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Managing Product Variety and Collocation in a Competitive Environment: An Empirical Investigation of Consumer Electronics Retailing

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Product variety is an important strategic tool that firms can use to attract customers and respond to competition. This study focuses on the retail industry and investigates how stores manage their product variety, contingent on the presence of competition and their actual distance from rivals. Using a unique data set that contains all Best Buy and Circuit City stores in the United States, the authors find that a store's product variety (i.e., number of stock-keeping units) increases if a rival store exists in its market but, in the presence of such competition, decreases when the rival store is collocated (within one mile of the focal store). Moreover, collocated rival stores tend to differentiate themselves by overlapping less in product range than do noncollocated rivals. This smaller and more differentiated product variety may be because of coordinated interactions between collocated stores. In summary, this paper presents evidence of both coordination and competition in retailers' use of product variety.

Key words: product variety; competition; collocation; differentiation
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1. Introduction

Managers in many industries use product variety as a strategic lever (Bayus and Putsis 1999, Sorenson 2000). This lever appears increasingly appealing in the retail industry, where more and more retailers have adopted "price match guarantees" (e.g., Best Buy, Sears, Staples, Vons, and sometimes Walmart) and cannot resort to temporary price reductions as effectively as they might have in the past to attract consumers. Considerable research has studied why variety might theoretically benefit the firm (e.g., Kahn 1998a, b; Lancaster 1990, 1998) and examined empirically the benefits (e.g., Kekre and Srinivasan 1990) and costs of expanding variety (e.g., Randall and Ulrich 2001). However, little research has focused on competition as a key determinant of product variety.

Working in the context of retail competition for consumer electronics, we build on prior efforts (e.g., Olivares and Cachon 2009, Watson 2009) to study how competition influences product variety decisions. We extend these efforts by exploring two previously ignored variables: collocation and product range overlap. We address the following questions: will a store change its level of product variety if a key competitor is present (versus not present) in its market area? Given such competition, does it matter if the competing store is collocated? Apart from the level of product variety, will collocation influence the extent to which the focal store's product assortment overlaps with the competing store?

We consider explicitly whether collocation, which strengthens competition and also may expand the market, influences product variety over and above the general presence of competition. Conventional studies on spatial competition presume that geographic proximity increases competition, and "heightened competition reduces rents for all" (Chung and Kalnins 2001, p. 969). But when collocated, firms also can enjoy agglomeration gains, because geographic concentration helps consumers reduce their search costs (Stahl 1982), and thus heightens demand for collocated stores (Cachon et al. 2008, McCann and Folta 2008).

In part because of the agglomeration benefits, many direct rivals—such as CVS and Walgreens, Home Depot and Lowe's, and Best Buy and Circuit City—locate in the same shopping plaza or open stores across a street. Jackson Lan, the founder and former owner of the PC Club chain, was referred to by Stavro (1999) in a *Los Angeles Times* article as "the strategist next door," because from 1992 to 1999 he strategically located his 19 PC Club stores within walking distance of CompUSA, Best Buy, or Fry's Electronics. His rationale was that this copycat location strategy not only helped PC Club attract foot traffic but also avoided overspending on advertising campaigns and market research about where to locate. Our focus on collocated competition allows us to see how the interplay of these contrasting forces affects rival stores' product variety decisions. Moreover, no previous studies have ever examined whether collocated competitors differentiate more by reducing the extent of product range overlap than do noncollocated competitors. We probe both the level and composition of product variety, that is, the number of variants and the proportion of overlapping products with competitors. This initial exploration of product range overlap and our unique focus on collocation constitute the primary contributions of our research.

Our research is further distinct from prior work in that our data set covers every retail outlet of the two largest specialty consumer electronics retail chains in the United States in 2006, Best Buy and Circuit City. With this extensive data set, we provide a more expansive and pertinent research setting than most previous work (e.g., Watson 2009). Since the time of our data collection, Circuit City has declared bankruptcy and exited the market.[1] However, this industry setting in 2006 offered two key benefits for our study. First, the competitive dynamics between Best Buy and Circuit City showcased the importance of product variety and were potentially representative of many pairs of U.S. and international retail chains (e.g., CVS versus Walgreens, Walmart versus Carrefour). Second, the location and in-store product variety information for each Best Buy and Circuit City store was available on their websites and updated frequently. Advanced computer search and data collection techniques enabled us, through great effort, to retrieve and compile information with better reliability than would be possible through manual data collection.

[1] On November 10, 2008, Circuit City filed for bankruptcy protection under Chapter 11, followed by store closures and layoffs. When we first collected the data in November 2005, Circuit City was in no sign of trouble. According to Circuit City's quarterly earnings filing with the U.S. Security and Exchange Commission, during the last quarter of 2005, it was still profitable (net earnings $10 million) and issuing dividends.

Our investigation reveals that a store's product variety increases significantly when a rival store appears in the local geographic market (within a 10-mile radius of the focal store). However, given the presence of such competition, the focal store's product variety decreases relative to noncollocated competition when the rival store is collocated (within one mile). Moreover, collocated stores are more inclined to differentiate themselves by overlapping less in product assortments than do pairs of distant rivals. This smaller and more differentiated product variety implies the possibility of coordinated interactions between collocated stores.[2] Their coordinated behavior can blunt their competition and allow both stores to reap agglomeration benefits by attracting more consumers with lower stocking costs. In summary, we document empirically that both coordination and competition with rivals occur in retailing and that product variety, in terms of both level and overlap, can be managed strategically to adapt to the competitive environment.

We organize the remainder of this paper as follows: We review literature on the motives for and consequences of changing product variety in §2. In §3, we describe a simple model to illustrate our intuitions and propose several hypotheses about how a store's product variety (level and overlap) might change according to the competition and collocated competition it faces. We outline the empirical methodology in §4 and present the empirical results in §5. Finally, we discuss implications of the key results, our contributions and limitations, and some directions for further research.

2. Prior Literature

Research from many disciplines, including economics, marketing, operations management, and strategy, indicates that product variety can help firms attract customers and respond to competition. Previous empirical studies report the benefits of high-variety strategies, such as sales increases (Kekre and Srinivasan 1990), higher prices (Pigou 1920), and enhanced survival rates (Sorenson 2000). Yet launching and maintaining a large product variety incurs considerable costs, because of higher inventory levels (Kekre 1987), the loss of scale economies, and the imposition of supply-chain market mediation (Randall and Ulrich 2001).

The benefits of product variety may derive from several sources. Marketing scholars have identified

[2] We avoid the term "implicit collusion," which implies antitrust violations. The terms "coordination" and "coordinated interaction" come from the Horizontal Merger Guidelines of the U.S. Department of Justice and the Federal Trade Commission.

consumer-based motivations for an increase in product variety (for reviews, see Kahn 1998b, McAlister and Pessemier 1982). If each consumer knows his or her preference precisely in a product category and chooses the same option repeatedly, "more variety in [the] product line will make it more likely that each consumer finds exactly the option he or she desires" (Kahn 1998a, p. 46). Alternatively, when consumers make different choices over time, especially in low-involvement, low-risk product categories, they may seek variety to meet their intrinsic drive for stimulation (Raju 1980) or satisfy their curiosity about novel things (Hirschman 1980). In both scenarios, greater product variety can increase customer satisfaction and loyalty. Lancaster (1998) also suggests some information- and producer-based motivations for increasing variety. An incumbent firm may offer product variety that exceeds "some long-run market equilibrium," (p. 4) if it can attain economies of scope by doing so or if it lacks information about consumer preferences and therefore needs to offer as many products as possible to find out which ones consumers prefer. Moreover, greater product variety can establish barriers to entry, in that the incumbent firm preemptively fills all potential market gaps in which an entrant could have entered, as empirically documented by Putsis and Bayus (2001) in the personal computer industry.

Despite this good understanding of the consequences of and theoretical motives for increasing product variety, little empirical research has examined product variety as a strategic tool for responding to competition. Most studies focus on pricing, not product variety, as a competitive instrument (e.g., Mazzeo 2002, McGahan and Ghemawat 1994, Thomadsen 2007). The few extant studies on product variety competition focus on the impact of competitors' actions and market structure on firm-level variety. For example, Bayus and Putsis's (1999) investigation of the personal computer industry during 1981–1992 shows that if competitors broaden their product line, firms also should increase their product variety. Berry and Waldfogel (2001) examine commercial radio stations in 243 U.S. markets in 1993 and 1997 and find that the greater concentration of ownership in a market, wrought by the 1996 Telecommunications Act, was associated with an increase in per-firm product variety (i.e., number of different programming formats relative to the number of competitors in a market).

