Strategic Product Variety Choice: Theory and Empirical Evidence*

Ulrich Kaiser** Markus Reisinger***

March 18, 2017

Preliminary Version

Abstract

We investigate theoretically and empirically how firms choose their product variety in response to changes in the market environment. We consider a model in which firms decide on the optimal number of products and on the optimal investment in quality. The interplay between these two choices yields to novel predictions on how market conditions shape a firm's product variety. We find that higher revenue per consumer leads to a reduced number of products, whereas an increase in the number of competitors or a larger share of loyal consumers induces firms to expand their product variety. Using data from the German magazine industry, we find supportive evidence for these predictions.

Keywords: Product Variety, Quality Investment, Consumer Loyalty, Consumer heterogeneity, Price Competition, Magazine Industry

*We thank Simon Anderson, Greg Crawford, Christian Peukert, Yossi Spiegel, Julian Wright and participants at the Media Economics Workshop in Zurich for very helpful comments and discussions.

**University of Zurich; ulrich.kaiser@business.uzh.ch; Copenhagen Business School; Centre for European Economic Research; IZA Institute of Labor Economics.

***Frankfurt School of Finance & Management; m.reisinger@fs.de.

1 Introduction

The optimal choice of product variety constitutes one of the core problems managers need to solve. In most industries, firms offer multiple products, and they do so even within the same segment. For example, in the magazine industry, publishers sell multiple titles within and across segment, thereby catering to different reader preferences; car manufacturers offer many different variants of their car models and are increasingly active in many different segments; in the beer industry, large breweries sell many different brands with different tastes—a tendency that has increased during the merger wave of the last decade.

The management and economics literature has identified many reasons for why firms engage in producing a variety of goods. Lancaster (1990), in his survey article, pointed out that from a demand side perspective, a firm's choice of product variety is mainly driven by two factors: the potential to increase demand by offering more variety and the use of product variety for strategic purposes, such as entry deterrence. On the production side, the existence of economies of scope is among the main drivers to offer multiple products. Several studies have analyzed the profitability of product variety along these lines, both theoretically and empirically. For example, Kekre and Srinivasan (1990) provide empirical evidence that matching products to heterogeneous consumer needs by expanding the product variety outweights the associated costs. Draganska and Jain (2005) in an econometric model demonstrate the limits of profitable product line extensions. On the theoretical side, Judd (1985) analyzes under which conditions an incumbent can preempt entry by strategically investing into new products. The effects and profitability of this proliferation strategy has been investigated by many subsequent studies, both theoretical (e.g., Gilbert and Matutes, 1993; Shaked and Sutton, 1990) and empirical (Berry, 1992). Lieberman and Montgomery (1988) provide a survey of the earlier literature.

The existing literature focuses on investments in product variety alone, leaving aside other strategic decisions of the firm. However, since consumers usually buy products repeatedly, firms can mainly gain market shares by attracting consumers who are willing to switch from a rival company. Going back to the magazine or beer example we started with: consumers repeatedly decide which product to buy, often weekly or monthly, with some consumers sticking to their previous choice while others switch to a substitute. If most consumers are satisfied with the quality of their previous purchase (e.g., because quality is high), only few consumers will switch, which affects the profitability of a firm's product variety choice. This suggests that there is a strong interplay between investment in quality and product line breadth.

In this paper, we provide a model that takes the relation between these two decisions into account and demonstrate how they affect each other. We show that this gives rise to novel predictions about how product variety choice is influenced by the profitability of a market segment, competition from other producers, consumer differentiation, and consumer loyalty. We test our predictions using data from the German magazine industry and find supportive evidence for the hypotheses we derive from our model.

Specifically, we build a model of oligopolistic competition between firms with multiple products. Firms make three sequential decisions. The first is to choose the number of products to offer. Second, they invest in the quality of their products. Finally, firms compete in prices. Offering a broader product variety and higher quality is costly but generates a higher demand. On the demand side, there are multiple types of consumers. Loyal consumers stick to their previous product choice. They are therefore not influenced by any of the three competition variables we consider: competition from other producers, consumer differentiation and consumer loyalty. By contrast, non-loyal consumers are willing to switch if they are dissatisfied with the quality of their previous purchase. Hence, among the non-loyal consumers, those who are satisfied will repeat the previous choice, whereas those who are not satisfied will buy a different product. Among these consumers, a fraction only cares about the price of the products and buys the cheapest one whereas the remaining fraction chooses the product that matches its preference best (provided that the price is not too high). This captures the degree of differentiation between consumers. If consumers are relatively homogeneous, products are alike and price competition are the main driver of consumers' choices. By contrast, if consumer preferences are heterogeneous, price competition plays less of a role which also reflects the idea that consumers like to experiment and to try out new goods, e.g. if they are attracted by an appealing magazine cover page at the newsstand.

We first demonstrate that the decisions to invest in quality and to increase product variety are substitutes. If firms offer products of higher quality, more consumers are satisfied with this previously purchased product, which induces less of them to switch to a new one. However, the benefit of offering a broad product variety is to better match the heterogeneous tastes of consumers to attract new ones. If there are fewer switching consumers, investments in product variety extensions are less profitable.

We subsequently show how this trade-off between quality and product variety investment is shaped by important parameters of the competitive environment. We start with the value of a market and demonstrate that the revenue per consumer has a non-monotonic effect on the equilibrium number of products. If revenues are low, optimal product variety increases with a rise in revenue per consumer but falls if revenues are high. While the former effect has the expected direction, the latter one is more surprising. The related intuition is rooted in the substitutional relation between quality and product variety: if consumers are particularly valuable, firms find it optimal to keep many of their buyers by providing high quality. This leads to few switching consumers, implying that firms optimally provide a narrow product variety.

The result therefore gives rise to the prediction that the number of products is smaller the higher revenue per consumer is. This result runs counter to the predictions of standard models with multi-product competition which predict that a larger number of products is more profitable if revenues from consumers are larger. However, our model provides a clear intuition for the reverse prediction based on the trade-off between quality and product variety. Our prediction thus stems from purely strategic considerations and does not rely on technological factors.

We also show that the negative effect of increased revenue per consumer on optimal product variety is larger if consumers are less heterogeneous. With increased consumer homogeneity, price competition for switching consumers is fiercer, resulting in lower profits from these consumers. A consequence of this is that firms have a higher incentive to retain their previous consumers which leads them to increase their investment in quality. Consequently, the equilibrium number of products is lower.

Second, we investigate how the number of firms affects optimal product variety and find a curvilinear relationship: the number of products falls with the number of competitors if the revenue per consumer is low but increases if it is high. As above, the first result is not surprising: if there are more competitors, each firm can gain only few switching consumers by expanding its product variety, which leads to fewer product offerings per firm. The second result again is more interesting. Its intuition is again rooted in the trade-off between investment in quality and investment in variety: with many competing firms in the market, the market share of each firm is small. A firm can then induce only few consumers to rebuy by providing a high-quality product. This dissuades firms from investing in quality, thereby leaving several customers unsatisfied and willing to switch. This in turn renders a larger product variety particularly valuable to attract consumers, explaining the positive relationship between the number of competitors and the number of products in equilibrium.

Third, we analyze the relationship between consumer loyalty and product variety, finding a concave relationship, where optimal product variety increases with loyalty for low levels of loyalty and falls for high levels of loyalty. Intuitively, a larger number of loyal consumers implies fewer switching consumers, which has a direct negative effect on the optimal number of products. However, a countervailing effect arises because more loyal consumers also implies that quality investment is less profitable. This implies that the share of switching consumers is larger among the non-loyal consumers, which leads to an increase in equilibrium product variety. We show that this indirect effect dominates the direct one if the number of loyal consumers is relatively small.

We test these predictions using data from the German magazine industry, one of the largest magazine markets of the world. In this industry, fixed publishing costs are usually relatively high, which implies that market segments with a low revenue per readers are not served. We therefore expect our results to apply for the case with high per-reader revenue. This implies that our predictions are that optimal product variety decreases in revenue per reader and increases in the number of competitors in the market. We find strong empirical support for these hypotheses. Interestingly, both of our findings are contradictory to conventional wisdom, thereby providing evidence that our novel effects are relevant in this market. We also find support for the concave effect of loyalty on product variety.

Our paper is connected with both the theoretical and the empirical literature on product variety choices. The theoretical literature on product variety focuses either on strategic effects of changing the number of products or on product line rivalry. Schmalensee (1978) demonstrates how an incumbent firm can strategically introduce new products to engage in proliferation and deter entry. Judd (1985) shows that this strategy is not necessarily credible if a firm can withdraw products later on and determines circumstances for when it is profitable. This idea has been generalized (e.g., Shaked and Sutton, 1990) and applied to other market environments (e.g., Gilbert and Matutes, 1993), to elicit under which conditions proliferation constitutes a successful entry deterrence strategy. Berry (1992) empirically tests the effects identified in this literature using airline industry data.

