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Current interdisciplinary research suggests that organizational capabil-
ities have a direct, unconditional impact on firm performance. The authors
extend this literature by developing a framework that proposes a contin-
gency approach to the value of organizational capabilities. This frame-
work highlights the effect of information in the external environment in
stimulating firms to deploy their technology and marketing capabilities to
influence the level and speed of relevant product development activities.
Using a longitudinal quasiexperiment to isolate the effects of external
information on the relationship between firm capabilities and product
development outcomes, the authors obtain results that are consistent with
this framework. The authors therefore conclude that the most valuable
characteristic of firm capabilities may be their ability to serve as flexible
strategic options. In this role, firms can deploy them in ways
consistent with environmental forces.

The Contingency Value of Complementary Capabilities in Product Development

Current marketing literature suggests that firms' capabili-
ties, competencies, or memory influence competitive per-
formance (e.g, Day 1994; Dickson 1996; Hunt and Morgan
1995, 1996). This literature is influenced by resource-based
and industrial economic theories (Penrose 1959; Rumelt,
Schendel, and Teece 1991) and related theories of strategic
management (Barney 1986; Prahalad and Hamel 1990;
Wernerfelt 1984, 1995; Winter 1987), which identify firm-
level investments in resources and capabilities that generate
higher-than-average returns from the market. Related empir-
ical research has shown, for example, that information rou-
tines exert a positive influence on performance (Jaworski
and Kohli 1993; Moorman 1995; Narver and Slater 1990),
experience in product development influences the financial
performance of new products (Moorman and Miner 1997;
Song and Parry 1997), and different skills exist for market

pioneers, early followers, and late entrants (Bowman and
Gatignon 1995; Kalyanaram, Robinson, and Urban 1995).

In this article, we investigate the relationship between an
organization's marketing and technology capabilities and
product development outcomes. Current research in market-
ing assumes that capabilities have a direct, unconditional
impact on firm performance (e.g., Deshpandé, Farley, and
Webster 1993; Gatignon and Xuereb 1997; Jaworski and
Kohli 1993; Song and Parry 1997). We challenge this
assumption and instead suggest a conditional relationship
between capabilities and their effect.

First, we predict that the impact of capabilities on product
development outcomes is contingent on the presence of
information in the external environment, which stimulates
firms to compete in certain ways. This view draws on the
economics of information literature, which suggests that
information can facilitate consumer search, as well as
increase competitive activities (e.g., Stigler 1961).

Second, we argue that firm capabilities may not be valu-
able as single assets. Instead, we focus on the value of com-
plementary capabilities in product development. With few
exceptions, the marketing literature has tended to focus nar-
rowly on marketing capabilities (e.g., Day 1994; Kohli and
Jaworski 1990; Srivastava, Shervani, and Fahey 1998).
However, there may be other capabilities that complement
marketing capabilities' impact on product development out-
comes. Following other work (e.g., Griffin and Hauser
1996), we predict that two key capabilities must be pre-
sent—marketing capabilities and technology capabilities—
for effective product development.

In addressing these two theoretical issues, our research
also seeks to overcome several methodological limitations

associated with prior literature on this topic. First, a great deal of the literature linking firm capabilities to the exploitation of external information is anecdotal, conceptual, or derived from stylized, but nonempirical, models. Second, of the limited empirical studies that exist, all but Cohen and Levinthal's (1990) are cross-sectional, and none has any degree of experimental or quasi-experimental control and therefore is limited in their ability to isolate the influence of external information to stimulate firm behavior. Third, much of the research on this topic relies on managers' perceptions of firm capabilities and outcomes, thus raising questions about common methods variance and other method biases. Our methodology empirically examines our predictions using a longitudinal quasi-experimental design with data collected from secondary and field sources.

CONCEPTUAL FRAMEWORK

Focal New Product Outcomes

We selected product development as the competitive context examined in this research for several reasons. First, the domain is acknowledged as critically important to long-term competitive performance (Adams and Lacugna 1994; Cohen, Eliashberg, and Ho 1997; Day 1994; Griffin 1997; Lieberman and Montgomery 1988; Wind and Mahajan 1997). Second, we found that we could measure certain organizational capabilities relevant to the product development context using archival data sources and also measure product development outcomes using careful fieldwork. These approaches enabled us to test our hypotheses without surveying managers about product development outcomes or their organizations' capabilities, a key goal of this research.

Within the product development context, we first examine *improvements to brand quality*, defined as positive changes to objective quality indicators. Our second focal outcome is *speed of brand quality improvements*, defined as the time lapse between the availability of external information and improvements to brand quality.

These outcomes were selected because changes to product quality have been linked to the presence of information by economists for the past three decades (e.g., Akerlof 1970; Benham 1972; Salop 1976, 1977; Salop and Stigliz 1977; Schwartz and Wilde 1985; Stigler 1961). As Mazis and colleagues (1981, p. 12) note, "improved product quality occurs whenever new information allows some consumers to alter their choices, thus providing a signal to sellers to change their products." They cite the Federal Trade Commission–forced disclosure of tar and nicotine levels on cigarette labels as a stimulant of competitive activity for low tar and nicotine products. More generally, Tellis and Wernerfelt (1987) find that price–quality correlations increase with consumer information in markets (see also Hjorth-Anderson 1984; Salop 1976, 1977; Salop and Stigliz 1977). Information can emanate from many sources, including competitors, third-party rating systems, or regulation. For example, if the Consumers' Union makes attribute quality ratings available, firms may choose to compete on these attributes in the design and promotion of their brands (for example, see Bloom and Szykman's 1998 examination of the effect of *BusinessWeek* ratings on competition among business schools).

The Impact of Complementary Capabilities

Because our primary interest is in understanding the nature and effects of capabilities important to product quality improvements and the timing of those improvements, we concentrated on the types of capabilities important to these outcomes. The rationale for our selection was influenced by Day's (1994) conception of product development as a "spanning process" that integrates inside-out (e.g., research and development [R&D] and technology development) and outside-in (e.g., effective management of customer and channel relationships) capabilities. This view also is supported by theorists, who suggest that firms need effective internal and external learning (Bierly and Chakrabarti 1996; Roth and Jackson 1995). Therefore, we focused on a firm's product technology capability and product marketing capability.

Product technology capability refers to a firm's technological ability to formulate and develop new products and related processes. Other researchers similarly have identified technical proficiency, R&D, and engineering or technical resources and skills as important to new product and process developments (Bierly and Chakrabarti 1996; Calantone and di Benedetto 1988; Cooper 1993; Nelson 1982; Roth and Jackson 1995). Gatignon and Xuereb (1997, p. 82) suggest that a firm's technological orientation includes "the use of sophisticated technologies in new product development, the rapidity of integration of new technologies, and a proactivity in developing new technologies and creating new product ideas." Montoya-Weiss and Calantone's (1994) meta-analysis of more than 40 studies examining new product success factors finds that technical proficiency was important to new product success (see also Rothwell 1972; Song and Parry 1997). Technological capabilities are also important to the speed of product development, because greater R&D investments have been found to influence time to market (Rabino and Moskowitz 1981).

Product marketing capability refers to a firm's ability to develop and maintain relationships with customers, including both end users and channel members. Deshpandé, Farley, and Webster (1993) find that customer orientation is related to firm performance. Jaworski and Kohli (1993) also find that a firm's market orientation, defined as the ability to use market intelligence about exogenous market factors that influence current and future customer needs, is related positively to business performance (see also Narver and Slater 1990). In addition to these effects, channel relationships may create barriers to entry (Reve 1986) and have been found to provide a competitive advantage when managed effectively and structured over time (Heide 1994), especially in conditions of high environmental uncertainty (Noordewier, John, and Nevin 1990).

Prior research investigating product technology and product marketing capabilities has conceived of them as operating independently with regard to their effect on new product outcomes. Song and Parry (1997) and Gatignon and Xuereb (1997), for example, find that marketing and technological proficiency independently influence competitive advantage, though they also find that the two are correlated. This approach is consistent with most other studies in the new product literature (Calantone and di Benedetto 1988; Cooper 1993; Cooper and Kleinschmidt 1987; Montoya-Weiss and Calantone 1994).

Rather than emphasizing the importance of the independent effects of product marketing and product technological capabilities, we suggest that product development is most effective when firms exhibit both capabilities. When both capabilities are held, product development can benefit from their *complementarity* (Milgrom and Roberts 1990, 1995), which refers to the degree to which the value of an asset is dependent on the level of other assets. As Milgrom and Roberts (1990, p. 514) state, "The defining characteristic of ... complements is that if the levels of any subset of the activities are increased, then the marginal return to increases in any or all of the remaining activities rises." Therefore, when assets are complementary, an asset may be difficult to build, due not to its own initial level, but to the level of a complementary asset (Dierickx and Cool 1989).

