synergy, has not been investigated. Searching for such synergies and extracting the resulting rents is an important managerial goal. A positive interaction effect of design and technology innovations on consumer and investor responses is proposed. The key argument is that technology and design innovations are *complementary*; i.e., they combine to produce synergistic performance impact (synergistic rents). Design innovation may amplify the effects of technology innovation; i.e., the effects (the betas) of technology innovation on sales and Tobin's q will be greater for the firm that heavily exploits possibilities for design innovations rooted in new technology.

Specifically, design and technology innovations should have a synergistic effect on consumer responses for two reasons. First, technology and design innovations provide different benefits to consumers and help them attain different goals (cf. Chitturi et al., 2007). Consumers *not* forced to choose between technology and design innovations may experience positive emotions because consumers do not like to make functional versus hedonic trade-offs (Chitturi et al., 2008). Second, Rindova and Petkova (2007) argue that product forms help consumers make sense of the embodied technology innovation. Design can reduce the anxiety and uncertainty that inhibits technology adoption. An appropriate product form helps consumers activate a new categorization schema, thus maximizing the success of the product itself (Gregan-Paxton and John, 1997). For example, the Palm Pilot was designed to resemble an agenda book rather than a computer, and was thus seen as an over-performing agenda book not an under-performing computer (Rindova and Petkova, 2007). Thus:

H3a: The interaction of technology versus design innovations has a positive effect on sales.

Investors positively value actions that can (1) lower cash flow volatility and vulnerability and/or (2) enhance the firm's future cash flows (Srivastava et al., 1998). Design and technology interact positively to impact investor response by enabling these two functions. First, many industries go through cyclical periods of technological ferment and stability. During stability, offerings are increasingly standardized, and competition revolves around cost reduction (Tushman and Anderson, 1986; Tushman and O'Reilly, 1997); consumers accept minimal updating of core product function (i.e., minimal technology innovation). However, Eisenman (2009) shows that firms can still grow by differentiating through design innovation. This means that (1) the value of design innovation is higher during the periods of relative stability in technology innovation as compared to the periods of ferment in technology innovation, and (2) firms pursuing both technology and design innovations have the capability to grow regardless of ferment or stability and are thus more attractive to investors because of reduced cash flow volatility.

Second, a firm can incorporate the same core function or technology into aesthetically different designs; e.g., primarily changing the external appearance of the product, while leaving the technology inside virtually unaltered, is a strategy that car producers routinely adopt to launch new models every year. Such design innovations can become more important as product technology standardizes, which means that the value of design innovations is greater when low technology innovation permits standardization to take place. Design innovation can prevent or delay commoditization (Eisenman, 2009). In other words, technology innovations create *platforms* for design innovations, while design innovations can create multiple exploitations of the core functional innovation, thus multiplying the sources of cash flow. Also, by embodying the core technology in design innovations, multiple layers of protection for technology are created, making it harder for competitors to imitate and reducing the vulnerability of cash flow.

H3b: The interaction of technology versus design innovations has a positive effect on Tobin's q.

Branding Strategy as Moderator

The current research explores the contingent effects of *branding strategy* as originally defined by Laforet and Saunders (1994) and examined in Rao et al. (2004): (1) Corporate Branding versus (2) Mixed Branding versus (3) House of Brands.

In Corporate Branding, the firm uses one overarching brand name for all products (e.g., McDonald's; Dell). A strong consumer brand image results, which facilitates brand extensions. Corporate Branding also communicates to investors in an efficient and focused way, which facilitates building firm reputation. Economies of scale and efficiency in marketing to both consumers and investors are major advantages. However, product categories must be managed to maintain corporate brand identity; overextension risks losing established core meanings. At the other extreme, the House of Brands strategy involves different brands for different product markets, with each brand having to build its own reputation (e.g., Procter & Gamble's numerous brands). House of Brands encourages distinct brand positioning, an advantage in garnering shelf space. However, introducing new products can be costly and marketing efforts can be inefficient overall if products cannot take advantage of a corporate brand halo effect. Mixed Branding is an intermediate strategy that reaches customers with different needs, yet has brand names around which product lines can be managed. The corporate name (or other heavily used name) along with a unique product-specific name identifies the product (e.g., Kellogg's Corn Flakes). This strategy attempts to capture the advantages of the other two while avoiding the disadvantages.

Rao et al. (2004) hypothesized that Corporate Branding would yield the highest stock return, while House of Brands would yield the lowest. They found the coefficients' rank order to be Corporate, House of Brands, and Mixed, but recognized that this ordering is perhaps "inconsistent with the concept of market segmentation" (p. 139). They suggested that this ordering reflects an under-appreciation of "Noncorporate" strategies *by investors, as measured by Tobin's q*. They did not study sales, nor did they investigate anything about innovation. This research explores whether the impacts (the betas) of technology innovation, design innovation, and their interaction differ across branding strategies. The rationale is that *these very strategic branding categories are distinguished by their thrusts in innovation and marketing*. Moderation hypotheses for the two extremes (Corporate Branding versus House of Brands) are proposed.

Technology innovation might be risky for Corporate Branding because entering new markets bears the risk of losing established core image, with negative effects on consumer and investor responses (Rao et al., 2004). At the other extreme, in House of Brands, new technologies can be assigned a new branding and organizational structure, which enables the firm to establish a new brand identity and reach specific consumer segments. Indeed, House of Brands may have originally evolved in this fashion (Rao et al., 2004), and firms pursuing this strategy may have long experience in designing marketing gestalts to parallel core technology innovations. Further, technology innovation brings the risk of cannibalization (Chandy and Tellis, 1998), a risk particularly high in Corporate Branding but limited in House of Brands (Rao et al., 2004). This suggests that House of Brands firms benefit more from technology innovation. Thus:

H4: The positive effect of technology innovation on (a) sales and (b) Tobin's q is stronger for House of Brands than for Corporate Branding.

The positive effect of design innovation rests in part on its ability to stimulate new demand by creating excitement and interest. Firms adopt design innovation to assign a new meaning to the brand image (Eisenman, 2009; Rindova and Petkova, 2007). This positive effect is likely to be higher in the case of Corporate Branding because of halo effects: introducing one design innovation may be sufficient to raise the image of all the company's products since all bear the corporate name. In House of Brands, the positive effect of design innovation is limited largely to the brand under whose name the innovation is introduced. Hence:

H5: The positive effect of design innovation on (a) sales and (b) Tobin's q is stronger for Corporate Branding than for House of Brands.

H3 previously argued that the source of the positive interaction of technology and design innovation is design innovation's ability to leverage technology innovation's impact; i.e., exploitation and amplification of new technology through design innovations produce synergistic performance impact. However, it was also argued that technology innovation is worth more under House of Brands than Corporate (H4), which means that over the long run, technology innovation levels will be higher under House of Brands. If the value of design increases with higher levels of technology innovation *and* technology innovation levels are higher under House of Brands, then the interaction effect will be greater under House of Brands. Thus, we explore:

H6: The positive interaction effect of technology and design innovations on (a) sales and (b) Tobin's q is stronger for House of Brands than for Corporate Branding.