Somewhat more related to our study, in their investigation of more than 200 U.S. General Motors dealerships, Olivares and Cachon (2009) find that dealers carry more inventory when they face more competition (measured as the number of dealerships in a local geographic market). Watson's (2009) analysis of the display inventories of eyewear retailers in the midwestern United States presents contrasting results at two levels: At the market level, average per-retailer variety decreases with the number of rivals; at the retailer level, when more rivals are located nearby, retailers first stock more product variety before eventually reducing the level. Building on these two recent studies, we aim to paint a richer picture of product variety competition by exploring two new directions: collocated competition and the extent of assortment overlap.

3. Model and Hypotheses

We model how stores change their product variety in a market that includes two direct, mutually acknowledged competing retail stores (Chen 1996).[3] Because many retail stores, such as Best Buy and Circuit City, offer "price match guarantees," we do not focus on price competition[4] and instead place our emphasis on how rival stores interact with one another by choosing appropriate product variety levels.

3.1. The Model

Consider a local geographic market consisting of two competing stores that carry product varieties V_j and V_i to attract consumers ($i, j = 1, 2$, $i \neq j$). We begin by specifying the demand function of each store based on a set of assumptions. First, a store's absolute product variety drives up its own demand by increasing the likelihood that store visitors can find products to match their tastes (Kahn 1998a). We use V_i^α to describe how store i's product variety influences its demand. Second, carrying more product variety than a competitor store increases the likelihood that consumers will choose to visit the focal store, which in turn increases the focal store's market share and demand (Shugan 1989). We use $(V_i/V_j)^\beta$ to capture how the relative variety between store i and j influences store i's demand, such that a larger β represents a more

[3] Chen (1996) posits that a competitor analysis is based on two factors: whether firms have similar types and amounts of resources (resource similarity) and whether they compete in many markets that are important to them (market commonality). If firms have both high resource similarity and market commonality, they are direct and mutually acknowledged competitors (e.g., Sony and Toshiba, Coke and Pepsi, Best Buy and Circuit City).

[4] To validate the point, we collected price data in March 2006 for all Best Buy and Circuit City stores in two product categories: digital cameras and televisions. We conducted paired t-tests on the prices of digital cameras and televisions and found no significant difference in price ($p = 0.53$ for digital cameras, 0.66 for televisions). Specifically, for digital cameras, the average paired price difference between the two chains is 0.23% of the price, and 47% of the matched products have same prices at both chains. For televisions, the average paired price difference is 0.45% of the price, and 36% of products have equal prices. Note that even though we observe very small differences in regular prices, larger differences in promotional prices might arise.

competitive market. Third, if the competing store is located *close enough* to the focal store, an agglomeration effect may occur. This agglomeration effect suggests that additional product variety by the proximate rival helps increase the focal store's demand. We use V_j^γ to capture this agglomeration effect, with a larger γ indicating a stronger agglomeration effect. Putting these components together, we follow Shugan (1989) and adopt the commonly used multiplicative functional form to set up store i's demand function:

$$Q_i = KV_i^\alpha \left(\frac{V_i}{V_j}\right)^\beta V_j^\gamma \quad i, j = 1, 2, i \neq j, \tag{1}$$

where Q_i is store i's demand; K is a constant that represents store i's absolute market potential; α denotes the marginal effect of own variety on demand; β represents the level of competitive intensity; and γ is the marginal agglomeration effect on demand. In a competitive market, all these parameters are strictly positive, whereas in a monopoly market that includes only one store, both competition and the agglomeration effect disappear ($\beta = 0$ and $\gamma = 0$).

The profit of store i in turn is

$$\Pi_i(V_i, V_j) = KV_i^\alpha \left(\frac{V_i}{V_j}\right)^\beta V_j^\gamma - \frac{1}{2}V_i^2 \qquad i, j = 1, 2, i \neq j, \tag{2}$$

where $\frac{1}{2}V_i^2$ denotes store i's costs of carrying product variety V_i (e.g., inventory, transportation, opportunity cost of shelf space).[5] Based on the demand and profit functions, next we analyze three questions: (1) How does a store change its product variety if a competitor exists in its local geographic market? (2) In a competitive market, do collocated rivals differentiate more in their product range than do distant rivals? (3) How do rival stores that compete in the market change the level of product variety if they are collocated? We provide the proofs in the appendix.

3.2. Product Variety and the Presence of Competition

In this subsection, we compare store-level product variety in a competitive market to that in a monopoly market. In a competitive market, each competitor chooses its own product variety to maximize its *own* profit. In other words, the problem for each store is $\max_{V_i} \Pi_i(V_i, V_j)$ $(i, j = 1, 2, i \neq j)$. Solving the profit maximization problems of both stores allows us to propose the following:

Proposition 1. *In a competitive market there exists a symmetric equilibrium: Each store chooses the optimal variety* $V_i^{*d} = [K(\alpha+\beta)]^{1/(2-\alpha-\gamma)}$ $(i = 1, 2)$. *In a monopoly market, the optimal product variety of the monopolistic store is* $V_i^{*m} = (K\alpha)^{1/(2-\alpha)}$. *It holds that* $V_i^{*d} > V_i^{*m}$. *In addition,* $\partial V_i^{*d}/\partial\beta > 0$.

Proposition 1 suggests that the optimal variety of a competitive store is always greater than that of a monopolistic store. More generally, a store's optimal product variety increases with the level of competitive intensity (β), and a monopoly market is a special case when competition disappears. The intuition behind this proposition holds that more product variety contributes to store demand and profit because it is more likely that each consumer finds his or her most preferred style (Kahn 1998a), and more variety allows each consumer to enjoy a diversity of options (McAlister and Pessemier 1982). In a competitive market, any store that lags behind its competitor in providing variety faces the consequences of lower demand and lower profits. Because of such an "arms race," both stores must provide higher levels of variety than either would have provided in a monopoly market of the same size. Accordingly, we empirically test the following hypothesis:

Hypothesis 1 (H1). *A store's product variety increases if a rival store competes in the same market.*

3.3. Differentiation and Collocated Competition

We now focus on the case of a competitive market. We explore the possibility that rival stores may differentiate themselves using their product ranges, and we examine how the extent of differentiation varies when rival stores are collocated. A store can differentiate by carrying fewer products that also are available at the competitor' store (overlapping products) and/or increasing the number of products that the competitor does not carry (nonoverlapping products). Differentiation softens competition (Mazzeo 2002, Porter 1991). It can also strengthen the agglomeration effect: If a store adds an overlapping product, the total product variety of both stores remains unchanged. In contrast, if a store differentiates by introducing a nonoverlapping product, the total product variety increases, which further reduces consumer search costs and enhances the attractiveness of the overall marketplace.

We introduce a parameter θ to capture the impact of differentiation (or the reverse of product range overlap) on competition and the agglomeration effect.[6] We assume that $\theta \geq 1$, with $\theta = 1$ representing no differentiation and $\theta > 1$ denoting the existence of

[5] The coefficient $\frac{1}{2}$ is added for mathematical convenience and does not change the results substantively. We use a quadratic cost function for the uniqueness of the solution. Such a cost function is commonly employed to describe the increasing costs of operation as input increases (Mas-Colell et al. 1995).

[6] We treat differentiation (denoted by the parameter θ) as a choice variable that needs to be coordinated by both stores. Because it can be adjusted only slowly through coordination, in the short run it can be treated as fixed, as we do in deriving our Proposition 3. Moreover, note that for Proposition 2, we only model a one-period

differentiation. The profit function in Equation (2) can be rewritten as follows:

$$\Pi_i(V_i, V_j, \theta) = KV_i^{\alpha}\left(\frac{V_i}{V_j}\right)^{\beta/\theta} V_j^{\gamma\theta} - \frac{1}{2}V_i^2 \qquad i, j = 1, 2, \quad i \neq j, \qquad (3)$$

where we divide β by θ to indicate that differentiation reduces competition and multiply γ by θ to show that differentiation increases the agglomeration gain.[7] Again we solve the profit maximization problems of the two rival stores and obtain each store's optimal variety and corresponding profit.