Papers focusing on product line rivalry usually distinguish between horizontal and vertical differentiation. For example, Brander and Eaton (1984) consider horizontal product differentiation and determine which equilibria arise if firms can offer two products each, with some being more substitutive than other to one another. Champsaur and Rochet (1989) analyze vertical product differentiation and find that firms will never choose overlapping product lines. Johnson and Myatt (2003) develop a model of quality-differentiated products (i.e., consider vertical differentiation) and determine how product lines change with entry of competitors. None of these papers considers the interplay between firms' decisions to retain previous consumers and product variety, which is the heart of our paper.

On the empirical side, several studies scrutinized the profitability to invest in a product variety, trading-off the benefits of gaining market share with the investment costs. Kekre and Srinivasan (1990) used a large sample of manufacturing firms and find that the benefits are higher than the costs. Putsis and Bayus (2011) analyze data from the personal computer industry to study how firms of different size respond to changes in the market environment. They demonstrate that large product lines are used as entry barriers. Berger et al. (2007) use seven laboratory experiments to determine precisely why multi-product firms obtain larger demand and find that consumers perceive these firms to have better expertise or core competency. By contrast, our study analyzes how the market environment shapes the number of products in an industry, testing the predictions derived from the theoretical model.

The rest of the paper is organized as follows. Section 2 provides the model. Section 3 solves for the equilibrium and presents the results. Section 4 states the hypothesis predicted by the model. Section 5 describes the data and Section 6 provides the empirical results. Finally, Section 7 concludes.

2 The Model

There is a mass 1 of homogeneous consumers. The valuation of a consumer for a firm's product is denoted by v. There are M firms in the market, denoted by $i = 1, ..., M$.

Firms compete for consumers in several dimensions: they choose the number of products to offer, determine the quality of the products and compete in prices. These choices are made in a sequential order. First, firms simultaneously choose the number of products to offer. We denote the number of products of firm i by m_i. For simplicity we treat m_i as a continuous variable. One can think of this as a mass of products. There are fixed costs f of offering a product. Therefore, the aggregate fixed costs of the products of firm i are fm_i, implying that an increased product variety leads to higher costs. After the number of products of each firm is determined, firms (simultaneously) invest in the quality of their products. We denote the quality chosen by each firm by q_i. Quality investment is costly, and the cost function is cq_i^2. To simplify the exposition, a firm's quality applies to all its products, that is, each product is of quality q_i and the cost function is an overall cost function but not a per-product cost function. This reflects the general idea that an investment in quality can be used for many different products because the different variants share a common element. For example, discovering stories, making interviews or pictures can be used for various magazines in the same segment and not just one. In fact, this is often done in the magazine industry, where similar stories appear in several magazines of the same publisher.[1] Finally, after product variety and quality choices have been made, firms simultaneously set the prices for their products. To keep the model as simple as possible, we assume that firms set the same prices for their products. As will become evident below, all our results are unchanged if we allow firms to set different prices for different products. Hence, this assumption just simplifies the analysis.

The timing of the choices captures the idea that prices can be changed very quickly,

[1] Including an investment in the quality of each product would also not affect the qualitative predictions of our model.

whereas the quality adjustment require longer time spans. This is even more so for product variety choice as a long-term decision.

At the outset, each product is bought by the same mass of consumers. This implies that firms are symmetric and each has an overall consumer mass of $1/M$. There are two types of consumers, loyal with mass α and non-loyal with mass $1-\alpha$. Loyal consumers will stick to their choice of the previous period independent of the quality level chosen by the firm (as long as the product's price does not exceed v). By contrast, the non-loyal consumers potentially buy a different product than in the previous period. Firms can influence a non-loyal consumer's choice by investing in quality. In particular, if a consumer is satisfied with her product she will buy it again. The probability that the consumer is satisfied is directly linked to quality investment. To express this in a simple form, suppose that a consumer who was a previously buying a product of firm i sticks to her product choice with probability q_i and does not re-buy with probability $1-q_i$.

If a consumer decides to switch, her product choice depends either on the prices chosen by the firms or on her preference, that is, which product she is attracted to. Specifically, among the switchers, there is a fraction β of consumers who will buy the cheapest product. That is, the consumer buys a product from firm i if the price of this product, denoted by p_i, is lower than the price of all other products. The remaining fraction $1-\beta$ of consumers decides which product best fits their preferences and do not care about the price (given that the price of the product they prefer is weakly below v). Since firms do not know the preferences of consumers ex ante, the probability with which a switching consumer will buy the product of firm i is $m_i/\sum_{i=1}^{M} m_i$. The idea here is that a consumer's preferences may change from one period to the next and that she spontaneously choose to buy a product she is attracted to as long as it is not overly expensive. For example, in the magazine industry, several readers decide spontaneously at the news stand which magazine to buy. Parameter β can therefore be interpreted as representing product differentiation in an industry. If β is close to zero, all products are very similar to one another (consumers have a very uniform taste), implying that most consumers decide in favor of the cheapest product. By contrast, β close to 1 implies that price plays only a minor role in product choice since firms offer a large product variety and most consumers are attracted by a particular one and decide in favor of it.

In summary, the model captures in a simple way three important dimensions by which firms compete to attract consumers. First, firm can provide high quality which allows them to keep many of their previous consumers because these are satisfied with the product. In this respect, quality can also be interpreted as customer relationship management. Second, firms can offer a high variety of products to attract many switching consumers because these a product out of this variety s is likely to match the preference of a switcher. Third, firms can set low prices to attract those consumers who are price sensitive.

As a consequence, there are several different sources of demand for a firm. The first is loyal consumers, those who previously bought from the firm. Since there is a fraction α of these consumers and firms have a symmetric number of consumers in the previous period, the loyal consumers of firm i have a mass α/M. Second, among the non-loyal consumers a fraction q_i re-buys the product of firm i because they are satisfied, implying that these consumers have a mass of $(1-\alpha)q_i/M$. Third, among the non-loyal consumers who switch because they are not satisfied, firm i attracts a fraction of $1-\beta$ because a product of the firm matches their preference best. These consumers have a mass of

$$\sum_{j=1}^{M} \frac{(1-\alpha)(1-\beta)(1-q_j)m_i}{\sum\limits_{j=1}^{M} m_j}.$$

Finally, firm i attracts the fraction β of switching consumers if it charges the lowest price.

The model therefore captures the dynamic incentives of firms to increase quality and product variety to attract new consumers in a simple way. However, increasing these demand parameters is costly to firms.

Finally, to guarantee interior solutions and qualities that do not exceed 1, we need to assume that investment in quality is sufficiently costly. Specifically, we assume that $c > (v(1-\alpha)(2M^2 - 3(1-\beta)(M-1))/(4M^3)$ for $M \leq 3$ and $c > (v(1-\alpha)(M-1+\beta))/(2M^2)$ for $M \geq 3$.[2] In other words, the quality cost function is sufficiently convex.

3 Analysis and Results

Analysis

Given the assumption above, the profit function of publisher i can be written as

$$\frac{\alpha p_i}{M} + \frac{(1-\alpha)q_i p_i}{M} + \text{Prob}\left(p_i < \hat{p}_{-i}\right)\left[\sum_{j=1}^{M}\left(\frac{(1-\alpha)\beta(1-q_j)p_i}{M}\right)\right] \tag{1}$$

$$+\text{Prob}\left(p_i \leq \hat{p}_{-i},\, p_i = p_{-i}\,\text{for}\,k\,\text{firms}\right)\left[\sum_{j=1}^{M}\left(\frac{(1-\alpha)\beta(1-q_j)p_i}{kM}\right)\right]$$

$$+\sum_{j=1}^{M}\left(\frac{(1-\alpha)(1-\beta)(1-q_j)p_i}{M}\right)\left(\frac{m_i}{m_i + \sum_{j=1,\, j\neq i}^{M} m_j}\right) - cq_i^2 - fm_i,$$

[2]The two expression are the same for $M = 3$.

with $\hat{p}_{-i} = \min\{p_1, \cdots, p_{i-1}, p_{i+1}, \cdots, p_M\}$. The first two terms are the revenues from loyal and satisfied non-loyal consumers. The third term is the revenue from price-sensitive switchers in case firm i demands the strictly lowest price for its products. The fourth term is the profit from price-sensitive switchers in the case of several firms (including firm i) charging the lowest price. The fifth term is the profit from switchers who are not price sensitive. Finally, the sixth and seventh term are the costs for quality investment and product variety, respectively.

