Paper to be presented at DRUID19
Copenhagen Business School, Copenhagen, Denmark
June 19-21, 2019

# Strategic Product Variety Choice: Theory and Empirical Evidence

**Ulrich Kaiser**
University of Zurich
Dept. of Business Administration
ulrich.kaiser@business.uzh.ch

**Markus Reisinger**
Frankfurt School of Finance and Management
Economics
M.Reisinger@fs.de

## 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.

# Strategic Product Variety Choice: Theory and Empirical Evidence

February 26, 2019

**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

# 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, points 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 switching 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 is 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 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 effect 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 to 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 others. 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 product variety, trading-off the benefits of gaining market share with the investment costs. Kekre and Srinivasan (1990) use 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.

This paper unfolds 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 $i = 1, ..., M$. At the outset, each firm $i$ sells a number of $m_{i0}$ products. To simplify the exposition, we assume that each product is bought by the same number of consumers, which implies that the demand for each product is

$$\frac{1}{\sum_{j=1}^{M} m_{j0}}.$$

The firms compete to attract new consumers and keep their existing consumers. They do so via two choice variables: choosing the number of products to offer (i.e., the product range) and investing to raise the level of consumer satisfaction. Specifically, we denote the number of products of firm $i$ by $m_i$. For simplicity and to be able to apply differentiation techniques, we treat $m_i$ as a continuous variable, that is, it represents the mass of products of a firm.[1] 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.

In addition, firms invest into the customer satisfaction value. For example, a firm invests in increasing the quality of its products, invest in customer relationship management or costumer maintenance, which raises the satisfaction level of customers and thereby induce her to buy the product again with a higher probability. We denote the customer satisfaction level for the products of a firm by $s_i$. Investment into customer satisfaction is costly, and the cost function is $cs_i^2$. We assume that there are economies of scale in these investment cost in the sense that a firm chooses $s_i$ for all of its products, that is, the cost function is an overall cost function applying to all of the firm's products and but not a per-product cost function. This assumption is only made to simplify the analysis. In fact, all results are unchanged if

[1] This is in line with most papers on multi-product firms, such as Dewan et al. (2003), Johnson and Myatt (2003), or Hamilton (2009).

firms invest into the satisfaction level for each product separately (i.e., there are no economies of scale), and we present this analysis in Section 4. Our assumption is motivated by the idea that an investment in quality can be used for many different products because the different variants share a common element. For example, in the magazine industry, investigative stories, interviews or photos can be used for various magazines in the same segment and not just one. In fact, similar stories appear in several magazines of the same publisher.[2]

In the baseline model, we abstract from price competition between firms. However, the model can be easily extended to incorporate price setting by firms, and we provide one such extension that fits well with our application in Section 4. Without price competition, each firm will set a price of $v$ for each of its products. This implies that $v$ is a measure of the value of the market.

On the demand side, there are two types of consumers, loyals and non-loyals. There is a mass $\alpha$ of loyal and a mass $1-\alpha$ of non-loyal consumers. Loyal consumers stick to the product they have bought at the outset, regardless of the satisfaction level. By contrast, a non-loyal consumer potentially buys a different product than the one she bought at the outset. Firms can influence a non-loyal consumer's choice by investing in the satisfaction level. In particular, if a consumer is satisfied with her product she will likely buy it again. To express this in a simple form, we assume that a consumer of firm $i$'s product sticks to the firm with probability $s_i$ and does not re-buy with probability $1-s_i$.

If a consumer decides to buy a different product at the outset, she will look at all products available in the market and decides in favor of the one that best fits her preference. Since firms do not know the preferences of consumers ex ante, the probability with which firm $i$ can attract a non-loyal unsatisfied consumer is

$$\frac{m_i}{\sum_{j=1}^{M} m_j}.$$

This implies that a consumer's choice when deciding not to re-buy the product again, is independent of the product she has at the outset, and, from the firm's perspective, the consumer makes random choice. The idea here is that a consumer's preferences may change over time, that is, she spontaneously chooses to buy a product she is attracted to. For example, in the magazine industry, several readers at one point would like to try out a new magazine and decide spontaneously at the news stand which magazine to buy.[3]

[2] This logic also holds for other industries. For instance, in the soft-drink industry, investments to improve the drinks' recipes can usually be used not only for a single product but for many.

[3] In the extension including price competition in Section 4 a switching consumer's choice which product to buy will be a combination of products' prices and her preference.

As a consequence, there are three different sources of demand for a firm. The first are loyal consumers of the firm, as these stick to their previous product. Second, among the non-loyal consumers a fraction $s_i$ re-buys the product of firm $i$ because it is satisfied. Third, among the non-loyal consumers who change their product choice because they are not satisfied, firm $i$ attracts a fraction through its choice of the product variety.

With respect to the timing of the game, we assume that firms play a simultaneous game, that is, they choose the customer satisfaction level $s_i$ and the product variety $m_i$ simultaneously. Our equilibrium concept is therefore Nash equilibrium. Again, the assumption of simultaneous choices simplifies the presentation of the analysis. In Section 4, we show that our qualitative results are unchanged if the choices are sequential and $s_i$ is chosen before $m_i$.