Proposition 2. *A symmetric equilibrium exists such that each store chooses the optimal variety*

$$V_i^* = \left[K\left(\alpha + \frac{\beta}{\theta}\right)\right]^{1/(2-\alpha-\gamma\theta)}$$

to earn profit

$$\Pi_i^* = \left[K\left(\alpha + \frac{\beta}{\theta}\right)\right]^{2/(2-\alpha-\gamma\theta)} \left[\frac{1}{\alpha+\beta/\theta} - \frac{1}{2}\right] \quad (i = 1, 2).$$

As a result, we have (a) $\partial\Pi_i^*/\partial\theta > 0$. *That is, a store's equilibrium profit increases with the level of differentiation.*
(b)

$$\frac{\partial(\partial\Pi_i^*/\partial\theta)}{\partial\beta} > 0, \qquad \frac{\partial(\partial\Pi_i^*/\partial\theta)}{\partial\gamma} > 0.$$

That is, the positive impact of differentiation on profit is greater when there is more competition and an agglomeration effect.

Proposition 2(a) suggests that because more differentiation leads to higher store profit, stores have an incentive to differentiate. Proposition 2(b) indicates that this incentive is stronger when stores face higher levels of competition and agglomeration gains, two features associated with collocation. On the one hand, when rival stores are collocated (e.g., in the same shopping plaza), transport cost across collocated stores declines to nearly nothing, which should reduce consumers' switching costs and thereby increase the intensity of the rivalry between the sellers ($\beta\uparrow$). On the other hand, the demand-heightening agglomeration effect emerges with collocation ($\gamma\uparrow$). Differentiation helps dampen the more fierce competition between collocated stores and further enhances the agglomeration gains by increasing the collocated region's total product variety, thereby contributing to store profits to a greater extent. As a result, collocated stores are more inclined than distant rivals to differentiate. In line with Proposition 2, we submit the following hypothesis:

Hypothesis 2 (H2). *Given competition in a market, collocated rivals are more likely than distant rivals to differentiate by reducing their product range overlap.*

3.4. Product Variety and Collocated Competition

Many rival retailers have coexisted for a long time and are likely to interact repeatedly. Some rival retailers even become increasingly similar in their resources and markets (Chen 1996), as exemplified by Best Buy and Circuit City in our empirical setting. Repeated interaction among a few similar players encourages coordination (Tirole 1988, p. 240). In choosing its competitive tactics then, a store must take into account not only the possible increase in short-term profits but also the possibility of long-run losses from the rival's retaliation in the future. Moreover, when rival retailers encounter each other in multiple geographic markets, they need to weigh gains in one market against dangers of retaliation in other markets. Such multimarket contact can blunt the incentives for rivalry and further facilitate coordination (Tirole 1988, p. 243).

We now use a simple case to demonstrate why coordination can result in lower product variety at each store. If two rival stores coordinate fully, they no longer behave noncooperatively to maximize their individual profit. Instead, their combined problem becomes choosing product variety levels (V_i^{*c}) to maximize joint profits. For a given level of differentiation (θ), the common objective shared by two rival stores is $\max_{V_1, V_2}[\Pi_1(V_1, V_2 \mid \theta) + \Pi_2(V_1, V_2 \mid \theta)]$. By solving this problem we are able to state the following:

Proposition 3. *For a given level of* θ, *we have* $V_i^{*c} < V_i^*$. *That is, the optimal product variety when both stores fully coordinate is smaller than that when each store acts noncooperatively with the sole objective of maximizing its own profit.*

Proposition 3 shows that the respective product variety of two fully coordinated rivals is smaller than the optimal level chosen by two rivals that do not coordinate (i.e., competitive level of variety). Because two fully coordinated stores choose variety levels to maximize their joint profits, they are not engaged in a harmful "arms race" to add extra product variety and attract customers away from the competition, which also would incur higher stocking costs. Instead, two rival stores behave *as if* they were one big store, each

game in which rival stores may or may not coordinate to such extent that makes the level of differentiation consistent with the equilibrium. This type of coordination, however, is most likely to occur when rival stores interact repeatedly, as is true in our empirical study.

[7] To model the differential impacts of differentiation on β and γ, we also could write $\beta/(\tau\theta)\,(\tau\theta \geq 1)$ and $\gamma\sigma\theta$ $(\sigma\theta \geq 1)$. In this case, τ and σ indicate the differential magnitude of impact. For parsimony though, we assume $\tau = 1$ and $\sigma = 1$ without loss of generality.

offering a lower product variety to reduce stocking costs.

Such full coordination is more likely in collocation conditions. When collocated, rival stores forego the possibility of differentiating through locations and confront more fierce competition, which can reduce each other's profitability (Chung and Kalnins 2001). They thus have greater incentives to develop an implicitly coordinated market (Shugan 1985) to mitigate such head-to-head competition. If one of the stores defects from the coordinated interaction by increasing product variety, it may enjoy an immediate gain from the defection, but it will suffer a punishment loss in the future because the collocated rival can detect its defection easily and retaliate by escalating its own product variety. Compared with distant rivals, collocated rivals can access each other's updated status, carrying costs, and planned product variety moves more easily through in-store visits, informal daily communications, and personal networks among employees, thereby reducing the information lag and encouraging rapid retaliation. The smaller information lag and quicker retaliation associated with collocation make the implicit coordination more likely to be sustainable (Tirole 1988, p. 241). Considering the collocated stores have both the motivation and the capability to coordinate effectively, we conclude that collocation may lead to lower level of product variety.

Hypothesis 3A (H3A). *Given the existence of a rival store in a market, a focal store's product variety decreases if the rival store is collocated.*

Yet fully coordinated stores also might choose a level of differentiation that differs from the level chosen by nonfully coordinated stores. In other words, θ may not be the same in the two cases. When we factor in this potential variation in differentiation, it is unclear whether $V_i^{*c}(\theta) < V_i^*(\theta)$ still holds.[8] This adds ambiguity to predictions about product variety level under collocation.

Intuitively, such ambiguity can be explained as a result of two intertwined tendencies of collocated rivals: on the one hand, compared with distant competing stores, collocated rivals tend to differentiate more (as predicted by Proposition 2) by carrying fewer overlapping and/or more nonoverlapping products; on the other hand, they are also inclined to offer a smaller product variety to save stocking costs (as discussed in H3A). When rival stores are collocated, consumers can search both stores with little transport cost and purchase from either, therefore what may be more important to consumers is the total product variety of both stores (i.e., the sum of two stores' varieties less the number of overlapping products) rather than each store's variety. Two possible scenarios then emerge: If collocated rival stores differentiate mainly by carrying fewer overlapping products, even though each store offers a lower product variety, the total product variety of two collocated rivals can still stay at the same level as that of distant rivals. However, if collocated stores differentiate primarily by carrying more nonoverlapping products, then each store's respective variety may not decline. Instead, with the addition of nonoverlapping products, each store likely offers a larger variety, as a result of which the total product variety of the collocated region becomes even higher than that of the distant rivals. Because this second scenario suggests the possibility that collocated rival stores may increase both individual variety and differentiation, we submit a new hypothesis that competes with H3A:

Hypothesis 3B (H3B). *Given the existence of a rival store in a market, a focal store's product variety increases if the rival store is collocated.*

[8] Our proof in §3.2 of the appendix shows that $V_i^{*c}(\theta) < V_i^*(\theta)$ may not hold when the level of differentiation (θ) in the fully coordinated case differs from that in the nonfully coordinated case.