We solve the game by backward induction. In the last stage, each firm sets the price for its products. It is evident that the reaction function of each firm is discontinuous here as it receives demand from the price-sensitive switching consumers only if it charges the lowest price. However, even if the firms sets the highest possible price to receive some demand, which is v, it obtains some demand, which comes from the loyal consumers and the switchers who found one of firm i's product most attractive. Therefore, the third stage of the game is similar to games of price competition with informed and uninformed consumers, such as Rosenthal (1980), Varian (1980), Narasimhan (1988), or Simester (1997). As these papers show, there is no pure-strategy equilibrium with this demand structure. Instead, there is only a mixed-strategy equilibrium in prices, in which prices are drawn from a continuous distribution without mass points. We now briefly characterize the prices in this mixed-strategy equilibrium and determine the expected profits.

Denote the equilibrium cumulative distribution function of firm i in this mixed-strategy equilibrium by $G_i(p|\mathbf{q}, \mathbf{m})$, where $\mathbf{q} = \{q_1, ..., q_M\}$ and $\mathbf{m} = \{m_1, ..., m_M\}$ are the vectors of the second and first-stage choices, respectively. Then, firm i sets the lowest price with probability

$$(1 - G_1(p|\mathbf{q}, \mathbf{m})) \times \cdots \times (1 - G_{i-1}(p|\mathbf{q}, \mathbf{m})) \times (1 - G_{i+1}(p|\mathbf{q}, \mathbf{m})) \times \cdots \times (1 - G_M(p|\mathbf{q}, \mathbf{m})),$$

that is, all other $M-1$ firms charge a higher price than firm i. With the counter probability the firm does not set the lowest price and does not obtain demand from the price-sensitive switching consumers.[3] The highest price in the mixing range is v. By choosing this price the firm receives the highest profits from the non-price-sensitive consumers but will never receive demand from the price-sensitive ones. Firm i's profit is therefore given by

$$\Pi(v|\mathbf{q}, \mathbf{m}) \equiv \frac{\alpha + (1-\alpha) q_i v}{M} + \sum_{j=1}^{M} \left(\frac{(1-\alpha)(1-\beta)(1-q_j)v}{M} \right) \left(\frac{m_i}{m_i + \sum_{j=1, j \neq i}^{M} m_j} \right) - c q_i^2 - f m_i. \tag{2}$$

[3]Because the distribution function contains no mass points, we can ignore the probability of a tie in prices.

When charging the lowest price in the mixing range, firm i receives demand from the price-sensitive consumers with certainty. Since all prices charged with positive probability must lead to the same profit, the lowest price denoted by $\underline{p}$ is defined by

$$\frac{\alpha+(1-\alpha)q_i\underline{p}}{M}+\left[\sum_{j=1}^{M}\left(\frac{(1-\alpha)\beta(1-q_j)\underline{p}}{M}\right)\right] \tag{3}$$

$$+\sum_{j=1}^{M}\left(\frac{(1-\alpha)(1-\beta)(1-q_j)\underline{p}}{M}\right)\left(\frac{m_i}{m_i+\sum_{j=1,\,j\neq i}^{M}m_j}\right)-cq_i^2-fm_i=\Pi(v|\mathbf{q},\mathbf{m})$$

The profit function of firm i can therefore be rewritten as

$$\int_{\underline{p}}^{v}\Big\{\frac{\alpha+(1-\alpha)q_ip}{M}+\sum_{j=1}^{M}\left(\frac{(1-\alpha)(1-\beta)(1-q_j)p}{M}\right)\left(\frac{m_i}{m_i+\sum_{j=1,\,j\neq i}^{M}m_j}\right) \tag{4}$$

$$+(1-G_1(p|\mathbf{q},\mathbf{m}))\times\cdots\times(1-G_{i-1}(p|\mathbf{q},\mathbf{m}))\times(1-G_{i+1}(p|\mathbf{q},\mathbf{m}))\times\cdots\times(1-G_M(p|\mathbf{q},\mathbf{m}))$$

$$\times\left[\sum_{j=1}^{M}\left(\frac{(1-\alpha)\beta(1-q_j)p}{M}\right)\right]-cq_i^2-fm_i\Big\}dG(p)dp.$$

Again using the fact that all prices in the mixing domain must lead to the same profit, in equilibrium the term in curly parentheses must be equal to $\Pi(v|\mathbf{q},\mathbf{m})$, which yields

$$(1-G_1(p|\mathbf{q},\mathbf{m}))\times\cdots\times(1-G_{i-1}(p|\mathbf{q},\mathbf{m}))\times(1-G_{i+1}(p|\mathbf{q},\mathbf{m}))\times\cdots\times(1-G_M(p|\mathbf{q},\mathbf{m}))$$

$$=\frac{\frac{\alpha+(1-\alpha)q_i(v-p)}{M}+\sum_{j=1}^{M}\left(\frac{(1-\alpha)(1-\beta)(1-q_j)(v-p)}{M}\right)\left(\frac{m_i}{m_i+\sum_{j=1,\,j\neq i}^{M}m_j}\right)}{\sum_{j=1}^{M}\left(\frac{(1-\alpha)\beta(1-q_j)p}{M}\right)},\quad i=1,...,M. \tag{5}$$

Since this holds for all firms $i=1,...,M$, we have M equations to solve for the cumulative distribution functions. Therefore, the equilibrium in the third stage is given by prices chosen in the mixing domain from $\underline{p}$ to v, where $\underline{p}$ is defined in Equation (3) and the cumulative distribution functions implicitly given by Equation (5). The expected profit is $\Pi(v|\mathbf{q},\mathbf{m})$ defined in Equation (2).

We note that if firms could charge different prices for their products, they needed to take into account how a change in one of their products affected the sales of other products. This happens for example if a firm charges the lowest and the second-lowest price for two of its products. This additional complication changes the shape of the distribution function. However, the expected profit of firm i is still $\Pi(v)$ since it could charge just a price of v

for all of its products. Hence, the subsequent analysis on quality and product variety will remain unchanged.

We can now turn to the second stage. From solving stage 3, we know that expected profit are given by

$$\frac{\alpha + (1-\alpha)q_i v}{M} + \sum_{j=1}^{M} \left(\frac{(1-\alpha)(1-\beta)(1-q_j)v}{M} \right) \left(\frac{m_i}{m_i + \sum_{j=1,\, j\neq i}^{M} m_j} \right) - cq_i^2 - fm_i.$$

Maximizing this with respect to e_i yields[4]

$$e_i = \frac{(1-\alpha)v\left(\beta m_i + \sum_{j=1,\, j\neq i}^{M} m_i\right)}{2cM\left(\sum_{j=1}^{M} m_i\right)}, \quad i = 1, ..., M. \tag{6}$$

It is easy to deduce that quality and product variety are substitutes (i.e., the optimal q_i is falling in m_i) from this formula. The intuition is as follows: a greater investment in quality induces a smaller mass of consumers to switch. The reason to increase product variety for a firm is to attract switchers, consumers who were not satisfied with their previous choice. As there is a smaller number of switchers, the benefit of an increased product variety is diminished. As a consequence, introducing additional products provides a lower revenue if the chosen quality of a firm is higher. This induces the firm to lower its product variety.

We now turn to the first stage, the choice of product variety. To simplify the analysis and to be able to apply differentiation techniques, we follow most papers on multi-product firms (such as Dewan et al. (2003), Johnson and Myatt, 2003, or Hamilton, 2009) and treat the mass of products as a continuous variable. Inserting the values for e_i given in Equation (6) in the profit function of firm i, we can then take the derivative with respect to m_i. Solving for the symmetric equilibrium (i.e., $m_1 = m_2 = \cdots = m_M = m$) yields[5]

$$m^\star = \frac{(1-\alpha)(1-\beta)(M-1)v\left(2cM^3 - v(1-\alpha)(1+(M-\beta)(M-1))\right)}{2fcM^5}. \tag{7}$$

Inserting this back into the optimal effort gives

$$q^\star = \frac{(1-\alpha)v(M+\beta-1)}{2cM^2}, \tag{8}$$

where $q^\star = q_1^\star = q_2^\star = \cdots = q_M^\star$. Our assumption on c implies that the equilibrium quality level is strictly below 1. Finally, from (5), we can solve for the equilibrium price distribution.

[4]Due to the convexity of the quality cost function, the second-order condition is satisfied.
[5]The second-order condition is fulfilled by our assumption on c.

Since the equilibrium number of products and the qualities are symmetric, the left-hand side of (5) can be written as $(1-G(p))^{M-1}$. Solving for the equilibrium price distribution then yields

$$1 - G(p) = \left(\frac{\alpha + (1-\alpha)(1-\beta)(1-\beta+\beta q^\star)(v-p)}{M(1-\alpha)\beta(1-q^\star)p} \right)^{\frac{1}{M-1}},$$

with the upper boundary being v and the lower boundary being

$$\underline{p} = \frac{v(1-\beta+\beta q^\star)}{1-\beta+\beta q^\star + M\beta(1-q^\star)}.$$

Results

Our main interest is how a firm's product variety is affected by the market environment. To analyze this we perform comparative-static exercises on the equilibrium product variety $m^\star$.