We suggest that a firm's product marketing and product technology capabilities can interact to achieve complementarity in two key ways: Marketing capabilities facilitate the effect of the technology capabilities or technology capabilities facilitate the effect of the marketing capabilities. In the case of marketing capabilities facilitating the effect of technology capabilities, Dierickx and Cool (1989, p. 1508) point out that "to the extent that new product and process development find their origin in customer requests or suggestions (von Hippel 1978), it may be harder to develop technological know-how for firms who do not have an extensive service network." This complementarity is also evident in Teece's (1988) examples of the successful commercialization of new drugs as dependent on the presence of specialized sales support activities and the introduction of Mazda's rotary engine as dependent on the presence of specialized customer repair facilities.

In the case of technological capabilities facilitating marketing capabilities, Milgrom and Roberts (1990) cite the example of technologies such as CAD/CAM systems, which coincide with the adoption of product policies that allow for frequent updates in response to customer demands. More generally, Cohen and Levinthal (1990) show that firms must develop a certain degree of internal knowledge (i.e., technical knowledge) to anticipate the value of and apply the insight from external knowledge (i.e., market knowledge) (see also Bierly and Chakrabarti 1996).

Complementarities, which also have been referred to as cospecialization (Teece 1988), interconnectedness (Dierickx and Cool 1989), synergy (Park and Zaltman 1987), and integration (Baldwin and Clark 1994; McDuffie and Krafcik 1992) in related literature, are valuable because the interaction of parts increases firm effectiveness and efficiency (Park and Zaltman 1987; Walker and Ruekert 1987). Moreover, firms exhibiting complementarities are likely to inhibit potential entrants that find them difficult to imitate (Grant 1991; Lippman and Rumelt 1982; Reed and DeFillippi 1990).

In light of this literature, we argue that organizations with both product technological and product marketing capabilities are more likely to make quality improvements to their brands and to make these improvements faster relative to competing brands. Our prediction, however, also rests on additional theoretical considerations related to the impact of external information.

The Impact of External Information on the Effect of Firm Capabilities

Prior research acknowledges the importance of environmental conditions to the success of strategic investments. Nearly all of the strategy and marketing strategy literature suggest, for example, that successful firms are those that fit their strategies, including those related to new products, to market conditions (Andrews 1971; Booz, Allen, and Hamilton 1982; Glazer 1991; Lehmann and Winer 1991; Miles and Snow 1978; Ruekert, Walker, and Roering 1985; Rumelt 1974; Varadarajan 1983). The fit or mesh (Dickson 1997) between a firm and the environment is believed to be most effective when firms can exercise their strengths to exploit current or emerging environmental trends (Day 1990; Porter 1985).

This view also is found in economic and financial theories that examine how firms make investments that, in turn, create future options for the firm. As Dixit and Pindyck (1994, p. 9) state, "for most firms, a substantial part of their market value is attributable to their options to invest and grow in the future, as opposed to the capital they already have in place." From this perspective, capabilities are considered "options" (created by investments) that firms can apply to future opportunities. Research in this area attempts to describe how firms should and actually do make investment decisions that influence the value of strategic options (Baldwin and Clark 1994; Hayes, Wheelwright, and Clark 1988). The firm's challenge is one of maximizing the fit between current investments (and the capabilities or options they create) and the firm's future competitive threats and opportunities (Gilbert 1989; Tirole 1988). This is accomplished by using information to reduce uncertainty about the future value of investments and the nature of threats and opportunities.

Despite the theoretical entrenchment of the idea that firms use information to fit their capabilities to environmental conditions, no research that we are aware of has demonstrated the impact of external information on the relationship between firm capabilities and firm outcomes. Therefore, we propose an important contingency on the impact of firm capabilities on product development outcomes. Specifically, we predict that firms will deploy their capabilities to influence the degree and speed of product development activities in the presence, but not the absence, of external information.

Drawing on the aforementioned literature, we suggest that underlying this effect are likely to be managerial assessments that capabilities have greater potential value when they are deployed in ways consistent with external conditions. For example, if unit pricing information is mandated and consumers use the information in their decision making, successful firms will deploy current capabilities to decrease price per unit and position the product on price. Deploying capabilities to fit the environment can be especially valuable when firms with greater capabilities can move faster or more effectively, even though all industry members may be experiencing similar external conditions (Wood 1986). Such advantages are likely because capability-rich firms are more apt to draw correct inferences about the value of external information (Cohen and Levinthal 1990, 1994).

It is important to note that though we offer these supporting literature as explanations for *why* organizations might deploy their capabilities, our focus is not on investigating these motivations, how firms deploy their capabilities, or whether capabilities actually were deployed by firms. Instead, we seek to examine *how* the relationship between firm capabilities and product development outcomes changes in the presence and absence of external information. Therefore, if supported, our predictions will allow us only to conclude that our results are consistent with capabilities being deployed in reaction to the external information.

It is also important to note that we restrict our theory to external information that is likely to reduce consumers' search costs, including reducing acquisition, computation, and comparison costs (Russo et al. 1986), and therefore can stimulate response among firms in an industry. This excludes feature or benefit information provided by a single firm in an industry (that is not imitated by other firms) or competitive information that goes unnoticed by consumers and therefore will not influence firm strategies. We hypothesize:

H₁: The greater the level of both product technology and product marketing capabilities, the greater is the likelihood that firms will exhibit more brand quality improvements relative to the competition in the (a) presence, but not in the (b) absence, of external information.

H₂: The greater the level of both product technology and product marketing capabilities, the greater is the likelihood that firms will exhibit faster brand quality improvements relative to the competition in the (a) presence, but not in the (b) absence, of external information.

METHOD

Overview of Research Context and Design

We used a longitudinal quasiexperiment to test our predictions (Campbell and Stanley 1963; Cook and Campbell 1979). In particular, our design examined the impact of external information created by the Nutrition Labeling and Education Act of 1990 (NLEA), which required food manufacturers to provide nutrition information about their products in a truthful and complete manner by May 1994 by including a standardized "Nutrition Facts" label on all food products. The presence of label information from 1994 enabled us to examine how this information influenced the impact of firm capabilities on product development relative to the absence of label information. A critical point about the generalizability of the NLEA as a stimulant to competitive activity is that the NLEA only required firms to communicate nutrition information; changes to product development were a strategic choice, not a regulatory mandate.

The key benefit of using the NLEA is the opportunity to design a longitudinal quasiexperiment that isolates the effects of external information on the relationship between firm capabilities and relevant product development outcomes. Because of its conceptual or cross-sectional status, prior research has been unable to separate out such effects from other occurrences, such as when firm capabilities, external information, and strategy outcomes co-occur but are not related causally.

The NLEA is, however, only one type of external information, and it is created by regulation. The information economics literature examines the market-level effects of information from regulation, competitor, or third-party sources.

The underlying assumption of this literature is that actual and/or expected consumer search on the disseminated information will prompt firms to compete on attributes communicated in the information (e.g., Mitra and Lynch 1995; Moorman 1996; Stigler 1961). There is evidence to suggest that these dynamics do occur (e.g., Bloom 1997; Cady 1976; Ippolito and Mathios 1990, 1991; Moorman 1998; Tellis and Wernerfelt 1987). For example, there have been several studies of external information with a competitive origin that was initially created by a few firms in the ready-to-eat (RTE) cereal industry (Ippolito and Mathios 1991; Levy and Stokes 1987). These firms provided fiber information and made claims about the linkage of fiber to cancer reduction. As a result, other firms provided fiber information on their packaging, and consumer search related to fiber, consumer purchase of fiber-rich cereals, and the fiber level in cereals all increased.

It is also the case that firms use external information from both competitive and regulatory sources in a strategic manner (e.g., Wood 1986). In other words, a firm's strategy likely will depend on its capabilities, the positioning of its brands, and the sensitivity of its target markets to the attributes focused on by the external information. For example, Moorman (1998) documents that firms changed the quality of their current brands and new brand extensions in ways that emphasized unique attributes, enabling brands to occupy distinct strategic positions in the market. As a result, strategic factors will be accounted for in our investigation as well.

We could argue that there is always information in the external environment and that tracking the competitive effects of any one type of information, such as that resulting from the NLEA, can be problematic. However, because we have restricted our theory to external information that is likely to reduce consumers' search costs, we focus on information that stimulates competitive activity at the industry level.

With the NLEA as a context, our design uses field and secondary data, spanning a six-year time period, to test the predictions. Table 1 summarizes the variables adopted in testing our hypotheses, and Table 2 includes a summary of sample and measure information.

Sample and Procedures

One hundred twenty-four brands were selected randomly from 22 different product categories. An average of six brands was selected from each category. This approach was adopted instead of considering only a few product categories in order to increase the external validity of our results. The six brands selected from each category comprised an average of 26% market share across categories, with a range of 3.3% to 76% (see Table 2).

