Word of Mouth and Sales Concentration*

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Abstract

I examine the role of word of mouth in consumer's product discovery process and its implications for the firm. I present a model where consumers face a large assortment of horizontally differentiated products supplied by a monopolist, and may search for a product match by drawing products from the assortment or by seeking product recommendations from other consumers. I analyze the underlying consumer interactions that lead to the emergence of word of mouth, characterize the optimal pricing strategy of the firm, and explain the impact of word of mouth on the concentration of sales within the assortment. The results contribute to explain recent empirical findings in online retail and provide a rationale for the firm's adoption of personalization mechanisms such as recommender systems. The model is well suited for experience good markets such as music, cinema, literature, and video game entertainment.

Keywords: Search, Product Discovery, Product Recommendations, Recommender Systems, Long Tail

JEL Classification: D42, D83, L15, M31

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1 Introduction

Word of mouth is fundamental to the product discovery process of consumers. In product categories such as music, films, books, or video games, consumers often identify products that match their taste through the recommendations of others. And in recent years, widespread Internet adoption and the expansion of electronic commerce has led this word of mouth exchange to increasingly take place online. Online retailers are participating in the process by encouraging consumers to post product recommendations and reviews on their websites, as well as implementing personalization mechanisms such as recommender systems that generate personalized product recommendations for their customers. It is increasingly recognized that this transition is triggering changes in consumption patterns, but the drivers of these changes are not yet well understood.

Recent studies suggest that demand-side factors are contributing to drive down sales concentration within the assortments of online retailers, increasing the sales of products with low market shares within the assortment relative to those with high market shares. Brynjolfsson, Hu, and Simester (2011) examine online and offline sales concentration within the assortment of a clothing retailer, controlling for supply-side differences in product availability, and find lower sales concentration online. They also find that the recommender system is the major contributor to the concentration shift. Oestreicher-Singer and Sundararajan (2010) find that sales concentration is lower among book categories on Amazon.com where personalization is expected to be more accurate. Ehrmann and Schmale (2008) report similar findings on Amazon.de. Other effects have also been reported in addition to shifts in the concentration of sales. De, Hu, and Rahman (2010) show with server log data that a recommender system increases sales volume. Chevalier and Mayzlin (2006) find that online consumer reviews of books increase relative sales at the retailer they are posted on. Feng and Zhang (2010) find that online consumer reviews of videogames have a stronger impact on niche products.

This paper presents a formal model of consumer search with word of mouth that explains consumers' demand (and supply) of product recommendations, and how they affect sales concentration and product pricing within large assortments. The modeling exercise is based on the observation that word of mouth processes are increasingly taking place online. Consumers that may have traditionally discovered new products through word of mouth within their social circles are turning to online recommendations posted in affinity communities or generated by recommender systems that account for their preferences. I argue that this reduces the cost of obtaining product recommendations in the market and improves the preference matching between consumers supplying and demanding recommendations. The analysis reveals that both of these factors benefit consumers with less prevalent preferences in the population the most, increasing their relative participation in the market and reducing the concentration of sales, rationalizing the findings reported in the empirical literature. The model provides a novel explanation for several aspects of consumer product discovery and informs the design of marketing strategies that exploit it.

The intuition for the result can be outlined with an example. Consider the implications of the exchange of product recommendations between consumers with different product preferences. A large share of the consumer population has mainstream preferences, and a smaller share has niche preferences. Other factors equal, product recommendations will benefit mainstream consumers the most because they more often originate from consumers with mainstream preferences, and this increases the participation of mainstream consumers in the market relative to that of niche consumers. Word of mouth then tends to increase the sales of products preferred by mainstream consumers more so than those preferred by niche consumers. This increases the concentration of sales, and may explain word of mouth in the offline world. What happens when word of mouth moves online becoming accessible at a lower cost and improving the matching of consumers based on their product preferences? This levels the playing field for both consumer types, benefiting niche consumers the most. As a result, it reduces the concentration of sales.

The example oversimplifies the problem, of course. Consumer search strategies and product prices are jointly determined by the interactions that arise in the market. On the one hand, consumers do not depend on word of mouth to discover products. They can also search the assortment and sample products in order to locate one that meets their taste. Consumers with niche preferences will anticipate that word of mouth does not pay off for them and will choose to search the assortment instead. This in turn will affect the word of mouth exchange between consumers of both types. On the other hand, the firm will account for the fact that mainstream consumers benefit more from word of mouth when pricing products, and this can overturn their advantage. The modeling exercise presented below formally addresses these concerns and proves that the intuition provided in the above example is robust.

The paper relates to the recent literature on consumer search and e-commerce. Kim, Albuquerque and Bronnenberg (2010) estimate the consumer's search problem based on camcorder sales data retrieved from Amazon.com, and consistent with the results presented here, find that consumer search costs have a significant impact in the market and that Amazon's product recommendations lower them. Kuksov and Villas-Boas (2010) evaluate the impact of assortment size in a search model where consumers anticipate higher search costs when facing larger assortments. Chen, Wang and Xie (2011) study Amazon sales data to disentangle the effect on consumer demand of word of mouth from that of observational learning based on sales rankings. Sun (2011) examines the informational role of consumer product ratings and shows that niche products are associated with higher variance of ratings. Choi and Bell (2011) consider the benefits of e-commerce for preference minorities, consumers who are not well served by local brick and mortar stores due to the constraints of physical distribution. The findings reported here also suggest that consumers with niche preferences and the products that appeal to them stand to benefit the most from online retail.

To the best of my knowledge, no previous theoretical work has explored the links between word of mouth and sales concentration. Bar-Isaac, Caruana and Cuñat (2011) model how reductions in

consumer search costs affect product design choices on the supply side of the market, which can lead to lower sales concentration by increasing the market shares of firms with rare designs. Fleder and Hosanagar (2007) evaluate the impact of different recommender systems on sales concentration and volume by using simulations with consumers and products located on a 2-axis space. Tan and Netessine (2011) evaluate the demand for mainstream and niche titles across time using Netflix data. Other contributions have focused on improving the performance of personalization mechanisms by applying Bayesian learning or other methods, as in Ansari, Essegaier and Kohli (2000), Ying, Feinberg and Wedel (2006), Bodapati (2008), and Atahan and Sarkar (2010).

A large strand of literature in marketing has examined the impact of word of mouth. Recent contributions include that of Berger and Schwartz (2011), who analyze the drivers of word of mouth across product categories and over time. Chen, Harper, Konstan and Li (2010) study how social comparisons can boost word of mouth contributions in user communities. Aral and Walker (2011) examine how the viral features of products can foster word of mouth. Chintagunta, Gopinath and Venkataraman (2010) analyze how online user reviews impact the box office performances of movies through their geographical rollout. Manchanda, Xie and Youn (2008) evaluate the comparative performance of word of mouth and marketing communication in the pharmaceutical industry. Cheema and Kaikati (2010) evaluate how consumers' concerns for uniqueness impact word of mouth.

1.1 A search framework for word of mouth

This paper presents a search model where consumers face a large assortment of horizontally differentiated products supplied by a monopolist. The approach is based on that introduced by Anderson and Renault (1999) to analyze a market with search costs and product differentiation. Similarly to their model, consumers incur a search cost to learn about both the price and the utility they derive from a product on each draw. I simplify product differentiation by considering the case where there are two types of consumers and products in the market. And I introduce word of mouth by assuming consumers have two search strategies: they can search the assortment by directly browsing products or they can search with word of mouth by seeking product recommendations from other consumers.

When searching the assortment, consumers become informed about products by sampling them. They may do this by visiting the retailer's store and browsing through the assortment, in the context of traditional retail, or by browsing product pages on the retailer's website in the context of online retail. Consumers incur a sampling cost each time they sample (draw) a product, and in the process learn the utility they derive from the product and its price. The model abstracts from the precise details of the search process, but assumes that consumers searching the assortment do so independently and have a constant probability of identifying a product that matches their taste on each draw.

Consumers searching with word of mouth learn from consumers who previously located a preferred product by searching the assortment. The timing ensures that word of mouth is valuable because product recommendations are supplied by informed consumers. These consumers recommend their preferred product to others. In the offline context, consumers searching with word of mouth may seek recommendations by conversing with those in their social circles about their preferred products. In the online context, consumers may visit forums or message boards where others discuss their preferred products or may use personalization tools implemented by online retailers that guide them through the assortment and highlight the opinions of others with similar taste.[1]

Consumers incur a cost each time they draw a recommendation (or seek a new interaction) and in doing so learn about the utility they derive from the recommended product and its price. Consumers will benefit from recommendations when interacting with others that share their same product preferences, but interactions between consumers with different preferences are prone to arise because consumers cannot readily identify the preferences of others before interacting with them. Because some consumers must prefer to search the assortment for others to obtain recommendations, I let consumers differ in their sampling costs to ensure that word of mouth arises in equilibrium.