Method

Sample

The consumer electronics industry was selected because technology and design innovations are relevant in this context. The member list of the Consumer Electronics Association (CEA) was the sampling frame. The CEA is the biggest association of consumer electronics producers, including more than 2200 U.S. members and all the most important electronics firms worldwide. Capital IQ was tapped to identify the 200 biggest companies in market capitalization. Capital IQ, a division of Standard's and Poor, is a market research company that provides information about companies' financials. The final sample was comprised of 1168 firm–year observations.

The sample firms were split into three subsamples as per branding strategy: (1) Corporate Branding ($n = 83$ firms); (2) Mixed Branding ($n = 44$ firms); and (3) House of Brands ($n = 73$ firms). Mixed Branding and House of Brands were also grouped together to form a subsample of "Noncorporate Branding" (to contrast Corporate Branding). Classification proceeded following Rao et al. (2004). Information came from the companies' web sites, annual reports, and *Brands and Their Companies* database. Consistent with Rao et al. (2004), when a firm predominantly uses corporate branding but also owned a minor brand, it was categorized as "Corporate."

Measurement of Dependent Performance Constructs

Measures were collected for 2002 to 2007 from Capital IQ. Sales data reflected consumer response; Tobin's q was used as an indicator of investor response. Tobin's q is defined as capital market value divided by the replacement value of assets, thus isolating the book value of the firm (Srinivasan and Hanssens, 2009). A *q*-value greater than 1.0 reflects an unmeasured source of value attributed to intangible assets. Tobin's q is considered a forward-looking, stock-market based measure of firm performance. Table 1 summarizes all measures and data sources.

Measurement: Technology versus Design Innovation

Most firms patent significant innovations in the United States (Tellis, Prabhu, and Chandy, 2009). The U.S. Patent and Trademark Office (USPTO) issues six different types of patents; this research focuses on utility and design patents. "Utility" patents are issued for a new machine, device, or manufactured item and concern the functionality of a product; utility patents indicate technology innovation. In contrast, "design" patents are granted for a "new, original, and ornamental design" that is not necessary for the product's proper functioning. Design patents are not issued for technology or utility; rather, their scope is limited to the "overall, ornamental, visual impression," making them a good indicator of design innovation. Data were collected from 1997 to 2006 from Delphion (see e.g., Chandy, Hopstaken, Narsimhan, and Prabhu, 2006).

The measure of Technology Innovation was constructed in two steps. First, correcting for truncation bias was accomplished by following the procedure explained in Hall, Jaffe, and Trajtenberg (2001). Then, citation-weighted patent counts were constructed in order to capture the importance of patents; research has shown that citation-weighted patents are better measures of a firm's ability to appropriate returns from its innovations than are unweighted patents (Sorescu, Chandy, and Prabhu, 2007). The total number of patents that a firm grants in one year was divided by the total number of citations that a firm received in one year, as calculated in the first step.

Finally, the citation-weighted patents issued during a five-year period were used to build Technology Innovation. Following Moorman and Slotegraaf (1999), the value of utility patents were depreciated over the legal life of 20 years. Thus, Technology Innovation (TI) is:

Table 1. Measurement and Data Sources

Variable	Measure	Notes
A. Dependent variables		
Sales	Sales	Measures consumer response (Pauwels et al., 2004); data from Capital IQ for 2002–2007
Tobin's q	(Capital Market Value)/(Asset Replacement Value)	Measures investor response (Srinivasan and Hanssens, 2009); data from Capital IQ 2002–2007
B. Independent and control variables		
Independent variables:		
Tech innovation (5-year)	$TI_{in} = \sum_{n=1}^{5}(\delta_{in})\left[\sum_{p=1}^{m} CWP_{pin}\right]$	Measures technology innovation (Moorman and Slotegraaf, 1999); data from Delphion, USPTO utility patents; 2001–2006
Design innovation (5-year)	$DI_{in} = \sum_{n=1}^{5}(\delta_{in})\left[\sum_{p=1}^{m} CWP_{pin}\right]$	Measures design innovation; data from Delphion for USPTO design patents; 2001–2006
Control variables:		
New product introductions	Number of new products introduced each year	Data from Capital IQ for the years 2001–2006
Advertising expenditures	(Advertising expenditures)/(Total assets)	Expenditures from TNS Media Intelligence; assets from Capital IQ; all for 2001–2006
R&D expenditures	(R&D expenditures)/(Total assets)	Data for both R&D and assets from Capital IQ; years 2001–2006
Operating margin	(Net income before depreciation)/Sales	A control for the **TOBIN'S Q** model only (Rao et al., 2004); all data from Capital IQ for 2001–2006
Size	Log of employees	A control variable; data from Capital IQ for 2001–2006

$$TI_{in} = \sum_{n=1}^{5} (\delta_{in}) \left[\sum_{p=1}^{m} CWP_{pin} \right]$$

CWP_{pin} refers to the citation-weighed patent p for firm i for each of the five years, using only utility patents as input. δ_{in} is the depreciation value for firm i at time n. The weights are 1 for $n = 1$, .95 for $n = 2$, .90 for $n = 3$; .85 for $n = 4$; and .80 for $n = 5$.

For Design Innovation, the same procedure was followed (using USPTO design patents instead of utility patents as input). Since a design patent is granted for only 14 years, design patents were depreciated by 7.14% (1/14) per year rather than by 5% (1/20).

Validation of innovation measures. Data on the quality of innovations were collected from CNET Editors' ratings for products introduced in 2006. CNET is a premiere review service; a team of editors uses, tests, and provides quality ratings for a vast range of consumer electronics. CNET rates design versus technology separately. If the editor reviewed more than one feature, the ratings were averaged. The average technology rating across all products was computed to obtain a company level measure. The same was done for design ratings. Data were obtained for 143 companies. The correlation between technology as measured with patents versus these ratings was .85; the correlation for design was .76. These findings support face validity.

Measurement of Control Variables

All control variables (Table 1) are thought to be positively related to firm performance. For both the sales and the Tobin's q models, New Product Introductions, Advertising Expenditures, R&D Expenditures, and Size served as controls (as supported in, e.g., Srinivasan et al., 2009; Szymanski, Bharadwaj, and Varadarajan, 1993). New Product Introductions is the number of new products introduced, as per Capital IQ data for 2001–2006. Advertising Expenditures were measured as the ratio of advertising expenditures to total assets (Rao et al., 2004). Data (2001–2006) for the numerator came from TNS Media Intelligence while the denominator came from Capital IQ. R&D/total assets measured R&D Expenditures. Size (log of employees) has been extensively used to control for resource availability (e.g., Greve, 2003); the effect of firm size is also controlled since the variables within firms were normalized. Finally, for the Tobin's q model only, Operating Margin was included because Rao et al. (2004) argued that higher margins mean higher cash flow expectations. Note that operating margin is net income before depreciation, divided by sales (as in Rao et al., 2004). The correlation matrix is in Appendix A.