There were several restrictions placed on the sample. First, we randomly selected among the strata of brands that were not positioned on the basis of nutrition when the study was initiated in 1993. Therefore, we selected from brands that did not focus explicitly on health as a key product feature and avoided brands that stressed the elimination or addition of nutrients. These brands were identified in 1993 by relying on brand packaging information. Specifically, brands making reduction claims of negative attributes such as "less," "lower," or "no x"; addition claims of positive nutrients such as "added"; or

Table 1

SUMMARY OF HYPOTHESES AND MEASURES

	Test	Sample	Years Examined	Independent Variables	Dependent Variables
H$_1$: Impact on level of brand quality improvements	Absence of external information flows (pre-NLEA)	124 brands from 22 categories	1991–1993	Product technology capability measured by the number of patent registrations 1987–1991 by SBU. Product marketing capability measured by 1991 market share levels.	Improvements in index of nutritional quality from 1991–1993 collected from nutrition labels in stores and company sources.
	Presence of external information flow (post-NLEA)s	124 brands from 22 categories	1993–1996[a]	Product technology capability measured by the number of patent registrations 1989–1993 by SBU. Product marketing capability measured by 1993 market share levels.	Improvements in index of nutritional quality from 1993–1996 collected from nutrition labels in stores and company sources.
H$_2$: Impact on speed of brand quality improvements	Absence of external information flows (pre-NLEA)	124 brands from 22 categories	1991–1993	Product technology capability measured by the number of patent registrations 1987–1991 by SBU. Product marketing capability measured by 1991 market share levels.	Time elapsed before nutritional quality improvements made to brands (1991, 1993, or later).
	Presence of external information flows (post-NLEA)	124 brands from 22 categories	1993–1996[b]	Product technology capability measured by the number of patent registrations 1989–1993 by SBU. Product marketing capability measured by 1993 market share levels	Time elapsed before nutritional quality improvements made to brands (1994, 1995, 1996, or later).

[a]For H$_1$, the focus is on the level of quality improvements. For that variable, it is necessary to show the change from a pre-NLEA time (1993) to the post-NLEA time (1996). Therefore, the time horizon is 1993 to 1996 for H$_1$.

[b]H$_2$ focuses on the speed of changes to quality improvements. Therefore, the dependent variable involves whether quality improvements occurred in each year following the pre-NLEA time to estimate the length of time for the quality improvement to occur, specifically, from 1993 to 1994, 1993 to 1995, or 1993 to 1996.

claims of any health attribute, such as "filled with fiber" on the package, were eliminated from the sample. This approach was selected instead of examining firm strategy statements or advertising claims because of the ease of collecting and examining label information. These brands were not included because it was unclear how the NLEA might affect them. On the one hand, the NLEA might have little impact on their quality level because the brands were already nutritionally superior. On the other hand, the NLEA might prompt even further competitive activity in the nutrition area. By avoiding these brands and instead focusing on brands not explicitly competing on nutrition, we sought to increase the generalizability of our results. There were, however, some categories (e.g., orange juice) in which most of the brands were positioned on nutrition, resulting in their inclusion in the sample. We controlled for this status in our models.

Second, the brands chosen were selected to encompass variety in share size. Within each category, the median brand-share level was calculated using published data; brands higher than this level were considered high share, and brands below this level were considered low share. This sampling procedure was used so that the actions of both high- and low-share brands could be assessed.

Product categories were chosen to generate variance on the initial healthiness of the category and included the fol-

lowing: orange juice, cake mix, cake frosting, peanut butter, RTE cereal, margarine, salad dressing, cheese, oils, crackers, cookies, potato chips, pasta, frozen dinners and entrees, ice cream, nonfrozen yogurt, hot dogs, bread, soup, frozen pizza, and canned corn. Although variety across categories was desired, brands within each of the categories were selected so that they would not vary on too many characteristics, thereby reducing the level of unnecessary noise in the data. For example, all brands of yogurt were strawberry, and all brands of pizza were pepperoni.

In general, the study used a longitudinal design with product label evaluations at five points in time before and after the May 1994 implementation of the NLEA. The five evaluations of brand label information occurred in 1991, 1993, 1994, 1995, and 1996. The 1993, 1994, 1995, and 1996 data were collected from product labels in the summer of each year in local Cub Foods Stores, a large chain carrying most national, regional, and local brands. Label information was not always available in 1993 because, prior to the NLEA, label disclosure was optional and only necessary if an explicit health claim was made. Missing 1993 and 1991 data were obtained by writing to the firms that owned the brands and asking them to complete a questionnaire that requested nutrition information for each year. Firms typically had such information and were willing to share it. Individual nutrient information was not

Table 2
SAMPLE AND MEASUREMENT INFORMATION

Product Category	Number of Brands in Category[a]		Product Category Cost Structure[b]		Brands in Sample[c]	Total Market Share of Brands in Sample[d]		Average Number of Nutrients in Index[e]			Average Brand Nutrition Level[f]	Average Number of Patents for Divisions Owning Brands in Samples[g]						
	1993	1996	1991–1993	1993–1996	1991–1996	1991	1993	1991	1993	1996		1987	1988	1989	1990	1991	1992	1993
Bread	68	40	8.0	1.0	6	6.80	5.00	5.80	8.20	7.00	1.80	1.00	.30	.00	.50	.30	1.00	.50
Cake frosting	7	12	15.0	12.0	3	60.10	71.50	9.30	10.00	10.00	7.00	8.30	7.00	16.00	13.70	18.00	15.30	15.70
Cake mix	8	11	19.0	14.0	5	71.30	76.00	6.80	8.60	9.20	4.60	5.00	3.70	11.30	8.20	10.30	9.00	10.30
Canned corn	18	17	-10.0	9.0	4	11.80	10.50	6.80	8.30	8.50	2.00	.50	1.00	2.30	2.80	5.70	3.30	2.70
Cheese	17	12	6.0	19.0	6	7.10	6.00	4.00	8.50	6.67	2.20	.50	.50	1.30	4.20	4.80	4.80	6.00
Cookies	44	57	11.0	11.0	6	6.50	3.30	6.00	7.67	10.00	4.70	5.70	6.50	7.30	5.80	6.70	4.80	2.70
Crackers	25	23	11.0	11.0	9	20.70	20.80	4.70	8.33	8.33	3.00	6.30	7.00	7.50	5.80	6.70	4.80	2.80
Frozen dinners	25	17	-3.0	8.0	9	35.00	52.90	7.17	6.44	6.67	3.11	2.70	1.30	.20	.90	.67	2.00	1.56
Frozen entrees	15	14	-3.0	8.0	6	17.80	19.60	3.50	7.80	7.30	3.17	1.70	.30	.30	2.50	4.17	5.50	7.00
Frozen pizza	17	23	-3.0	8.0	6	38.90	17.00	5.20	3.20	9.00	3.00	.30	1.00	2.00	5.70	8.50	8.30	10.80
Hot dogs	38	28	13.0	-2.0	6	27.60	22.80	3.00	3.20	10.00	4.80	.00	.20	.00	2.00	4.00	4.70	6.20
Ice cream	18	11	1.0	9.0	6	10.40	12.70	2.50	4.50	8.50	4.30	.00	.20	.00	4.00	7.70	8.70	11.70
Margarine	20	11	-41.0	25.0	6	31.90	29.60	5.00	9.67	10.00	4.80	4.70	6.20	7.30	7.30	11.70	15.20	13.50
Oils	20	28	54.0	-6.0	6	48.40	51.00	5.70	10.00	10.00	5.50	3.30	2.80	3.80	3.80	5.30	4.30	2.80
Orange juice	12	12	2.0	19.0	6	26.20	28.70	8.00	6.00	10.00	2.00	.60	.40	.40	.20	.40	.80	1.80
Pasta	31	11	13.0	12.0	4	9.30	7.70	4.30	7.80	10.00	1.30	1.00	1.00	1.50	3.00	1.50	.80	.50
Peanut butter	9	8	-19.0	4.0	5	53.60	53.70	4.40	8.60	10.00	3.80	3.20	2.80	3.70	3.80	5.50	4.50	3.00
Potato chips	41	17	-4.0	-17.0	5	9.10	11.30	7.40	7.80	8.33	5.70	5.20	4.40	6.40	6.20	6.60	5.20	3.40
Ready-to-eat cereal	68	63	19.0	-9.0	6	7.30	6.40	7.30	9.00	9.30	1.60	1.20	.60	4.40	8.00	11.40	12.20	17.00
Salad dressing	14	22	23.0	-1.0	6	4.50	12.40	3.30	7.50	6.67	6.00	.00	.00	.00	4.80	9.20	10.80	14.60
Soup	10	6	4.0	8.0	5	54.40	44.60	3.20	8.60	7.40	3.40	1.20	.80	1.20	2.30	2.70	2.70	2.80
Yogurt	29	18	2.0	8.0	6	33.20	20.10	4.80	7.30	6.33	2.50	1.60	.80	5.20	6.20	7.40	7.20	10.00
Average Product Category	25	21	5.4	6.9	124[h]	26.90	26.53	5.37	7.59	8.60	3.65	2.45	2.24	3.73	4.62	6.33	6.18	6.70

[a]The number of direct brand-level competitors (e.g., competing brands of strawberry yogurt).
[b]The change in cost structure is measured using the Producer Price Index.
[c]The number of brands within each product category included in our sample.
[d]The percentage market share represented by the brands included in our sample.
[e]The average number of nutrients available to compute the overall change in nutrition quality index.
[f]Brand nutrition level (on a scale of 1 "very healthy" to 7 "not at all healthy") evaluated by two certified nutritionists. This rating reflects an average brand nutrition level from the brands sampled within the category.
[g]The average number of patents produced by all divisions owning brands in the sample. The number of patents acquired was measured at the strategic business unit level.
[h]This reflects the total of all brands in the sample.
Note: A small set of brands in our sample did not survive from selection in 1993 to the post-NLEA evaluation in 1996, reducing our sample from 124 to 112. Likewise, there were brands in our sample in 1993 that were new introductions that year. Therefore, 1991 nutrition data were not available, resulting in a loss of 5 brands from 1991 to 1993.

always complete on surveys but typically ranged between 70 and 80%, depending on the nutrient.[1] Details regarding how missing data were managed are discussed subsequently.