The construction is well suited for experience goods such as music, films, books, or video games. Consumer preferences in these product categories are highly idiosyncratic, and the utility consumers derive from products cannot be anticipated based on their objective characteristics such as title, genre, or plot. Search is meaningful because consumers need to sample a product in order to learn the utility they derive from it. And the best substitute to personal exposure is arguably a detailed account of that of others with similar preferences. Hence, word of mouth is meaningful because consumers can learn from the experience of others.

Consumers draw products randomly from the assortment, and draw recommendations from others given an exogenous preference matching process which can be interpreted to vary in different word of mouth environments. This implies that consumers do not observe individual product prices or market shares in order to selectively draw products, and do not observe the preferences of others to selectively seek product recommendations. Thus the model explains the search strategies of rational consumers who are imperfectly informed about the assortment and the preferences of the population, and search costs can be interpreted as the costs of acquiring information in the market.[2]

[1]Note that word of mouth is interpreted as a product discovery mechanism; consumer reviews posted on the product pages of retailers and which do not link to other products (or provide comparisons with other products) are better understood as reducing sampling costs rather than providing guidance through the assortment.

[2]The consumer with zero sampling costs $c_i = 0$ incurs no positive cost to observe the price and the utility she derives from products in the assortment. If all consumers had zero sampling costs in the model, the outcome is equivalent to the benchmark case where consumers are perfectly informed about the assortment. In this case all products are priced at u, all consumers purchase, and word of mouth does not arise because consumers do not benefit from product recommendations.

To derive the results, several simplifications are made in the analysis. I consider a static model where consumers exhibit unit demand and purchase at most one unit in the market, and do not evaluate the implications of repeated word of mouth interactions among consumers.[3] On the supply side, I model the assortment as a continuum of products. This simplifies the search strategies of consumers by ensuring that the expected value of future draws is constant during search, so stopping rules depend only on having located a preferred product. The assumption is sensible for large assortments where sampling individual products does not alter consumer expectations about the value of the remaining (e.g., disliking a movie does not alter consumers' expected valuation of movies in general). I also assume the composition of the firm's assortment is fixed. The firm acts as an intermediary or gatekeeper that supplies all products varieties on the market, for instance due to agreements with large publishers or threat of entry by a competitor. Optimal assortment composition in the presence of word of mouth is a complex problem and is beyond the scope of this paper.

The next section formalizes the building blocks of the search model, and a table summarizing the notation is included in Appendix A. Consumer search strategies are characterized as a function of product prices in Section 3, which explains the drivers of word of mouth in the model. Section 4 solves equilibrium prices and explains the implications of word of mouth on firm profits. Section 5 characterizes the impact of word of mouth on the concentration of sales within the assortment. Section 6 concludes by reviewing the marketing implications for the firm.

2 The model

Consider a market where a monopolist supplies a product assortment consisting of a continuum of products of measure one. The monopoly case is of interest because it allows for a direct evaluation of the value captured by the firm in the presence of consumer search, and which would otherwise be eroded by competition. Consumers differ in their product preferences and in their costs of sampling products. The product preferences of consumers are simplified to a binary classification – consumers derive positive utility from their preferred products and zero utility from the remaining. The simplest instance of the model that yields the results is that where some product preferences are more prevalent than others in the consumer population and there is no overlap in the set of preferred products of consumers with different preferences.

I consider two types of consumer preferences and partition the assortment into two product pools of equal size. There is a mass m of consumers of type 1 who derive utility only from products pertaining to the first pool, and there is a mass n of consumers of the type 2 who derive utility

[3]The model provides a proxy for multiple purchases when these are executed simultaneously and successive recommendation draws remain independent and identically distributed random variables. The complexity of the problem increases substantially in a game where consumers return to the market in successive periods to execute new purchases and engage in repeated word of mouth interactions with others.

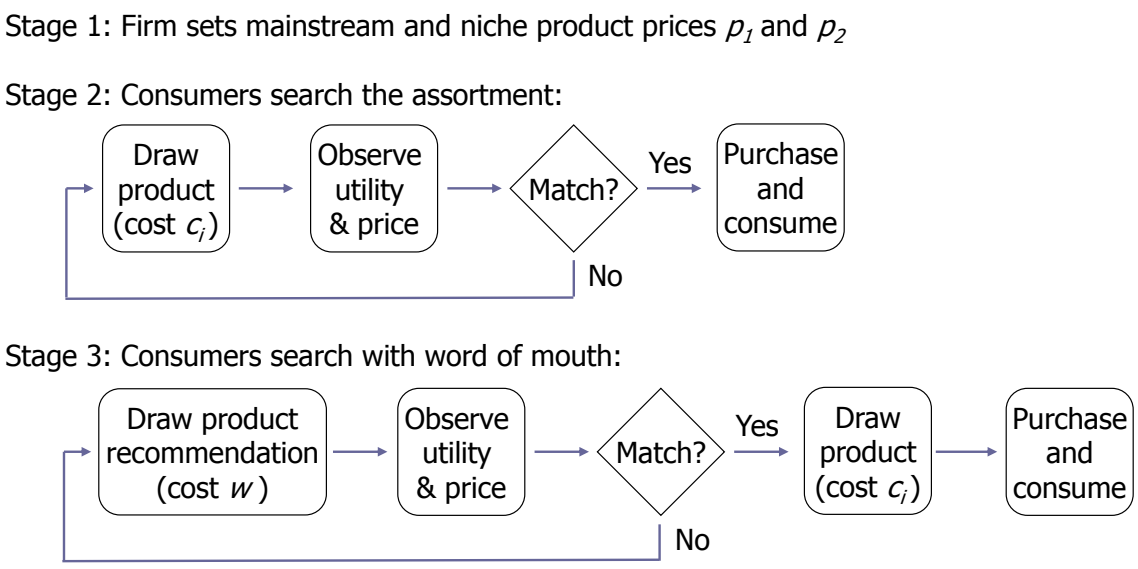

Figure 1: The timing of the game.

only from products pertaining to the second pool. I will assume that $m > n$, so consumers of type 1 are more prevalent in the population than consumers of type 2. Therefore, I will refer to consumers of type 1 as mainstream consumers and to consumers of type 2 as niche consumers. Similarly, I will refer to products in the first pool as mainstream products, and to products in the second pool as niche products. Also note that $m - n$ provides a measure of preference diversity in the population.

Consumers arrive to the market imperfectly informed about the assortment and the preferences of the consumer population. They observe the structure of the assortment, consisting of product pools and the prices across product pools, but cannot map individual products to product pools. All products are ex-ante identical to consumers, who cannot infer the price and the utility derived from specific products on arrival. Similarly, they observe the preference structure of the consumer population, but do not observe the type of individual consumers. But they can become informed by sampling the assortment or by seeking product recommendations from other consumers who have done so previously, and have the information required to form a correct expectation of the value of both search strategies. A product *match* is achieved when a preferred product is identified. Consumers exhibit unit demand, and may participate in the market to identify and purchase a preferred product or stay out.

Sampling costs are uniformly distributed in the consumer population independently of product preferences, where the cost of consumer i is given by $c_i \sim U[0, \overline{c}]$. So sampling a product which does not yield a match incurs disutility c_i, and sampling and consuming a product match yields utility $u - c_i$. I assume that $\overline{c}$ is sufficiently high for the market to remain uncovered in equilibrium. This ensures a positive mass of consumers chooses not to participate and simplifies the analysis by avoiding corner solutions in the pricing game.

Figure 1 depicts the timing of the game. In the first stage, the firm sets prices p_1 and p_2 for mainstream and niche products. Consumers willing to participate in the market can either search during the second stage or the third stage by choosing between two sequential search strategies. In the second stage, consumers may search the assortment by randomly drawing and sampling products. Consumers incur sampling cost c_i on each draw, and learn the price and their match with the product. A product match is achieved with probability $\beta = 1/2$ on each draw, given that consumers draw randomly from a continuum of products and obtain a match only from those pertaining to their preferred product pool. Consumers draw products until they locate a match, executing a purchase and concluding their search once they do so. In the third stage, consumers who did not search in the second stage may search with word of mouth by drawing product recommendations from those who completed their search in the second stage – those consumers will recommend and inform others about the product they matched with.