Analysis Methodology

Random effects panel analysis was used to test the hypotheses. Variables were normalized by subtracting the mean and dividing by the standard deviation; this facilitates interpretation because all coefficients now fall between −1 and +1 and are easily compared. Equations (1) and (2) below were analyzed separately in each Brand Strategy segment:

$$\begin{aligned} Sales_{it} = {} & \beta_{0S} + \beta_{1S} TI_{i(t-1)} + \beta_{2S} DI_{i(t-1)} + \beta_{3S} TI_{i(t-1)} \\ & \times DI_{i(t-1)} + \beta_{4S} NP_{i(t-1)} + \beta_{5S} Ad_{i(t-1)} + \beta_{6S} NP_{i(t-1)} \\ & \times Ad_{i(t-1)} + \beta_{7S} R\&D + \beta_{8S} Size_{i(t-1)} + \beta_{9S} 2002 \\ & + \beta_{10S} 2003 + \beta_{11S} 2004 + \beta_{12S} 2005 \\ & + \beta_{13S} 2006 + \upsilon_{Si} + \varepsilon_{Sit} \end{aligned} \quad (1)$$

With $\varepsilon_{Sit} = \eta_{Sit} + \rho\varepsilon_{Si(t\text{-}1)}$

$$\begin{aligned} TQ_{it} = {} & \beta_{0T} + \beta_{1T} TI_{i(t-1)} + \beta_{2T} DI_{i(t-1)} + \beta_{3T} TI_{i(t-1)} \\ & \times DI_{i(t-1)} + \beta_{4T} NP_{i(t-1)} + \beta_{5T} Ad_{i(t-1)} + \beta_{6T} NP_{i(t-1)} \\ & \times Ad_{i(t-1)} + \beta_{7T} R\&D + \beta_{8T} Size_{i(t-1)} + \beta_{9T} 2002 \\ & + \beta_{10T} 2003 + \beta_{11T} 2004 + \beta_{12T} 2005 \\ & + \beta_{13T} 2006 + \upsilon_{Ti} + \varepsilon_{Tit} \end{aligned} \quad (2)$$

With $\varepsilon_{Tit} = \eta_{Tit} + \rho\varepsilon_{Ti(t\text{-}1)}$

βs are the parameters to be estimated; the subscripts i and t refers to firm and time, respectively; TI is technology innovation, and DI is design innovation; NP is the number of new products introduced each year; Ad is advertising expenditures; $R\&D$ is R&D expenditures; the interaction between new product and advertising expenditures was included since previous studies suggest a positive interaction effect (e.g., Srinivasan et al., 2009); η_{it} is independent and identically distributed (i.i.d.) with mean 0, variance σ^2_η; υ_i are the random-effects assumed to be i.i.d. with mean 0, variance σ^2_υ; $|\rho| < 1$. Dummies for each year were included to account for differences across years (2001 was the reference year). Also, lagged independent variables were used to rule out potential reverse-causal explanations. A Hausman test shows that a random effects model is not inconsistent and thus nearly as good as a fixed effects model. Since the random effects model has better efficiency, it was adopted for this research. Finally, a Woolridge (2002) test did reject the null hypothesis that the errors are not first-order serially correlated ($p < .05$), thus supporting the inclusion of a first-order autoregressive error term (ρ).

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Results

Hypothesis Testing: Sales and Tobin's q Results per Brand Strategy Grouping

The results for Sales are in Table 2: Part A lists the standardized estimates per brand strategy group; Part B reports the Corporate/Noncorporate comparison. The final columns report the results for Roy–Zellner tests of equality of coefficients across groups. The corresponding results for Tobin's q are in Table 3. Overall, the models fit well. *R*-squares for Sales models are in the range of .42–.49, and those for Tobin's q are in the range .24–.29. Summaries of hypothesis testing showing patterns of (non)significant results are in Table 4.

Table 2. Model Results for the Dependent Variable SALES (Standardized)

(A) Results of the analysis of Corporate Branding versus Mixed versus House of Brands

$SALES_t$ = dependent variable	1. Corporate Branding	2. Mixed Branding	3. House of Brands	Tests for Equality
Constant	.05	−.07	−.07	1 > 2 = 3
Tech innovation$_{(t-1)}$	.00	.13***	.08*	2 = 3 > 1
Design innovation$_{(t-1)}$	.10***	−.03	.02	1 > 2 = 3
Design innovation$_{(t-1)}$X Tech innovation$_{(t-1)}$	−.01	.13*	.07*	2 = 3 > 1
New product introductions$_{(t-1)}$	.28***	−.03	−.08	1 > 2 = 3
Advertising expenditures$_{(t-1)}$	.09*	.13***	.12**	1 = 2 = 3
New product introductions$_{(t-1)}$X Advertising expenditures$_{(t-1)}$	−.03	.26***	.18**	2 > 3 > 1
R&D expenditures$_{(t-1)}$	.10**	−.08	.01	1 > 2 = 3
Size$_{(t-1)}$	.22***	.16***	.20***	1 = 2 = 3
Year 2002	.001	.02	.01	
Year 2003	−.002	−.003	−.001	
Year 2004	.01	.03	.03	
Year 2005	.02	.01	.02	
Year 2006	.003	.002	.002	
Serial correlation	.28	.39	.36	
Fraction of variance due to u_i	.37	.22	.53	
Number of firms (observations)	83 (474)	44 (258)	73 (436)	
R^2	.45	.45	.42	

(B) Results for Corporate Branding versus Noncorporate Branding (Mixed + House)

$SALES_t$ = Dependent Variable	1. Corporate Branding	2. Mixed Branding + House of Brands	Tests for Equality
Constant	.05	−.08	1 = 2
Tech innovation$_{(t-1)}$	.00	.10***	2 > 1
Design innovation$_{(t-1)}$	.10***	−.01	1 > 2
Design innovation$_{(t-1)}$X Tech innovation$_{(t-1)}$	−.01	.09***	2 > 1
New product introductions$_{(t-1)}$	.28***	−.03	1 > 2
Advertising expenditures$_{(t-1)}$	.09*	.16**	2 = 1
New product introductions$_{(t-1)}$X Advertising expenditures$_{(t-1)}$	−.03	.21***	2 > 1
R&D expenditures$_{(t-1)}$	.10**	−.02	1 > 2
Size$_{(t-1)}$	.22***	.18***	1 = 2
Year 2002	.001	.02	
Year 2003	−.002	−.002	
Year 2004	.01	.03	
Year 2005	.02	.02	
Year 2006	.003	.002	
Serial correlation	.28	.38	
Fraction of variance due to u_i	.37	.47	
Number of firms (observations)	83 (474)	117 (694)	
R^2	.45	.49	

* $p < .05$; ** $p < .01$; *** $p < .001$.