The internal validity of all quasiexperiments is threatened by "history," in which possible confounds between the pretest and the posttest may influence the dependent variable and produce an alternative explanation for the results (Cook and Campbell 1979). We are aware that some firms, in an attempt to gain a competitive advantage with the NLEA, may have introduced the new labels early. However, our in-store estimates suggest that this activity was low (1% of products checked included the new label five months prior to the NLEA). In addition, we tracked other potential sources of external information sources during the study period and found no other sources that reduced consumers' search costs. As a result, the internal validity threat associated with history is not a viable rival hypothesis (Campbell and Stanley 1963).

Measures of Product Development Outcomes

The level of brand quality improvements was operationalized as the level of brand nutritional quality improvements. There are, of course, many other ways to improve brand quality besides nutrition, including taste, ingredients, and packaging, all of which are performance-related. However, given that the external information was related to nutrition, theory suggests that a key set of firm responses should be related to brand nutritional improvements (Cady 1976; Ippolito and Mathios 1990; Tellis and Wernerfelt 1987). This theory suggests that consumers will respond to the presence of external information by searching more and that firms will respond to these consumer activities by improving brand quality. It is, of course, reasonable to expect firms to compete on other forms of quality as well, depending on the nature of their brand strategy. For example, if a firm's strategy focuses on taste, to the exclusion of health, we might expect to see fewer changes to nutritional quality following the NLEA. Likewise, if a brand is focused on value, we would expect less emphasis on nutritional quality and more emphasis on price promotion (Moorman 1998). However, we expect that successful firms will be those that deploy resources to meet the needs of a changing market, even within the confines of their strategy. As we subsequently discuss, our models include variables to control for the impact of brand strategy.

Nutritional quality can be improved by reducing negative attributes (e.g., fat) or increasing positive attributes (e.g., vitamins) (Russo et al. 1986). However, because we are interested in overall improvements in a brand's nutritional quality, not merely the change in a single nutrient, we computed an index that reflects the overall improvements to each brand's nutrition level in the presence (1993–1996) and absence (1991–1993) of external information. The presence condition began in 1993, not 1994, because NLEA implementation occurred in 1994, and we wished to observe changes occurring as a result of the NLEA relative to the pre-NLEA period.

Within each of these experimental conditions (1991–1993 versus 1993–1996), the levels of ten nutrients were compared between the first (e.g., 1993) and the last (e.g., 1996) year, and each time a negative nutrient decreased or a positive nutrient increased, a +1 was added to the index. Each time a negative nutrient increased or a positive nutrient decreased, a –1 was added to the index. The five negative nutrients were sodium, total fat, saturated fat, unsaturated fat, and cholesterol; the five positive nutrients were vitamin A, the total of vitamin Bs, vitamin C, calcium, and iron. Vitamin A and the total of Vitamin Bs were included because of their importance to diet and the ease of collecting nutrition information. However, the remaining nutrients were selected because they represent attributes that government studies (Ippolito and Mathios 1991; USDA 1992) and food industry reports (The NPD Group 1997) suggest consumers had interest in and that food companies might use as a competitive focus. Fiber and sugar would have been additional positive nutrients ideally included in our index. However, the percentage of brands with sugar and fiber information from 1991 to 1996 was only about 20%, making the inclusion of these nutrients problematic.

To eliminate the instrumentation threat to internal validity, we took extra precautions regarding possible changes in the measurement process (Cook and Campbell 1979). Specifically, to eliminate changes introduced by the NLEA, which mandated that serving sizes reflect more typical consumption levels, nutrients were divided by serving size within each year before examining differences between years.

The nutritional quality index also was constructed to ensure that brand comparisons were equivalent. First, it was necessary to ensure that the index was not influenced by missing values. Therefore, if one brand had seven nutrients and another brand had nine, the quality scores were adjusted so they were comparable. This adjustment involved dividing each score by the number of nutrients used to create the index (e.g., +9/9 nutrients = 1.0 and +7/7 nutrients = 1.0), reducing the relevant range from +1 to –1. Second, it was necessary to adjust the index for brands that already were performing as well as possible on particular nutrients (e.g., no fat). To prevent giving these brands an unfair disadvantage, the number of nutrients used to construct the index was adjusted by reducing both the denominator (number of nutrients) and the numerator (change level) by the number of optimized nutrients.[2]

The nutritional quality index also was used to measure the speed with which brand quality improvements occurred. To do so, we examined when brand nutritional quality improvements were made. Therefore, the speed of brand quality improvements was operationalized as a discrete variable, reflecting whether improvements to the brand took place in 1994, 1995, 1996, or not at all (presence of exter-

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[1]Although individual nutrient information was reasonably complete, there were occasions when brands in our sample did not survive from 1993 to 1996, resulting in a loss of 12 brands. Likewise, there were brands that we selected for our sample in 1993 that were introductions that year. Therefore, 1991 nutrition data were not available, resulting in a loss of 5 brands from 1991 to 1993.

[2]An anonymous reviewer pointed out that the index may still be sensitive to the number of nutrients used to construct it because the relative influence of each nutrient change is greater for brands with more missing data. We therefore examined our model using an approach that computes the absolute number of nutrients that change without dividing by the number of nutrients used to create the index. This alternative approach adds variance to our model; however, it does not alter our results.

nal information) or in 1991 or 1993 (absence of external information).

Measures of Organizational Capabilities

There are two general approaches to measuring organizational capabilities. The first approach, which is most typical in marketing strategy research and organizational sociology, is to measure directly the underlying knowledge and skills that are likely to constitute organizational capabilities through surveys or fieldwork within organizations. The second approach, which is more typical in marketing models research and the field of economics, is to measure observable outcomes associated with the presence of capabilities. In this approach, the measures do not examine how capabilities work in practice. Instead, the focus is on outward manifestations of the capability that can be measured and linked to the underlying knowledge and skills. For example, this approach would suggest that firms with strong technical skills also will tend to have more patents. We chose the latter approach to measure firm capabilities.

Product technology capability. Conceptualized as a firm's ability to formulate and develop new products and related processes, we measured product technology capability by counting the number of patents introduced by the division that owns the brand. We selected this approach given empirical evidence of a strong relationship between R&D expenditures and successful patent applications (e.g., Bound et al. 1984; Griliches 1990; Pakes 1985; Pakes and Griliches 1980). The use of patents as a measure of R&D capabilities is not without limitations, however. One limitation is that useful innovations are not always patented (Pakes 1985), which may underestimate the R&D capabilities of a firm. Another limitation is that the number of patents produced by any firm can vary because of technological, institutional, and market circumstances (Pakes 1985). Despite these limitations, however, both the research previously noted and more recent use of patents and patent citations as a measure of technological capability in marketing point to the validity of this measure across firms (Dutta and Weiss 1997).[3]

Patent information was collected from a national database of patents and trademarks developed by the U.S. Department of Commerce Patent and Trademark Office, which contains a comprehensive listing of all patents registered in the United States from 1969 to 1997 (only two months after registration). The database provides information at the overall organizational level, as well as the strategic business unit level. To capture the level of product technology capability likely to influence brand strategies, we measured it at the strategic business unit level. For example, we counted the number of patents acquired by Oscar Mayer, not Phillip Morris, for the brands of Oscar Mayer Hot Dogs in our sample.

To obtain a stable measure of product technology capability, the number of patents produced during a five-year period was used for the presence condition (1989–1993), as well as for the absence condition (1987–1991). This multiyear approach was used because it has been shown that the amount of patent production in one year does not predict

patent production in subsequent years (Hall, Griliches, and Hausman 1986). Therefore, we wanted to capture the variation inherent in these levels across years. In addition, because a firm's level of technological know-how depreciates over time, so that investments in product technology contribute less as time passes (Dierickx and Cool 1989; Hall, Griliches, and Hausman 1986), we depreciated the value of patent contribution over its legal life of 17 years (Merges 1997). Using a straight depreciation approach, the value of a patent's contribution to a firm's product technology capability declines by 5.88% (1/17) each year.[4] We elected to use five years as the appropriate technology accrual time period because it was large enough to reduce instabilities that often occur in patent production within firms, but not too large to result in complete depreciation of the value of patents that occurs over time.

Two other considerations related to our measure of product technology capability are important to mention. The first consideration involves the overlap in the present and absent measures of this capability. Although no overlap would be optimal, our decision to allow this overlap was viewed as less problematic because our predictions focus on the contingency effect of external information on the relationship between firm capabilities and product development outcomes, rather than on the direct effect of these capabilities. Moreover, as described previously, we adopted standard depreciation rates for patents, which lessened the effect of the overlap on the final measures.