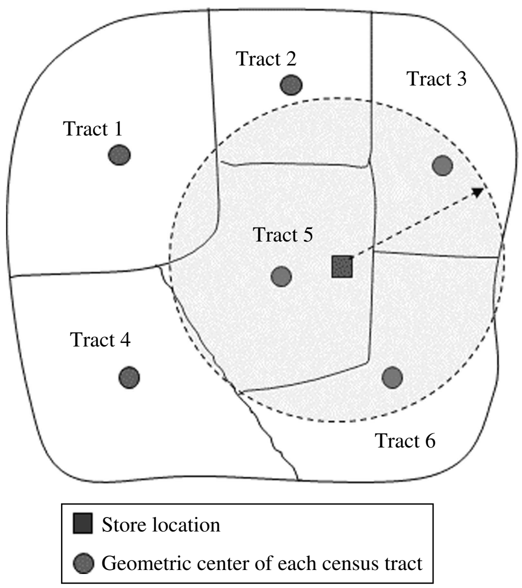
4. Research Design

4.1. Data

We collected data of Best Buy and Circuit City in 2006 from their websites, http://www.bestbuy.com and http://www.circuitcity.com. Using a Web crawling program, we retrieved the address of each Best Buy and Circuit City store in the United States (including Alaska and Hawaii) as of March 2006. Another Web crawling program collected in-store product variety information for each Best Buy and Circuit City store in a single product category: digital cameras. To ensure that the data crawling processes wrapped up within the same day to minimize any possible changes in the product information, we used 20 computers that extracted webpages simultaneously. To verify data accuracy, we interviewed several store managers, who confirmed the consistency between their actual in-store product variety and the information listed online. We also manually collected product variety information in the digital camera category by visiting several stores; we found no difference between the hand-collected information and the data collected using our Web crawling program. In 2006, Best Buy maintained 710 stores and Circuit City had 619 stores, so we have 1,329 observations for the digital camera product category.

We delineate local markets according to the method proposed by Zhu and Singh (2009). The U.S. Census partitions each county into subregions called census

Figure 1 Details of a Local Market



tracts.[9] Because the address of each store is available, we can map each store onto the corresponding census tract using the Census Bureaus' TIGER/Line files. We then draw a circle of 10-mile radius around each store's location, with the presumption that this distance represents a relevant area in which each store potentially competes with other stores. In Figure 1, we flesh out the details of a local market, which we define as the 10-mile circle around the focal store, across a number of tracts. In our data set, each market covers 35 tracts on average. Figure 2 depicts the locations of all the stores in our data.

4.2. Measures

Before going into detail about variable measurements, we explain how we define a pair of competitors. First, using each store's address, we find the latitude and longitude of each store.[10] Second, we calculate the spherical distance between a focal store and each store of the rival chain. Third, we select the rival store that is the shortest distance from the focal store and define these two stores as a pair of competitors for our study.

Our research considers two dependent variables. We measure the total product variety (*PV*) of each store as the logged number of stock-keeping units (SKUs) in the digital camera product category. SKUs provide a good measure of product variety from the perspective of consumers. According to Fader and Hardie (1996), SKU choice is a more fitting description than brand for consumers' purchase decision processes, because consumers typically choose among SKUs on the basis of various product attributes, one of which is the brand. We use a log transformation because the number of SKUs exhibits approximately log-normal distributions in our data.

To capture the extent of product range overlap, we compare and match the detailed product descriptions (e.g., model numbers, major attributes) of both chains.[11] We next count the number of overlapping SKUs for each store and its nearest competitor (*COMPV*). We then take into account the possibility that if the universe of SKUs in a particular market is higher, the likelihood of overlap is larger by random probability.[12] Following the spirit of the dartboard approach proposed by Ellison and Glaeser (1997), we measure product range overlap for each pair of stores as the raw number of overlapping SKUs, less the randomly drawn overlap:

$$\begin{aligned} OVERLAP_i &= \log(COMPV_i) - \log(RandomCOMPV_i) \\ &= \log(COMPV_i) - \log\left(\frac{n_i n_j}{N}\right). \end{aligned} \tag{4}$$

where n_i denotes the number of SKUs available at the focal store i, n_j is the SKUs available at the rival store j, and N indicates the total universe of SKUs in the particular market of store i. All the elements of the calculation are shown in Table 1. Whereas the actual number of overlapping SKUs is x, the expected number of overlapping SKUs based on probability (i.e., $RandomCOMPV_i$) is $n_i/N \cdot n_j/N \cdot N = n_i n_j/N$.

Our two independent variables are indicator variables that indicate whether a competitor exists (*COMP*) and is collocated (*COLLOCATE*) in a given market. We code COMP as 1 if the distance between a focal store and its nearest rival store is not greater than 10 miles—that is, if a competitor of the focal store appears within the 10-mile circle—and 0 otherwise. Following Rosenthal and Strange (2003), we code *COLLOCATE* as 1 if

[9] More detailed information about the definition and basic characteristics of census tracts is also available at http://www.census.gov.

[10] The primary online source of our information was http://terraserver-usa.com. This website is now renamed as http://msrmaps.com.

[11] In some consumer electronics categories, manufacturers put different model numbers on identical products sold to different retailers to soften downstream price competition. Digital camera manufacturers sometimes do so across global markets. We do not observe such practices in the digital camera category across the two retail chains in the U.S. market though. In our data set, based on the product information extracted, we find that no identical products are sold under different names at these retailers. The SKUs differ in tangible features, including brand name, design type, megapixels, optical versus digital zoom, and so on.

[12] We thank an anonymous reviewer for pointing out this possibility. Imagine the total universe of SKUs is 100. One pair of stores stocks 30 SKUs, and another pair of stores stocks 50. For a pair of stores, if we randomly assign their SKUs to the 100 possible cells (throw darts at 100 cells), the likelihood of overlap is smaller for the first pair than for the second pair of stores, because we would throw two sets of 30 compared with two sets of 50 darts.

Figure 2 Locations of Best Buy and Circuit City Retail Stores in Our Data

the nearest rival store is within one mile of the focal store, and 0 otherwise. By defining these two variables, we can categorize our 1,329 observations into the following types of market structures: 191 observations appear in the no local competition category ($COMP = 0$), and 1,138 observations reveal local competition ($COMP = 1$); within this competitive category, 609 observations indicate collocated competition ($COLLOCATE = 1$, $COMP = 1$), and 529 reveal noncollocated competition ($COLLOCATE = 0$, $COMP = 1$).

As a control variable, we use an indicator variable for Best Buy stores (*BESTBUY*), which captures the store-specific characteristics of the Best Buy chain, such as its organizational culture, reputation, standard customer service, store cleanliness, employee training, and friendliness. We also add two market-level demographic variables calculated from census data: *INCOME* (log of medium household income in a market) and *POPDEN* (population density in a market, or the size of the population per square kilometers/1,000). Both *INCOME* and *POPDEN* relate to a market's product variety; the former indicates potential income constraints on purchasing behavior (Hoch et al. 1995), and the latter affects the market's demand level and relative profitability (Watson 2009). Finally, we control for several demographic variables that may describe the market conditions, namely, average household size (*HHSIZE*), the fraction of the population with a college education (*COLLEGE*), the fraction of the population over 18 years of age (*ADULT*), the fraction of male residents (*MALE*), and the fraction of consumers who are nonwhite (*NONWHITE*). The demographic data reflect census information for tracts within the local market, which we aggregate to the market level by taking weighted averages using tract-level population as the weight. If store i's local market (defined as its 10-mile radius) overlaps with the markets of many other stores, we identify common tracts shared by these $n+1$ stores. We then divide the demographic data of those common tracts by $n+1$, such that the shared tracts are equally allocated to nearby stores. This adjustment ensures each store's local market is mutually exclusive from other stores' markets. In Table 2, we provide summary and descriptive statistics for all the variables in this study. The product variety and overlap profile for each type of market structure is presented in Table 3.

Table 1 Overlapping and Nonoverlapping SKUs in a Pair of Rival Stores

SKUs available in store i	SKUs available in store j: Yes	SKUs available in store j: No	Row sum
Yes	x	$n_i - x$	n_i
No	$n_j - x$	$N - n_i - n_j + x$	$N - n_i$
Column sum	n_j	$N - n_j$	N[a]

[a]The total universe of SKUs (N) varies by local market. We also use the total universe of SKUs across all geographic markets to measure N. That universe is the same for both Best Buy and Circuit City, that is, 80 product variants in total. Our data analysis results hold with this alternative definition of the total universe of SKUs.