Table 3. Model Results for the Dependent Variable TOBIN'S Q_t (Standardized)

(A) Results of the Analysis of Corporate Branding versus Mixed versus House of Brands

TOBIN'S Q_t = Dependent Variable	1. Corporate Branding	2. Mixed Branding	3. House of Brands	Tests for Equality
Constant	.02	−.01	−.12*	1 = 2 = 3
Tech innovation$_{(t-1)}$	.14**	.10*	.12**	1 = 2 = 3
Design innovation$_{(t-1)}$	.07*	−.01	.00	1 > 2 = 3
Design innovation$_{(t-1)}$X Tech innovation$_{(t-1)}$	−.09**	.05**	.10*	2 = 3 > 1
New product introductions$_{(t-1)}$	.13*	.05	.04	1 > 2 = 3
Advertising expenditures$_{(t-1)}$	.10*	.13**	.17**	1 = 2 = 3
New product introductions$_{(t-1)}$X Advertising expenditures$_{(t-1)}$	−.07	.09*	.35**	3 > 2 > 1
R&D expenditures$_{(t-1)}$	−.01	−.10	.04	1 = 2 = 3
Operating margin$_{(t-1)}$	.00	.00	.00	1 = 2 = 3
Size$_{(t-1)}$	−.05	−.07	−.08	1 = 2 = 3
Year 2002	.03	.02	.03	
Year 2003	−.01	−.03	−.02	
Year 2004	.00	.05	.04	
Year 2005	.05	.03	.03	
Year 2006	.04	.02	.03	
Serial correlation	.28	.22	.26	
Fraction of variance due to u_i	.56	.32	.42	
Number of firms (observations)	81 (435)	43 (230)	73 (393)	
R^2	.24	.29	.28	

(B) Results for Corporate Branding versus Non-Corporate Branding (Mixed + House)

TOBIN'S Q_t = Dependent Variable	1. Corporate Branding	2. Mixed Branding + House of Brands	Tests for Equality
Constant	.02	−.06	1 = 2
Tech innovation$_{(t-1)}$	.14**	.12***	1 = 2
Design innovation$_{(t-1)}$	.07*	.02	1 > 2
Design innovation$_{(t-1)}$X Tech innovation$_{(t-1)}$	−.09**	.08***	2 > 1
New product introductions$_{(t-1)}$	.13*	.03	1 > 2
Advertising expenditures$_{(t-1)}$	.10*	.15*	1 = 2
New product introductions$_{(t-1)}$X Advertising expenditures$_{(t-1)}$	−.07	.25***	2 > 1
R&D expenditures$_{(t-1)}$	−.01	−.01	1 = 2
Operating margin$_{(t-1)}$	.00	.00	1 = 2
Size$_{(t-1)}$	−.05	−.08	1 = 2
Year 2002	.03	.02	
Year 2003	−.01	−.03	
Year 2004	.00	.04	
Year 2005	.05	.03	
Year 2006	.04	.02	
Serial correlation	.28	.25	
Fraction of variance due to u_i	.56	.36	
Number of firms (observations)	81 (435)	116 (623)	
R^2	.24	.28	

* $p < .05$; ** $p < .01$; *** $p < .001$.

For Sales (Table 2), the results show that H1a concerning the impact of Technology Innovation on sales is supported for Mixed Branding and House of Brands, while H1b concerning the impact of Design Innovation is supported only for Corporate Branding. The positive interaction in H3a is supported for Mixed Branding and House of Brands only. The tests for equality show two distinct patterns: (1) Corporate coefficients are always significantly different from Mixed and House of Brands, which are not significantly different from each other; (2) for Technology Innovation, Corporate has the smallest coefficient among the Branding groups, in support of H4a; (3) for Design Innovation, Corporate has the greatest coefficient, in support of H5a; and (4) as for the

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Table 4. Summary of the Results of Testing the Hypotheses

Hypothesis	1. Corporate Branding	2. Mixed Branding	3. House of Brands	Equality of Betas across Branding
H1a: Tech innovation →Sales	ns[a]	Supported	Supported	2 = 3 > 1 (H4a supported)
H1b: Design innovation →Sales	Supported	ns	ns	1 > 2 = 3 (H5a supported)
H3a: Design × Tech →Sales	ns	Supported	Supported	2 = 3 > 1 (H6a supported)
H2a: Tech innov→ Tobin's q	Supported	Supported	Supported	1 = 2 = 3 (H4b not supported)
H2b: Design innov→ Tobin's q	Supported	ns	ns	1 > 2 = 3 (H5b supported)
H3b: Design × Tech → Tobin's q	ns (Negative)[b]	Supported	Supported	2 = 3 > 1 (H6b supported)

[a] ns = not supported (coefficient was nonsignificant).
[b] ns (Negative) = not supported (coefficient was significant but negative; contradicts H3b).

interaction, Corporate's coefficient is least, in support of H6a.

For Tobin's q (Table 3), Technology Innovation has a positive effect in every grouping, supporting H2a. However, these coefficients are not significantly different from one another, thus rejecting H4b. The positive effect of Design Innovation (H2b) is supported only for Mixed Branding and House of Brands. As for the interaction effect, it is significantly negative for Corporate Branding (contradicting H3b), but positive for the other two strategies. Tests for equality show: (1) for Technology Innovation, the coefficients are not significantly different across branding strategies, rejecting H4b; (2) for Design Innovation, Corporate is the largest, in support of H5b; and (3) for the interaction, Corporate's coefficient is least, in support of H6b.

Interaction Effects per Brand Strategy Grouping

A significant interaction effect can be interpreted as a conditional effect on the main effects (Jaccarrd, Turrisi, and Wan, 1990); the coefficients represent the conditional effect of one variable when the other variable is *at its mean or some other value*. The interactions (Design Innovation) × (Tech Innovation) are graphed in Figure 2 for Sales and Figure 3 for Tobin's q (data are unstandardized). These figures illustrate the "high design" versus the "low design" line, where the former is defined as the mean plus one standard deviation, and the latter is the mean minus one standard deviation; the *y*-axis is Sales (or Tobin's q), and the *x*-axis is Tech Innovation.

Consider Sales first (Figure 2). For Corporate Branding (2A), Tech Innovation was nonsignificant, as was the interaction; thus, the "high design" and "low design" lines are relatively flat and parallel in appearance, with the gap representing visually the significant effect of Design Innovation. For Mixed Branding and House of Brands (2B and 2C), Tech Innovation and the interaction were significant, while Design Innovation's main effect was not. This means that the impact of Design Innovation on Sales *increased with the level of Tech Innovation* and the impact of Tech Innovation on Sales *increased with the level of Design Innovation*; the latter is represented visually in the figure by the "high design" line having an apparently greater slope than the "low design" line. Overall, these Sales results show that the more innovation in one area (i.e., Design or Tech), the higher the *marginal* impact on Sales of one more unit of the other.