The second consideration draws from a perspective which suggests that measures of firm capabilities should be adjusted by the financial base or size of the firm. The logic here is that such an adjustment is necessary to ensure that the capability measure does not merely reflect higher levels of financial resources. An alternative approach, referred to as the "input–output approach" (Dutta, Narasimhan, and Rajiv 1997), involves adjusting capability measures by actual investments in R&D, which results in a measure of the capability's efficiency. We did not employ the latter approach because we were unable to access divisional levels of marketing and R&D investment from secondary databases. To account for firm resources, however, we used a third approach, which was to control for it in our model estimation. This was accomplished by entering a control variable, division size, into our models.

Product marketing capability. Conceptualized as the firm's ability to manage customer relationships, we measured product marketing capability by relying on measures of market power. Specifically, we used measures of market share as an outward manifestation of marketing capability. Therefore, product marketing capability was measured by share of category volume, which is the brand's percentage market share for the defined category in Information Resources Inc.'s *Marketing Factbook*. We used the 1993 brand share for the present condition and the 1991 brand share for the absent condition. Unlike patent production, which is inherently less stable over time, market share tends

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[3]We used patent counts and not patent citations because our interest was not in the innovativeness of a firm's technology capability, which has been linked with number of patent citations (Albert et al. 1991), but rather with the ability to formulate and develop new products and related processes.

[4]For example, for the measure of product technology capability in the absence of information condition (1987–1991), the measure was equal to mean[1987patents(.7648) + 1988patents(.8236) + 1989patents(.8824) + 1990patents(.9412) + 1991patents(1.0)], and a similar calculation was made for the measure of product technology capability in the presence of information condition (1989–1993).

to be more stable, which reduces the need for more than one year in our measure.

Our rationale in adopting this approach was both theoretical and pragmatic. Theoretically, it seems logical to expect that firms with marketing capability will acquire market share. Managerial knowledge and skills, as well as investments in marketing research, distribution, advertising, sales force, and promotion—which, some might argue, provide direct measures of marketing capability—should be correlated with market performance.

In support of this view, Szymanski, Bharadwaj, and Varadarajan (1993) overview the literature regarding how marketing variables influence market share. Although they ultimately are interested in factors that influence the market share–profitability relationship, their comprehensive review suggests strong support for the impact of product quality, product customization, advertising expenditures, and sales force expenditures on market share. Likewise, several studies have documented a positive relationship between investments in product quality and market share (Buzzell and Gale 1987; Buzzell and Wiersema 1981a, b), advertising investments and market share (Assmus, Farley, and Lehmann 1984; Tellis 1988), and sales force investments and market share (Gatignon and Hanssens 1987).

Regarding the pragmatic reasons for our measure selection, we are aware that other measures of marketing expenditures, such as advertising or marketing research expenditures, may provide additional insight into marketing capability (see Dutta, Narasimhan, and Rajiv 1997). However, divisional level estimates of these expenditures for firms in our sample are not available publicly, making the use of overall firm-level marketing expenditures our only viable option. Because we established our unit of analysis at the divisional level for product technology capability in an effort to reduce the level of noise in our measure of organizational capabilities, we opted for the use of market share as an observable indicator of the division's product marketing capability.[5]

Having demonstrated that the literature finds a link between marketing investments and market share, it is also clear that market share is an imperfect measure of marketing capabilities. One concern is that market share levels also may reflect some degree of product technology capability because product technology influences product quality in important ways. Although this view has validity, we offer two points that suggest it might not affect our results. First, given that we are studying food products, which are frequently purchased, nondurable consumer goods, market share is likely to reflect marketing activities and investments and not technological advancements. In this nondurable context, brand differences are often defined by perceptual distinctions created by marketing investments in sales force, advertising, or promotion that often are not related to underlying technological differences (Aaker 1991; Cooper and Nakanishi 1988; Keller 1993). If, however, we were studying consumer durables or industrial products,

market share might well reflect both marketing and technology capability.[6]

Second, there is some research indicating a lack of a relationship between market share and R&D expenditures, which often are used as a measure of technical capabilities (Cohen and Levinthal 1990, 1994). Buzzell and Gale (1987) report little variation in the R&D:sales ratio for companies in various categories of market share performance. Likewise, Szymanski, Bharadwaj, and Varadarajan (1993) find no relationship between R&D expenditures and market share outcomes in their meta-analysis of the relevant literature.

In terms of empirical distinctions between the variables, the correlation between product technology capability and product marketing capability is $\rho = .301$ ($p < .05$) in the presence of the external information and $\rho = .312$ ($p < .05$) in the absence of the information. Despite the significance of both these correlations, they are well within the bounds of conventional levels to establish discriminant validity between the two capabilities. Multicollinearity levels between the two variables also were not found to exceed acceptable standards (see the "Results" section). Finally, though collinearity is unlikely given the diagnostics we examine here and in the results, a collinearity threat works against support for our predictions and is thus less problematic.

Measures of Control Variables

Our models also include variables to control for various factors that might influence our results. First, a measure of brand nutrition level was used to control for inherent brand differences in healthiness relative to other food products in the marketplace. This was not a measure of change in nutritional quality, but a surrogate for whether the brand strategy focused on nutrition or value. Brand nutrition level was measured by having two certified nutritionists independently evaluate each brand in terms of its overall nutrition level using a Likert scale where 1 is "very healthy" and 7 is "not at all healthy." The 1993 label information was used for this evaluation to establish a common benchmark. Interjudge reliability assessments were 74.9%, indicating adequate agreement. Minor differences (e.g., between a rating of 2 and 3) were resolved by taking the mean of the assessments. Major differences were resolved by asking the nutritionists to produce a new assessment (see Table 2).

Second, a dummy variable was added that reflected whether pre-NLEA labels already contained nutritional information. The reasoning is that if nutrition information was present prior to the NLEA, the impact of the NLEA on these brands might be weaker. Third, a variable was entered to control for varying levels of competition within the product category. This was measured by counting the number of brands competing directly with the brand. For example, in the frozen entree category, brands of lasagna were counted as direct brand competitors of lasagnas in our sample. Fourth, we included division size, as measured by the number of employees in the organization in 1995, in the model. This variable controls indirectly for the size of the division's resource base, thereby providing for better assess-

[5]Our view of product marketing capabilities as market power also includes an element of competitor orientation, as suggested by Narver and Slater (1990) and Gatignon and Xuereb (1997), because market power suggests not only effective relationships with customers and channel members, but also that the focal firm outsmarts the competition in developing and delivering on those relationships.

[6]This is not to say that technological breakthroughs do not occur in the food industry or that technical skills are not important to product quality levels, as our predictions suggest. Our point is only that market share differences are more likely to reflect marketing capability differences, not technology capability differences, in this category of products.

ments of the effect of capabilities on product development outcomes.

Fifth, a control variable was added to account for the degree to which the divisions responsible for the brands in our sample exhibited a general tendency to emphasize product-related or process-related patents in their product technology capability.[7] Process patents tend to make technical advancements in the manufacturing process in terms of the effectiveness, time, or costs of manufacturing. Product patents tend to focus on the development of products, ingredients, and/or compositions. We expect both types of technological advancements to influence our dependent variables (level and speed of quality improvements), and both, therefore, are included in our conceptualization of product technology capability. However, if most of the patents acquired by firms in our sample tend to be of a product (process) nature, the level of quality improvements (speed of quality improvements) might reveal effects but the other dependent variable might not.

To measure this variable, we took the following actions: First, we selected three of the seven years (1989, 1991, and 1993) used to construct the product technology variable. We selected three years because we believed it would enable us to determine whether firms exhibited a tendency to be process- or product-oriented without having the burden of coding all seven years of patent data in our measure. Second, for each of these three years, we pulled full patent claim information for all food-related patents acquired by the divisions in our sample. This involved using the patent database on the Internet at www.patents.ibm.com. Third, to ensure we were classifying the patents in our sample correctly, we consulted a patent specialist who works for the University of Wisconsin-Madison's patent office. The expert coded 10% of the patents in our sample, one of the authors coded all of the patents, and the other coded 90% of the patents. The classification was fairly straightforward; processes generally were referred to as "processes," "methods," or "apparatus for manufacturing," whereas products generally were referred to as "products," "compositions," or "ingredients." The reliability between the authors was 85%, and we met to resolve differences. We then compared our codes to the expert's codes and found an agreement level of 90%.

Considering the results of the coding, one surprising finding was that there was not a clear dichotomy between process and product patents. Instead, relative to the total number of patents, the proportion of patents making product-only claims was 25%, process-only claims was 35%, and both product and process claims was 40%. With these results, we have less concern that the nature of the patents as process- or product-only will bias the impact of the product technology measure. However, as an additional check, we created a control variable of the ratio of process patents to total patents acquired by each division for each of the three years in our sample. We aggregated these years because we found no statistical difference

between the proportion across the years ($F_{(2,137)} = .260$, $p > .10$).