Consumers searching with word of mouth incur a positive cost w on each recommendation draw, and learn the price and their match with the recommended product. Word of mouth interactions are governed by preference matching parameter τ: when consumers of different types supply recommendations in the market, a consumer drawing a recommendation learns from a consumer of her own type with probability τ, and with probability $1 - \tau$ learns randomly from the mass of consumers supplying recommendations. Consumers sequentially draw recommendations until they locate a match, and then draw the preferred product at cost c_i and execute a purchase to conclude their search. Note that although word of mouth can deliver unsuccessful recommendation draws, consumers searching with word of mouth avoid the sampling costs incurred with failed assortment draws. For simplicity, I assume consumers supplying product recommendations are willing to "speak" for free as long as others with their same preferences listen. That is, as long as their recommendations generate value in the market. The analysis will reveal that in doing so they also benefit from lower prices.

3 Consumer search strategies

I proceed to solve the game by backwards induction and characterize the search strategies of consumers in the third and second stages. I provide a general characterization of search strategies to clarify the logic of the model before deriving the closed-form solution.

Word of mouth search. Consider the problem of an unmatched consumer of type $t \in \{1, 2\}$ in the third stage. Searching with word of mouth implies sequentially drawing product recommendations from consumers who searched the assortment to locate a match in the second stage and supply recommendations in the market. A consumer searching with word of mouth will only obtain a product match when drawing a recommendation from another consumer of her same type. Denote the probability of locating a match on each recommendation draw by consumers of type t by α_t.

If only consumers of type t supply recommendations, drawing a recommendation will always yield a match, $\alpha_t = 1$. If consumers of both types supply recommendations, then the match probability on each draw will depend on preference matching τ. Denote the share of consumers of each type that located a match in the second stage by s_t^a, where $s_t^a > 0$ for both types. Consumers drawing recommendations sample with replacement because unsuccessful past draws do not affect future draws. There is a continuum of consumers providing recommendations, so the odds when sampling the population α_t remain constant throughout the search. Each recommendation draw is a Bernoulli trial with the same success probability for all consumers of type t given by

$$\alpha_t = (1 - \tau)s_t^a + \tau. \tag{1}$$

The match probability when seeking recommendations will differ across types whenever $s_t^a \neq s_{t'}^a$ and there is imperfect preference matching $\tau < 1$. That is, the larger the share of second-stage consumers who located a match of a consumer's own type, the larger her match probability when drawing a recommendation.

The expected utility of drawing a new recommendation for an unmatched consumer of type t with sampling cost c_i given α_t when her preferred products are priced at p_t is

$$U_{t,i}^w = \alpha_t(u - p_t - c_i) - w, \tag{2}$$

as the consumer only purchases if a match is located but incurs recommendation cost w on every draw. The expected utility will differ across types due to α_t and p_t as well as within types depending on c_i.

Denote by c_t^w the consumer of type t who is strictly indifferent between searching with word of mouth and not participating in the market. Given $\alpha_t > 0$, searching with word of mouth may pay off for consumers of type t depending on w. To pin down c_t^w given that the utility of successive recommendation draws is constant throughout the search, the indifferent participant is identified by equating $U_{t,i}^w$ to zero,

$$c_t^w = \frac{\alpha_t(u - p_t) - w}{\alpha_t}. \tag{3}$$

Unmatched consumers of type t with sampling cost $c_i \leq c_t^w$ choose to search with recommendations in the third stage, and those such that $c_i > c_t^w$ prefer to stay out of the market. Consumers searching with word of mouth sequentially draw recommendations until they obtain a match, which on average requires $1/\alpha_t$ draws. The search process finalizes once a match is located, searching for a second match cannot be optimal.

Assortment search. I next turn to the second stage of the game and characterize direct search through the assortment. Note that consumers sample with replacement because there is a continuum of products, so the odds when sampling the assortment remain constant throughout

the search and each draw is a Bernoulli trial with success probability β common for all consumers. The expected utility of a new product draw for an unmatched consumer of type t with sampling cost c_i when her preferred products are priced at p_t is

$$U^a_{t,i} = \beta(u - p_t) - c_i, \tag{4}$$

given that the consumer only purchases if a match is located but incurs sampling cost c_i on each draw. The expected utility will vary across types depending on prices p_t and within types depending on the sampling costs of consumers c_i. Consumers searching the assortment will sequentially draw products until they obtain a match, which on average requires $1/\beta$ draws. The search process finalizes once a match is located, searching for a second match cannot be optimal.

Denote by c^a_t the consumer of type t who is strictly indifferent between searching the assortment and not participating in the market. Given that the utility of successive draws from the assortment is constant throughout the search, this consumer can be identified by equating $U^a_{t,i}$ to zero,

$$c^a_t = \beta(u - p_t). \tag{5}$$

When consumers of type t do not participate in word of mouth, those with a sampling cost $c_i \in [0, c^a_t]$ choose to search the assortment in the second stage and the remaining prefer to stay out of the market.

Search strategy choices. I next analyze the search strategy choices of consumers in the second stage. Consumers anticipate that they may search with word of mouth in the third stage, so they decide which search strategy to pursue (if any) by comparing the expected utility derived from both. Consumers of type t will perform this comparison by accounting for the fact that the expected number of draws required for a match differs between both strategies, as given by β and α_t. Note that this comparison holds at any point of the search process for an unmatched consumer, as the expected utility of both search strategies is unaffected by past unsuccessful draws. This implies that no consumer that chooses to search the assortment in the second stage will ever prefer to abort the search in order to search with word of mouth in the third.

The indifferent searcher of type t, denoted by c^s_t, obtains the same expected utility from both search strategies. The indifferent searcher is identified by equating $U^a_{t,i} = U^w_{t,i}$ accounting for the expected number of draws required for a match with both search strategies, which is given by $1/\beta$ when searching the assortment and $1/\alpha_t$ when searching with word of mouth.[4] Therefore,

$$u - p_t - \frac{c^s_t}{\beta} = u - p_t - c^s_t - \frac{w}{\alpha_t}, \tag{6}$$

[4]Expression (6) can also be derived as follows. Let $\bar{U}^a_{t,i}$ and $\bar{U}^w_{t,i}$ denote the (total) expected utility of searching the assortment and searching with word of mouth, respectively, for a consumer of type t with search cost c_i. Because consumers sample with replacement, $\bar{U}^a_{t,i} = \beta(u - p_t) + (1 - \beta)\bar{U}^a_{t,i} - c_i$, which implies that $\bar{U}^a_{t,i} = u - p_t - (c_i/\beta)$. Similarly, $\bar{U}^w_{t,i} = \alpha_t(u - p_t - c_i) + (1 - \alpha_t)\bar{U}^w_{t,i} - w$, so $\bar{U}^w_{t,i} = u - p_t - c_i - (w/\alpha_t)$. Equating $\bar{U}^w_{t,i} = \bar{U}^a_{t,i}$ and substituting c_i for c^s_t delivers expression (6)

which implies that

$$c_t^s = \frac{w\,\beta}{\alpha_t(1-\beta)}, \tag{7}$$

and the solution is given by an implicit equation because α_t depends on c_t^s for types participating in word of mouth. When both types participate and there is imperfect matching $\tau < 1$, the solution is given by a system of equations (with one equation per type) reflecting the interdependencies that arise with the exchange of recommendations across types. Note that consumers have the information required to rationally anticipate the equilibrium search strategies of others in order to decide their own. I solve the system below for the case of two consumer types.

When consumers of type t participate in word of mouth, those with sampling cost $c_i \in [0, c_t^s]$ prefer to search the assortment in the second stage and those with sampling cost $c_i \in (c_t^s, c_t^w]$ prefer to search with word of mouth in the third stage. Remaining consumers of type t stay out of the market.

In equilibrium, the configuration of types that participate in word of mouth is determined by product prices and these are characterized in Section 4. Note that the above characterization of consumer search strategies assumes an uncovered market, and this implies a lower boundary on $\overline{c}$ such that $\overline{c} > c_t^w$ for types participating in word of mouth and $\overline{c} > c_t^a$ for types that only search the assortment.

Closed-form solution. I next derive the closed-form solution for search strategies. Consider first the case where both types participate in word of mouth. The shares of consumers of each type searching the assortment s_1^a and s_2^a can be written as a function of the indifferent searchers of each type c_1^s and c_2^s, where the share of mainstream consumers searching the assortment is given by $s_1^a = (c_1^s/\overline{c})m$ and that of niche consumers by $s_2^a = (c_2^s/\overline{c})n$. Writing α_t in (1) for each type as a function of the indifferent searchers and substituting α_1 and α_2 into (7) for each type provides a system of two equations for c_1^s and c_2^s. The system yields a unique positive solution satisfying $c_1^s > 0$ and $c_2^s > 0$. The indifferent participants c_1^w and c_2^w are then obtained by directly substituting the solution in (3). It can be readily verified that

$$\begin{aligned}
c_1^s =& \frac{w(2\,m + (m-n)\tau + M)}{2\,m(1+\tau)} \\
c_2^s =& \frac{w(2\,n + (n-m)\tau + M)}{2\,n(1+\tau)} \\
c_1^w =& \frac{2\,m(u - p_1 - w) + m\,\tau(2u - 2p_1 - w) + w(n\,\tau - M)}{2\,m(1+\tau)} \\
c_2^w =& \frac{2\,n(u - p_2 - w) + n\,\tau(2u - 2p_2 - w) + w(m\,\tau - M)}{2\,n(1+\tau)}
\end{aligned} \tag{8}$$

where

$$M = \sqrt{4\,m\,n + (m-n)^2\tau^2}, \tag{9}$$

and the solution is well defined for prices p_1 and p_2 such that $c_1^w > c_1^s$ and $c_2^w > c_2^s$.