4.3. Statistical Method

To estimate how competition affects a store's product variety, we would normally estimate the model:

$$PV_i = \delta_0 + \delta_1 COMP_i + X_i\omega + \varepsilon_i, \tag{5}$$

where *COMP* is the key independent variable that indicates whether a competitor for a focal store i

Table 2 Summary and Descriptive Statistics of Variables

Variable	Description	Mean	SD	Min	Max
Dependent variables					
PV	Logged number of a store's product variety (SKUs)	3.604	0.145	3.135	3.932
OVERLAP	Logged number of common products (i.e., products carried by a store and its nearest competitor) minus logged number of randomly drawn common products	−0.583	0.147	−1.306	−0.277
Independent variables					
COMP	Indicator = 1 if a store's distance from its nearest competitor ≤ 10 miles	0.856	0.351	0	1
COLLOCATE	Indicator = 1 if a store's distance from its nearest competitor ≤ 1 mile	0.458	0.498	0	1
Control variables					
BESTBUY	Indictor variable for Best Buy stores	0.534	0.499	0	1
INCOME	Median household income in a market (US$, logged units)	10.780	0.227	10.149	11.421
POPDEN	Population density in a market (population size per square kilometers/1,000)	0.653	0.889	0.003	8.381
COLLEGE	Decimal fraction of the population with a college education in a market	0.192	0.066	0.054	0.460
ADULT	Decimal fraction of the population older than 18 years in a market	0.744	0.031	0.647	0.859
MALE	Decimal fraction of male consumers in a market	0.487	0.011	0.461	0.570
NONWHITE	Decimal fraction of consumers who are nonwhite in a market	0.254	0.144	0.021	0.830
HHSIZE	Average household size in a market	2.678	0.241	2.188	3.749
SUPERURBAN	Indicator variable for "superurban" market	0.290	0.454	0	1

Note. $N = 1{,}329$; March 2006 digital camera full sample.

appears in a given market, ω is a coefficient vector, and X_i is a vector of control variables that might influence product variety (e.g., demographic variables that describe market-level consumer taste heterogeneity). However, we must allow for the possibility that the presence of competition in the market ($COMP = 1$), like product variety, depends on market-level control variables. Unobservables that are not included in the vector of control variables in Equation (5) can yield biased and inconsistent estimates of the coefficient for *COMP* using an ordinary least squares (OLS) estimation (Greene 1990).

To address the potential endogeneity of *COMP*, we use the instrumental variables (IV) method. We first apply a probit model to estimate the probability that there exists a competitor for a focal store in a given market as a function of the exogenous (predetermined) demographic variables. The functional form we choose is

$$\Pr(COMP_i = 1 \mid Z_i) = \Phi(Z_i\delta), \tag{6a}$$

where $\Phi(\cdot)$ is the cumulative distribution function of the standard normal distribution and Z_i includes *BESTBUY*, *INCOME*, *POPDEN*, and the demographic variables (*MALE*, *ADULT*, *COLLEGE*, *NONWHITE*, and *HHSIZE*) that may affect market demand and thus are related to the level of competition in a given market. We then use the predicted value from Equation (6a) ($\widehat{COMP}$) as an instrumental variable for *COMP* in Equation (6b), the equation of primary interest:

$$PV_i = \delta_{IV0} + \delta_{IV1}COMP_i + X_i\omega_{IV} + \varepsilon_i, \tag{6b}$$

where X_i includes *BESTBUY, INCOME, POPDEN*, and four demographic variables (*MALE, ADULT,*

Table 3 Product Variety and Overlap by Market Structure

Market structure	No. of obs.[a]	Average no. of store-level SKUs	Average no. of overlapping SKUs[b]	Average no. of nonoverlapping SKUs[b]	Average no. of total SKUs[b]
Monopoly	191	35.6	N/A	N/A	N/A
Noncollocated competition	529 (509)	37.4	14.0	23.4	61.1
Collocated competition	609 (601)	37.4	13.7	23.8	61.2

[a]In column (2), the number in each parentheses refers to the number of observations in which the overlapping, nonoverlapping, and total SKUs data are available.

[b]Columns (4)–(6) apply only to the competitive markets where for each pair of rivals, we compare the product range overlap and calculate the total variety of both stores. Note that the total variety is the sum of both stores' SKUs less the number of overlapping SKUs.

Table 4 Models of the Impact of Competition and Collocated Competition on Product Variety

	All areas included			Superurban effect controlled		
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	*PV*	*OVERLAP*	*PV*	*PV*	*OVERLAP*	*PV*
CONSTANT	2.810***	0.252	4.435***	3.046***	−0.361	4.296***
	(0.272)	(1.280)	(0.820)	(0.293)	(0.669)	(0.722)
COMP[a]	0.045***			0.046***		
	(0.017)			(0.017)		
COLLOCATE[a]		−0.346**	−0.214**		−0.308**	−0.168*
		(0.157)	(0.098)		(0.157)	(0.092)
BESTBUY	−0.218***	−0.022*	−0.220***	−0.218***	−0.021*	−0.219***
	(0.005)	(0.013)	(0.008)	(0.005)	(0.013)	(0.008)
INCOME	0.103***	0.033	0.019	0.081***	0.052	0.019
	(0.020)	(0.079)	(0.050)	(0.023)	(0.074)	(0.044)
POPDEN	0.006*	−0.007	0.001	0.003	−0.005	0.001
	(0.003)	(0.011)	(0.006)	(0.004)	(0.010)	(0.005)
COLLEGE	−0.074	−0.267	−0.032	−0.043	−0.273	−0.007
	(0.069)	(0.181)	(0.114)	(0.070)	(0.175)	(0.103)
ADULT	0.397***	0.315	0.005	0.348***	0.362	0.025
	(0.118)	(0.346)	(0.227)	(0.120)	(0.324)	(0.199)
MALE	−1.067***	−2.420***	−1.595***	−0.998***	−2.340***	−1.417***
	(0.245)	(0.753)	(0.482)	(0.247)	(0.742)	(0.447)
NONWHITE	−0.012	0.048	−0.072*	−0.021	0.058	−0.066*
	(0.022)	(0.065)	(0.043)	(0.022)	(0.061)	(0.038)
SUPERURBAN				0.016**	−0.003	0.012
				(0.007)	(0.019)	(0.011)
No. of obs.	1,329	1,110[b]	1,138	1,329	1,110[b]	1,138
Durbin-Wu-Hausman test	$\chi^2(1)=7.87$ ($p=0.005$)	$\chi^2(1)=9.92$ ($p=0.002$)	$\chi^2(1)=12.32$ ($p=0.000$)	$\chi^2(1)=7.91$ ($p=0.005$)	$\chi^2(1)=6.90$ ($p=0.009$)	$\chi^2(1)=6.82$ ($p=0.009$)

Note. Standard errors are in parentheses.

[a]Predicted values of *COMP* and *COLLOCATE* from the first-stage probit analyses are the instrumental variables for *COMP* and *COLLOCATE*, respectively.

[b]The competitive subsample for models (3) and (6) contains 1,138 observations, but only 1,110 contain product range overlap information, so $n=1{,}110$ for models (2) and (5).

***Significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

COLLEGE, and *NONWHITE*) that reflect a market's diversity in gender, age, education, and ethnicity and thus relate to the market's aggregate taste for variety.

Such IV estimations require at least one "extra" explanatory variable that influences the first stage but not the second stage, which is often referred to as the exclusion restriction requirement (Wooldridge 2002). We include the demographic variable *HHSIZE* in the first-stage probit model but exclude it from the second stage. Household size should relate to market demand and affect the number of stores in this market, which suggests that we should include this variable in the probit model. Product variety, the dependent variable in the second stage, primarily depends on consumer heterogeneity in a market. But *HHSIZE* does not capture the heterogeneity across households and therefore should not directly influence product variety.[13]

To examine how a collocated competitor, compared with a noncollocated competitor, affects product variety and product range overlap, we conduct similar IV estimations that account for the endogeneity of *COLLOCATE* on a subsample of only competitive cases with the following second-stage functional forms:

$$OVERLAP_i = \delta_{IV0} + \delta_{IV1} COLLOCATE_i + X_i \omega_{IV} + \varepsilon_i, \quad (7)$$

$$PV_i = \delta_{IV0} + \delta_{IV1} COLLOCATE_i + X_i \omega_{IV} + \varepsilon_i. \quad (8)$$

[13] We note two additional points regarding the exclusion restriction requirement. First, this restriction is not absolutely required in our case, because we use probit—a nonlinear, binary response model—in the first stage to generate our instrumental variable (Amemiya 1985). Although the nonlinearity of the first-stage probit model allows our second-stage equation to be technically identified, we go further and apply the restriction requirement to make the source of the identification clearer. Second, our estimation results remain intact regardless of whether we include this "extra" variable in the first stage.