We start with consumer valuation v. A larger v implies that consumers are willing to pay higher prices for the firms products and hence firms can obtain higher revenues. Taking the derivative of $m^\star$ with respect to v yields

$$\frac{\partial m^\star}{\partial v} = \frac{(1-\alpha)(1-\beta)(M-1)\left(cM^3 - v(1-\alpha)(1+(M-\beta)(M-1))\right)}{fcM^5}. \tag{9}$$

It is easy to check that this derivative is negative if

$$v > \frac{cM^3}{(1-\alpha)(M^2-(1-\beta)(M-1))}.[6] \tag{10}$$

Hence, we obtain our first result:

Result 1. *The optimal number of products decreases in revenue per consumer v for v sufficiently large.*

The result shows that a more valuable market segment might induce firms to offer a lower variety of products. This is potentially counter-intuitive. If a market becomes more valuable (i.e., consumer willingness-to-pay increases), firms usually find it more profitable to offer a larger number of products to attract more consumers. In fact, as the cost of introducing more products is unchanged but the value that can be reaped for each product is higher, firms optimally expand their product range.

However, in our model there is a countervailing effect. As a market segment gets more valuable, each firm has an increased incentive to retain its buyers. It will do so by providing a

[6] It is readily checked that the threshold value of v is compatible with our assumptions.

higher quality, thereby inducing fewer consumers to switch. It is easily seen from Equation (8) that quality investment increases in v. Because all firms invest more, the aggregate number of switching buyers falls, implying that each firm can only attract fewer of these buyers by increasing product variety. As a consequence, firms respond with a reduction in the number of products they offer. Result 1 shows that this effect dominates if v is particularly large. The reason is that with a large v, the quality provided by firms is high inducing most consumers stick to their choice. Therefore, investing in new product variety does not pay off much. By contrast, if v increases starting from a small level the direct effect is still large, implying that the number of products increases in order to capture the more valuable consumers: this counter-intuitive effect results from the interplay between investment in quality and in product variety. In fact, if quality was fix, an increase in v would unambiguously lead to an increase in the number of products. However, since investments in quality and product variety are substitutes, this result no longer holds.

Second, we turn to the number of firms M. The number of firms represents the degree of competition for switching consumers. The more firms are in a particular segment, the lower the average price and the probability that a switching viewer who decides only according to her preferences will buy one of the products from a firm. Taking the derivative of $m^\star$ with respect to M yields

$$\frac{\partial m^\star}{\partial M} = -\frac{(1-\alpha)(1-\beta)\left(2cM^3(M-2) - v(1-\alpha)(2M^3 - 3M^2(2-\beta) + (8M-5)(1-\beta))\right)}{2fcM^6}. \tag{11}$$

The derivative is positive if

$$v > \frac{2cM^3(M-2)}{(1-\alpha)(2M^3 - 3M^2(2-\beta) + (8M-5)(1-\beta))}.[7] \tag{12}$$

We can then state our second result:

Result 2. *The optimal number of products increases in the number of firms in a segment M for sufficiently large v.*

Result 2 demonstrates that an increase in competition caused by a larger number of firms might nevertheless induce firms to expand their number of products. The intuition behind this potentially surprising result is again rooted in the interplay between quality investments and the optimal number of firms. First, there is a direct effect of the number of firms on optimal product variety. If the number of firms rises, each firm faces a lower probability to attract switching buyers with its products. Because the costs of investing in new products

[7] This threshold value if below the one of Result 1 and therefore also compatible with our assumptions.

are unchanged, firms optimally reduce product variety.

At the same time, an increase in the number of firms also implies that each firm has a lower market share of its existing buyers. Consequently, providing high-quality products pays off less because fewer consumers experience this high quality and hence fewer of them will stick with the firm's products. Quality investment therefore falls. This in turn results in a larger number of switching buyers, which renders a higher product variety profitable for each firm. Hence, this second effect runs counter to the direct effect. We show that, as in Result 1, the indirect effect dominates the direct one if v is large. This is again due to the effect that a reduction in quality investment caused by an increase in the number of firms is high if v is large.

Third, we study the share of loyal consumers α. Loyal consumers stick with the product they previously bought, regardless of quality. Since an increasing share of loyal consumers implies that firms can attract fewer consumers with their products, this share will affect the product variety in equilibrium. Taking the derivative of $m^\star$ with respect to α yields

$$\frac{\partial m^\star}{\partial \alpha} = -\frac{(1-\beta)(M-1)v\left(cM^3 - v(1-\alpha)(1+(M-\beta)(M-1))\right)}{fcM^5}. \tag{13}$$

The second derivative is

$$\frac{\partial^2 m^\star}{\partial \alpha^2} = -\frac{(1-\beta)(M-1)v^2\left(1+(M-\beta)(M-1)\right)}{fcM^5} < 0. \tag{14}$$

It is readily seen that the first derivative can either be positive or negative and that it is positive if $\alpha < 1 - (cM^3)/(v(1+(M-\beta)(M-1)))$.

Result 3. *The relationship between the optimal number of products changes and the share of loyal consumers is concave.*

The result shows that there is non-monotonic relationship between product variety and share of loyal consumers. The decreasing part of this non-monotonicity is unsurprising. The optimal number of products can fall in the share of loyal consumers, as new products are less valuable since there are fewer switching consumers.

The increasing part is more surprising. Its intuition has its roots in the change in quality investments. If firms face more loyal consumers, who do not react to quality changes, they find it optimal to lower their quality investments. This implies that among the non-loyal consumers, more consumers are willing to switch because they are not satisfied with the quality of the previously bought product. This in turn induces firms to offer an increased variety of products to attract more such consumers. If the share of non-loyal consumers is large (i.e., if α is small), this effect dominates and leads to a positive relationship between

$m^\star$ and α.

Finally, we turn to the interaction effect of the value per consumer and the degree of homogeneity among consumers β. As explained above, a high β implies that a large fraction of consumers views the products as homogeneous and decides which one to buy according to the prices charged. Taking the derivative of $\partial m^\star/\partial v$ with respect to β, we obtain

$$\frac{\partial^2 m^\star}{\partial v \partial \beta} = -\frac{(1-\alpha)(M-1)\left(cM^3 - v(1-\alpha)(M^2 + (1-\beta)(M-1))\right)}{fcM^5}. \tag{15}$$

The right-hand side of this expression is equal to

$$-\frac{(1-\alpha)(1-\beta)(M-1)^2}{fcM^2(1+(M-\beta)(M-1))} < 0 \tag{16}$$

at the threshold value for v from Result 1. It stays negative until $v \leq (cM^3)/[(1-\alpha)(M^2 - 2(1-\beta)(M-1))$. We therefore obtain the following result:

Result 4. *The negative effect of v on the optimal number of products increases in absolute value as consumers become more homogeneous if*

$$\frac{cM^3}{(1-\alpha)(M^2-(1-\beta)(M-1))} \leq v \leq \frac{cM^3}{(1-\alpha)(M^2-2(1-\beta)(M-1))}.$$

The intuition behind the result can be grasped by the effect that an increase in homogeneity has on the quality of firms' products. It is evident from Equation (8) that a larger β increases quality investment. The reason is that as consumers are more homogeneous, it is more detrimental for a firm if a consumer does not re-buy. This is because firms compete more fiercely for switching consumers and therefore obtain lower profits from them. The consequence of the increased quality investment is that fewer consumers switch. If the market now becomes profitable (i.e., v increases), both effects drive up quality investment, thereby making a large product variety less important. As a consequence, an increase in homogeneity further strengthens the negative effect of an increase in v on product variety.

4 Empirical Predictions

We now turn to the predictions that can be derived from our theoretical analysis. We will test our results on German magazine data. In this market, publishers are likely to only be active in market segments with a sufficiently high consumer valuation due to large fixed costs, i.e. a sufficiently large v. Segments with only few interested readers or readers with a low willingness-to-pay will not be served since fixed costs and sunk costs cannot be recovered. We therefore assume that v indeed is sufficiently large which leads to unambiguous predictions from our theoretical model. Specifically, we can formulate our first hypothesis capturing Result 1.

Hypothesis 1. *The number of magazine titles by the same publisher in a segment is negatively related to consumer valuation.*

Similarly, we can formulate our hypothesis relating to the number of competing firms and thereby to the number of competing titles (Result 2).

Hypothesis 2. *The number of magazine titles by the same publisher in a segment is positively related to the number of titles by other publishers in the own segment.*

From Result 3, we deduce how a firm's product variety changes with the level of loyalty of consumers. We obtain a curvi-linear (non-monotonic) effect that can be expressed by the following hypothesis.

Hypothesis 3. *The number of magazine titles by the same publisher in a segment is concavely related to consumer loyalty.*

Finally, we obtain an hypothesis on the interaction between the value of a market segment and the degree of consumer homogeneity (Result 4).

