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Abstract

We present a game theoretic model for the availability of product information in Internet markets, where buyers can search for multiple products in parallel. We use a multiple-circle variation of Salop's "unit circle" model of product differentiation where vendors are able to differentiate their products both horizontally (taste) and vertically (quality). We explore the conditions under which vendors make horizontal and vertical product information available to potential customers in equilibrium. We demonstrate that vendors will choose not to provide their full horizontal product information, and will rather leave the buyers with some probabilistic knowledge about their exact horizontal product locations. However, the vendors will release enough horizontal product information for their products to appear distinct from those of competitors. The sellers' incentives to disseminate vertical product information are shown to be fundamentally different: only the worst possible quality vendors will withhold information on vertical product parameters. Our results suggest an answer for the question that is the title of this paper: Is it the case that online vendors release product information primarily to advertise their product's superiority or to make clear that their products do not have close competing substitutes? We find that for high quality products the former is more important while the latter gains significance for lower quality products. We present empirical observations of nearly 2,000 products in the PC game industry that provide evidence in favor of the model's predictions.

Keywords: Electronic markets, product information, product differentiation, shopbots, PC games

Introduction

The economic importance of the Internet goes well beyond the size of online sales. The Internet is primarily a source of information for prospective buyers of products and services. In markets ranging from automobiles to digital cameras, the Internet has become the primary source of information, regardless of whether the actual sale takes place online or offline. Consequently, vendors' decisions about the information released to consumers online are crucial to their products' success.

Models that consider both horizontal and vertical product differentiation are relatively scarce compared to models that consider only quality related product variations (Moorthy 1988), or only horizontal, taste related, product variations, as the models by Economides (1989) and Novshek (1980). A well known example of both horizontal and vertical differentiation is due to Neven and Thisse (1990), who have investigated horizontal and vertical differentiation as well as pricing decisions in a duopoly setting. Our own model is based on Economides' (1993), as we discuss in some detail below.

Consumer demand for product information has usually been studied in the Von Neumann expected utility framework (Varian 1992), where the consumers choose the quantity for each good, to maximize their utility, subject to budget constraints (Kihlstrom 1974; Nelson 1970). The Von Neumann framework asserts that consumers always prefer products of certain value to those of uncertain value. Therefore, more information (at least for horizontal product parameters) is always better (Gu et al. 2002). We are beginning to understand that this result may be an oversimplification and that, in reality, the interaction between consumer information endowment (the degree to which consumers can inform themselves about exact product locations before purchase decisions) and vendor profitability may be more complex, and that information endowment also affects optimal product placement (Markopoulos 2004).

Brynjolfsson, Smith, and Hu (2003) were able to measure the welfare gains from increased product variety in electronic markets. Furthermore, the use of information as a means of retailer differentiation has also been established (Clay et al. 2002), although in this paper, following the tradition of the spatial differentiation literature, we consider product manufacturers to be the actual vendors. Various authors have also argued that increased availability of product information on the Internet eventually leads to more differentiated markets (Kuksov 2004; Markopoulos 2004) and Lynch and Ariely (2000) were able to provide experimental support to this argument. The aforementioned body of work underlines the importance of information about product parameters in on-line markets of differentiated goods, and motivated us to put forth the question that is the title of this paper.

Our Model

Model Description

We employ a two-circle variation of Salop's (1979) classic model of product differentiation. In our model there exist two circles where sellers can locate their products. The two circles have the same center point. The inner circle corresponds to products of lower quality than the outer circle. Our market consists of $N > 2$ sellers and M buyers, where M is assumed to be a very large number, close to infinity, so that one can expect to find a buyer at every location of the product space. Sellers choose the quality of their product by deciding whether to place their product on the outer circle (high quality) or inner circle (low quality). They can further differentiate their products horizontally, by choosing an exact location on the circle they have chosen. Both sellers and buyers are risk neutral.

We define an arbitrary measure of *angular location*. Angular locations on each of the two circles correspond to the angular distance of that location with the circle radius that passes through the northernmost point of the two circles. Angular locations increase counterclockwise. For example, the northernmost point in each of the two circles is at zero, the westernmost point is at 90° and the Easternmost point is at 270°. All arithmetic is modulo 360°.

Each buyer has a most preferred angular product location θ^*. Alternatively, we can view buyers as having a most preferred circle radius. Buyers' preferences are uniformly distributed in the space of all possible radii. The buyer incurs a fit cost $C(\theta, \theta^*)$ when she purchases a good at angular location θ. We assume the fit cost to be a linear function $t \cdot |\theta - \theta^*|$ of the angular distance between θ and θ^*, where t is the fit cost parameter that controls the strength of consumers' preferences. Buyers demand one unit of the good, subject to a reservation utility $v + q$, for high quality products and v for low quality products. We assume that v is high enough so that all buyers are served. All players are rational and sellers supply a single good with constant marginal cost (normalized for convenience to be zero). Thus, the utility that Buyer j, with ideal angular product location θ_j^*, receives from purchasing a product from Seller i, at angular location θ_i, and priced at p_i is given by $v + q_i - p_i - t \cdot |\theta_i - \theta_i|$, where q_i is zero if Seller i is located on the inner circle and q if Seller i is located on the outer circle.