The final control variable included in our study strives to capture variability in the cost structure of firms in the food industry. This variable ideally would be measured at the business unit level. However, this information is not available, and so, we measured differences in cost structure at the product category level. This information was gathered from the Producer Price Index published in the 1998 edition of *Manufacturing USA*. This index describes the change in cost structure by Standard Industrial Classification (SIC) code in the presence (1993–1996) and the absence (1991–1993) conditions. We classified our product categories by SIC code (e.g., our RTE cereal products were classified as belonging to SIC code 2043) and used the index change reported for each relevant SIC code. Generally, this categorization process was straightforward. However, a few categories, such as peanut butter, cake frosting, and yogurt, had to be classified with the closest, albeit imperfect, grouping.

RESULTS

The Impact on Brand Quality Improvements

Overview of model-testing approach. Given the form of H_1 and the continuous nature of the dependent and independent variables, there are two analytic approaches that can be adopted. First, a hierarchical moderator regression model could be used, in which the three-way interaction of time, product marketing capability, and product technology capability on brand quality improvements is examined. Second, with the categorical time variable (presence versus absence of external information), a hierarchical moderator regression model could be used to investigate the two-way interaction of product marketing and product technology capabilities on brand quality improvements in two separate models. Because of the presence of a categorical time variable, we selected the latter approach because it is a statistically valid, but easier to interpret, approach to testing our contingency effect.

Using this approach, two models were estimated for H_{1a} and H_{1b}. For both models, the continuous independent variables (product marketing and product technology capabilities) and their interaction were entered as predictors of brand nutritional quality improvements from 1993 to 1996 (presence) or 1991 to 1993 (absence). Prior to constructing the interaction (their product), the continuous predictors were mean-centered to reduce the collinearity between the main and interaction effects (Cronbach 1987). Low levels of collinearity were confirmed by the interaction's variance inflation factor of 1.336 in the presence model and 1.539 in the absence model, which is less than the threshold levels described by Mason and Perreault (1991). In addition, the collinearity associated with the two predictor variables also was found to be low in the presence (product marketing 1.448 and product technology 2.232) and the absence (product marketing 1.393 and product technology 1.950) conditions.

Model estimation results. Following the recommendations of Cohen and Cohen (1983) and Pedhazur (1982), the variables were entered into the model in three steps: control

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[7]A special thanks to an anonymous reviewer for pointing out this interesting possibility.

variables (Step 1), main effects (Step 2), and interaction term (Step 3). An F-test associated with the change in R^2 for the third step is examined as an indication of the significance of the interaction term. Table 3 contains results from these models.

To test H_{1b}, the index of nutritional quality improvements was computed for 1991–1993, and a regression model was estimated using the six control variables, product market capability (1991), product technology capability (1987–1991), and the interaction of the two capabilities. Results indicate that the overall model was significant (adj. $R^2 = .094$, $F_{(9,96)} = 2.215$, $p = .027$). However, none of the predictors (see Table 3) was significant, with the exception of the control variables, reflecting whether the brand contained nutrition information prior to 1993 (b = .404, t = 2.588, $p < .05$), brand nutrition level (b = .085, t = 2.079, $p = .05$), and the proportion of process patents (b = .645, t = 2.149, $p < .05$). Thus, complements of organi-

zational capabilities have no effect on brand quality improvements when external information is absent, in support of H_{1b}.

Examining the model in the presence of external information, the index of improvements to nutritional quality was calculated (1993–1996), and a regression model was estimated using the six control variables, product market capability (1993), product technology capability (1989–1993), and the interaction of the two capabilities. As indicated in Table 3, the overall model was significant (adj. $R^2 = .167$, $F_{(9,97)} = 3.360$, $p = .001$). The entry of the interaction of product technology and product marketing capabilities in the third step explained a significant level of additional variance, beyond the main effects ($F_{(1,97)} = 3.94$, $p < .05$). Specifically, the interaction shows a significant and positive effect on brand nutritional quality improvements from 1993 to 1996 (b = .002, t = 1.984, $p = .05$), in support of H_{1a}. Neither the main effect for product technology capability nor the main effect

Table 3
THE CONTINGENCY EFFECT OF EXTERNAL INFORMATION
ON THE FIRM CAPABILITY–LEVEL OF BRAND QUALITY IMPROVEMENT RELATIONSHIP

	External Information			
	Absent (pre-NLEA)		Present (post-NLEA)	
	b	t-value	b	t-value
Control Variables				
Product category competition level	.003	.711	–.000	–.041
Brand nutrition level	.085	2.079*	–.004	–.118
Nutrition information prior to NLEA	.404	2.588*	–.615	–4.735**
Division size	–.002	–1.026	.001	.382
Product category cost structure	.003	.791	–.003	–.481
Process patent ratio	.645	2.149*	–.138	–.577
Main Effects				
Product marketing capability	–.003	–.333	–.001	–.032
Product technology capability	–.014	–1.187	–.003	–.379
Interaction Effect[a, b, c]				
Product marketing capability				
× Product technology capability	.000	.232	.002	1.984*
Overall Model				
Adjusted R^2	.094		.167	
F-statistic	2.215*		3.360**	
Degrees of freedom	9,96		9,97	

[a]An incremental F-test performed on the entry of the interaction term in the information-present condition was significant: $F_{(1,97)} = 3.94$, $p < .05$.

[b]There is a significant difference in the bs associated with the product technology–product marketing interaction effect in the information-present condition and the information-absent condition ($z = 2.0$, $p < .05$).

[c]To facilitate interpretation of the significant interaction in the presence of external information, we also provide the level of brand quality improvements for categorical splits of capability predictors:

		Product Marketing Capability		
		Low	High	Marginal Means
Product Technology Capability	Low	.10 (n = 61)	–.06 (n = 15)	.07 (n = 76)
	High	–.02 (n = 16)	.16 (n = 15)	.07 (n = 31)
	Marginal Means	.075 (n = 77)	.05 (n = 30)	.07 (n = 107)

*$p < .05$.
**$p < .01$.

for product marketing capability was significant (see Table 3).[8] To facilitate interpretation, we examined the interaction by splitting the continuous capability variables into categorical variables consisting of high and low levels (see Table 3, note c). This approach produces results that, of course, mirror the continuous interaction: no significant variation in the marginal means in the two-way matrix for either the technology $(t_{(1,103)} = .074, p > .10)$ or the marketing $(t_{(1,103)} = -1.197, p > .10)$ capability. However, the interaction of the two capabilities is revealed by significant variation of the average diagonal means $(t_{(1,103)} = 34.88, p < .01)$, which suggests that firms with high marketing and high technology capabilities tend to make more brand quality improvements.[9, 10]

Of the control variables, brand nutrition level, category competition level, division size, product category cost structure, and the proportion of process patents were also not significant. The presence of some nutrition information prior to 1993, however, did have a significant negative effect $(b = -.615, t = -4.735, p < .01)$, which suggests that brands with nutrition labels prior to the NLEA made fewer improvements to the nutritional quality following the introduction of the NLEA.

Having found a significant interaction for product marketing and product technology capabilities in the presence but not the absence of external information, we now subject our data to a final test of the difference in the size of the parameters associated with these interactions across the two time periods. We follow the recommendations of Cohen and Cohen (1983, p. 111) and test the null hypothesis that the b_i from the interaction of each of the two models are equal. Our results indicate that the test of equality between the b_i of the interaction from the model in the information-absent condition as compared with the b_i of the interaction from the model in the information-present condition can be rejected; the parameters are significantly different $(z = 2.0, p < .05)$.

The Impact on the Speed of Brand Quality Improvements

Overview of model-testing approach. H_2 predicts that complements of product marketing and product technology capabilities influence the speed of brand quality improvements in the presence but not the absence of external information. To test this rate of change hypothesis, we used a hazard rate model, because it is an effective approach for examining duration times (Helsen and Schmittlein 1993). In particular, a hazard modeling approach is more effective than regression, logit, or discriminant analysis for estimating longitudinal effects and handling sample selection biases (Helsen and Schmittlein 1993). Hazard rate models have been used, for example, to estimate the duration between purchase (e.g., Jain and Vilcassim 1991) and examine duration of a channel relationship (e.g., Bowman 1998). The key duration time in this article reflects the time from introduction of the external information to brand quality improvements.

The time horizons we examined were 1991 to 1993 for the absent condition and 1994 to 1996 for the present condition. For the presence condition, the data are right-censored after 1996, so that "later" refers to organizations that had not made any quality improvements to their brands by 1996. Similarly, for the absence condition, the time horizon is left-censored at 1991 and right-censored after 1993. Because our given time horizons introduce this sample selection bias of censoring, it was more appropriate to use a hazard rate modeling approach (Helsen and Schmittlein 1993). It is important to recognize that, though firms may not have made a brand quality improvement by 1996, we cannot make any inferences about whether they will make a brand quality improvement after 1996 (i.e., the censored portion of our time horizon).