Hypothesis 4. *Increasing consumer homogeneity strengthens the negative relation between consumer valuation and the number of magazine titles by the same publisher in a segment.*

5 Data

Data set

We use the data of Chandra and Kaiser (2014) who study targeted advertising and its relationship to an increasingly internet-affine audience. Their data stems from Germany's equivalent to the Audit Bureau of Circulation in North America, "Informationsgemeinschaft zur Feststellung der Verbreitung von Werbeträgern e.V. (IVW)". IVW ascertains, monitors, and publishes information on print media readership. The core data consist of information on the total number of copies sold, cover prices (which we convert into 2000 prices), advertising rates, subscriber shares and identifiers for magazine segments. This core data has been collected quarterly since 1972. Chandra and Kaiser (2014) supplement this core information by magazine-specific data on readers' gender, age, household income and internet use provided by Arbeitsgemeinschaft Media-Analyse (AG.MA), an association of the German advertising industry for the research of mass communication. The data is the same that is used by advertisers willing to place ads in the magazines in our data. Publishers provide this information to the advertising clients in form of "factsheets" which bundle data on readership characteristics.[8] It is available for the years 1998 to 2010 on an annual basis.

The appropriate segmentation of the magazine market is important for our paper. It is defined by IVW and includes 31 separate segments. These segments differ in terms of readership characteristics (like the various types of women's magazines) and topic (like TV, cars, politics etc.). It is a very broadly accepted industry standard and used by e.g. AG.MA.

Our data consist of 6002 observations on 179 magazines tracked over 49 time periods between 1998 and 2010. These magazines are published by 45 unique publishers. We account for mergers and acquisitions such that publishing groups are considered as a single publisher.

The level of analysis is publishers in magazine segments. We thus aggregate the data to the segment-publisher-period level by taking means across segments and publishers. This leaves us with 4149 segment-publisher-period observations.

Empirical proxies

Our theoretical model contains three variables which we need to proxy in our empirical analysis: value, loyalty and differentiation. We find "natural" proxies for the first two, copyprice and subscriber shares. We also directly observe a measure for reader homogeneity that we base on the four different magazine-specific reader characteristics we have in our data: gender (the share of women in total readers), income (the share of readers with a monthly net income of below 2000, between 2000 and 2500 Euros and of more than 2500 Euros), age (the share of readers in the age categories 14-19, 20-29, 30-49, 50-59 and older than 60 years) and Internet use (the share of readers who regularly use the Internet). To generate a single measure for reader differentiation we follow Breshnahan et al. (2002) and first calculate magazine-specific Hirshman-Herfindahl indices four each reader characteristic. Second, we aggegregate the indices to the segment-publisher-period level and normalize the aggregated variable. Third, we sum over all indices and again apply a normalization. To test Hypothesis 4 we interact copyprices with our newly generated variable.

Descriptive evidence

Table 1 provides a first look at our data by showing descriptive statistics of our dependent

[8]The publisher Bauer Verlag for example maintains an easy to navigate website for factsheet downloads: http://www.baueradvertising.de/marken/zeitschriften/

variable, the number of title per publisher and segment, as well as the associated copyprices of each of the magazine segments. We display both means and maxima for each variable to provide evidence for the extreme case as well as the average. The table sorts segments by the number of titles by publishers in the segment in descending order. It shows that most publishers only have a single title in each segment. There is, however, considerable variation. The maximum (across time) number of titles is as high as seven for TV magazines and it is five for motor vehicles, weekly counselling women as well as weekly entertaining women magazines. Table 1 also shows that copyprices vary substantially across segments. Fashion magazines are by far most expensive while most magazine segments on average price around two Euros. Another takeaway from Table 1 is that the ordering of magazine segments is quite unaffected by using maxima or means which indicates that differences in the number of magazines per publisher and segment are not driven by a single publisher.

Table 1 here

To provide another first descriptive assessment of our hypotheses, Figure 1 displays scatterplots (left part) and the results of fitted quadratic regressions of of the number of magazine titles per publisher per segment (right part) on the one hand and (i) copyprices (top), (ii) the number of other publishers in the segment (middle) as well as (iii) subscriber shares (bottom) on the other. We annualize the data by taking the means (across segments and time) of each variable. We choose a quadratic rather than linear regressions for our fitted regressions since this is consistent with Hypothesis 3 and in order to allow for more flexibility in parameter estimates.

The association between the number of titles per publisher and segment appears to be negative indeed as indicated by the related scatterplot on top of Figure 1. The fitted quadratic regression indicates a negative relationship for copyprices below 4.8 Euros after which the relationship is upward sloping. Since only 7.6% of the copyprices are above that value we conclude that the relationship indeed is negative for relevant price ranges, lending descriptive support to Hypothesis 1. The scatterplot and the associated quadratic fit for the mapping between the number of titles (per publisher and segment) and the number of titles by other publishers indicates a positive relationship as it is consistent with Hypothesis 2: it is concave but upward sloping for relevant copyprices. Finally, Figure 1 shows the relationship between the number of titles and the share of subscribers at its bottom. Both the scatterplot and the quadratic fit indicate a u-shaped association for subscriber shares which is in line with Hypothesis 3.

Figure 1 here

Our empirical model contains two additional control variables (at the publisher-segment-period level) that are not theory-driven but nonetheless are likely to affect the number of titles: potential market size and the total number of other titles published by the own publisher. The latter variable is a measure of economies of scope and should be positively related to the number of titles by the own publisher in the same segment. The first variable should be a natural determinant of optimal portfolio size and is also expected to be positively related. We calculate it by first determining the most important reader group in terms of both gender and age from the reader characteristics data we have at our disposal. We subsequently link these most important reader groups to German Federal Statistical Office data on the entire population of the respective gender/age combination.

Table 2 display descriptive statistics of all variables involved in our estimations at the publisher-segment-period level. It shows that the average number of titles by the same publisher in a segment is 1.44, varying between one and seven. Real copyprices are 2.6 Euros on average, ranging between 0.52 and 7.18 Euros. There are on average 2.68 other publishers in each magazine segment. Some segments are monopolies, other have up to seven players. Subscriber shares vary between zero and one with an average of 0.23. Our product differentiation variable is normalized with mean zero and a standard deviation of one. Its minimum value is -2.02, its maximum is 2.88. The average of our scope variable is 9.76. It ranges between no and 25 other magazines per publisher. Finally, average market size is 11 mio. persons, varying between 2.05 and 12.83 million across segments. Total revenue per reader, i.e. the sum of copyprice and advertising revenue per reader is 17.3 Euros on average, i.e. advertising revenues hence play a key role for total revenues per reader. We shall use this variable in a robustness check as an alternative measure of consumers' value attached to magazines.

Table 2 here

6 Empirical results

Main results

Our dependent variable is the number of products per publisher and time period. It is a count variable so we model it by a count data model. Since our estimation results do not provide any indication for overdispersion, we use a Poisson model instead of a negative binomial count data model. We lag all explanatory variable by one period and display estimation results in Table 3.

Model (I) does not include the copyprice/differentiation interaction while Model (II) does. We cluster standard errors at the publisher-segment level. The coefficient estimates do not differ much between Model (I) and Model (II) which is why we do not discuss them separately. We find strong evidence for a negative relation between copyprices and the number of titles. The coefficient estimate is 0.16 and statistically highly significant which is fully consistent with Hypothesis 1. Since the Poisson model has an exponential conditional mean function (see Appendix A for details), the corresponding marginal effect is 0.16 times the number of titles of the own publisher in the own segment (it is twice as large for two titles etc.). E.g., if the own publisher only has one title, an increase in average copyprices within in the segment by one Euro is associated with a decrease in the number of titles by 0.16. Figure 2 shows the effect of changes in copyprices on the number of titles by a single publisher in a segment and indicates that the estimated effect is statistically significant for all copyprices observed in our data. Appendix A explains in detail how we generate the figure and how we calculate the associated confidence bands, the gray area in Figure 2 and the figures to follow.

The coefficient estimate on the number of titles by other publishers in the own segment is also estimated with high precision. The coefficient estimate is 0.1 which translates into a marginal effect of the same size for publishers with just one title in the respective segment. This is fully consistent with Hypothesis 2. Figure 3 provides a visualization and shows that if there is one title by another publisher in the own segment the expected number of own titles is 1.16. It increases to 2.23 if the number of other publisher's titles is seven, the highest value we observe in our data.

Hypothesis 3 predicts a u-shaped relationship between subscriber shares, our measure of reader loyalty, and the number of titles. Table 3 displays estimation results that are consistent with this hypothesis as the linear term on subscriber share is positive while the quadratic one is negative. Both are jointly and separately statistically highly significant. These results are fully consistent with Hypothesis 3. The number of titles is maximzed for subscriber shares of 0.44. Figure 4 displays the concave relationship by mapping subscriber share to the expected number of titles.