5. Results and Robustness Checks

We provide the results of the IV estimations in which we examine the impact of *COMP* or *COLLOCATE* on product variety in Table 4.[14] We report the results of Durbin-Wu-Hausman tests, which confirm the endogeneity of the *COMP* and *COLLOCATE* variables and indicate that their coefficients, if estimated by OLS, should differ significantly from those of the IV estimations.

Model (1) contains the IV estimation results for the impact of competition on product variety. As expected, the coefficient of *COMP* is positive and highly significant ($\delta_{IV1} = 0.045$ with a t-statistic of 2.65), in support of H1; that is, the existence of a competing store is associated with greater total product variety of a focal store. If we hold the other regressors equal, the average number of product variants in a competitive market ($COMP = 1$) is 5% ($= e^{0.045} - 1 = 0.05$) higher than in a market without competition ($COMP = 0$). Model (2) reports the IV estimations of the impact of collocation on product range overlap for only competitive cases. The IV coefficient of *COLLOCATE* is negative and statistically significant ($\delta_{IV1} = -0.346$, with a t-statistic of -2.20), which implies that a store is less likely to carry overlapping products when the competitor is collocated. All else being equal, the average extent of product range overlap by collocated competitors ($COLLOCATE = 1$) is approximately 29% ($= 1 - e^{-0.346} = 0.29$) lower than that carried by noncollocated competitors ($COLLOCATE = 0$). H2 is thus supported. Model (3) presents the IV estimation results of the impact of collocated competition on product variety for competitive cases. The coefficient of the *COLLOCATE* variable in model (3) is negative and significant ($\delta_{IV1} = -0.214$, with a t-statistic of -2.18); that is, collocated competitors carry a smaller product variety than do noncollocated competitors, in support of H3A. When the other regressors remain constant, collocated competitors display a level of product variety that is approximately 19% ($= 1 - e^{-0.214} = 0.19$) lower than noncollocated competitors.

The control variables have some effects of interest. For example, Best Buy stores display a lower level of product variety than Circuit City stores, and when they collocate with their nearest competitors, they differentiate slightly more than do Circuit City stores by displaying a lower level of product range overlap. A higher fraction of male residents in a market is associated with lower product variety, which implies that men's tastes tend to be more homogenous than are women's. In the full sample analysis (model (1)), we also find that markets with higher income levels, larger population sizes, and larger fractions of adults display higher levels of product variety.

We use several alternative specifications to test the robustness of our results. First, there are some highly urbanized areas such as New York City, Chicago, and Boston, which we label as "superurban" areas, where competitors may be more likely to collocate within one mile. In other areas, competing stores may not collocate as much and instead coexist only within 10 miles. Thus, the effects we have observed for the independent variables *COMP* and *COLLOCATE* might reflect not the impact of competitive proximity but rather whether the store is located in a superurban area. To control for the effects of these superurban areas, we generate an indicator variable *SUPERURBAN* that equals 1 if the focal store's zip code is categorized by Census 2000 to be in a core based statistical area (CBSA) that can be subdivided into two or more "metropolitan divisions" (and 0 otherwise).[15] The estimation results with this variable included, as shown in models (4)–(6) in Table 4, still support H1, H2, and H3A. We also run the analysis on the subsample that includes only the nonsuperurban areas. The results in models (7)–(9) in Table 5 indicate that all our major findings still hold in this subsample.

Second, we change the collocation cut-off point from 1 mile to 0.5 miles. The results using this alternative measure, as reported in models (10) and (11) in Table 5, support both H2 and H3A. We also use the distance from the nearest rival as a continuous measure for the degree of collocation and find that geographically closer rivals tend to overlap less and each carries a smaller product variety. This finding is consistent with the results when collocation is measured as noncontinuous variables.

Third, we define a local geographic market as the 15-mile radius of a focal store. With a larger market, we can explore competitive dynamics in nonsuperurban areas, where stores may locate farther away from one another. After recalculating all the market-level demographic variables, we repeat the analyses from models (1)–(11); all the results still hold.

Finally, we note the possible impact of the presence of Walmart, which sells consumer electronics too. Nationwide data indicate that approximately

[14] The results of the first-stage probit models that we used to generate the instrumental variables can be obtained from the authors upon request.

[15] With the zip code information of each store, we collected the corresponding micro, metro, and CBSA division data. A CBSA is the official term for a functional region based around an urban center of at least 10,000 people, based on standards published by the Office of Management and Budget in 2000. A CBSA is broken into micro and metro subcategories, depending on population densities. To be considered a micro area, the population must be between 10,000 and 50,000. A metro area's population must exceed 50,000. If a metro area contains an urbanized area of at least 2.5 million people, it can be subdivided into two or more "metropolitan divisions." Of our 1,329 stores, 385 are in areas with "metropolitan divisions," which we call superurban areas.

Table 5 Selected Models for Robustness Check

	Only nonsuperurban areas included			Superurban effect controlled, "collocate" as ≤ 0.5 miles	
	(7)	(8)	(9)	(10)	(11)
Dependent variable	*PV*	*OVERLAP*	*PV*	*OVERLAP*	*PV*
CONSTANT	3.073***	−0.121	4.575***	0.531	4.946***
	(0.354)	(1.104)	(0.789)	(1.534)	(1.039)
COMP[a]	0.075***				
	(0.024)				
COLLOCATE[a]		−0.254*	−0.199**	−0.452**	−0.303**
		(0.144)	(0.101)	(0.230)	(0.151)
BESTBUY	−0.209***	−0.020	−0.209***	−0.022	−0.219***
	(0.007)	(0.014)	(0.010)	(0.015)	(0.010)
INCOME	0.060**	0.042	−0.031	0.025	−0.014
	(0.028)	(0.077)	(0.055)	(0.092)	(0.062)
POPDEN	−0.011	0.006	−0.006	−0.005	−0.002
	(0.014)	(0.026)	(0.018)	(0.012)	(0.008)
COLLEGE	−0.023	−0.032	0.214	−0.152	0.072
	(0.088)	(0.221)	(0.155)	(0.218)	(0.146)
ADULT	0.425***	0.062	−0.068	0.011	−0.234
	(0.148)	(0.354)	(0.251)	(0.480)	(0.325)
MALE	−0.776***	−1.827***	−0.912*	−2.508***	−1.643***
	(0.297)	(0.679)	(0.485)	(0.906)	(0.612)
NONWHITE	0.007	0.094	−0.016	0.085	−0.054*
	(0.028)	(0.064)	(0.046)	(0.067)	(0.045)
SUPERURBAN				−0.004	0.012
				(0.023)	(0.015)
No. of obs.	944	754[b]	771	1,110[c]	1,138
Durbin-Wu-Hausman test	$\chi^2(1) = 12.06$ ($p = 0.001$)	$\chi^2(1) = 4.43$ ($p = 0.035$)	$\chi^2(1) = 8.99$ ($p = 0.003$)	$\chi^2(1) = 10.67$ ($p = 0.001$)	$\chi^2(1) = 15.63$ ($p = 0.000$)

Note. Standard errors are in parentheses.

[a]Predicted values of *COMP* and *COLLOCATE* from the first-stage probit analyses are the instrumental variables for *COMP* and *COLLOCATE*, respectively.

[b]The competitive subsample that includes only nonsuperurban areas for model (9) contains 771 observations, but only 754 contain product range overlap information, so $n = 754$ for model (8).

[c]The competitive-only subsample for model (11) contains 1,138 observations, but only 1,110 contain product range overlap information, so $n = 1{,}110$ for model (10).

***Significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

3,000 Walmart stores existed in the United States in March 2006 (recall that there were 710 Best Buy and 619 Circuit City stores). Therefore, at least one Walmart store appears in every defined local market we study, and the presence of Walmart is a common factor for all our data observations. This form of competition therefore cannot explain our findings. Moreover, our findings continue to receive support after we control for the distance (as a measure of the extent of collocation) from Walmart.

6. Discussion and Conclusions

6.1. Implications of Major Findings

A store's product variety expands significantly if a rival store exists in its market. In a competitive market, each rival store has an incentive to add product variety, beyond the level that it would have stocked had it been a monopolist. This larger variety can enhance customer satisfaction and loyalty, as well as encourage customers to switch away from competing stores. This first key finding generally parallels existing studies. For example, Lancaster (1990) shows theoretically that a monopoly, facing no competition, should produce the least product variety of any market structures. In a study of the video rental market in a district of Edmonton, Alberta, de Palma et al. (1994) find that centrally located stores, which face the most competition, tend to offer more product variety than do stores on the market boundaries.

In the presence of competition, collocated rival stores tend to differentiate more than distant rivals do by overlapping less in product range. Firms within the same industry often collocate (e.g., hotels, Baum and Haveman 1997; Chung and Kalnins 2001; footwear producers, Sorenson and Audia 2000; new biotechnology firms, Zucker et al. 1998). Our data pertaining to the consumer electronics retail industry show that more than half (609 of 1,138) of the stores for two competing chains collocate (within one mile). Collocation is associated with more fierce competition and agglomeration benefits, but through differentiation, rival stores can reduce their losses because of competition and reap more gain from agglomeration. The pattern that differentiation reduces competition is consistent with the prediction from industrial organization (Mazzeo 2002, Porter 1991). Similarly, Baum and Haveman (1997) find that new Manhattan hotels tend to locate geographically close to established hotels that differ in size, such that the competition loss because of spatial proximity can be offset by a gain through differentiation.

Our empirical findings also show that collocated rival stores introduce smaller product variety than noncollocated stores. We attribute the smaller product variety to the possible existence of coordinated interactions between collocated stores. At the time of our study, Best Buy and Circuit City engaged in multimarket contacts, such that their competitive actions and responses spread over many geographic markets. Of the 710 Best Buy stores in our data, 583 competed with a rival Circuit City store in their 10-mile radius, and 555 of the 619 Circuit City stores faced such competition from Best Buy. Both theoretical (Matsushima 2001) and empirical (Baum and Korn 1996, Gimeno and Woo 1999) research shows that such multimarket contacts encourage mutual forbearance and enhance firms' ability to sustain coordination. Our two focal stores also likely encountered repeated competitive games in a single market, and collocation increased the intensity of their rivalry, as well as the speed and effectiveness of potential retaliation. Thus, defection from this cooperative interaction offers small gain, whereas coordination offers more long-term, sustainable benefits (Shugan 1985, Tirole 1988). This coordination in product variety is similar to the coordination through pricing in retail gasoline markets that Borenstein and Shepard (1996) describe.

Another explanation for collocated rivals' smaller product variety is that a greater level of differentiation may help maintain the total variety of collocated stores, even if each store decreases its level of product variety. Our extended data analysis suggests that more differentiation (less overlap) in our research setting is associated with less store-level product variety.[16] Moreover, when we calculated the total product variety for each pair of rival stores, we found that the total variety for collocated rivals is not significantly different from that for distant rivals,[17] in line with the first scenario we discussed in relation to H3B. When each store's product variety is small but contains little overlap, the total product variety of both stores may still benefit consumers as much as when each store offers a large product variety but also a lot of overlap.

6.2. Contributions and Future Research Directions

We make several contributions to existing research. First, this study is the first to use a *nationwide* data set from *chain* stores (for which price variations are reasonably well controlled) to study the impact of competition on product variety. Casual observation of the growth of chain-store retailing suggests that a key success factor is its ability to satisfy consumer tastes with a broad range of products. Yet actual empirical studies are rare and quite recent, mostly because of the difficulty of collecting nationwide, cross-sectional data about product variety choices. Existing studies (e.g., de Palma et al. 1994, Watson 2009) focus on nonchain stores in a specific region, despite the prevalence of retail chains in many markets. In contrast, we include all the stores of two competing chains nationwide, as well as the potential systematic pattern that chain stores may exhibit when they determine store-level product variety.

Second, we document and analyze the degree of overlap in the product ranges of geographically proximate competitors, which represents the first attempt to study the interaction between such overlaps and spatial competition. By investigating product range overlap, we acknowledge the nuances of retail stores' product variety decisions. Moreover, whereas extant research (e.g., Baum and Mezias 1992, Baum and Singh 1994) examines differentiation along dimensions such as geographic location, organizational traits (e.g., size), price, product features, or quality, we offer a new perspective for studying firms' differentiation.

Third, our study complements extant research by proposing collocation as an important moderator in the context of spatial variety competition. Collocation has a particular effect on product variety; the

[16] The impact of differentiation on store-level product variety is theoretically indeterminate, as discussed in relation to H3B. To examine empirically how differentiation affects the level of product variety, we analyze the data by adding the variable "*OVERLAP*" to the second-stage IV estimation of model (6). The coefficient of *OVERLAP* is significantly positive at the 1% level (t-statistic = 3.15), suggesting that more differentiation is associated with less variety. The coefficient of *COLLOCATE* remains significantly negative (t-statistic = −2.17).

[17] A t-test (t-statistic = −0.209, p-value = 0.84) confirms that the total product variety of collocated rivals is not significantly different from that of distant rivals. We also conduct further analysis by changing the dependent variable in model (6) from store-level product variety to the total variety of two competing stores. This IV estimation shows that the coefficient of *COLLOCATE* does not have a significant impact on the total product variety (with a t-statistic of −1.29).

smaller and differentiated product variety in collocated stores implies that they attempt to forbear from aggression and engage in coordinated interaction. We find evidence of mutual forbearance or coordinated interaction in prior studies that concentrate on pricing (Parker and Röller 1997), market entry, growth, and market exit (Baum and Korn 1996, Haveman and Nonnemaker 2000), but no prior work documents these concepts along product variety dimensions.

The limitations of our study provide directions for future research. We focus only on one product category (digital cameras) which is characterized by substantial heterogeneity in consumer preferences and requires relatively high inventory costs. Scholars can examine if a similar pattern of product variety competition can be found in categories like televisions, major home appliances, personal computers, office equipment, and large automobile parts. We also restrict our analysis to two competitors; allowing for multiple competitors and incorporating the effect of firm characteristics (e.g., size, age, and decision-making system) would greatly extend our research. Furthermore, we do not consider possible interactions between product variety and other competitive tools, such as price. Future research could add other actions, such as price variations (both regular and promotional) and advertising campaigns, to determine how they might interact with product variety. Finally, our study and several other works (e.g., Olivares and Cachon 2009) suggest the possibility of using abundant online information as a plausible data source. We recommend that more researchers consider online data as a promising source.

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Appendix. Proofs of Propositions

Part 1

There are two competing stores, store 1 and store 2, in a market. Each store's profit function is

$$\Pi_i(V_i, V_j) = \underbrace{KV_i^{\alpha}\left(\frac{V_i}{V_j}\right)^{\beta}V_j^{\gamma}}_{Q_i(V_i,V_j)} - \underbrace{\frac{1}{2}V_i^2}_{C_i(V_i)} \quad i, j = 1, 2,\ i \neq j. \quad (9)$$

Solving the first-order conditions (FOCs) with respect to V_i $(i = 1, 2)$, we obtain each store's optimal variety and the corresponding profit:

$$V_i^{*d} = [K(\alpha+\beta)]^{1/(2-\alpha-\gamma)},$$
$$\Pi_i^{*d} = [K(\alpha+\beta)]^{2/(2-\alpha-\gamma)}\left(\frac{1}{\alpha+\beta} - \frac{1}{2}\right) \quad i = 1, 2. \quad (10)$$

Assumptions: (1) $K \geq 1/\alpha$ such that $V_i^{*d} \geq 1$; (2) $\alpha + \beta < 2$ such that the cost function of variety is more convex and the optimal profit Π_i^{*d} is bounded; (3) $\beta > \gamma$ such that a competing store's variety has a stronger business-stealing effect than the agglomeration effect; in other words, $\partial\Pi_i/\partial V_j < 0$.