Consider next the case where one consumer type participates in word of mouth and the other type does not. Search strategies for the type that searches with word of mouth are obtained by directly substituting $\alpha_t = 1$ in (7) and in (3),

$$\begin{aligned} c_t^{\hat{s}} &= w \\ c_t^{\hat{w}} &= u - p_t - w. \end{aligned} \tag{10}$$

For types that do not participate in word of mouth and only search the assortment, search strategies are obtained directly from (5),

$$c_t^a = \frac{u - p_t}{2}. \tag{11}$$

Proposition 1. *When both mainstream and niche consumers participate in word of mouth, consumers of type t with sampling cost $c_i \in [0, c_t^s]$ search the assortment and those with sampling cost $c_i \in (c_t^s, c_t^w]$ search with word of mouth. When only one type participates in word of mouth, consumers of that type with sampling cost $c_i \in [0, c_t^{\hat{s}}]$ search the assortment and those with sampling cost $c_i \in (c_t^s, c_t^{\hat{w}}]$ search with word of mouth. Consumers of types not participating in word of mouth with sampling cost $c^i \in [0, c_t^a]$ search the assortment. All remaining consumers stay out of the market.*

Consumers searching the assortment independently sample products in order to locate a match. The probability of locating a match on each draw is common for all consumers, and search is costly because consumers incur sampling costs on each draw. Consumers searching with word of mouth interact with those who searched the assortment before them, incurring costs to obtain product recommendations from them and learn about the prices and their match with the preferred products they identified. Consumers only benefit from product recommendations originating from others who share their product preferences (same type t) as only those recommendations yield a match.

Consumers decide which search strategy to pursue by comparing the expected utility derived from both. Searching the assortment generally incurs unsuccessful product draws, and word of mouth generally incurs unsuccessful recommendation draws. Consumers form a correct expectation of the value of both search strategies by accounting for the costs of each draw and the expected number of draws required for a match. The comparison between both will depend on the search strategy choices of other consumers because of the interdependencies that arise with word of mouth – with imperfect preference matching $\tau < 1$, the more valuable recommendations are for one type in the market, the less valuable they are for the other. Thus the search strategy choices of consumers are jointly determined across the population as a whole.

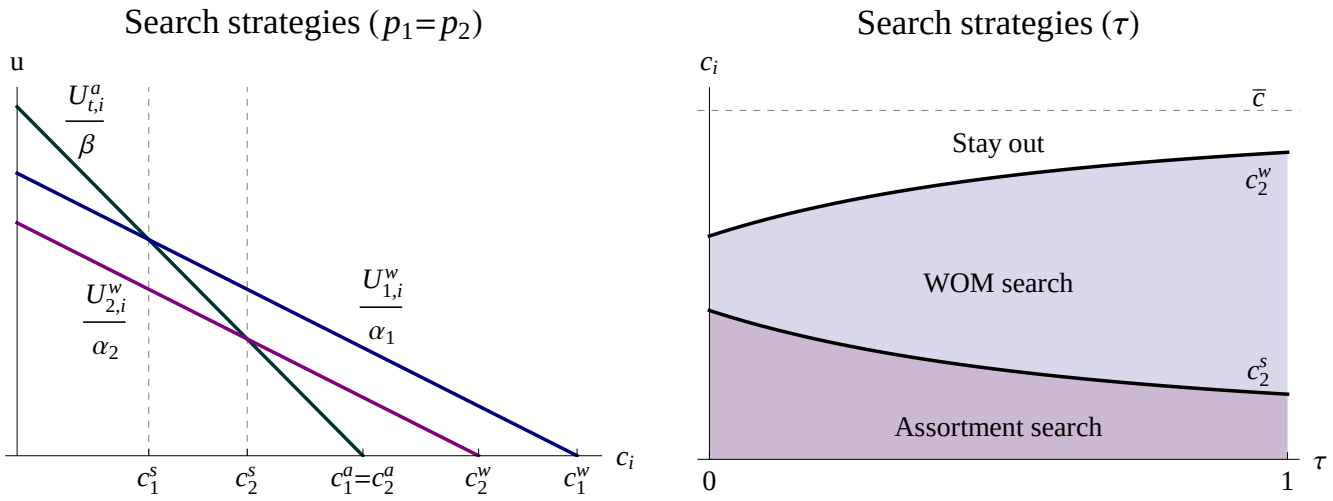

Figure 2: Utility of both search strategies for mainstream and niche consumers as a function of their sampling cost c_i plotted for the case of homogenous prices $p_1 = p_2$ (left) and search strategy choices across the niche consumer population as a function of preference matching τ (right)

Figure 2 illustrates the characterization of consumer search strategy choices. Consumers with low sampling costs prefer to search the assortment, consumers with high sampling costs prefer to search with word of mouth, and those with the highest sampling costs choose to stay out of the market. The sampling cost cutoffs between both search strategies follow from the inherent tradeoffs they present: the probability of a match on each recommendation draw will vary as a function of the consumers' type, but consumers with low sampling costs who suffer less from failed product draws than from failed recommendation draws will benefit more from searching the assortment. Consumers with high sampling costs who suffer comparatively more from failed product draws will instead prefer to search with word of mouth. The sampling cost cutoffs for participation are determined by product prices, which affect the willingness of consumers to participate in the market by engaging in costly search. If prices are sufficiently high, the participation cutoff ensures no consumers search with word of mouth and participating consumers only search the assortment.

Word of mouth reduces search costs in the market and increases consumer participation. Consumers searching with word of mouth would incur higher costs to locate a match if searching the assortment, and some of them would prefer not to participate. The value of word of mouth for consumers depends on recommendation cost w and preference matching τ, which jointly determine the total search costs incurred to locate a match with word of mouth. Reductions in w and improvements in τ increase the share of consumers searching with word of mouth and overall participation in the market.[5]

When both consumer types participate in word of mouth, mainstream consumers with more

[5]Note that recommendations enjoy no salience, as consumers do not place additional value on a match that results from a recommendation. Senecal and Nantel (2004) report a series of experiments that suggest recommendations have an influential effect on consumers beyond awareness. If salient recommendations increase the utility consumers derive from a product match, then salience increases the value of word of mouth for both types.

prevalent preferences in the population benefit more from recommendations than niche consumers and participate comparatively more in the market, other factors equal. This follows from the fact that a larger mass of mainstream consumers is willing to search the assortment, and thus mainstream consumers enjoy a higher rate of successful recommendation draws when searching with word of mouth. The population advantage enjoyed by mainstream consumers increases with preference diversity in the population $m-n$, recommendation cost w, and decreases with improvements in preference matching τ.

The effect is not surprising given that there is a larger mass of mainstream consumers in the market, but the analysis also reveals that niche consumers are over-represented among those searching the assortment precisely because they benefit less from word of mouth. Therefore, although the value of word of mouth tends to be higher for mainstream consumers, their advantage is somewhat mitigated by the stronger incentives of niche consumers to search the assortment. Because the firm also affects the value of word of mouth for both consumer types by setting product prices, the equilibrium preservation of the advantage will depend on the pricing strategy of the firm. This dimension of the problem is analyzed in the next section.

4 Equilibrium prices and search strategies

I turn to the first stage of the game and analyze the pricing strategy of the firm given the search strategies of consumers derived in Proposition 1. Candidate market configurations and optimal prices are derived below, and the characterization of boundary conditions for these to hold in equilibrium is relegated to Appendix B.