Next, consider Tobin's q (Figure 3). For Corporate Branding (3A), both Tech and Design Innovation main effects were positive, while their interaction was negative. This means that the impact of Design Innovation on Tobin's q *decreased with the level of Tech Innovation* and vice versa. This time, the "low design" line has an apparently greater slope when compared visually to the "high design" line, since the interaction is negative; i.e., for Corporate Branding, the more innovation in one area (i.e., Design or Tech), the lower the *marginal* impact on Tobin's q of the other. For Mixed Branding and House of Brands (3B, 3C), Tech Innovation and the interaction were positive, while Design Innovation was nonsignificant. Thus, in these cases, the pattern of results for Tobin's q is the same as that for Sales discussed previously: the more innovation in one area (i.e., Design or Tech), the higher the *marginal* impact on Tobin's q of the other.

Monotonic versus Nonmonotonic Interaction Effects

Interaction effects are monotonic if their signs don't change over the relevant range. Following Schoonhoven (1981), the partial derivative of Sales (or Tobin's q) on Design Innovation was calculated, and then this partial derivative was plotted (on the *y* axis) over the range of Tech Innovation (x-axis). The point on the range of Tech Innovation for which Design Innovation has no effect on

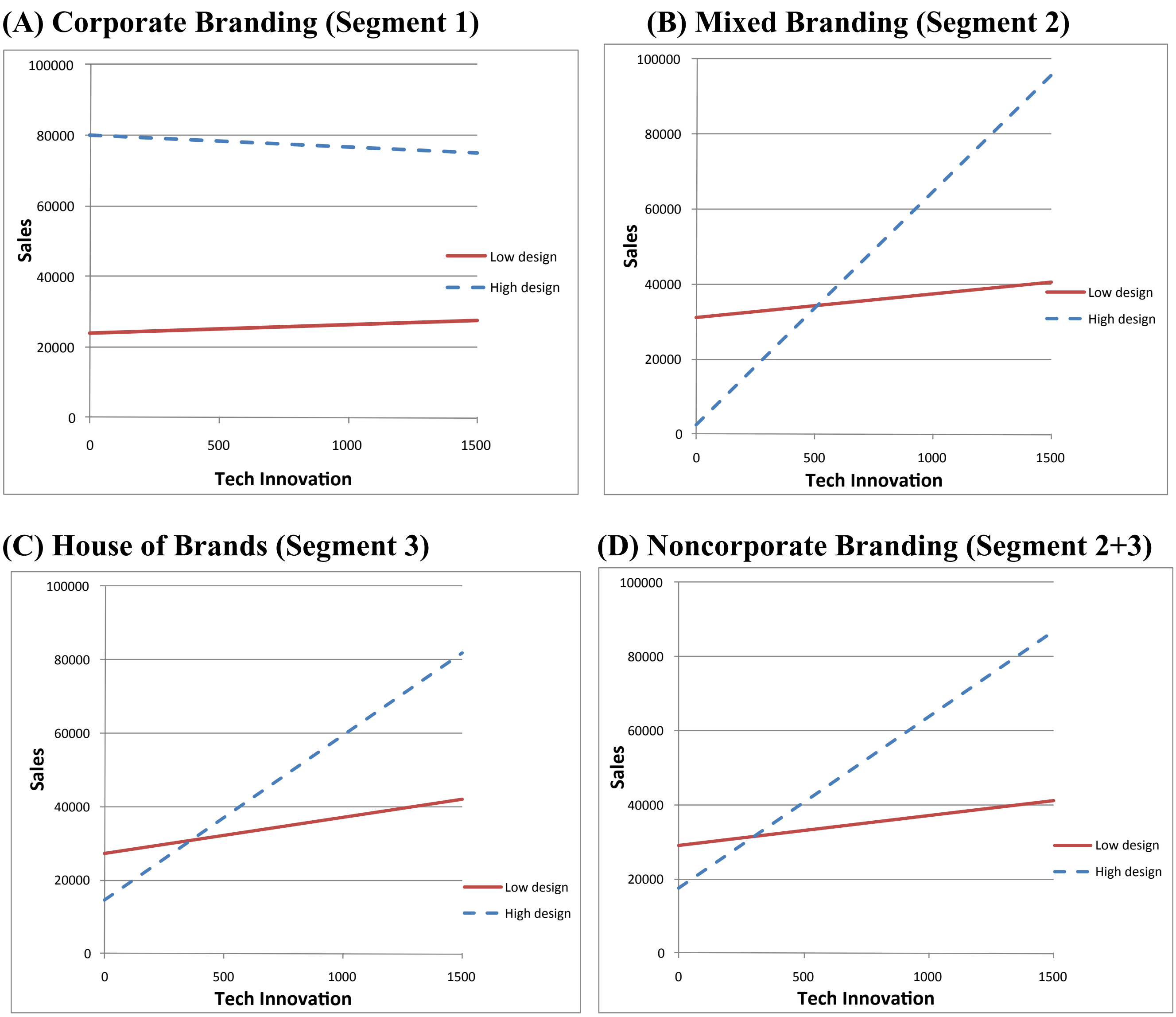

Figure 2. Design versus Tech Interaction Results for Sales (Unstandardized)

the dependent variable is calculated as $(-b_1/b_2)$, where b_1 is the coefficient for Design Innovation and b_2 is the coefficient of the interaction term. If this “tipping point” is *within* the range of sample Tech Innovation values (i.e., crosses the *x*-axis), then the interaction effect is nonmonotonic; if not, then the interaction effect is monotonic. This analysis uses unstandardized variables because standardizing variables may change the distribution of the variable itself, thus potentially biasing the detection of a nonmonotonic effect.

Figure 4 (for Sales) and Figure 5 (for Tobin’s q) show per brand strategy how the partial derivative (dY/dDesign Innovation) changes with Tech Innovation. The tipping point and the percentage of firms whose Tech Innovation is smaller than this tipping point are also reported. For example, Figure 5A shows the results for Corporate Branding on Tobin’s q. No firm in the Corporate Branding segment has Tech Innovation smaller than 5.1, thus suggesting that the interaction effect is monotonic (always negative). In contrast, Figure 5B shows that the tipping point for Mixed Branding is 554.39. This value is within the range of Tech Innovation, and thus, Design Innovation has a nonmonotonic effect. In this case, whether the effect of Design Innovation is positive or negative depends on the value of Tech Innovation. In this segment, 59% of the firms have Tech Innovation below the tipping point 554.39, which means that for 59% of firms in the Mixed Branding segment, Design Innovation has a negative effect on Tobin’s q.