Proposition 1. $\partial V_i^{*d}/\partial\beta > 0$.

Proof. This proposition is an immediate consequence of the expression for V_i^{*d} in Equation (10), since following $\alpha + \beta < 2$, $\beta > \gamma$, we obtain that $\alpha + \gamma < 2$. □

Part 2

We now introduce θ with $\theta > 1$ denoting the existence of differentiation. Each store's profit function becomes Equation (11). Solving the FOCs with respect to V_i $(i = 1, 2)$, we obtain each store's optimal variety and the corresponding profit as shown in (12).

$$\Pi_i(V_i, V_j, \theta) = KV_i^{\alpha}\left(\frac{V_i}{V_j}\right)^{\beta/\theta}V_j^{\gamma\theta} - \frac{1}{2}V_i^2 \quad i, j = 1, 2,\ i \neq j, \quad (11)$$

$$V_i^{*} = \left[K\left(\alpha + \frac{\beta}{\theta}\right)\right]^{1/(2-\alpha-\gamma\theta)},$$
$$\Pi_i^{*} = \left[K\left(\alpha + \frac{\beta}{\theta}\right)\right]^{2/(2-\alpha-\gamma\theta)}\left(\frac{1}{\alpha+\beta/\theta} - \frac{1}{2}\right) \quad i = 1, 2. \quad (12)$$

Assumptions: (1) $K \geq 1/\alpha$ such that $V_i^{*} \geq 1$; (2) $\alpha + \beta/\theta < 2$ such that Π_i^{*} is bounded; (3) $\beta/\theta > \gamma\theta$ such that $\partial\Pi_i/\partial V_j < 0$.

Proposition 2. (a) $\partial\Pi_i^{*}/\partial\theta > 0$; (b) $\partial(\partial\Pi_i^{*}/\partial\theta)/\partial\beta > 0$, $\partial(\partial\Pi_i^{*}/\partial\theta)/\partial\gamma > 0$.

Proof.

$$\frac{\partial \ln \Pi^{*}}{\partial\theta} = \ln\left[K\left(\alpha + \frac{\beta}{\theta}\right)\right]\frac{2\gamma}{(2-\alpha-\gamma\theta)^2} + \frac{2\beta(\beta/\theta - \gamma\theta)}{\theta^2(\alpha+\beta/\theta)(2-\alpha-\beta/\theta)(2-\alpha-\gamma\theta)} > 0$$
$$\Rightarrow \quad \partial\Pi_i^{*}/\partial\theta > 0, \quad (13)$$

$$\partial(\partial \ln \Pi^{*}/\partial\theta)/\partial\beta = \frac{2\gamma}{\theta(\alpha+\beta/\theta)(2-\alpha-\gamma\theta)^2} + \frac{\theta}{\alpha+(\beta/\theta)^2(2-\alpha-\beta/\theta)^2}$$

$$\cdot\left\{\left(\frac{\beta}{\theta}-\gamma\theta\right)\left[\alpha\left(2-\alpha-\frac{\beta}{\theta}\right)+\frac{\beta}{\theta}\left(\alpha+\frac{\beta}{\theta}\right)\right]+\frac{\beta}{\theta}+\left(\alpha+\frac{\beta}{\theta}\right)\left(2-\alpha-\frac{\beta}{\theta}\right)\right\}$$

$$\Rightarrow\ \partial(\partial\Pi_i^*/\partial\theta)/\partial\beta>0, \tag{14}$$

$$\partial(\partial\ln\Pi^*/\partial\theta)/\partial\gamma = \ln\left[K\left(\alpha+\frac{\beta}{\theta}\right)\right]\frac{2(2-\alpha+\gamma\theta)}{(2-\alpha-\gamma\theta)^3} - \frac{2*(\beta/\theta)}{(2-\alpha-\gamma\theta)^2(\alpha+\beta/\theta)} > \frac{2}{(2-\alpha-\gamma\theta)^2}\left\{\ln\left[K\left(\alpha+\frac{\beta}{\theta}\right)\right]-\frac{\beta/\theta}{\alpha+\beta/\theta}\right\}.$$

Because

$$\ln\left[K\left(\alpha+\frac{\beta}{\theta}\right)\right] > \frac{K(\alpha+\beta/\theta)-1}{K(\alpha+\beta/\theta)} \ge \frac{\beta/\theta}{\alpha+\beta/\theta},$$ [18]

we have

$$\partial(\partial\ln\Pi^*/\partial\theta)/\partial\gamma>0\ \Rightarrow\ \partial(\partial\Pi_i^*/\partial\theta)/\partial\gamma>0. \tag{15}$$

Based on (13)–(15), we conclude the proof of Proposition 2. □

Part 3

3.1

Proposition 3. V_i^{*c} (*fully coordinated variety*) $\le V_i^*$ (*non-fully coordinated variety*) *for a given* θ.

Proof.

$$\max_{V_1,V_2}[\Pi_1(V_1,V_2\mid\theta)+\Pi_2(V_1,V_2\mid\theta)] = \max_{V_1,V_2}\left[KV_1^{\alpha}\left(\frac{V_1}{V_2}\right)^{\beta/\theta}V_2^{\gamma\theta}-\frac{1}{2}V_1^2 + KV_2^{\alpha}\left(\frac{V_2}{V_1}\right)^{\beta/\theta}V_1^{\gamma\theta}-\frac{1}{2}V_2^2\right]. \tag{16}$$

Differentiating (16) with respect to V_1, V_2 and solving both FOCs, we obtain,

$$V_1^{*c}=V_2^{*c}=[K(\alpha+\gamma\theta)]^{1/(2-\alpha-\gamma\theta)}. \tag{17}$$

As we assume $\gamma\theta<\beta/\theta$, we have $V_i^{*c}<V_i^*=[K(\alpha+\beta/\theta)]^{1/(2-\alpha-\gamma\theta)}$.

We thus complete the proof of Proposition 3. □

3.2.

Proof.

$$\frac{\partial\ln V_i^{*c}}{\partial\theta} = \frac{1}{(2-\alpha-\gamma\theta)^2}\cdot\left\{\gamma\ln[K(\alpha+\gamma\theta)]+\frac{\gamma(2-\alpha-\gamma\theta)}{\alpha+\gamma\theta}\right\}>0 \Rightarrow\ \partial V_i^{*c}/\partial\theta>0,$$

$$\frac{\partial\ln V_i^{*}}{\partial\theta} = \frac{1}{(2-\alpha-\gamma\theta)^2}\cdot\left\{\gamma\ln\left[K\left(\alpha+\frac{\beta}{\theta}\right)\right]-\frac{\beta(2-\alpha-\gamma\theta)}{\theta^2(\alpha+\beta/\theta)}\right\}. \tag{18}$$

[18] We know for any given $x>1$, it always holds that $\ln(x)>(x-1)/x$. In this case, let x be $K(\alpha+(\beta/\theta))$. Because $K(\alpha+(\beta/\theta))>1$, we can derive the inequality as shown above.

For notational convenience, let

$$Z=\frac{\beta/\theta}{(\alpha+\beta/\theta)\ln[K(\alpha+\beta/\theta)]}.$$

We find an upper bound for γ, that is, $\bar{\gamma}=Z(2-\alpha)/((1+Z)\theta)$.

$$\begin{aligned}&\text{If } \gamma<\bar{\gamma}, \text{ we have } \partial\ln V^*/\partial\theta<0\ \Rightarrow\ \partial V_i^*/\partial\theta<0.\\ &\text{If } \gamma\ge\bar{\gamma}, \text{ we have } \partial\ln V^*/\partial\theta\ge0\ \Rightarrow\ \partial V_i^*/\partial\theta\ge0.\end{aligned} \tag{19}$$

With (18) and (19), we show that

$$\frac{\partial V_i^{*c}}{\partial\theta}>0;\qquad \frac{\partial V_i^*}{\partial\theta}<0 \quad\text{or}\quad \frac{\partial V_i^*}{\partial\theta}\ge0.$$

Therefore, $V_i^{*c}(\theta)<V_i^c(\theta)$ may not always hold if θ is not fixed, as noted in Footnote 8.

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