Sellers move first by simultaneously choosing a location for their products and choose a price, having observed each others' locations. We introduce the idea of a *parallel search*, which is a mechanism that is analogous to a search using an electronic search engine, and that returns the *approximate* angular (horizontal) location of *all* products. Our assumption is that in the absence of detailed and exhaustive product information, the buyer can only know of an angular range within which the product is located and not the exact location of the product (which is a composite of all product attributes and not just the ones that are available to the search device). Thus, the buyer can only learn a seller's approximate angular location within an angular range $2a$, such that any angular location within the range is equiprobable. We call this interval of size $2a$ the vendor's *horizontal uncertainty interval*. Thus, we employ the parameter a as our measure of horizontal uncertainty.

Buyers do not initially receive information about the vertical differentiation of the sellers. That is, the buyers are initially unable to tell whether a product is located in the inner or outer circle, unless the sellers choose to reveal this information.

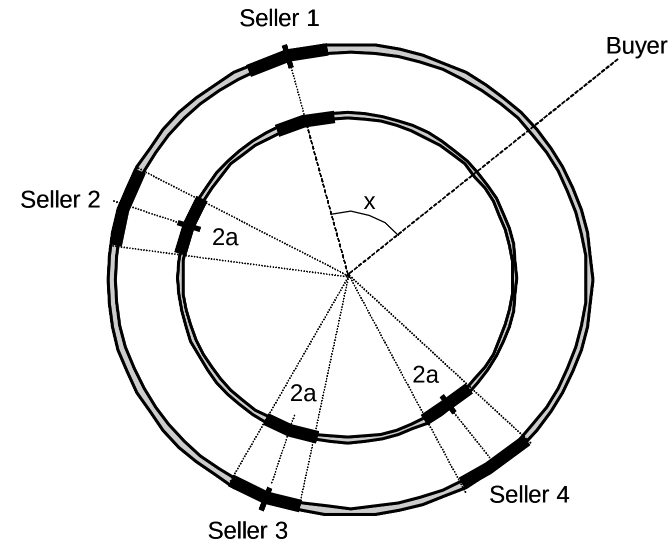

Figure 1. An Instance of Our Model of Product Differentiation

We assume that when the sellers decide to release more information, they incur a small cost. This cost is assumed for convenience to be smaller than any other positive quantity that appears in our calculations, yet strictly positive.[1] We further assume that the sellers cannot lie about their true locations (we can alternatively assume that the penalties for a false claim are very high and product characteristics are perfectly observable post sale), and they can only choose to reveal or withhold detailed information.

Finally, we assume that the buyers use a free shopbot for their parallel search, incurring no search costs. Keeping in line with most functioning electronic markets, we assume that the price information of a seller is a product attribute that the shopbot returns.

An instance of our model is depicted in Figure 1, for $N = 4$. There are four sellers in this market. We depict one buyer in the figure which has an ideal angular product location, as shown. The buyer can only observe the sellers' horizontal locations within a range of size $2a$. Furthermore, the buyer cannot initially know (unless the sellers reveal this information) if, for example, Seller 2 is located at the location depicted on the inner circle, or at the projection of that location on the outer circle. If the buyer decides to purchase from Seller 1, and if Seller 1 is situated on the outer circle, the utility that the buyer receives is on expectation[2] $v + q - p_1 - x \cdot t$, where x is the angular distance, as shown in the figure. However, the buyer may initially believe the seller to be situated on the inner circle, in which case the utility that the buyer expects to receive is given by $v - p_1 - x \cdot t$.

> **Definition 1**. *Two sellers are called neighbors, iff in a projection of all sellers' true locations to the inner circle, there exists no other seller in between these two sellers.*

According to our definition of neighbor sellers, we only require to know about the sellers' horizontal locations to determine if two sellers are neighbors or not. For example, a seller on the outer circle can have two neighbors that are both located on the inner circle. Also, according to this definition, each seller has exactly two neighbors.

We can now present the timing of the game we analyze. The space of strategies open to sellers in each stage is exogenously determined.

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[1]This assumption is used to avoid the complications that would arise if vendors would find it preferable to forgo sales revenue in order to save on information dissemination costs.

[2]This fact is demonstrated in Equation 1, below.

- **Stage 1**: the sellers simultaneously choose their location on either of the two circles.
- **Stage 2**: the sellers are able to observe each others' locations and choose a price for their products.
- **Stage 3**: the sellers are able to observe each others' locations and prices and decide whether or not to release detailed product information by setting their $a = 0$ and/or inform the buyers about whether they occupy the inner or the outer circle.