In our analysis, we used Cox's (1972) proportional hazard, or survival distribution estimate. Helsen and Schmittlein (1993, p. 398) note that when "characterizing the dynamics of duration times, it is convenient to consider the hazard rate $h(t) = f(t)/(1 - F(t))$, which is the conditional likelihood that the event of interest occurs at duration time t, given that it has not occurred in the duration interval $(0,t)$." Specifically, if a firm improved brand quality in 1994 rather than in 1995, 1996, or later, it is perceived to have a shorter duration time. A shorter duration time indicates a faster organizational response with respect to brand quality improvements. Using a partial likelihood approach and given that our data are annual, we analyzed the duration time using a discrete-time hazard rate model.[11] In addition,

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[8]These results, though consistent with our theoretical focus on complementarities, or the joint effects of firm capabilities, raise the important question of whether interaction effects can exist without main effects. Statistical treatments of this question indicate that this is possible (Cohen and Cohen 1983, pp. 301–50; Keppel 1991; Pedhazur 1982). Moreover, these treatments also suggest that interpreting main effects in the presence of interaction effects can be deceptive. As Pedhazur (1982, p. 362) suggests, "When the interaction is significant it is generally not meaningful to interpret the main effects. This is because the presence of an interaction indicates that their effects vary depending on the treatments of the other factors with which they are combined ... with certain patterns of interactions it is possible even to obtain main effects that are all zero or negligible."

[9]We are aware that it is also possible to investigate the continuous interactions for H_1 because it involves continuous variables and a standard regression approach (Aiken and West 1991; Cohen and Cohen 1983). However, to be consistent across the two hypotheses, we adopted the categorical splits required to examine H_2. Consistent with the results from the categorical approach, using the continuous approach reveals that technology capabilities had a significant positive relationship with level of nutritional quality improvements when marketing capabilities were high. However, for low marketing capabilities, technology capabilities exhibit a significant negative effect on the level of brand quality improvements. Although unexpected, finding the second-highest level of product quality improvements in the low/low cell of Table 3, note c, might be explained in several ways. First, because of our focus on the complementarity of marketing and technology capabilities, it is not inconsistent to find the highest levels among those firms that have congruent levels of these capabilities (high/high or low/low). Second, another view is that firms with weak technology or marketing capabilities may have the most to gain by developing strategies that focus on product quality. These are firms with low market shares and firms that historically have shown less leadership on technological issues. Therefore, the NLEA may have motivated such firms to act to improve their products in the hopes of improving performance and position in the market. Such action, in the absence of capabilities, suggests that the strategies are more improvisational in nature (Moorman and Miner 1998; Weick 1993).

[10]In splitting the continuous capability variables for both H_1 and H_2, we made the decision to use mean instead of median splits. Our decision was influenced by the distribution of the product technology variable, which is highly skewed toward zero levels. Specifically, almost 40% of the firms in our sample had no patents during the post-NLEA study period. Therefore, a median split at .33 would include firms with .34 patents and firms with 26 patents in the high product technology capability level. However, if we do a mean split at 4.66, we generate what we believe are much more reasonable categorical product technology capability levels (0–4.66 for low and 4.67–26.05 for high product technology capability levels). We believe this approach reduces some of the measurement error naturally introduced by categorical splits (Aiken and West 1991).

[11]Although the dependent variable is categorical, a discrete-time hazard rate model is more appropriate than a multinomial logit model given the goal of estimating duration time (Helsen and Schmittlein 1993).

Table 4
THE CONTINGENCY EFFECT OF EXTERNAL INFORMATION
ON THE FIRM CAPABILITY-SPEED OF BRAND QUALITY IMPROVEMENT RELATIONSHIP

| | External Information | | | |
| | Absent (pre-NLEA) | | Present (post-NLEA) | |
	b	t-value	b	t-value
Control Variables[a]				
Product category competition level	-.003	-.287	-.015	-.893
Brand nutrition level	-.019	-.161	-.186	-1.283
Nutrition information prior to NLEA	1.786	3.299**	-1.397	-2.551**
Division size	-.006	-1.010	.003	.404
Product category cost structure	.007	.649	-.033	-1.281
Process patent ratio	1.763	1.919*	-1.060	-1.033
Main Effects				
Product marketing capability	-.008	-.374	.019	.626
Product technology capability	-.045	-1.238	-.074	-1.603
Interaction Effect[b, c]				
Product marketing capability				
× Product technology capability	-.003	-.872	.013	2.688**
Overall Model				
Overall model chi-square (degrees of freedom = 9)	26.672**		23.628**	

[a]The chi-square critical value for the overall model with 9 degrees of freedom and $p = .01$ is 21.666, $p = .05$ is 16.919, and $p = .10$ is 14.684.

[b]An incremental test of the likelihood ratio shows that the entry of the interaction terms in the information-present condition is significant $(\chi^2_{(1)} = 9.791, p < .01)$.

[c]There is a significant difference in the bs associated with the product technology-product marketing interaction effect in the information-present condition and the information-absent condition $(z = 2.744, p < .01)$.

*$p < .10$.
**$p < .01$.

because of our small sample size, we used the negative log-likelihood function to examine overall model significance (Cox and Oakes 1984). Finally, following the recommendations of Jain and Vilcassim (1991), we interpreted the model coefficients in a manner similar to a regression model.

Similar to the analysis for H_1, the same six variables were included in the model to control for various extraneous factors. As previously, the continuous predictor variables were mean-centered, and their product was used to construct the interaction term. The main and interaction effects, as well as the control variables, then were entered into the discrete-time hazard rate model.

Model estimation results. Table 4 contains the results for H_2. In the absence of external information, faster quality improvements were measured as whether the change occurred in 1991, 1993, or later, with "later" referring to organizations that had not made any quality changes to their brands by 1993. Estimating the model with the six control variables, product market capability (1991), product technology capability (1987-1991), and the interaction of the two capabilities, the results indicate support for H_{2b}. Specifically, though the overall model is significant $(\chi^2_{(9)} = 26.672, p = .002),$[12] neither of the main effects (product marketing $b = -.008$, $t = -.374$, $p > .10$; product technology $b = -.045$, $t = -1.238$, $p > .10)$ nor the interaction effect $(b = -.003$, $t = -.872$, $p > .10)$ was significant. Therefore, product technology and product marketing capabilities do not influence the speed of brand quality improvements when external information is absent, in support of H_{2b}. In terms of

the control variables, the presence of nutrition information prior to the NLEA had a significant effect $(b = 1.786$, $t = 3.299$, $p < .01)$ and the proportion of process patents had a moderately significant effect $(b = 1.763$, $t = 1.919$, $p < .10)$.

The model in the presence of external information is also significant $(\chi^2_{(9)} = 23.628, p = .005)$. In addition, the incremental test of the likelihood ratio on entry of the interaction of product technology capability and product marketing capability into the model shows that it explains a significant level of variance beyond the main effects model $(\chi^2_{(1)} = 9.791, p < .01)$. Consistent with this, the interaction has a positive significant effect on the speed of brand improvements $(b = .013$, $t = 2.688$, $p < .01)$, in support of H_{2a}. To facilitate interpretation of the interaction, we also examined the proportional hazard rate over time using survival estimates for the four conditions of high and low levels of the two capability predictors (Allison 1995; Klein and Moeschberger 1997). Using this approach, the expected probability of not making brand quality improvements for the high technology/high marketing condition is 0% for each of the three years in the post-NLEA period (1994, 1995, 1996). This indicates that firms with high marketing and high technology capabilities, on average, would make fast quality improvements. The other conditions were, as expected, on average much higher for the three-year period: high technology/low marketing (90%), low technology/high marketing (82%), and low technology/low marketing (57%).

Neither of the main effect variables is significant (product marketing $b = .019$, $t = .626$, $p > .10$; product technology $b = -.074$, $t = -1.603$, $p > .10)$. The only significant control variable was the presence of nutrition information prior to the NLEA $(b = -1.397$, $t = -2.551$, $p < .01)$, which was a negative significant predictor of speed.

[12]The chi-square critical value with 9 degrees of freedom and $p = .01$ is 21.66, $p = .05$ is 16.919, and $p = .10$ is 14.684.

Finally, as in H_1, we submit our findings to an additional test of the difference in the size of the parameters associated with the product technology and product marketing interaction across the two time periods (Cohen and Cohen 1983). Results indicate a significant difference between the b_i of the interaction from the model in the information-absent condition as compared with that from the model in the information-present condition ($z = 2.744, p < .01$).

DISCUSSION

The extant interdisciplinary literature suggests that the impact of organizational capabilities on performance is positive and unconditional. In this article, we challenge this view by suggesting two important contingencies. First, we predicted that not all capabilities are valuable as single assets. Instead, we focused on the value of complementary product technology and product marketing capabilities. Second, we argue that the effect of capabilities on product development outcomes is contingent on environmental conditions. In particular, we predicted that external information would stimulate firms to deploy their product technology and product marketing capabilities to influence the degree and speed of relevant product development activities.

Complementarities in Product Development

Our results are consistent with the proposed effect of complements of organizational capabilities on brand quality improvements. Specifically, brands were more likely to exhibit quality improvements and make these improvements faster relative to competitors when the organization had high levels of both product technology and product marketing capabilities. Although the idea that firms need to nurture technology and marketing capabilities concurrently is certainly not new in this age of quality function deployment and cross-functional teams, our results contribute in several important ways.