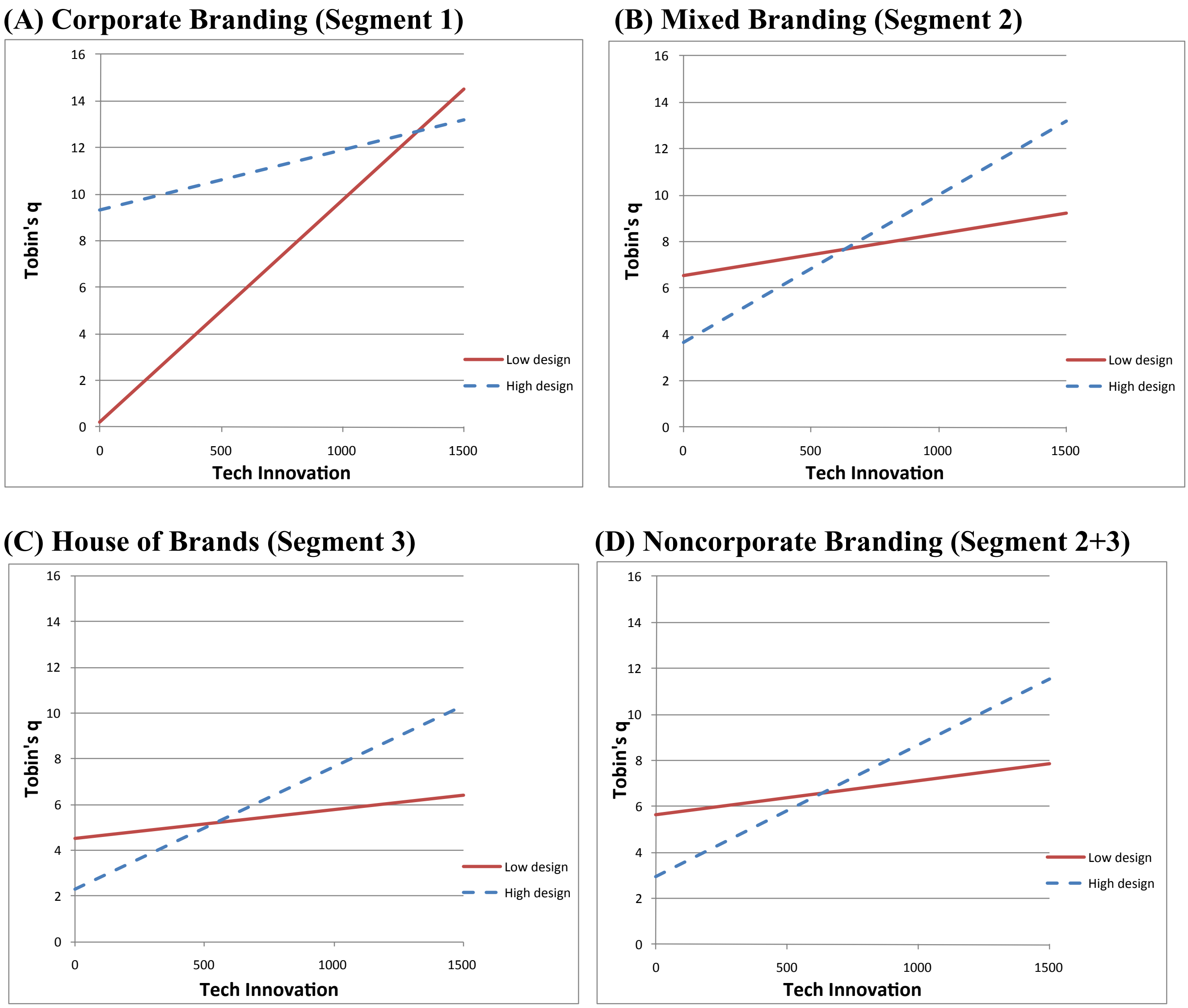

Figure 3. Design versus Tech Interaction Results for Tobin's Q (Unstandardized)

Robustness Checks

Potential endogeneity of number of new products. It might be possible that Tech or Design Innovation (or both) influences the number of new products introduced each year. To investigate this possible endogeneity of the variable "number of new products," a Durbin–Wu–Hausman test (Davidson and MacKinnon, 1993) was performed. First, the number of new products as a function of Tech Innovation and Design Innovation (plus their interaction effect and all other independent variables) was estimated to obtain the residuals; second, the residuals were used as an additional regressor in Equations (1) and (2). The residuals' parameter estimate was not significant ($p = .112$), thus showing that the number of new products is not endogenous.

Reverse causality. Lagged independent variables were used to rule out reverse causality. However, because managers may be forward-looking, Tech Innovation and Design Innovation at time *t-1* may be related to Sales and Tobin's q at time *t*. To completely rule out reverse causality, a Granger-causality Wald test between (1) Sales/Tobin's q and Design Innovation, and between (2) Sales/Tobin's q and Tech Innovation was run. The results show that Sales and Tobin's q do not "Granger cause" either Design or Tech Innovation. Hence, reverse causality is not a concern.