Notice that the game ends at stage three, when sellers release their product information. The sellers are not allowed to update their product prices after that stage. This assumption simplifies the mathematical analysis of this model, but is not essential for our results.

We proceed to calculate the expected fit costs for a buyer that purchases a product from a seller whose exact location is unknown, but the center of his uncertainty interval is at an angle x from the buyer's location (see Figure 2). If $x > a$, the expected fit cost is $\int_{x-a}^{x+a} \frac{y \cdot t}{2a} dy = x \cdot t$. If $x < a$, the expected fit cost is given by $\int_{0}^{a-x} \frac{y \cdot t}{2a} dy + \int_{0}^{a+x} \frac{y \cdot t}{2a} dy = \frac{a^2 + x^2}{2a} t$.

Summarizing, the expected fit cost from purchasing from a seller whose expected location is at an angle x is given by

$$g(x) = \begin{cases} x \cdot t, & if \quad x > \alpha \\ \dfrac{x^2 + \alpha^2}{2\alpha} t, & if \quad x < \alpha \end{cases} \qquad \text{Equation 1}$$

where 2α is the interval within which the seller's true position lies.

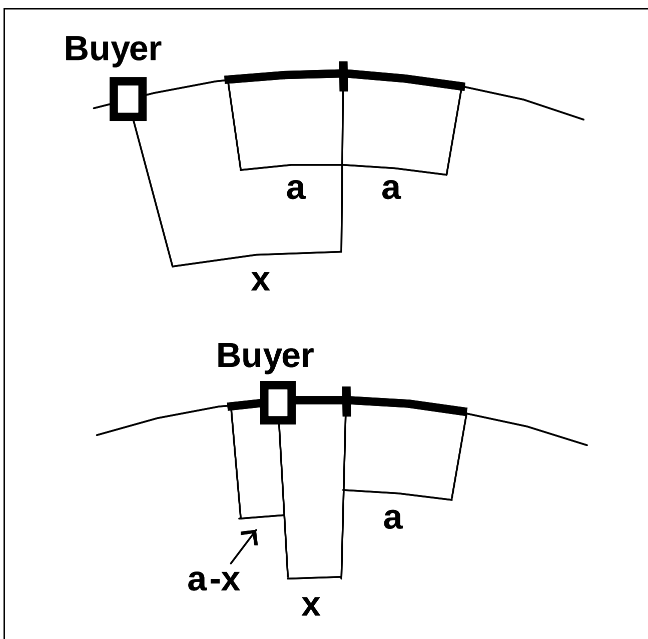

Figure 2. Fit Costs for a Buyer at Angle *x* from the Expected Location of a Seller

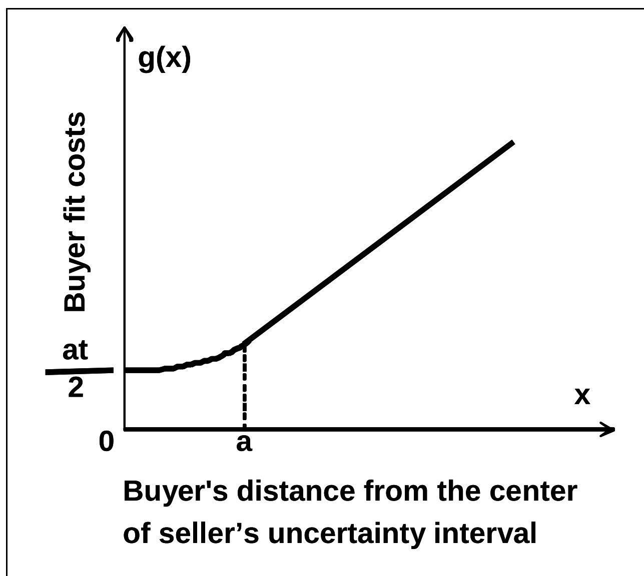

Figure 3. Buyer Expected Fit Costs as a Function of the Distance from the Middle Point of the Seller's Uncertainty Range

Model Critique

Here, it is important to discuss where the novelty of our model lies and demonstrate that the assumptions used are not an arbitrary collection of statements chosen for their convenience. In fact our model is firmly grounded on the tradition of the literature that followed Salop's (1979) unit circle model and very similar to the model developed by Economides (1993). Our main differences with Economides are as follow:

- We simplify Economides' assumption that buyers are heterogeneous regarding their quality preferences and assume that all consumers value quality the same way (by a premium given by q).

- We extend Economides' perfect information model to incorporate consumer uncertainty about product attributes.

Our models are thus very similar, but applied to fundamentally different questions. Whereas Economides investigates price and location equilibria, our focus in this paper is on the dissemination of information. More specifically, we include an additional stage in our game where vendors choose whether to provide detailed product information to consumers. Moreover, the assumptions we employ for the modeling of uncertainty about horizontal information (buyers knowing only of an interval within which the product's actual location lies) have been tested separately by the authors of this paper (Markopoulos et al. 2003, 2004) in both circular and linear market models that consider only horizontal product differentiation, as well as in markets where the search is a two step process with a parallel and a subsequent sequential component (Markopoulos et al. 2003). The uncertainty assumptions have been shown to yield qualitatively robust results, even when arbitrary uncertainty distributions are used (instead of the uniform distribution) and even when heterogeneous buyers form different opinions about the intervals on the circle circumference within which the products lie.