Firm pricing. I start by characterizing optimal prices under each candidate market configuration. Consider first the market configuration where both types participate in word of mouth. Firm profits are given by

$$\pi^w = \frac{c_1^w}{\bar{c}} m\, p_1 + \frac{c_2^w}{\bar{c}} n\, p_2. \tag{12}$$

Substituting c_1^w and c_2^w given by (8) into π^w and maximizing with respect to p_1 and p_2 obtains optimal prices,

$$\begin{aligned} p_1^w =& \frac{n\, w\, \tau + m(2u(1+\tau) - w(2+\tau)) - w\, M}{4\, m(1+\tau)} \\ p_2^w =& \frac{m\, w\, \tau + n(2u(1+\tau) - w(2+\tau)) - w\, M}{4\, n(1+\tau)} \end{aligned} \tag{13}$$

where M is given by (9)

Consider next the market configuration where only one type participates in word of mouth. When only mainstream consumers search with word of mouth, firm profits are given by

$$\pi^{wa} = \frac{c_1^{\hat{w}}}{\bar{c}} m\, p_1 + \frac{c_2^{a}}{\bar{c}} n\, p_2. \tag{14}$$

When only niche consumers search with word of mouth, firm profits are given by

$$\pi^{aw} = \frac{c_1^{a}}{\bar{c}} m\, p_1 + \frac{c_2^{\hat{w}}}{\bar{c}} n\, p_2. \tag{15}$$

Optimal prices for the type searching with word of mouth and the type that does not are the same in both market configurations. Denote these prices by $p^{\hat{w}}$ and p^a respectively. Substituting $c_t^{\hat{w}}$ given by (10) for the type that searches with word of mouth and c_t^a given by (11) for the type that does not into either π^{wa} or π^{aw} and maximizing with respect to prices obtains,

$$\begin{aligned} p^{\hat{w}} =& \frac{u-w}{2} \\ p^{a} =& \frac{u}{2}. \end{aligned} \tag{16}$$

The last market configuration is that where there is no word of mouth in the market. Firm profits are given by

$$\pi^{a} = \frac{c_1^{a}}{\bar{c}} m\, p_1 + \frac{c_2^{a}}{\bar{c}} n\, p_2. \tag{17}$$

Substituting c_t^a from (11) into π^a and maximizing with respect to prices reveals that optimal prices coincide with p^a in (16) for both types.

The equilibrium is characterized by identifying the parameter ranges under which each set of optimal prices effectively yields the corresponding market configuration. The derivations are relegated to Appendix B, where τ^*, w^*, w^{**}, and w^{***} are characterized. The following proposition summarizes the result.

Proposition 2. *Equilibrium market configurations and prices are summarized in the following table:*[6]

		Market configuration	*Firm profits*	*Prices*
$\tau \in [0, \tau^*)$	$w \in [0, w^*]$	*WOM holds for both types*	π^w	p_1^w, p_2^w
	$w \in (w^*, w^{***}]$	*WOM holds for type 1 only*	π^{wa}	$p^{\hat{w}}, p^a$
	$w \in (w^{***}, \infty)$	*no WOM*	π^a	p^a, p^a
$\tau \in [\tau^*, 1]$	$w \in [0, w^{**}]$	*WOM holds for both types*	π^w	p_1^w, p_2^w
	$w \in (w^{**}, w^{***}]$	*WOM holds for type 1 only*	π^{wa}	$p^{\hat{w}}, p^a$
	$w \in (w^{***}, \infty)$	*no WOM*	π^a	p^a, p^a

The result explains the impact of word of mouth on product prices and firm profits. Figure 3 plots equilibrium profits and shows that the firm benefits from word of mouth. Figure 4 plots

[6] I use "WOM" as an abbreviation for word of mouth in the following table and figures.

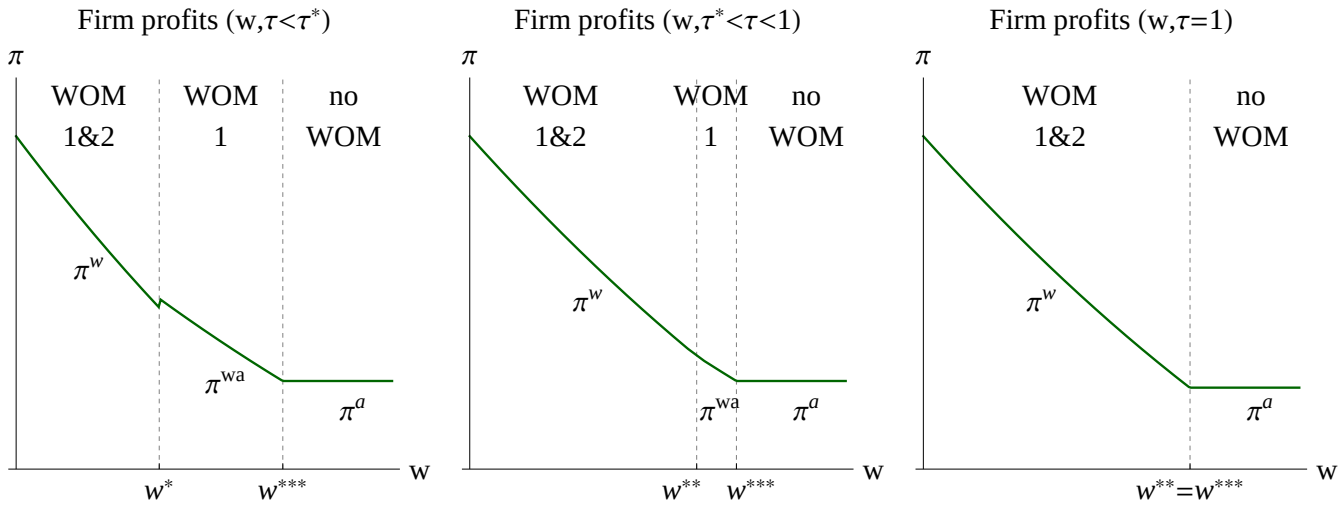

Figure 3: Equilibrium profits as a function of recommendation cost w for three different values of preference matching τ.

equilibrium prices and shows that the firm cuts prices for products that benefit from word of mouth. The intuition for the result stems from the search costs consumers incur to locate a match in the market. Because word of mouth reduces search costs for consumers with high sampling costs, it increases the surplus the firm can appropriate in the lower price range. To see this, note that product prices affect the search strategies of consumers. High prices preclude word of mouth because they reduce the willingness of consumers with high sampling costs to participate in the market. For this reason, whenever the value of word of mouth for consumers is high (low w or high τ), the firm cuts prices to ensure consumers participate in word of mouth. The increase in participation offsets the reduction in the surplus extracted from each individual consumer.

When the value of word of mouth for consumers is high, the firm quotes a higher price for mainstream products than for niche products. Both consumer types participate in word of mouth, but the population advantage enjoyed by mainstream consumers implies that they incur lower search costs than niche consumers, so the firm can extract more surplus from them by quoting higher prices while still ensuring their participation. The price differential between both product pools is a function of the difference in word of mouth value for both consumer types, and increases with preference diversity in the population $m - n$ and recommendation cost w, and decreases with preference matching τ. The result shows that the population advantage enjoyed by mainstream consumers in word of mouth is robust: they derive higher value from word of mouth in equilibrium despite the fact that niche consumers search the assortment comparatively more (thereby increasing the supply of niche product recommendations) and the fact that the firm quotes higher prices for mainstream products.

When the value of word of mouth is low, the firm quotes high prices and word of mouth no longer arises in the market. Only consumers with low sampling costs participate by searching the assortment. For interim parameter ranges, the firm quotes low prices for mainstream products

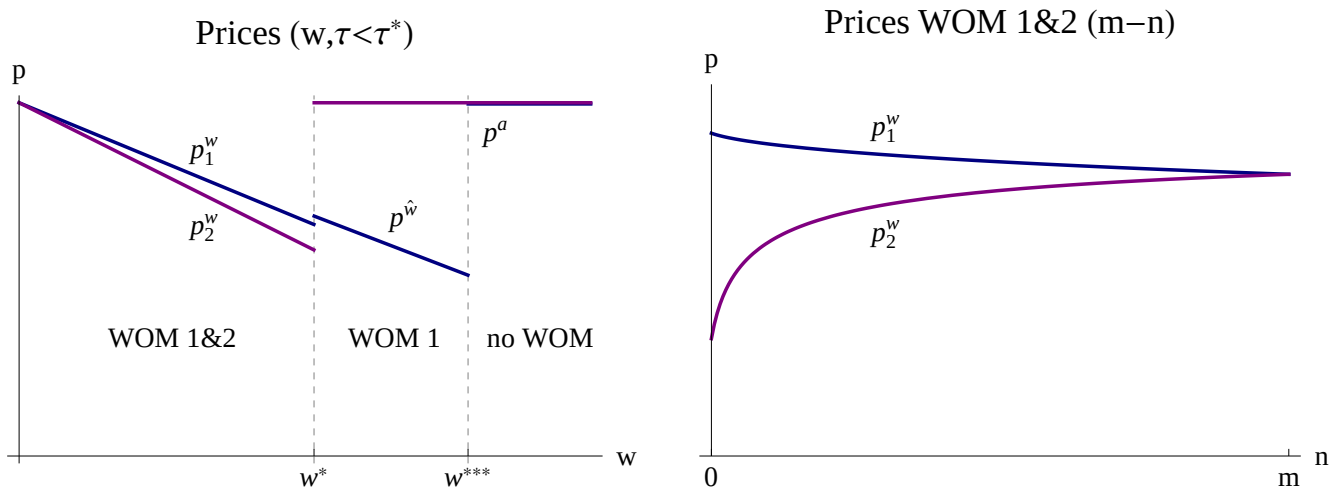

Figure 4: Equilibrium prices of mainstream and niche products as a function of recommendation cost w (left) and as a function of preference diversity in the population when both types participate in word of mouth (right)

and high prices for niche products, such that only mainstream consumers participate in word of mouth. In doing so, the firm strategically precludes the participation of niche consumers in word of mouth. Although this reduces the profits generated from niche consumers, it increases those generated from mainstream consumers because they no longer incur failed recommendation draws from niche consumers. The tradeoff pays off for the firm when the value generated by word of mouth for niche consumers is low, and the pricing shift explains the discontinuity in the firm's profit curve at $w = w^*$ when $\tau < \tau^*$. Note that the opposite case never arises; it is never profitable for the firm to preclude word of mouth participation by mainstream consumers to foster that of niche consumers.