While we do find strong support for our first three hypotheses, our estimation results do provide an immediate backing of Hypothesis 4 since the coefficient estimate on the interaction between copyprices and reader differentiation is statistically insignificantly different from zero as shown in Model (II). The coefficient estimate on copyprice remains the same as in Model (I). However, the sum of the non-interacted and the interacted coefficients is statistically highly significantly different from zero. Figure 5 displays the relationship between reader differentiation and the number of titles. Somewhat surprisingly given the insignificance of the interaction term, the absolute effects is statistically significant from 0. We trace that back to the joint significance of the two parameters. Even though Figure 5 does provide some evidence in favor of Hypothesis 4, it is only weakly supported given the insignificant interaction term between copyprices and reader differentiation.

Robustness checks

Alternative measure for "value"

Our measure of consumer valuation has so far been copyprice. As a first robustness check, we consider an alternative but still meaningful proxy for value given that we are dealing with a two-sided market which generates revenues from both readers and advertisers: total revenue per reader, the sum of copyprices and advertising revenue per reader. The latter variable is also part of our dataset. We show the results from re-running our Poisson regressions using total revenues per reader instead of copyprice in Appendix B. The coefficient estimate on total revenue per reader is statistically significantly negative which is consistent with Hypothesis 1. It is also substantially smaller than if copyprice is used as proxy for "value" which partly due to advertising revenue per reader being on average around eight times higher than copyprices. Appendix B displays estimation results for both Model I and Model II.

Identification

The number of other publishers active in the same segment might be endogenous since the same unobserved factors which affect the number of titles of other publishers in the own segment are likely to affect the number of own titles in a segment as well. In a second robustness check we therefore instrument this variable. We use the average share of readers of other publishers' magazines in the own and in other segments who regularly use the Internet and the average subcriber share of other publishers' magazines in the own (and its square) as well as in other segments. Our intuition behind the first instrument is that cannibalization from the Internet is prone to reduce the number of titles, both own (which our estimations already account) and others. At the same time, the online behavior of other publishers' readers is unlikely to affect the own number of titles. To strengthen this argument further, we use the average online share of readers of other magazines in other segments as a second instrument. The Internet use variable is closely described and analyzed in Chandra and Kaiser (2014). We consider other publishers' subscriber share as a second instrument since it reflects how succeful other publishers are at attracting loyal consumers which in turn affects the number of titles they publish. Its squared term is included since our model predicts a concave relationship. We display Poisson IV regression results in Appendix C in the first column along with our main estimation results in the second. For an instrument to be valid it needs to be (i) highly correlated with the endogenous variable and (ii) uncorrelated with the error term in the regression of interest. We test the first property by running an OLS regression of all exogeneous variables and the instruments on the number of titles by other publsihers in the own segment and find that all instruments are separately and jointly highly significant. The F test statistic associated with the joint test is 932 and hence way above the critical threshold of ten suggested by Staiger and Stock (1997). The second propety is tested by a Hansen J test which cannot reject orthogonality of the instruments at any conventional confidence level (the p-value is 0.31). Both tests hence indicate that our instruments are statistically valid.

Using IV instead of plain Poisson estimation leads to a reduction in coefficient estimate of the number of titles by other publishers in the same segment by almost a half which suggests that our original parameter estimates are biased upwards as expected. The coefficient is also much less precisely estimated which is a direct result of using IV. However, the coefficient estimate is still statistically significantly positive as predicted by our theoretical model. All other coefficient estimates remain qualitatively and generally also quantitatively unchanged.

Alternative econometric models

Our estimation results so far rely on a single econometric approach, the Poisson count data model. In a third robustness check we explore three alternative models: simple OLS, a Tobit model which accounts for left-censoring at 1 (most publishers publish one title per segment only) and a probit regression which models having one or more than one title per segment. The associated estimation results are displayed in Appendix C. It shows that the results are qualitatively very similar. Quantitative differences in coefficient sizes cannot be interpreted since the results from the different models are not comparable.

Table 3 here

7 Conclusions

In this paper, we investigated firms product variety choices in a theoretical model where firms can not only attract consumers by product line extensions but also by investing in the quality of their existing products to retain consumers. This interplay determines optimal product variety in equilibrium and gives rise to novel predictions on how firms can optimally adjust product variety to changes in market environments. We show that investments in quality and in product variety are substitutes because if quality improves, fewer consumers are induced to switch, implying that product variety investment pays off to a smaller extent.

This leads to the result that the number of products of each firm can fall as the revenue per consumer increases because quality investment grows relatively faster. Similarly, firms optimally choose a larger product variety if the number of competing firms increases or if consumers become more loyal — both of these changes decrease the effects of quality investment on profits. Our empirical analysis of the German magazine market lends strong empirical support to these predictions.

A potential shortcoming of our theoretical analysis is that it is of static nature. Specifically, it uses the fact that consumers have previously bought products but takes this choice as given. In a dynamic model, one could explicitly analyze how the possibility to gain demand not only in one period but in many periods shapes the incentives to invest in the number of products and in quality to retain consumers. This could give interesting insights on the dynamic interplay between these two decisions. We leave this extension for future research.

With respect to the empirical analysis, it seems most important to check if our results extend to other markets as well. For our model to be meaningful, we need multi-product firms and an accurate segmentation of the market. Beer and cars appears to be appropriate markets to study.

References

[1] Berger J, Draganska M, Simonson I (2007) The Influence of Product Variety on Brand Perception and Choice. *Marketing Science* 26(4), 460-472.

[2] Berry S (1992) Estimating a Model of Entry in the Airline Industry. *Econometrica* 60(4), 889-917.

[3] Brander J, Eaton J (1984) Product Line Rivalry, *American Economic Review*, 74(3) 323-334.

[4] Breshnahan T, Brynjolfsson E, Hitt L. (2002) Information Technology, Workplace Organization and the Demand for Skilled Labor: Firm-Level Evidence. *Quarterly Journal of Economics* 117(1), 339-376.

[5] Champsaur P, Rochet J-C (1989) Multiproduct Duopolists. *Econometrica* 57(3), 533-557.

[6] Chandra A, Kaiser U (2014) Targeted Advertising in Magazine Markets and the Advent of the Internet. *Management Science* 60(7), 1829-1843.

[7] Dewan R, Jing B, Seidmann A (2003) Product Customization and Price Competition on the Internet. *Management Science* 49(8), 1055-1070.

[8] Draganska M, Jain D (2005) ProductLine Length as a Competitive Tool. *Journal of Economics and Management Strategy* 14(1) 1-28.

[9] Gilbert R, Matutes C (1993) Product Line Rivalry with Brand Differentiation. *Journal of Industrial Economics* 93(3), 223-240.

[10] Hamilton S (2009) Excise Taxes with Multiproduct Transactions. *American Economic Review* 99(1), 458471.

[11] Johnson J, Myatt D (2003) Multiproduct Quality Competition: Fighting Brands and Product Line Pruning. *American Economic Review* 93(3), 748-774.

[12] Judd K (1985) Credible Spatial Preemption. *RAND Journal of Economics* 16(2), 153-166.

[13] Kekre S, Srinivasan K (1990) Broader Product Line: A Necessity to Achieve Success. *Management Science* 36(9) 12161231.

[14] Lancaster K (1990) The Economics of Product Variety: A Survey. *Marketing Science* 9(3), 189-206.

[15] Lieberman M, Montgomery D (1988) First-Mover Advantages. *Strategic Management Journal* 9(5), 41-58.

[16] Narasimhan C (1988) Competitive Promotional Strategies. *Journal of Business* 61(4), 427-449.

[17] Putsis W, Bayus B (2001) An Empirical Analysis of Firms' Product Line Decisions. *Journal of Marketing Research* 38(1), 110-118.

[18] Rosenthal R (1980) A Model in Which an Increase in the Number of Sellers Leads to a Higher Price. *Econometrica* 48(6), 1575-1579.

[19] Schmalensee R (1978) Entry Deterrence in the Ready-to-Eat Cereal Breakfast Industry. *Bell Journal of Economics* 9(3), 305-327.

[20] Shaked A, Sutton J (1990) Multiproduct Firms and Market Structure. *RAND Journal of Economics* 21(1), 45-62.

[21] Simester D (1997) Optimal Promotion Strategies: A Demand-Sided Characterization. *Management Science* 43(2), 251-256.

[22] Staiger D, Stock JH (1997) Instrumental Variables Regression with Weak Instruments. *Econometrica* 65, 557-586.

[23] Varian H (1980) A Model of Sales. *American Economic Review* 70(4), 651-659.