In summary, whereas our model does not deviate substantially from prior literature, it allows us to attack previously unsolved problems regarding the dissemination of information about horizontal and vertical product parameters.

Analysis

In order to analyze our model's equilibrium outcome, we start at the last stage of the game. The results that we present in this section are independent of any price and location decisions that have been made in the first two game stages. Thus, knowing what will happen in the game's last stage allows vendors to reason backward and optimize their actions in the first two stages as well. Here we analyze vendors' behavior during the third stage of the game, where sellers decide on whether to provide additional horizontal and vertical product information to prospective buyers. That is, vendors decide about whether to reduce their horizontal uncertainty intervals to zero and inform consumers about which of the two co-centric cycles they occupy. We repeat our assumption that the decision to disseminate the detailed information that is required for the buyers to exactly identify a product's location prior to purchase carries a *very small* cost for the seller. For simplicity we will assume that this cost is smaller than any other positive quantity that appears in our analysis, yet strictly greater than zero. Please note that a is not smaller than any positive quantity, for this would imply that in the limit $\alpha \to 0$.

The results presented in this section are completely orthogonal to what happens in the first two stages of the game: it can be shown that the outcomes of the product location and pricing stages are the same as they would be in a model with no horizontal uncertainty intervals and perfect quality information. Since our focus in this paper is on information dissemination, we will not expand on product positioning and pricing equilibria. For example, Economides' (1993) analysis is valid for the first two stages, and other equilibria are attainable by endowing vendors with different production costs for the different quality levels or by assuming sequential or simultaneous market entry.

Horizontal Product Information

Regarding the dissemination of horizontal product information, we can prove the following two propositions:

> **Proposition 1**. *If the horizontal uncertainty intervals of two neighboring vendors overlap,[3] at least one of the two vendors will reveal detailed product information in the game's last stage. As a result of this, at the end of the game, there will be no horizontal uncertainty interval overlap.*

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[3]According to the definition of our game, this can occur at the end of stage two.

> **Proposition 2**. *If the marginal buyer between two sellers is located outside the sellers' horizontal uncertainty intervals, then for any positive cost, howsoever small, associated with disseminating detailed information, the sellers will choose not to provide detailed product information.*

The proof of this and all other statements can be found in the Appendix of the first author's dissertation (Markopoulos 2004, pp. 176-183) available on-line at **http://opim.wharton.upenn.edu/~markopou/papers/dissertation.pdf**.

The intuition behind the proof for Proposition 1 is given by Equation 1 and Figure 3. If the horizontal uncertainty intervals of two vendors overlap, then the marginal buyer (the buyer that is marginally indifferent between a seller and his neighbor) will be located inside at least one horizontal uncertainty interval. When the marginal buyer is located inside the seller's uncertainty range, the seller can increase his market share by providing more detailed horizontal product information. This is because the new marginal buyer will be at a distance greater than the distance of the previous marginal buyer. This can be seen in Figure 3, where $\forall x < a$, the fit costs when the seller does not provide detailed horizontal information are greater than the fit costs when the seller provides detailed horizontal price information and the uncertainty range shrinks to zero size $a \rightarrow 0$.

The intuition behind the proof of Proposition 2 is that it is always the case that when a vendor releases additional horizontal product information, some customers will be "pleased" and some will be "disappointed." Some of the customers that receive the additional information will discover that the product is actually an even better fit than they initially thought; they will discover that the vendor's actual location is closer than his expected location at the center of the horizontal uncertainty interval. On the other hand, some of the customers that receive the additional information will realize that the vendor's product is even further away from their ideal. Thus, for a vendor that releases more horizontal product information, the customers that discover that the seller is actually closer to their ideal angular location will increase their willingness to pay for the product, and the customers that discover that the seller is actually located even further away than their ideal angular location will be willing to pay less. For a uniform distribution of customer preferences, the market share gain that the seller achieves on one side is exactly offset by a market share loss on the opposite side of the seller's location.

In order to understand the relevance to the Information Systems field, one must consider the two propositions in connection to each other: Taken together, they suggest that even when information dissemination costs are minimal, vendors will not provide perfect horizontal product information, but only enough horizontal product information to distinguish themselves from competing products with similar horizontal characteristics. In other words, vendors furnish more product information when they feel the competitive pressure of similar product offerings. Consequently, more product information will be available in markets where the products are tightly packed together in the product space, compared to markets where the products are more evenly spaced out in the product space.