I have analyzed the base scenario where the monopolist quotes separate prices for mainstream and niche products. The pricing strategy of the firm provides a rationale for consumers to willingly supply product recommendations in the market, given that they benefit from lower prices in equilibrium when others of their same type search with word of mouth.[7] If the monopolist commits to a single price scheme for all products, the optimal price is a population-weighted average of the prices characterized above. If the firm can price-discriminate consumers based on their search strategies, it can be shown that higher prices are charged to those searching the assortment than to those searching with word of mouth. The effect analyzed by Kuksov and Xie (2010) of providing lower prices or unexpected frills to early customers in order to profit from later customers is not present, as the surplus of consumers searching the assortment does not affect the value of word of

[7]It should be clear using a continuity argument that the model is robust to the presence of (small enough) communication costs incurred by consumers supplying recommendations. Furthermore, because consumers seeking recommendations incur a sunk cost w on each draw, the model suggests that they are willing to reward those that provide them. See Avery, Resnick and Zeckhauser (1999) for an analysis of reward schemes for the optimal provision of recommendations. A large body of literature has documented several motivations for consumers to contribute to word of mouth processes, see Dellarocas (2006) for a related discussion.

mouth in the market.

The analysis shows that lowering recommendation costs for consumers is profitable for the firm, and this provides incentives for the firm to facilitate the word of mouth exchange. Online retailers such as Amazon have pioneered mechanisms to facilitate consumer word of mouth on their websites, hosting product reviews and product lists contributed by consumers. Chevalier and Mayzlin (2006) analyze the impact of consumer reviews of books on Amazon and Barnes and Noble's websites, and find that reviews increase the relative sales at the retailer they are posted on. Feng and Zhang (2010) find that online consumer reviews of videogames have a stronger impact on niche products. If reviews provide product references that help consumers identify their preferred products in the assortment, their impact is consistent with a reduction of recommendation costs in the model. The findings suggest that part of the market growth spurred by electronic commerce may be attributable to facilitating online word of mouth alone.

The analysis also shows that improving preference matching in the recommendations exchange increases firm profits. The result provides a rationale for the implementation of personalization mechanisms such as recommender systems. Collaborative filtering algorithms underlie most commercial recommenders, identifying preference similarity among consumers in order to select which products to recommend (e.g. 'customers who bought this item also bought...') and guiding consumers to the feedback of others that is most relevant to them.[8] The model predicts that improvements in preference matching τ increase consumer participation and allow the firm to sustain higher prices. De, Hu and Rahman (2010), for instance, analyze the server log data of an online retailer and show that the recommender system increases sales volume.

5 The effect of word of mouth on sales concentration

I next characterize the equilibrium market shares of both product pools. Sales concentration within the assortment is directly measured by the difference between the market shares of both pools. When the difference is large, sales concentration is high because most sales occur within one of the pools, and when the difference is small, sales concentration is low because sales are evenly spread among both. All concentration indices in the literature satisfy this property, including for example the Gini index.

Sales concentration. The equilibrium market share of each product pool is obtained by

[8] Consider a simple instance of such an algorithm. The firm exploits a database containing a set C of consumers, a set N of products, and the ratings that consumers have provided for products. If consumer c_i has not rated product n_k, an expected value for that rating can be calculated by $E[Rating(c_i, n_k)] = \sum_{j \in C} Similarity(c_i, c_j) * Rating(c_j, n_k)$, where the *Similarity* function measures the taste proximity of any two consumers based on the correlation of their past product ratings. The algorithm will recommend to consumer c_i the unrated product which obtains a higher expected rating, thereby matching consumers with similar preferences. See Adomavicius and Tuzhilin (2005) for a taxonomy of recommender systems and an overview of the related computer science literature. For a brief discussion on the economics of recommender systems, see Resnick and Varian (1997). Murthi and Sarkar (2003) review the general implications of personalization technologies in the context of the firm.

dividing the sales volume generated by products pertaining to that pool over total sales volume across the assortment. Consider first the market configuration where both consumer types participate in word of mouth, and denote the market shares of mainstream and niche products in this configuration by MS_1^w and MS_2^w respectively. The sales volume of mainstream products is given by $(c_1^w/\overline{c})m$ and that of niche products by $(c_2^w/\overline{c})n$. Substituting c_1^w and c_2^w given by (8) and prices p_1^w and p_2^w from (13) yields

$$\begin{aligned} MS_1^w =& \frac{m(w(2+\tau) - 2\,u(1+\tau)) + w(M - n\,\tau)}{2(w\,M + (m+n)(w - u(1+\tau)))} \\ MS_2^w =& \frac{n(w(2+\tau) - 2\,u(1+\tau)) + w(M - m\,\tau)}{2(w\,M + (m+n)(w - u(1+\tau)))} \end{aligned} \tag{18}$$

where M is given by (9)

Consider next the market configuration where only mainstream consumers participate in word of mouth, and denote the market shares of both product pools by MS_1^{wa} and MS_2^{wa}. The sales volume of mainstream products is given by $(c_1^{\hat{w}}/\overline{c})m$ and that of niche products by $(c_2^a/\overline{c})n$. Substituting $c_1^{\hat{w}}$ from (10) and c_2^a from (11) and prices $p_1^{\hat{w}}$ and p_2^a from (16) obtains

$$\begin{aligned} MS_1^{wa} =& \frac{2m(u-w)}{(2m+n)u - 2\,m\,w} \\ MS_2^{wa} =& \frac{u\,n}{u\,n + 2\,m(u-w)}. \end{aligned} \tag{19}$$

The last market configuration which arises in equilibrium is that where there is no word of mouth. Denote the market shares of both products pools in this configuration by MS_1^a and MS_2^a. The sales volume of mainstream products is given by $(c_1^a/\overline{c})m$ and that of niche products by $(c_2^a/\overline{c})n$. Substituting c_t^a from (11) and p^a from (16) obtains

$$\begin{aligned} MS_1^a =& \frac{m}{m+n} \\ MS_2^a =& \frac{n}{m+n}. \end{aligned} \tag{20}$$

Inspection of market shares for the parameter ranges where they are well defined in equilibrium delivers the following result.

Proposition 3. *Word of mouth increases the concentration of sales within the assortment whenever there is imperfect preference matching. More precisely, given a fixed degree of preference matching $\tau = \bar{\tau}$:*

(I) $MS_1^{wa} > MS_1^w > MS_1^a$ and $MS_2^{wa} < MS_2^w < MS_2^a$ across all equilibria if $\bar{\tau} < 1$.

(II) $MS_1^{wa} = MS_1^a$ and $MS_2^{wa} = MS_2^a$ across all equilibria if $\bar{\tau} = 1$.

Furthermore, improvements in preference matching and reductions in the cost of obtaining product recommendations decrease the concentration shift induced by word of mouth: MS_1^w is strictly

decreasing in τ and strictly increasing in w (and MS_2^w is strictly increasing in τ and strictly decreasing in w) across all equilibria where both consumer types participate in word of mouth.

Word of mouth increases the market share of mainstream products and reduces that of niche products. To understand the drivers of this shift in market shares, consider how it affects consumer participation in the market. In the absence of word mouth, consumers only search the assortment and participation is homogenous across both types. The market shares of both product pools then coincide with the respective share of consumers of each type in the population. In the presence of word of mouth, however, mainstream consumers participate comparatively more in the market because of the population advantage they enjoy (which holds despite the higher prices of mainstream products in some market configurations). As a result, mainstream products are recommended more often and recommendations are more often sought by mainstream consumers. Word of mouth therefore increases the sales of mainstream products more so than those of niche products, shifting market share from niche products to mainstream products. The magnitude of the shift is largest when only mainstream consumers participate in word of mouth.