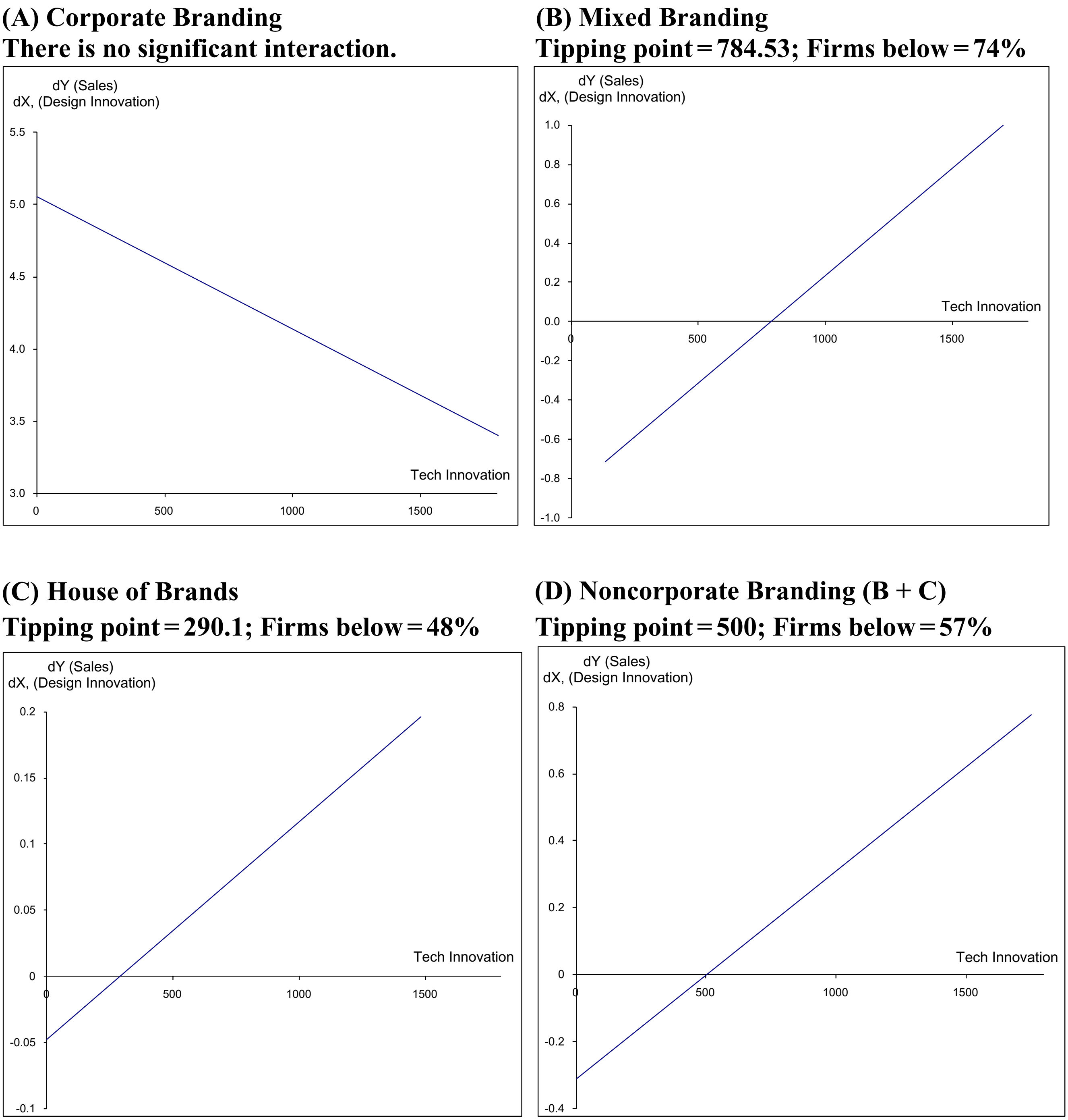

Figure 4. The Effect of Tech Innovation on the Relationship between Design Innovation and Sales

Potential correlation between consumer and investor responses. Investors might take into account consumer response as "value-relevant" information in anticipating future performance. Equation (2) was thus reestimated by including Sales as an explanatory variable, and it does have a positive effect on Tobin's q. Full results are available from the authors; the signs of the coefficients, and the substantive results reported in this article remain invariant.

Discussion

Firms can create new products in two broad ways: technology innovation or design innovation (Verganti, 2006).

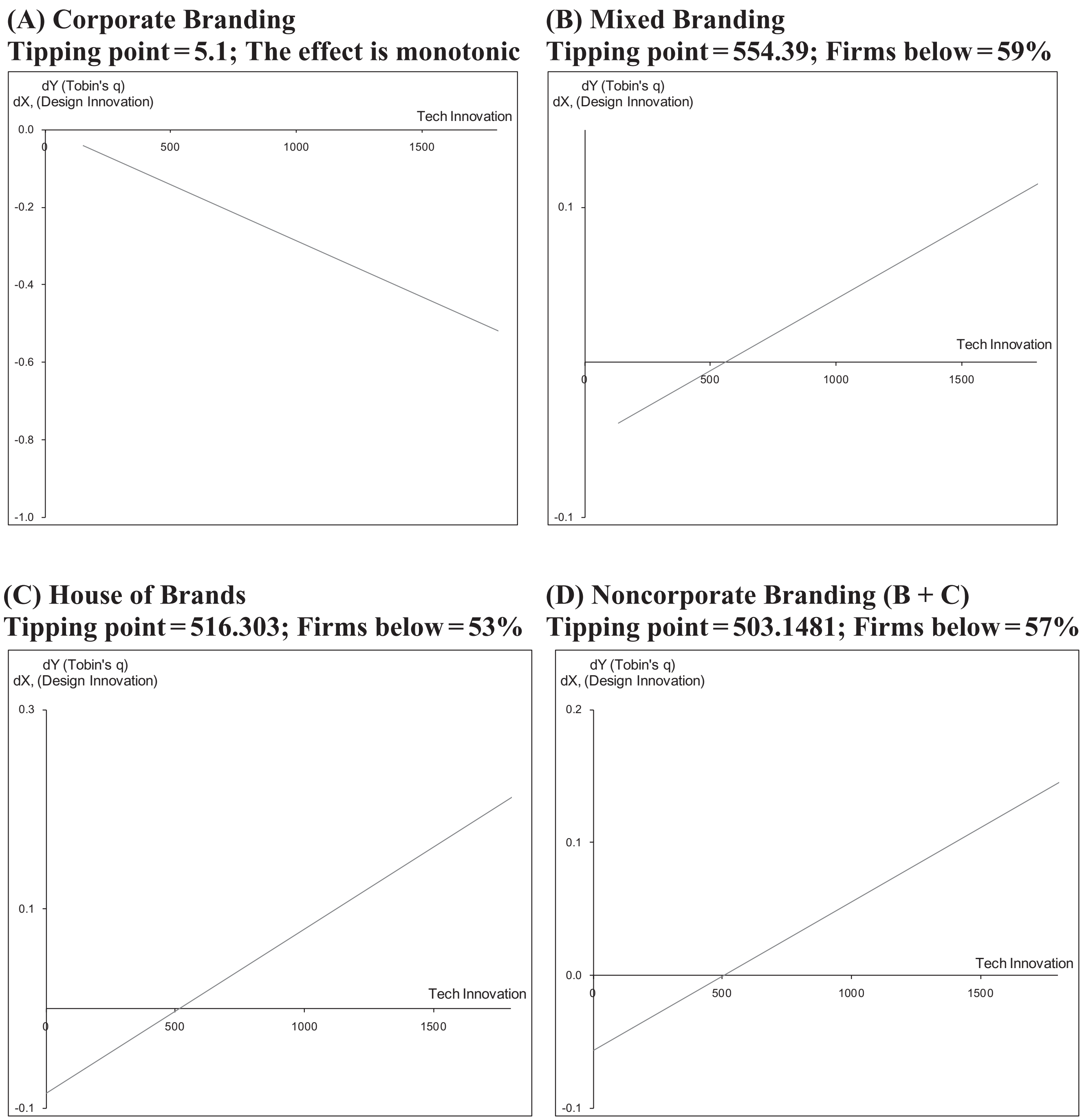

Figure 5. The Effect of Tech Innovation on the Relation between Design Innovation and Tobin's Q

Technology and design innovations can synergistically interact to impact performance; as mechanisms, technology innovation can provide the platform for design innovations, and design innovations can facilitate the adoption of technology innovations. Sales was tapped as the firm performance indicator reflecting consumer response, and Tobin's q as reflecting investor response. Overall, technology innovation, design innovation, and their interaction proved significant in many of the models examined. Their significance depends on branding strategy however. Finding this moderation is a major contribution of this research because it shows that the performance value of innovation is related to branding strategy.

Before discussing the results in detail, some limitations should be noted. First, only technology and design innovations were examined. There are other kinds of innovation that may be related to Sales and Tobin's q. For example, process innovations may have a major impact on Tobin's q if new processes significantly reduce costs and thus make the firm more profitable. Second, this research focused on consumer electronics and caution should be exercised when generalizing the results to other product markets. Third, only covariates considered to be the most important as far as the key innovation and/or branding issues were chosen. However, there may be other relevant covariates; e.g., there could be subcategory effects within the consumer electronics category. Examining the impacts of other kinds of innovation, other product markets, and other covariates are all possible directions for future research.