For example, imagine a camera lens manufacturer that developed a new zoom lens for Nikon digital SLR cameras (SLR stands for Single Lens Reflex; these non-fixed lens cameras target professionals and "prosumers" and their lenses can be replaced). If the lens has a range of focal lengths that already exists in the market, our model predicts that the manufacturer will feel compelled to release detailed product information, perhaps by releasing a large number of sample photographs that clarify in detail characteristics such as micro-contrast, picture sharpness, color saturation, etc. under a wide variety of operating conditions. On the other hand, if the lens offers a range of focal lengths that does not exist in the market (for example, starting with 50mm which is roughly equivalent to the human eye and reaching 8x zoom to 400mm), then we would expect thelens manufacturer to exert much less effort in releasing sample pictures to the public, resulting in a higher degree of uncertainty about the actual performance of the lens under different operating conditions. Of course in both cases, the lens manufacturer will release exact focal length information, because if he does not, consumers will be too uncertain about the product's horizontal characteristics, projecting a horizontal uncertainty range that encompasses a large number of competing offerings.

In another example, ignoring quality for now, PC game developers will not feel compelled to release demo versions of their game, unless they feel that other competing games are sufficiently similar in their competitive positioning. If sufficiently similar games do not exist, PC game developers may opt for the cheaper solution of providing just text descriptions, screen shots, and video sequences of actual gameplay. All of these types of information reduce consumers' horizontal uncertainty about what the game is about. If game developers feel that this information is sufficient to let prospective buyers know that competing games are not close (horizontal) substitutes, then they will forgo the costly development of a playable demo version. We verify this claim for the PC game market later in the paper.

Results similar to Propositions 1 and 2 have been derived by the authors in a model of a circular market where only horizontal product differentiation was possible (Markopoulos et al. 2004). Here, we are able to show that the results are still valid in more realistic settings that include vertical differentiation. This paper has shown that these two propositions reflect deep properties of markets where parallel search is available (today's electronic markets) and are not an artifact of simplifying assumptions that omit the existence of information that pertains to product quality attributes.

Vertical Product Information

Regarding the dissemination of vertical (quality) information, the following can be shown:

> **Proposition 3**. *Sellers that are located on the outer circle will disseminate vertical information, and sellers that are located on the inner circle will not.*

Proposition 3 makes a very intuitive statement about binary product features. It says that when the product feature is included in a product, the sellers will say so, and when the binary feature is not included in a product, sellers will choose not to explicitly provide this information. Examples of binary product attributes can be found everywhere: for example, many home appliances may or may not include child locks, and PC games may or may not have network multiplayer capability. From our everyday experience, we do indeed know that an appliance manufacturer or game developer is far more likely to provide this information when the feature is present in the product and say nothing otherwise. This is not true in the case of versioning, as we discuss at the end of this section.

However, many vertical product attributes can have a continuum of values, such as the energy consumption or noise levels for home appliances. These are clearly vertical product attributes, as people are likely to agree that less energy consumption is better and that less noise is always desirable. Other vertical product attributes can take a number of integer values, such as the number of different washing programs in washers, or the size of RAM memory in laptop and desktop personal computers. Product attributes that can take continuous values are often also reported as different integer levels. For example, *Consumer Reports* rates home appliances' noise levels with a score from 1 to 5.

The question regarding how sellers disseminate information in those cases is less obvious than it was for binary variables. For example, it is not obvious whether a seller that provides a vertical product feature whose value is slightly below the average value for similar products, should provide information about this feature or not.

To answer this question, we will extend our two-circle model to multiple circles and, thus, multiple qualities. Imagine that there are L circles in which sellers can place their products. The circles are numbered starting at 1 for the innermost circle up to L for the outermost circle. Each circle k has an associated "quality premium" q_k, such that a buyer that would purchase from Seller i, located on circle k, would receive utility equal to $v + q_k - p_i - x \cdot t$, where p_k is Seller i's product price, and x is the angular distance between the buyer and Seller i. According to our definition of vertical differentiation, $i < j \Leftrightarrow q_i < q_j$.

All horizontal product information propositions can be shown to also hold for multiple quality circles.

> **Proposition 4 (applies to multiple quality levels)**. *Only vendors located in the innermost circle will not disseminate their vertical information.*

or equivalently,

> *If a seller does not disseminate vertical product information, the buyers will rationally and correctly conclude that the seller's product is of the lowest possible quality.*[4]

According to Proposition 4, vertical product information should almost always be reported. In the absence of vertical product information, the buyer should conclude the worst possible product quality (or the worst possible value for a vertical product attribute) and the buyer would be correct in this assessment.

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[4]A simple corollary of the propositions presented so far is that, "At the end of the third stage all *marginal* buyers will be outside vendors' horizontal uncertainty intervals. Furthermore, all buyers will know exactly the quality of each seller." This is the reason why we claimed at the beginning of this section that the outcomes of the first two stages of the game are orthogonal to our results.