Our study is one of the first to model complementarities as an interaction and the first to find empirical support for the effect of these complementary capabilities on the nature and speed of brand quality improvements. Prior research investigating the influence of various organizational factors, orientations, or characteristics has tended to investigate the independent effects of these capabilities, ignoring their combined impact. Alternatively, research investigating complementarities has been drawn from evidence about a single firm or set of effective firms (e.g., Milgrom and Roberts 1990; Teece 1988). Such approaches are fruitful as a first step toward understanding deeply the nature of these complementarities. Our research confirmed the wisdom of these previous studies in a generalizable sample of firms over a six-year period using secondary data and careful fieldwork. Finally, prior work focusing on organizational capabilities (Day 1994; Jaworski and Kohli 1993; Moorman 1995; Narver and Slater 1990), cultures (Deshpandé, Farley, and Webster 1993), or orientations (Day and Nedungadi 1994; Gatignon and Xuereb 1997) has tended to use managers' retrospective perceptions of organizational-level phenomena as measures of organizational capabilities and product development outcomes. This article removes the potential for bias introduced by relying on managerial perceptions of both capabilities and outcomes.

Because we have demonstrated the value of complements of organizational capabilities in marketing and technology,

additional research should provide insight into the process by which product technology and product marketing capabilities work together to generate greater value for firms. Dougherty and Corse (1996) refer to "market-technology linking" mechanisms that connect the product to distribution, inventory, selling, and manufacturing systems (see also Griffin and Hauser 1992, 1996; Moenaert and Souder 1990). Linking mechanisms, such as cross-functional teams, have begun to emerge consistently as important in empirical research (Griffin 1997). Further research should consider the role of other psychological, organizational, and interorganizational factors that facilitate effective complementarities. In the case of interorganizational factors, the trend toward outsourcing capabilities and functions is likely to make the achievement of complementarities even more challenging. However, due to the contingency effect of environment information and the importance of accessing and using information from the environment, outsourcing paradoxically may be the best way to keep abreast of changing environmental conditions.[13]

The Effect of Capabilities in Product Development

A second major goal of this research was to suggest that the value of capabilities is contingent on their effective deployment or use. We asserted that this value occurs when firms deploy their capabilities in ways consistent with external information. In these conditions, a firm's capabilities increase their potential investment value. This is especially the case when capabilities enable some firms to move faster and more effectively, even though all industry members are experiencing similar external conditions.

The theoretical backdrop for these predictions is almost 30 years of strategy literature, both within and outside of marketing, that points to the importance of an organization deploying its capabilities to fit with the external environment (e.g., Amit and Shoemaker 1993). This literature and nearly all marketing strategy textbooks point to the importance of using capabilities in this way. Despite the entrenchment of this assumption, there has been no large-scale, systematic examination regarding whether this occurs in practice.

Using a longitudinal quasiexperiment provided the capability to isolate the effects of external information on the relationship between firm capabilities and product development outcomes. Because firm capabilities had no relationship with the focal product development outcomes prior to the introduction of the information into the external environment, our results suggest that firms were largely reactive to changes in the external environment. Prior research has been unable to separate out such effects from other occurrences, such as when firm capabilities, external information, and strategy outcomes co-occur but are not related causally.

Aside from the strategy concept of fit, we also drew on the view of capabilities as options that can be deployed toward strategic ends. Our findings support this perspective and contribute back to this literature by documenting the important impact of external information on the nature and value of investments. Specifically, by adopting a longitudinal and quasiexperimental design, our results imply that the most valuable characteristic of firm capabilities comes from their ability to serve as flexible strategic options. In this role, firms can deploy them in ways consistent with external

environmental forces. This, in turn, may imply that the value of capabilities rests on whether and how firms actually deploy them in response to the changing competitive landscape. It also points to the issue of how rationally managers actually respond to environmental information (Glazer, Steckel, and Winer 1992).

Another perspective on our results is that the capability level of a firm has an impact on its reaction and speed of reaction to events in the external environment. Considered in the context of the NLEA, these differences may have important implications for the competitive structure of the food industry. Specifically, if capability-rich firms are more likely to respond to external information, the presence of a strong information stimulus may result in increased market concentration and reduced price competition, with smaller, lower-capability firms suffering greater mortality rates. The policy and strategic implications of this possibility are important.

Limitations and Boundary Conditions

The first limitation of our research is that we did not examine whether or how firms actually deploy their capabilities toward product development outcomes. Instead, our method and measure choices focused on how the relationship between firm capabilities and product development outcomes changes in the presence and absence of external information. Therefore, though our predictions were supported, we can only conclude that our results are consistent with capabilities being deployed in reaction to the external information.

The second limitation is that this research focused on one specific type of information, created by a regulation that mandated all firms disclose nutrition information for their offerings on product labels. One question that this focus raises is whether information created by regulation would influence competitive responses differently than that created by other sources. For example, it could be that the more predictable nature of regulation increases firms' abilities to respond. Therefore, information emanating from less predictable sources, such as consumers or competitors, may weaken our results. In the case of the NLEA, however, there were several important uncertainties, including how consumers and competitors might react to truthful reporting of nutritional properties. Therefore, despite the lower uncertainty regarding the availability and timing of label information, there remained some uncertainty regarding consumer and competitor responses to the information.[14] Moreover, by limiting our theory to external information that has the potential to affect consumers' search costs, we believe we stay consistent with prior research in the economics of information literature, while

also allowing for a more strategic emphasis on external information flows.

A third limitation is that there also may be additional types of capabilities that play a role in product development outcomes. Dutta, Narasimhan, and Rajiv (1997) examine, for example, the impact of marketing capabilities on the effectiveness of R&D and production in high-tech firms. Likewise, the role of human resource capabilities in service operations or the role of finance capabilities in determining the value of investments made on behalf of customers (Rust, Zahorik, and Keiningham 1995) may be an equally important complementarity to the effectiveness of marketing capabilities.

The fourth limitation is that this and additional research could benefit from including a broader measure of product development outcomes. In the area of product quality, because our focus was on the impact of external information pertaining to nutrition information, we followed theory and focused on changes to brand nutritional quality. However, external information also may stimulate changes to brand taste or packaging that were not accounted for in this research. We controlled for some differences in brand strategy in our models, which might influence the degree of emphasis a brand strategy places on nutrition. However, more systematic investigations of other indicators of brand quality would be an important complement to this research.

Another product development outcome of interest is the effect of capabilities on the costs or efficiency of product development efforts. As one of our reviewers was quick to note, there are often important trade-offs associated with quality, speed, and the cost of product development (Cohen, Eliashberg, and Ho 1996, 1997). We agree that such trade-offs are likely and important, but we were unable to collect divisional-level cost data to examine this effect. We did include, however, product category cost structure as a variable in our model to control for potential differences. In addition, by including the ratio of process to total patents acquired by the firm, we controlled for the potential effects of cost differences due solely to process improvements.

Our research also did not examine the impact of product development outcomes on firm financial performance or the impact of external information on that relationship. Further research could examine this latter contingency by suggesting that product development changes or other marketing strategy elements that are consistent with external information should increase firm performance more than strategy changes that are not consistent with external information.

Finally, considering the independent variables in our research, additional research could improve on our capability measures by expanding the range of variables considered. In measuring product marketing capability, for example, measures might include assessments of relationship equity (Srivastava, Shervani, and Fahey 1998) or brand equity (Dutta, Narasimhan, and Rajiv 1997) that could underlie market share outcomes.

CONCLUSION

This research has made important strides in demonstrating the positive effect that complements of organizational capabilities have on product development outcomes. We adopted a longitudinal, quasiexperimental approach that used secondary

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[14]In addition to this uncertainty, firms appeared to recognize the importance of the NLEA to their brands' success. A survey of the brand managers responsible for the sample of brands in our study prior to the implementation of the NLEA indicates they had moderate levels of agreement with the view that the NLEA was important to their consumers. Specifically, responses from 61 of 124 of the managers (49.1%) to the question, "The new label requirements will affect consumers' decisions for brands in my product category" on a seven-point scale where 1 is "strongly disagree" and 7 is "strongly agree" reported a mean level of 4.49 (standard deviation = 1.72). This response suggests that the NLEA is a reasonable context for examining firm actions in response to external information.

and field data to show that product marketing and product technology capabilities jointly influence the degree to which firms improved the quality of their brands and the speed of these quality improvements. Even more important, our results are consistent with the view that the presence of external information in the environment clearly accentuates the value of such capabilities. Therefore, we conclude that the most valuable characteristic of firm capabilities may be their ability to serve as flexible strategic options. In this role, firms can display them in ways consistent with environmental forces.

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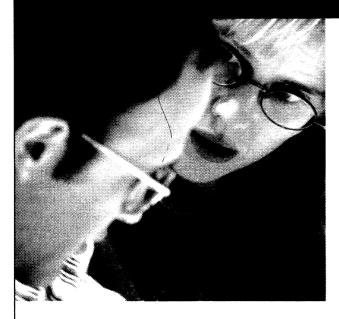
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