The mechanisms predicted by the model that lead to an increase in sales concentration have been identified in the empirical literature. Leskovec, Adamic, and Huberman (2007) analyze a large dataset originating from an online person-to-person recommendation network, and find that recommendations for products which are recommended more often also exhibit a higher success rate. Related findings have been reported for popularity feedback mechanisms that inform consumers of the popularity ranking of products. Salganik, Dodds and Watts (2006) study demand over a set of rare songs offered to test subjects on the Internet, and Tucker and Zhang (2011) analyze the click-through rates of a webpage indexing marriage agencies, and in both cases popularity feedback increases concentration and consumer participation. The findings are reminiscent of the double jeopardy effect discussed by Ehrenberg, Goodhardt and Barwise (1990), where small brands perform comparatively worse than large brands. The model suggests that word of mouth may be an explanatory factor. The model shows that products enjoy increasing returns to appealing to a larger share of the consumer population, and this reinforces their market shares to the point that these overestimate the appeal of best-selling products and underestimate that of lesser performing products.

Figure 5 plots market shares and the market share shift for the case where both consumer types participate in word of mouth. The magnitude of the shift grows with the population advantage of mainstream consumers, which increases with recommendation cost w and decreases with preference matching τ (the impact of population preference diversity $m-n$ is non-monotonic, however, because it also affects market shares in the absence of word of mouth). In the corner case of perfect matching $\tau = 1$, the shift is no longer present because mainstream consumers no longer enjoy an advantage due to their prevalence in the population.

The result shows that reductions in the cost of seeking recommendations and improvements

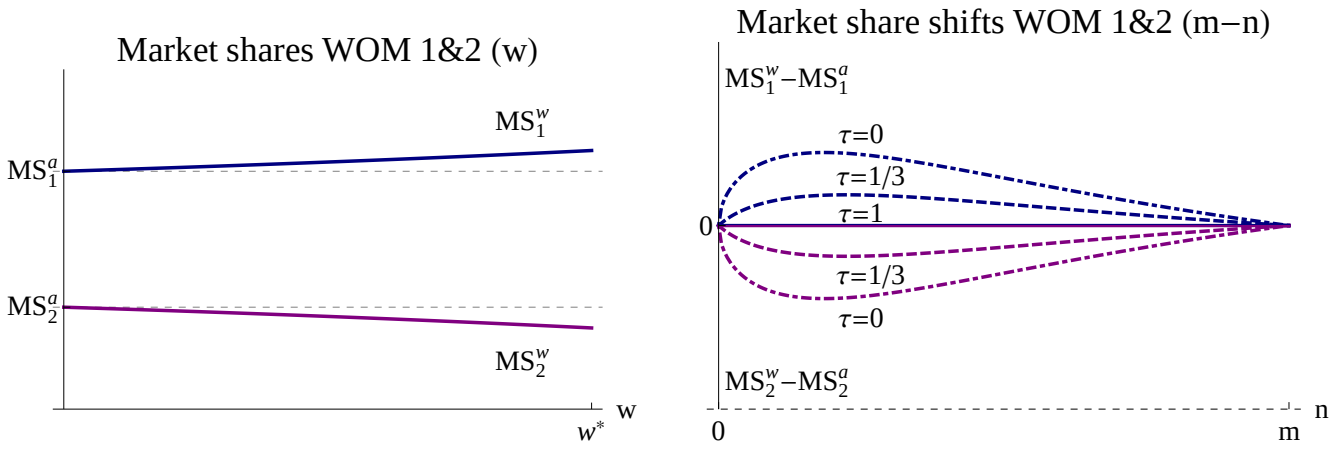

Figure 5: Equilibrium market shares as a function of recommendation cost w (left) and market share shifts as a function of preference diversity in the population for three different values of preference matching τ (right) when both types participate in word of mouth.

in preference matching reduce the concentration of sales. Section 4 shows that these factors also increase firm profits, providing a rationale for the firm to invest in their adoption. The implications are relevant to understand the impact of personalization mechanisms in online retail, and recent empirical work supports these predictions. Brynjolfsson, Hu and Simester (2011) examine online and offline sales concentration for a clothing retailer and find that concentration is lower online, with the server log data showing that it is mainly due to the recommender system. Oestreicher-Singer and Sundararajan (2010) examine sales concentration within book categories on Amazon.com and find that sales concentration is lower among categories with denser co-purchase networks, where personalization is expected to be more accurate. Using similar measures of concentration and co-purchase patterns, Ehrmann and Schmale (2008) report the same findings on Amazon.de.

6 Discussion

The exchange of product recommendations is valuable for consumers in markets characterized by large assortments of horizontally differentiated products such as those for music, cinema, literature, or video game entertainment. The recommendations exchange generally benefits all consumers, but benefits those whose preferences are more widespread in the population the most. This reinforces the sales of products that appeal to those consumers, increasing the concentration of sales within the assortment. The results contribute to explain the prevalence of word of mouth in the markets considered as well as the high concentration of sales they exhibit.

Word of mouth reduces search costs in the market, and this increases the surplus the firm can extract from consumers. The optimal pricing strategy of the firm is to cut prices for products that benefit from word of mouth recommendations, generating a demand expansion effect driven

by consumers who participate by seeking recommendations but would otherwise stay out of the market. The price cut accounts for the cost of word of mouth for consumers. This implies that the firm discounts the price of niche products with narrow appeal more so than those with widespread appeal, because consumers with less prevalent preferences incur higher search costs and benefit less from the exchange of recommendations.

Due to the mechanisms underlying word of mouth interactions, consumers with less prevalent preferences and the products that appeal to them are underserved in the market. The online environment holds the potential to alter this balance, lowering the costs for consumers to engage in word of mouth and allowing them to better match with others who share their preferences in the process. This reduces search costs in the market and enables the firm to sustain higher prices and derive higher profits. There is an opportunity for the firm to actively facilitate word of mouth and implement personalization mechanisms such as recommender systems to automate preference matching.

The changes driven by the online environment benefit consumers with less prevalent preferences the most, reducing the concentration of sales. This drives additional marketing considerations. By increasing the demand for products in the tail of the sales distribution, firms with low inventory costs stand to profit the most. These firms can increase the depth of their assortment beyond that of competitors, ensuring they are well positioned to serve the demand for niche products in the tail. Therefore, online retailers facilitating word of mouth and generating personalized recommendations that help consumers navigate their assortments increase the value of stocking a deeper assortment than brick and mortar competitors. The effect contributes to explain why online retailers have pioneered the provision of personalization mechanisms in the marketplace and invested heavily in their development.

In order to sustain a competitive advantage based on superior personalization, the firm needs to capture a share of the value it generates. This requires completing the transaction after helping consumers identify their preferred products. In the context of recommender systems and electronic commerce, the presence of switching costs and network effects suggests that firms can design strategies to achieve this. Recommender systems exhibit a learning curve to identify the preferences of new customers and benefit from large datasets of consumer activity to improve their accuracy. Firms with a large product assortment and customer base stand to profit the most. Consumers will receive less accurate recommendations when switching purchases across firms and, in general, when patronizing smaller firms. Both factors suggest a firm can benefit from rewarding consumers to join and grow its customer base, exploiting consumer word of mouth to generate a lock-in effect and outperform competitors over time.

Appendix A

Notation reference.

t	Consumer types, where type 1 is mainstream and type 2 is niche
m	Mass of mainstream consumers in the population
n	Mass of niche consumers in the population
u	Utility derived by consumers from a preferred product
c_i	Sampling cost of an individual consumer, where $c_i \sim U[0, \overline{c}]$ across the population
w	Cost of drawing a product recommendation
p_t	Prices of products preferred by consumers of type t
β	Match probability when drawing products from the assortment
α_t	Match probability of consumers of type t when drawing product recommendations
τ	Preference matching probability when drawing product recommendations
s_t^a	Share of consumers who searched the assortment in the second stage of type t
c_t^s	Consumer of type t indifferent between searching the assortment and searching with WOM
c_t^a	Consumer of type t indifferent between searching the assortment and staying out
c_t^w	Consumer of type t indifferent between searching with WOM and staying out
$c_t^{\hat{s}}$	Consumer of type t indifferent between searching the assortment and searching with WOM when only consumers of type t participate in WOM
$c_t^{\hat{w}}$	Consumer of type t indifferent between searching with WOM and staying out when only consumers of type t participate in WOM
π^w	Firm profits in the market configuration where both types participate in WOM
π^{wa}	Firm profits in the market configuration where only consumers of type 1 participate in WOM
π^{aw}	Firm profits in the market configuration where only consumers of type 2 participate in WOM
π^a	Firm profits in the market configuration where there is no WOM
p_t^w	Equilibrium prices of products preferred by consumers of type t in the market configuration where both types participate in WOM
$p^{\hat{w}}$	Equilibrium prices of products preferred by the consumer type that participates in WOM when the other type does not participate
p^a	Equilibrium prices of products preferred by consumer types that do not participate in WOM
MS_t^w	Equilibrium market share of products in pool t when both types participate in WOM
MS_t^{wa}	Equilibrium market share of products in pool t when only consumers of type 1 participate in WOM
MS_t^a	Equilibrium market share of products in pool t when there is no WOM