However, this is not what an empirical investigation for product availability for microwave ovens and refrigerators has shown us, a puzzle that we believe has not been addressed by the IS community. In a simple observation, we obtained a list of important vertical product attributes, what *Consumer Reports* suggests people should be looking for, in refrigerators and microwave ovens. Information about all of these attributes was readily available with the manufacturers of the home appliances, and thus the cost of disseminating information about these attributes is very low. We randomly generated lists of these vertical product attributes, and searched for the relevant information on the manufacturer's web site, for a number of popular refrigerator and microwave oven models, that are covered in *ConsumerReports.com*. On average, information on 27 percent of vertical refrigerator attributes was missing. For microwave ovens, the missing vertical information was close to 50 percent (Markopoulos et al. 2004). Proposition 4 cannot explain the outcome of this simple observation. Indeed, it is puzzling that so many vertical product attributes, from in-flight leg space, to the bandwidth that hotels provide to business travelers in their rooms, are not reported by the sellers. We come back to this topic later.

The Relative Importance of Vertical and Horizontal Product Information

Our model's results reveal an important practical distinction between the dissemination of horizontal versus the dissemination of vertical product information. The distinction stems from the fact that the results regarding horizontal product information dissemination are independent of the quality cycle that a vendor occupies, while vertical product information dissemination critically depends on product quality. In other words, for horizontal product information, it is true that the pressure to provide more information is independent of product quality. The same is not true for vertical product information.

According to Propositions 1 and 2, if there exist sufficiently similar offerings competing with a vendor's product, failure to thoroughly inform consumers about the product will reduce the vendors' profitability regardless of the quality of the product. It is as if the punishment that vendors receive for not informing consumers about horizontal product attributes is constant for any quality level, or more accurately (we refrain from detailed analysis here) the punishment does not strongly depend on product quality. However, according to Proposition 4, the buyers rationally interpret the absence of vertical information as a signal that the product is of very low quality. Therefore, the higher the quality of a product, the more severe the punishment received from the buyers for not disseminating quality information. In other words, the higher the product quality, the higher the monetary benefit from releasing information. And since the reduction of profitability from not disseminating horizontal product information does not strongly depend on product quality, we can draw the conclusion that *above a certain quality threshold, vendors should primarily be concerned in releasing quality information, while below that threshold the sellers are better off focusing on providing horizontal product information that underlines the distinctions between their product and those of competitors*.

Our conclusion that horizontal product information dissemination grows in importance for lower product qualities may seem irrelevant in markets where information dissemination costs are very low. In the next section, we will see that in the PC game market, where the development of game demo versions carries significant costs, product quality differences determine whether information dissemination is driven primarily by product differentiation or product quality.

Empirical Evidence

Data Set

This section discusses the results of an empirical observation of information availability in the entertainment software industry, a $7.3 billion industry with record growth in the last few years (ESA 2004). The entertainment software industry, and PC games especially, provide an excellent opportunity to test our hypotheses on product information availability. PC game developers have a 0–1 choice regarding the dissemination of their product information: they either release a demo version of the game or not. This binary choice allows us to unambiguously assess the information availability in the PC game market and correlate it with product quality and differentiation.

Product data on 1,825 games were collected from *Gamespot.com*. About 200 games were disregarded (the total number of games available in the web site at the time of the observation was a little more than 2,000), as the crawling agent reported missing information on the attributes it was programmed to extract.

The *Gamespot* web site employs reviewers that rate PC games from as far back as 1993. Games are rated from 0 to 10, according to five attributes. Following the industry's standard terminology, the attributes were "gameplay"—interface, control, and how fun the game is to play, "graphics", "sound," "value"—the game's longevity, and "reviewer's tilt", which allows the reviewers to include other product attributes, such as a compelling "story line" for example, or express their opinion in a more subjective manner as to how successfully the aforementioned attributes were combined. The results that we report below would be virtually unchanged if we excluded the tilt parameter from the analysis. If fact, they somewhat strengthen the support of our hypotheses.

The *GameSpot* web site also provides PC game demo versions. We consider the availability of a demo version for a game as a positive indicator that the game developer had incentives to release more detailed product information. We assume that the availability of game demos in *GameSpot* reflects the overall game demo availability of the market and that *GameSpot* does not intentionally and systematically correlate demo availability with the average distances in the product space and/or product quality.

Games are both horizontally and vertically differentiated. For example some games dominate other games in the same genre, as they score higher on all five attributes. At the same time, considerable horizontal differentiation can also be observed as a game can have better graphics and sound but lack longevity and gameplay, vis-à-vis another game. This is to be expected, as for a given budget, developers have to make such tradeoffs. Oftentimes the game parameters can be naturally conflicting, as for example, spectacular graphics can slow down the game or make the game environment more complicated, and thus create problems for interface and control. Therefore, the availability of a demo version can be viewed as both horizontal and vertical product information dissemination, and factors that influence both kinds of information dissemination will have an observable impact on overall game demo availability.