Table 1: **Number of titles per publisher in segment an associated copyprices**

	Maximum			Mean	
Segment	**# titles per publisher in segment**	**copyprice in segment**	**Segment**	**# titles per publisher in segment**	**copyprice in segment**
TV	7	1.6	TV	3.1	1.1
Motor vehicles	5	4.1	Motor vehicles	2.4	2.2
Weekly counselling women's	5	2.8	Weekly entertaining women's	2.3	1.3
Weekly entertaining women's	5	1.5	Science, nature and technology	2.0	5.4
Gardening	4	3.6	Weekly counselling women's	1.8	1.1
House and garden	3	4.1	Gardening	1.7	2.7
Finance	3	6.7	Handicraft fashion	1.6	3.2
Science, nature and technology	3	7.2	Food	1.6	2.4
Food	3	3.9	House and garden	1.6	2.6
Biweekly classical	2	3.3	Parenting	1.5	2.5
Handicraft fashion	2	4.6	Politics	1.3	2.6
Youth	2	4.7	Finance	1.3	3.6
Politics	2	3.6	Computer	1.2	3.3
Computer	2	7.1	Biweekly classical	1.1	2.2
Parenting	2	4.1	Youth	1	2.4
Adult	1	5.1	Gossip	1	2.2
Gossip	1	2.7	Monthly classical women's	1	2.5
Business	1	7.1	Fashion	1	4.8
Ecology	1	3.6	Adult	1	3.3
Travel	1	4.9	Health and medicine	1	3.9
Photo	1	4.6	Business	1	4.7
Do-it-yourself	1	3.1	Girls	1	1.8
Monthly classical women's	1	3.4	Lifestyle	1	3.0
Sports	1	3.9	Wellness	1	2.3
Health and medicine	1	5.6	Photo	1	3.7
Fitness	1	3.8	Ecology	1	3.5
Wellness	1	2.7	Pets	1	2.4
Pets	1	2.6	Sports	1	1.9
Lifestyle	1	3.5	Fitness	1	3.3
Fashion	1	6.2	Travel	1	4.7
Girls	1	2.4	Do-it-yourself	1	2.9

Notes: Magazine segments are sorted in descending order by the number of titles by a single publisher in each segment.

Table 2: **Summary statistics**

	Mean	**Std. dev.**	**Min.**	**Max.**
Dependent variable				
# of titles per publisher per segment	1.45	0.99	1.00	7.00
Key explanatory variables				
Copyprice	2.59	1.24	0.51	7.19
# other publisher in segment	2.68	1.58	0.00	7.00
Subscriber share	0.23	0.18	0.00	1.00
Product differention	0	1	-2.02	2.88
Additional explanatory variables				
Total # titles by own publisher	9.76	8.08	0.00	25.00
Potential market size (in 1000)	11071	2677	2053	12826

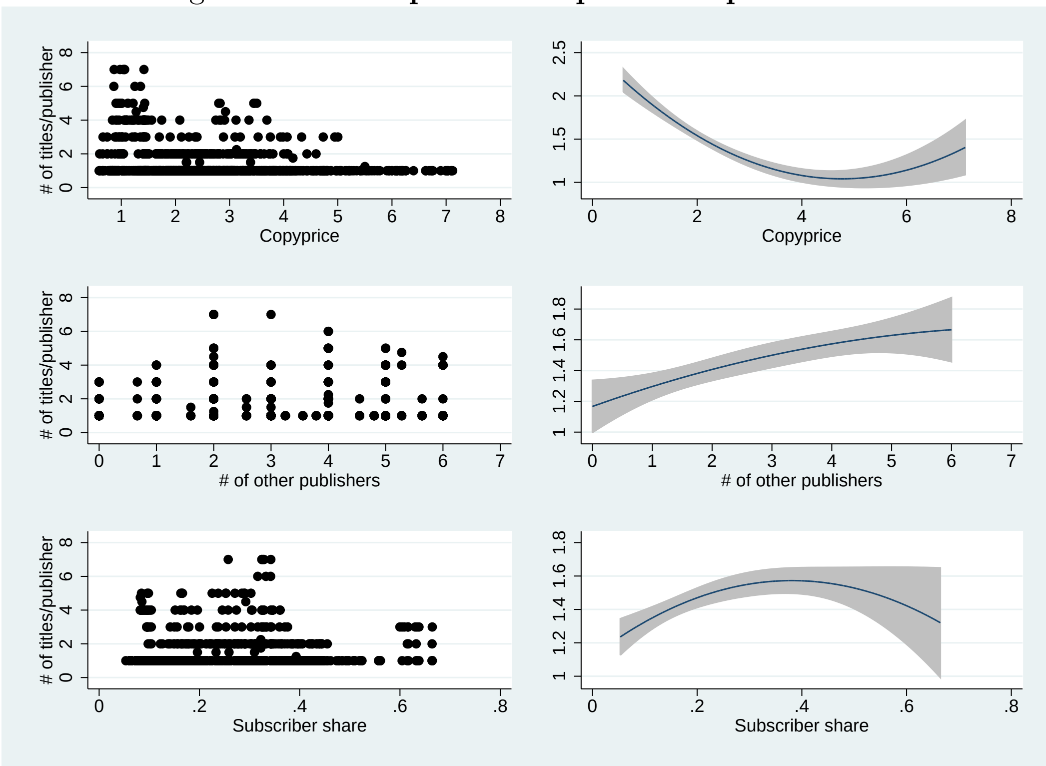
Note: 4098 observations.

Table 3: **Poisson estimation results**

	No interaction Coeff. (std. err.)	**Interaction Coeff. (std. err.)**
Copyprice	-0.12**	-0.12**
	(0.05)	(0.05)
# titles by other publishers	0.09***	0.09***
	(0.03)	(0.03)
Subscriber share	3.20***	3.25***
	(1.06)	(1.03)
Subscriber share squared	-3.68**	-3.74***
	(1.44)	(1.40)
ln(potential market size)	0.22***	0.23***
	(0.08)	(0.07)
# titles by own publisher	0.01	0.01
	(0.01)	(0.01)
Differentiation * copyprice		-0.02
		(0.05)
Differentiation		0.06
		(0.14)
Share readers online	-0.61**	-0.62**
	(0.30)	(0.30)
Constant	-1.66**	-1.75**
	(0.81)	(0.75)
Tests for joint significance (*p*-values)		
Period dummies	0.000	0.000
Subscriber share	0.005	0.003
Segment dummies	0.205	0.173
Copyprice variables		0.017
R^2 and # observations		
Pearson R^2	0.431	0.434
Observations	3,924	3,924

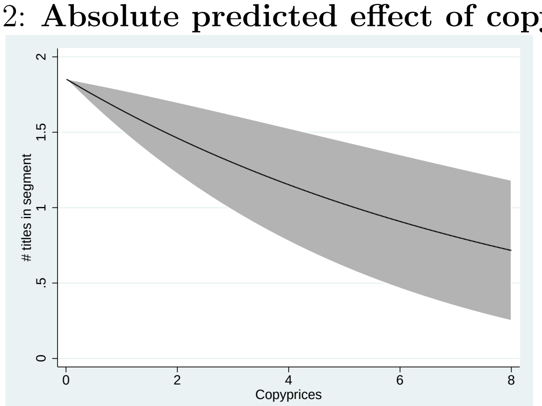
Notes: The dependent variable is the number of titles produced by the own publisher in a given segment. Standard errors are clustered at the publisher-segment level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 1: **Scatterplots and quadratic predictions**



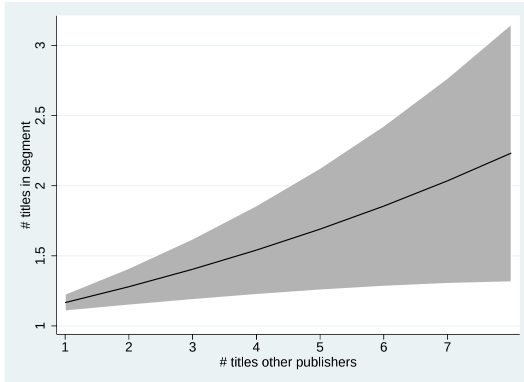
Notes: The shaded areas in the right panel are 99% confidence intervals. The data is annualized

Figure 2: **Absolute predicted effect of copyprice**



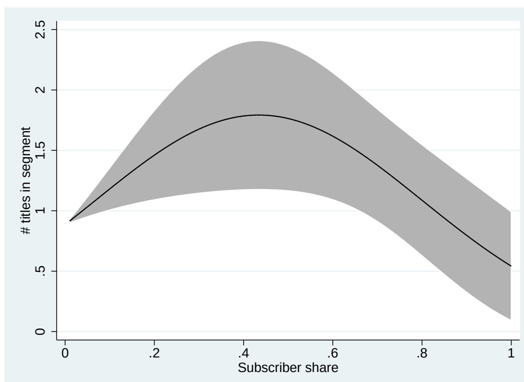
Note: The shaded areas in the right panel are 90% confidence intervals.