Moderation by Branding Strategy

The research found that moderation of model paths by branding strategy was pervasive across all variables. Overall, except for technology innovation → Tobin's q, Corporate Branding coefficients for technology innovation, design innovation, and their interaction *were always significantly different* from Mixed Branding and House of Brands coefficients, *which were not significantly different from each other*. A key question for future research is: in what respect is the tripartite classification of Rao et al. (2004) valid, as opposed to the simpler scheme of Corporate versus Noncorporate? Since Mixed Branding and House of Brands proved very similar in terms of characteristic relationships examined in this research, the results will be discussed below in separate sections for Corporate versus Noncorporate branding strategies.

The results show a clear distinction between Corporate Branding and any form of Noncorporate Branding. First, for *technology innovation*, the impact on both firm performance indicators for Corporate was less than or equal as compared to Noncorporate. Noteworthy was the result that technology innovation impacted Tobin's q *equally across all branding strategies*, demonstrating its value as far as investors are concerned; technology innovation appears to be key in assessing future cash flows, associated risks, and future stock performance. The impact on sales was significant only for Noncorporate strategies however; in terms of sales, technology innovation in firms following Corporate Branding does not differentiate performance levels.

Second, *for design innovation*, the impact on performance for Corporate was positive and greater than for Noncorporate (which were all nonsignificant); the same pattern was observed for sales and Tobin's q. This means that for those firms following a Corporate Branding strategy, increases in firm performance levels are related to increases in design innovation; but for Noncorporate, firm performance is unrelated to design innovation.

For Corporate Branding, increases in Tobin's q (investor response) are related to both technology and design innovation. Only for this branding strategy and only for this measure of firm performance were the main effects of *both* technology innovation and design innovation positive. In the five other combinations of branding strategy category and firm performance measures (3×2 combinations), *only one* of technology innovation or design innovation main effect was positive. The pattern of significant versus nonsignificant results clearly support combining Mixed Branding and House of Brands into Noncorporate and then differentiating Corporate versus Noncorporate. Whether these patterns hold for other firm performance indicators and for other forms of innovation remain subjects for future research.

Third, *for the interaction*, the impact for Corporate was null (Sales) or negative (Tobin's q) and significantly less than the positive impact in the cases of Noncorporate. Consider sales first. For Mixed Branding and House of Brands, technology innovation and the interaction were significant: this means that the *marginal* impact of design innovation on sales *increased with the level of technology innovation*. For Tobin's q, the same result was seen for both Noncorporate strategies. For Corporate Branding however, there was no interaction in the case of sales, and the (monotonic) interaction was negative for Tobin's q. These decreasing marginal effects could reflect investor perceived limits to the degree that corporate brand names can be extended.

The Determinants of Firm Performance: The Case of Corporate Branding

For Corporate Branding, the results show that (1) technology innovation was positively related to Tobin's q but not Sales; (2) design innovation was positively related to both; (3) their interaction was not related to Sales and negatively related to Tobin's q; and (4) only in the case of technology innovation→Tobin's q was the beta for Corporate equal to the betas for Mixed Branding and House of Brands. This pattern of coefficients supports Corporate Branding as distinct from both Noncorporate branding strategies.

The results also show that the main effects of new product introductions and advertising were positive for both firm performance constructs, but the interaction was nonsignificant (unlike for Noncorporate, discussed below). The effects of advertising were equal across all branding strategies, confirming the importance of advertising to sales (e.g., Leone, 1995) and stock returns (e.g., Rao et al., 2004). Corporate enjoyed the greatest impact on sales and Tobin's q in the case of new product introductions. Again, Corporate Branding exhibits a pattern distinct from Noncorporate strategies for these covariates.

The Determinants of Firm Performance: The Case of Noncorporate Branding

For Mixed Branding and House of Brands, the results show that (1) technology innovation was positively related to both sales and Tobin's q; (2) design innovation was related to neither; (3) their interaction was positively related to both sales and Tobin's q; and (4) in every case, the strengths of these relationships were equal across these two branding strategies. In terms of these coefficients, Mixed Branding and House of Brands are indistinguishable.

The results also show that new product introductions were unrelated to firm performance (unlike Corporate). Advertising was positively related to both sales and Tobin's q (and equally across all branding strategies). These main effects, whether significant or not, were equal across Mixed Branding and House of Brands. Their interaction was also positive, and these interaction effects on sales and Tobin's q were greater than the nonsignificant interaction in the case of Corporate Branding. This (monotonic) interaction means that the marginal impact of the number of new products *increased with the level of advertising*. Advertising appears to accelerate movement along the new product S-shaped adoption curve (hence the sales effect), but Srinivasan et al.'s (2009) proposal for a stock return impact of backing new product introductions with substantial advertising is also supported. Mixed Branding and House of Brands were distinguishable only because the ordering of the interaction's effect on sales was Mixed>House of Brands, while the ordering for Tobin's q was House of Brands>Mixed.

Conclusion

Rao et al. (2004) hypothesized that Corporate Branding would be the most advantageous branding strategy, while House of Brands would be the least (as measured by Tobin's q only); the order they found was Corporate, House of Brands, Mixed Branding. They explained that these results, which were perhaps "inconsistent with the concept of market segmentation" (p. 139), arose because investors undervalued the two "Noncorporate" strategies. This research offers no conclusions as to "best" strategy, only of significantly "different" strategies between Corporate and Noncorporate Branding. In particular, Noncorporate strategies benefit in terms of enhanced consumer and investor response from simultaneous design and technology innovations because these are synergistic complements when customized brands can be created.

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Appendix A: Correlation Matrix

	Mean	Std. Dev.	1.	2.	3.	4.	5.	6.	7.	8.
1. Sales	39340.67	43561.84	1							
2. Tobin's q	1.39	1.97	.24***	1						
3. Tech innovation	131.28	171.57	.23***	.12***	1					
4. Design innovation	92.17	83.69	.12***	.10**	.12***	1				
5. New products intros	12.71	29.24	.31***	.14***	.08	.12***	1			
6. Advertising exp.	.01	.04	.27***	.10***	.07	.01	.07	1		
7. R&D expenditures	.02	.01	.10*	−.04	0	.04	−.02	.28***	1	
8. Size	10.25	11.26	.51***	−.16	.15***	.09***	.30***	.15***	.12***	1
9. Operating margin	.13	.15	.03	−.02	−.02	.04	.04	.05	.05	.14***

* $p < .05$; ** $p < .01$; *** $p < .001$.
Note: All variables are defined in Table 1. Multicollinearity is not a serious problem in the analyses based on these data since the variance inflation factors are lower than 6 for sales, and lower than 4 for Tobin's q.