Hypotheses

Propositions 3 and 4 claim that when quality information is very cheap to disseminate, only the worst quality vendors will not provide quality information. This seems to imply that if we start with the worst possible quality games, apart from an initial "jump" in demo version availability as we gradually increase game quality, no further correlation between game quality and demo version availability will be observed. However, for this market, we need to be more careful: the model assumption that vendors can provide product information almost without cost is inappropriate for the data set. In reality, there are considerable costs to providing a demo version of a PC game. Demo versions are expensive projects in which, usually, the original game programmers must design a product version that includes as many product characteristics as possible, while at the same time is not a substitute for the actual game. Usually, the game has to be repackaged to a much smaller size for Internet distribution, and security issues have to be considered. Further complications arise from the specific technical details of game engines, which may impede a demo version repackaging. In reality, there are considerable costs associated with the production of a PC game demo version, and even more importantly, the costs can differ considerably from game to game, even within the same genre.

It would thus be interesting to test the model's predictions under the assumption of high information dissemination costs[5] that differ randomly from product to product, independent of the product's true quality. If this is the case, then, according to Proposition 4, the buyers rationally interpret the absence of vertical information as a signal that the product is of the lowest possible quality. Therefore, the higher the quality of a game, the more severe the punishment it receives from the buyers for not disseminating vertical product information. In other words, the highest the product quality, the highest the monetary benefit from releasing a demo version. If we also accept a significant dispersion of demo development costs, then we conclude that the higher the game quality, the higher the probability that the benefit from releasing a demo version will outweigh the demo development costs. Therefore, a relatively smooth increase of demo availability as game qualities increase is to be expected.

> **Hypothesis 1**. *PC game demo availability is positively correlated with game quality.*

As we already discussed, the combination of Propositions 1 and 2 implies that, other things being equal, more information will be furnished in markets where the distances between product offerings are smaller. Game developers will "feel pressured" by other similar games to release a demo version and underline the differences of their game to those of competitors.

> **Hypothesis 2** *PC game demo availability is negatively correlated with average product distance from other games.*

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[5]The magnitude of information dissemination costs that is required to alter vendor behavior can easily be quantified (Markopoulos and Clemons 2004).

Regression Analysis

The regression equation, including a number of dummy variables for game genre is[6]

$$DEMO = \alpha + \beta_1 D + \beta_2 Q + \beta_3 Action + \beta_4 Adventure + \beta_5 Driving + \beta_6 RolePlaying$$
$$+ \beta_7 Simulation + \beta_8 Sports + \beta_9 Strategy$$

Where *DEMO* is 1 if a game offers a demo version and 0 otherwise. *Q* is the game quality, calculated as the average score for the five different product parameters that *GameSpot* rates, on a 1-10 scale. *D* is the game's differentiation which is measured as the game's average product space distance from all other games in the market. The market for any given game is defined as the set of all games within the same genre released during a given time period *T*.

We considered two different cases for *T*. In the first case, the games were divided into three periods, 1993 through 1998, 1999 through 2000, and 2001 through 2003, according to their official release date. The dates were chosen to divide the number of games as evenly as possible. However, the problem with this approach is that it ignores the fact that a game released in 2001 was also competing with games of the same genre that were released in 2000 and, quite possibly, competing with at least some games from 1999. Thus, we also looked at a "three years rolling" schedule. In this case, a single game yields three different data points; for example, an action game introduced in 1998 is considered to be in the "Action 1996-1998" product space, as well as in "Action 1997-1999" and in "Action 1998-2000," having a different average distance from other games in all three product spaces, while of course having the same quality score in all three product spaces. The results are qualitatively the same in both cases, as we show below.

The distance of Game *i* from all other games in a given genre is given by the average squared Euclidian distance

$$D_i^* = \frac{1}{(G-1)} \sum_{j=1;\, j \neq i;}^{G} \frac{1}{K-1} \left(\sum_{k=1}^{K} (r_{ik} - r_{jk})^2 \right) \qquad \text{Equation 2}$$

where *G* is the number of games in the particular genre and period, *K* is the number of game attributes (in our case, five) and r_{ik} is the rating of game *i* on attribute *k*.

Since we are not trying to accurately predict game demo availability based on product quality and differentiation, but to merely establish the existence of a relationship between them, we employed ordinary least squares. We also do not consider the logit of DEMO, allowing for values outside the 0–1 range. The regression results are summarized in Tables 1 and 2.

Table 1. Analysis When Distances are Measured for Three Time Periods: 1993–1997, 1998–2000, 2001–2003

Score Range (# of data points)	**3-5** (187)	**4-6** (380)	**5-7** (642)	**6-8** (920)	**7-9** (908)	**8-10** (469)
D-Q correl.	-0.69	-0.73	-0.49	-0.04	0.51	0.61
Demo~D	–*	–*	–	–**	–	–
Demo~Q	+	–	+*	+	+	+**

Key: *p < .1; **p < .05; ***p < .01; test is against the null hypothesis that the correlation is zero; + = positive correlation; – = negative correlation

[6]Demo availability for different genres varies considerably. For example, a driving game is twice as likely to have a demo version as an adventure game, because driving games are more modular, consisting of multiple driving courses. On the other hand, adventure or role-playing games cannot easily be broken into small playable pieces. Furthermore we have used Puzzle games as a control group and the relevant variable is missing from the equation.