Figure 3: **Absolute effects of the number of titles by other publishers**



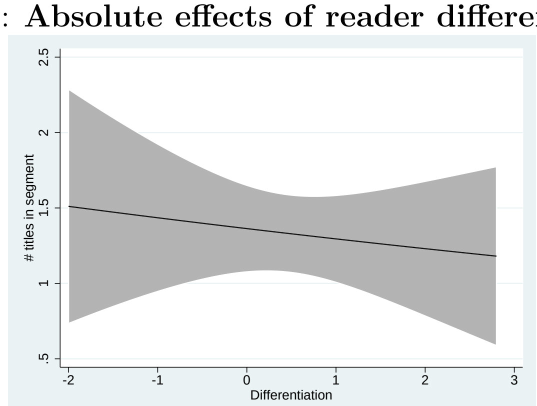
Note: The shaded areas in the right panel are 90% confidence intervals.

Figure 4: **Absolute effects of the share of subscribers**



Note: The shaded areas in the right panel are 90% confidence intervals.

Figure 5: **Absolute effects of reader differentiation**



Note: The shaded areas in the right panel are 90% confidence intervals.

Appendix A: Absolute effects and associated standard errors

Figure 2 to Figure 5 display the absolute effects of changes in (i) copyprices, (ii) the number of titles published by other publishers in the segment, (iii) subscriber shares and (iv) reader differentiation on the number of titles. This Appendix describes how we generate the figures. The conditional expected mean of our most general estimation model, the model with interactions, is:

$$E[\hat{T}_{ijt}|\boldsymbol{x_{ijt}}, \hat{\boldsymbol{\phi}}] = exp\Big(\hat{\alpha}p_{ijt} + \hat{\beta}T^o_{ijt} + \hat{\gamma}_1\text{SuS}_{ijt} + \hat{\gamma}_2\text{SuS}^2_{ijt} + \hat{\delta}\text{diff}_{ijt}p_{ijt} + \hat{\epsilon}\text{diff}_{ijt} + \boldsymbol{z_{ijt}}\hat{\boldsymbol{\kappa}}\Big), \quad (17)$$

where $\hat{T}_{ijt}$ denotes the predicted number of titles of publisher i in segment j at time t, x_{ijt} denotes the set of conditioning variables, p_{ijt} denotes the average copyprice of publisher i in segment j at time t, SuS_{ijt} denotes the subscriber share, T^o_{jt} denotes the number of titles of *other* publishers in segment j ($j \neq i$) and $\boldsymbol{z}_{ijt}$ denotes the set of additional control variables.

To calculate the absolute effects of copyprices share we first calculate the predicted values of $\hat{\boldsymbol{\phi}}\boldsymbol{x_{ijt}}$, where $\hat{\boldsymbol{\phi}}$ denotes the entire vector of estimated parameters, and subtract the predicted values associated with the variable in question. For copyprices we for example get: $M^{\text{p}}_{ijt} = \hat{\boldsymbol{\phi}}\boldsymbol{x_{ijt}} - (\hat{\alpha}p_{ijt} + \hat{\delta}\text{diff}_{ijt}p_{ijt})$. We subsequently take the mean across i, j and t and denote it by $\bar{M}^p$. The expected mean function then is:

$$E[\hat{T}|\bar{M}^{\text{p}}, \hat{\alpha}, \hat{\delta}] = exp\Big(\hat{\alpha}p + \hat{\delta}\bar{\text{diff}}\ p + \bar{M}^p\Big), \quad (18)$$

where $\bar{\text{diff}}$ denotes average reader differentiation. We proceed the same way for all other variables.

We calculate the corresponding standard errors using the "Delta-method" (Greene 2003), a method to calculate variance-covariance matrices for functions of estimated parameters. Let $\hat{\boldsymbol{\theta}}$ denote a vector of estimated parameters, let $\boldsymbol{\psi(\hat{\theta})}$ denote the corresponding variance-covariance matrix and let $\boldsymbol{C(\hat{\theta})}$ define the partial derivatives of the functions of the estimated parameters with respect to the relevant estimated parameters. The corresponding variance-covariance matrix is:

$$\boldsymbol{V}[\boldsymbol{C(\hat{\theta})}] = \boldsymbol{C(\hat{\theta})'\psi(\hat{\theta})C(\hat{\theta})}. \quad (19)$$

For copyprices we have $\boldsymbol{\theta} = (\hat{\alpha}, \hat{\delta})$ and $\boldsymbol{C(\hat{\theta})}$ is:

$$\boldsymbol{C}(\boldsymbol{\theta}) = \begin{pmatrix} p\ \bar{T} \\ p\ \bar{\text{diff}}\ \bar{T} \end{pmatrix}. \quad (20)$$

Similarly, for the number of titles by other publishers we get $\boldsymbol{C}(\hat{\beta}) = (T^0, \bar{T})$. For subscriber shares we have $\boldsymbol{C}(\gamma_1 \hat{,} \gamma_2) = (\text{SuS}\ \bar{T}, \text{SuS}^2\ \bar{T})$ and for reader differentiation we have $\boldsymbol{C}(\alpha \hat{,} \delta) = (\bar{p}\ \bar{T}, \bar{p}\ \text{diff}\bar{T})$.

Appendix B: Total revenue per reader as alternative measure for "value"

	No interaction Coeff. (std. err.)	**Interaction Coeff. (std. err.)**
Total revenue per reader/10	-0.06*	-0.13*
	(0.03)	(0.07)
# titles by other publishers	0.10***	0.11***
	(0.03)	(0.03)
Subscriber share	2.83***	3.09***
	(0.96)	(0.98)
Subscriber share squared	-3.35**	-3.76***
	(1.35)	(1.40)
ln(potential market size)	0	-0.01
	(0.04)	(0.05)
# titles by own publisher	0.03	0.03
	(0.15)	(0.16)
Differentiation * copyprice	0.19***	0.20***
	(0.06)	(0.06)
Differentiation	0.01	0.01
	(0.01)	(0.01)
Share readers online	-0.93***	-0.80***
	(0.29)	(0.29)
Constant	-1.34**	-1.48**
	(0.60)	(0.62)
Tests for joint significance (p-values)		
Period dummies	0.000	0.000
Subscriber share	0.005	0.003
Segment dummies	0.422	0.499
Copyprice variables	0.114	0.204
R^2 and # observations		
Pearson R^2	0.392	0.382
Observations	3,924	3,924

Notes: The dependent variable is the number of titles produced by the own publisher in a given segment. Standard errors are clustered at the publisher-segment level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Appendix C: Alternative econometric models

	IV Poisson	Poisson	Tobit	OLS	Probit
	Coeff.	**Coeff.**	**Coeff.**	**Coeff.**	**Coeff.**
	(std. err.)	**(std. err.)**	**(std. err.)**	**(std. err.)**	**(std. err.)**
Copyprice	-0.07***	-0.12**	-0.93***	-0.15**	-0.29**
	(0.03)	(0.05)	(0.07)	(0.07)	(0.13)
# titles by other publishers	0.04*	0.09***	0.14***	0.14***	0.23***
	(0.02)	(0.03)	(0.05)	(0.05)	(0.08)
Subscriber share	2.25***	3.25***	4.42***	4.42***	6.53***
	(0.68)	(1.03)	(1.63)	(1.63)	(1.79)
Subscriber share squared	-2.33***	-3.74***	-4.86**	-4.86**	-6.88***
	(0.77)	(1.40)	(1.97)	(1.97)	(2.57)
Differentiation * copyprice	-0.03	-0.02	-0.01	-0.01	-0.1
	(0.02)	(0.05)	(0.06)	(0.06)	(0.10)
Differentiation	0.13	0.06	0.05	0.05	0.32
	(0.09)	(0.14)	(0.22)	(0.22)	(0.28)
ln(potential market size)	0.16***	0.23***	0.26***	0.26***	1.31***
	(0.05)	(0.07)	(0.10)	(0.10)	(0.42)
# titles by own publisher	0	0.01	0.01	0.01	0.03**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Share readers online	-0.80***	-0.62**	-0.98*	-0.98*	-1.08
	(0.27)	(0.30)	(0.52)	(0.52)	(0.86)
Constant	-0.87	-1.75**	-0.9	-0.9	-11.46***
	(0.55)	(0.75)	(1.04)	(1.04)	(3.98)
Tests for joint significance (*p*-values)					
Period dummies	0.000	0.000	0.000	0.000	0.000
Subscriber share	0.004	0.003	0.003	0.025	0.000
Segment dummies	0.170	0.056	0.056	0.279	0.041
Copyprice variables	0.002	0.017	0.011	0.039	0.025
R^2 and # observations					
Pearson R^2	0.358	0.417	0.419	0.218	0.250
Observations	3'924	3'924	3'924	3'924	3'924

Notes: The dependent variable is the number of titles produced by the own publisher in a given segment. Standard errors are clustered at the publisher-segment level. $* \, p < 0.10$, $** \, p < 0.05$, $*** \, p < 0.01$.