Appendix B

Equilibrium corner conditions. I solve for the equilibrium of the game building on the characterization of market configurations and optimal prices derived in Section 4. I proceed by identifying the parameter ranges under which each set of optimal prices effectively yields the corresponding market configuration. I start by deriving the boundaries on w implied by consumer search strategies. Consider first the market configuration where both types participate in word of mouth. This requires that $c_t^s < c_t^w$ for both types. Equating $c_t^s = c_t^w$ for each type and solving for w yields

$$\dot{w}_1^w = \frac{m(u-p_1)(1+\tau)}{m(2+\tau) - n\,\tau + M}$$
$$\dot{w}_2^w = \frac{n(u-p_2)(1+\tau)}{n(2+\tau) - m\,\tau + M}$$

where M in the above expressions and those following below is given by (9)

Consider next the market configuration where only one type participates in word of mouth. This requires $c_t^{\hat{s}} < c_t^{\hat{w}}$ for the type that searches with word of mouth and $c_t^s \geq c_t^w$ for the type that does not. The latter is given by the intersections characterized above. For the type searching with word of mouth, equating $c_t^{\hat{s}} = c_t^{\hat{w}}$ and solving for w yields

$$\dot{w}_t^{\hat{w}} = \frac{u - p_t}{2}.$$

Optimal prices for each market configuration only induce an equilibrium for the range of w where they satisfy the boundary conditions for that market configuration to arise. I next derive the boundaries on w implied by optimal prices. Consider first the candidate equilibrium where both types participate in word of mouth. Substituting p_1^w from (13) in $\dot{w}_1^w$ and p_2^w from (13) in $\dot{w}_2^w$ provides two separate upper boundaries on w,

$$\overline{w}_1^w = \frac{2\,m\,u(1+\tau)}{3(m(2+\tau) - n\,\tau + M)}$$
$$\overline{w}_2^w = \frac{2\,n\,u(1+\tau)}{3(n(2+\tau) - m\,\tau + M)}.$$

Note that $\overline{w}_2^w < \overline{w}_1^w$, so the effective upper boundary is given by $\overline{w}_2^w$.

Consider next the candidate equilibrium where only mainstream consumers participate in word of mouth. Substituting $p^{\hat{w}}$ from (16) in $\dot{w}_t^{\hat{w}}$ and p^a from (16) in $\dot{w}_2^w$ provides, respectively, an upper and lower boundary on w,

$$\overline{w}_1^{wa} = \frac{u}{3}$$
$$\underline{w}_2^{wa} = \frac{n\,u(1+\tau)}{2(n(2+\tau) - m\,\tau + M)}. \qquad (w^*)$$

For the candidate equilibrium where word of mouth holds only for niche consumers, substituting $p^{\hat{w}}$ from (16) in $\dot{w}_t^{\hat{w}}$ and p^a from (16) in $\dot{w}_1^w$ provides, respectively, an upper and lower boundary on w,

$$\begin{aligned}\overline{w}_2^{aw} =& \frac{u}{3} \\ \underline{w}_1^{aw} =& \frac{m\,u(1+\tau)}{2(m(2+\tau)-n\,\tau+M)}.\end{aligned}$$

The last candidate equilibrium is that where there is no word of mouth in the market. Substituting p^a from (16) in both $\dot{w}_1^{\hat{w}}$ and $\dot{w}_2^{\hat{w}}$ provides a unique lower boundary on w,

$$\underline{w}^a = \frac{u}{4}.$$

I next compare firm profits in the different market configurations over the parameter ranges where they are well defined. There are four market configurations, where π^w is well defined for $w \in [0, \overline{w}_2^w]$, π^{wa} is well defined for $w \in [\underline{w}_2^{wa}, \overline{w}_1^{wa}]$, π^{aw} is well defined for $w \in [\underline{w}_1^{aw}, \overline{w}_2^{aw}]$, and π^a is well defined for $w \in [\underline{w}^a, \infty)$. When two market configurations are simultaneously valid for a given parameter range (for different sets of optimal prices) the firm will choose the solution that yields higher profits.

First, I establish that market configuration π^{aw} cannot constitute an equilibrium because it is dominated by other market configurations. Inspection reveals that $\pi^{wa} > \pi^{aw}$ for $w \in [0, u - u/\sqrt{2})$ and $\pi^a > \pi^{aw}$ for $w \in (u - u/\sqrt{2}, u]$, with equality $\pi^{wa} = \pi^{aw} = \pi^a$ at $w = u - u/\sqrt{2}$. Therefore, π^{aw} is never profit-maximizing for the firm and does not arise in equilibrium.

Next, note that both π^w and π^{wa} are strictly decreasing in w (over the range where they are well defined) and π^a does not depend on w. Evaluating the three profit curves at $w = 0$ reveals that $\pi^w(w=0) > \pi^{wa}(w=0) > \pi^a$. So given that market configuration π^w only requires an upper boundary on w, it must constitute an equilibrium for the lower range of w .

Consider the intersection between π^w and π^{wa}. Equating $\pi^w = \pi^{wa}$ and solving for w yields a unique positive solution for $w \in [0, \overline{w}_2^w]$:

$$\begin{aligned}w^{w\cap wa} =& m\,n^2\,u^2(1+\tau)^2/(2\,m\,n\,u(1+\tau)(n-m\,\tau+M) + [(m\,n^2\,u^2(1+\tau)^2(7\,m^3\,\tau^2 + \\ & n^2\,\tau(M-n\,\tau) + m\,n(5\,n\,\tau^2 - (\tau-2)2\,M) - m^2(7\,\tau\,M + n(\tau(4+5\tau)-14))))]^{\frac{1}{2}})\end{aligned} \qquad (w^{**})$$

Note that $w^{w\cap wa}$ is increasing in τ. Equating $\pi^w = \pi^{wa}$, substituting $w = \underline{w}_2^{wa}$, and solving for τ yields a unique solution in the range $\tau \in [0,1]$:

$$\tau^* = \frac{7\,m^2(5\,m-4\,n) - \sqrt{m(11m-n)(3\,m\,n+2n^2-7m^2)^2}}{14m^3 - 17m^2n + 3\,m\,n^2 + n^3}, \qquad (\tau^*)$$

so $w^{w\cap wa} \in [\underline{w}_2^{wa}, \overline{w}_1^{wa}]$ only when $\tau \in [\tau^*, 1]$. Therefore, when $\tau \geq \tau^*$ the intersection between both

profit curves pertains to the range where they are both well defined. When $\tau < \tau^*$ the intersection between both profit curves is below the range where π^{wa} is well defined, so it must be the case that $\pi^w < \pi^{wa}$ at $w = \underline{w}_2^{wa}$.

Consider next the intersection between π^{wa} and π^a. Equating $\pi^{wa} = \pi^a$ and solving for w yields a unique positive solution for $w \in [\underline{w}^a, \overline{w}_1^{wa}]$:

$$w^{wa \cap a} = u - \frac{u}{\sqrt{2}}. \qquad (w^{***})$$

Note that $\underline{w}_2^{wa} < w^{wa \cap a}$. Also, $w^{w \cap wa} < w^{wa \cap a}$ if $\tau < 1$ and $w^{w \cap wa} = w^{wa \cap a}$ for the case $\tau = 1$.

I can now characterize the equilibrium as a function of τ and w. If taste matching is low $\tau \in [0, \tau^*)$ then word of mouth for both types π^w holds in the range $w \in [0, \underline{w}_2^{wa}]$, word of mouth for mainstream consumers only π^{wa} holds in the range $w \in (\underline{w}_2^{wa}, w^{wa \cap a}]$ with the firm's profit function exhibiting a discontinuity at $\underline{w}_2^{wa}$, and no word of mouth π^a holds for $w > w^{wa \cap a}$. If taste matching is high $\tau \in [\tau^*, 1]$ then word of mouth for both types π^w holds in the range $w \in [0, w^{w \cap wa}]$, word of mouth for mainstream consumers only π^{wa} holds in the range $w \in (w^{w \cap wa}, w^{w \cap a}]$, and no word of mouth π^a holds for $w > w^{wa \cap a}$.

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