Table 2. Analysis for Distances Measured for Three Years Rolling: 1995–1997, 1996–1998, 1997–1999, 1998–2000, 1999–2001, 2000–2002, 2001–2003						
Score Range (# of data points)	**3-5** (481)	**4-6** (969)	**5-7** (1625)	**6-8** (2339)	**7-9** (2322)	**8-10** (1213)
D-Q correl.	-0.71	-0.74	-0.50	-0.05	0.53	0.64
Demo~D	–***	–**	–	–*	+	+
Demo~Q	+	–	+***	+	+	+***

Key: *p < .1; **p < .05; ***p < .01; test is against the null hypothesis that the correlation is zero; + = positive correlation; – = negative correlation

The correlation between demo availability and differentiation is negative, whenever it is statistically significant, and the correlation between demo availability and quality is positive, whenever it is significant, in accordance with our hypotheses.

The results of the regression analysis reveal that for high quality games (i.e., games that exceed 8/10 total score), under both scenarios, only game quality is a good predictor of demo availability while game differentiation is irrelevant. In other words, in that range, a game that scored 9/10 is more likely to have released a demo than a game that scored 8.5/10. The same is also true for games in the 5–7 score range. The results are mixed for the 6–8 range with the "Three Years Rolling" scenario showing quality as the statistically significant predictor of demo availability, and the "Three Periods" scenario showing differentiation as the statistically significant predictor. Surprisingly neither D nor Q is a good predictor of demo availability for games in the 7–9 range.

For low quality games (i.e., games with quality less than 6), the results are unambiguous: game differentiation is an excellent predictor of demo availability and game developers feel pressured by other games in the product space that appear similar to theirs to release game demos that underline the unique attributes of their game.

In summary, we believe that the tables paint a picture for PC game version availability that is in accordance with our earlier discussion. Quality is a good predictor of game demo availability for the highest quality games (games in the 8–10 out of 10 range), while differentiation is a good predictor of demo availability for low quality games, with mixed results for intermediate game qualities.

Discussion and Future Research

In this paper, we extended Economides' well-studied model from the established literature of spatial product differentiation by introducing consumer uncertainty about product parameters. In other words, our novelty was in making the dissemination of detailed product information an endogenous model parameter, decided by the vendors. The model analysis produced two sets of results.

- The intuitive result that vendor incentives to release detailed product information is positively correlated with product quality.

- The highly surprising (at least to the authors of this paper) result that product differentiation affects product information dissemination decisions, and that this is especially true for low quality products.

This is what we find surprising about the second result: imagine any *N*-dimensional product space, where each dimension describes a certain product attribute. All products in the market are points, of that *N*-dimensional space. By measuring the Euclidian distances between all of these points we can make predictions about how much information different vendors release about their products. This is a novel result that connects two important aspects of competitive strategy: product design and positioning decisions on one hand, and the amount of effort that goes into informing consumers about product details on the other.

These findings shed light on the mechanism by which product information is made available in electronic markets. Apart from the purely intellectual goal of better understanding information dissemination in Internet markets, the purpose of this paper was to also demonstrate that our model is simple enough to be mathematically tractable and yet versatile enough to produce intuitive results as well as to make verifiable predictions. This would make our model a good candidate for solving problems that are becoming more and more important, not only for the design of personal shopping agents, product comparison websites, and electronic shopping assistants in general, but also for the formulation of competitive strategy by managers who use electronic channels to inform consumers about their companies' products.

An example of the types of problems to which we are currently applying our model is the following: consider the problem of designing a new digital camera. The manufacturer will attempt to offer a combination of tens of different product features with the hope that the product will appeal to the maximum number of consumers while minimizing the amount of competition that it faces from competing product offers. However, consumers do not receive the same amount of information or with the same efficiency and ease on all digital camera parameters. For example shop.yahoo.com currently features nearly 800 digital cameras but allows consumers to search this huge and complicated product space along only 5 or 6 product parameters. While it is easy for consumers to learn the megapixel count, it is difficult to discern the noise levels that different cameras achieve under different operating conditions. So, what are the parameters on which the manufacturers should attempt maximum differentiation? What are the parameters on which the manufacturer should attempt to extend his product line, given that there are fundamental differences on the way the bulk of consumers can receive information about the different product parameters? Intuitively we realize that product information availability should be an important input in the product design process, but apart from this, little else is understood.

We hope that this fairly simple and mathematically tractable game-theoretic model, which brings together spatial product competition, pricing, and information availability will be a valuable tool to researchers and practitioners in MIS, product design, marketing, and competitive strategy.

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