To simplify the exposition we focus on a situation with symmetric firms, that is, all firms offer the same product variety at the outset in the main analysis. This assumption is not crucial for the results. In Section XX, we consider the case of asymmetric firms and show that all findings qualitatively hold

In summary, the model is intended to capture two important dimensions by which firms compete to attract consumers in a simple way. First, firms can provide high quality which allows them to keep many of their previous consumers because these are satisfied with the product. Second, firms can offer a large variety of products to attract many consumers who are no satisfied with their previous product and who therefore are willing to switch. However, becoming more attractive in either dimension is costly for firms.

Finally, to ensure that solutions are interior (i.e., the profit function of a firm is quasi-concave), we assume that the cost function for investment in consumer satisfaction is sufficiently convex. Specifically, we assume that $c > \left(v(1-\alpha)(M-1)(2M+1)\right)/(4M^3)$. As we will show later, this also guarantees that the consumer satisfaction level does not exceed 1 in equilibrium which needs to be the case as $s_i$ is a probability.

# 3 Analysis and Results

In this section, we solve for the Nash equilibrium of the game described in the previous section. Afterwards, we analyze how the product variety chosen by firms in equilibrium changes with the market environment (i.e., the value of the market, the number of competing firms, and consumer loyalty).

Denoting by $\mathbf{m} = \{m_1, ..., m_M\}$ and $\mathbf{s} = \{s_1, ..., s_M\}$ the vector of product varieties and customer satisfaction levels, respectively, the profit function of firm $i$ is

$$\Pi_i(\mathbf{s},\mathbf{m}) = \frac{\alpha v m_{i0}}{\sum\limits_{j=1}^{M} m_{j0}} + \frac{(1-\alpha) v m_{i0} s_i}{\sum\limits_{j=1}^{M} m_{j0}} + \left(\frac{(1-\alpha) v m_{i0}(1-s_i)}{\sum\limits_{j=1}^{M} m_{j0}}\right)\left(\frac{m_i}{\sum\limits_{j=1}^{M} m_j}\right)$$

$$+ \left(\frac{(1-\alpha) v \sum\limits_{j=1,\, i\neq j}^{M} m_{j0}(1-s_j)}{\sum\limits_{j=1}^{M} m_{j0}}\right)\left(\frac{m_i}{\sum\limits_{j=1}^{M} m_j}\right) - f m_i - c s_i^2.$$

The first term is the revenue from loyal consumers where firm $i$ faces a demand of $1/\sum\limits_{j=1}^{M} m_{j0}$ for each of its $m_{i0}$ products. A fraction $\alpha$ of consumers will re-buy the same product with firm $i$ charging a price of $v$ for its products. The second term is the revenue from non-loyal consumers of firm $i$ who are satisfied with the product they had at the outset. Since this occurs with probability $s_i$, a fraction $s_i$ of non-loyal consumers will stay with a product of firm $i$. By contrast, a fraction $1-s_i$ of firm $i$'s previous consumers is not satisfied and will therefore switch. However, with probability $m_i/\sum\limits_{j=1}^{M} m_j$, these consumers will again decide in favor of a product of firm $i$. The revenue from these consumers is represented by the third term.[4] The fourth term is the revenue from dissatisfied non-loyal consumers of all other firms but firm $i$ who choose to buy a product from firm $i$. Finally, the fifth and the sixth term are costs for investing into product variety and consumer satisfaction, respectively.

Taking derivatives of $\Pi_i(\mathbf{s},\mathbf{m})$ with respect to $m_i$ and $s_i$, yields the two first-order conditions[5]

$$\frac{\partial \Pi_i(\mathbf{q},\mathbf{m})}{\partial m_i} = -\frac{(1-\alpha) v \sum\limits_{j=1,\, i\neq j}^{M} m_j \left(\sum\limits_{j=1}^{M} m_j(1-s_j)\right)}{\left(\sum\limits_{j=1}^{M} m_{j0}\right)\left(\sum\limits_{j=1}^{M} m_j\right)^2} - f = 0.$$

[4]Since we treat $m_i$ as a continuous variable, the consumer will end up with the some product of firm $i$ (with which she was not satisfied) with a probability of (almost) zero. Changing this assumption an treating the product variety as a discrete variable yields the same results but makes the analysis more cumbersome.

[5]We show in Appendix A that the profit function $\Pi_i(\mathbf{s},\mathbf{m})$ is quasi-concave and, hence, the optimal values of $m_i$ and $s_i$ are characterized by the first-order conditions.

and

$$\frac{\partial \Pi_i(\mathbf{q},\mathbf{m})}{\partial s_i} = -\frac{(1-\alpha)vm_{i0}\sum\limits_{j=1,\, i\neq j}^{M} m_j}{\left(\sum\limits_{j=1}^{M} m_{j0}\right)\left(\sum\limits_{j=1}^{M} m_j\right)^2} - 2cs_i = 0.$$

It is evident that both strategy variables of a firm aim at increasing its demand. However, they achieve this in different ways. Increasing customer satisfaction helps a firm to retain its consumers, as only those consumers who are current customers of the firm can evaluate the firm's products. This implies that raising $s_i$ increases the demand of those consumers the firm already has at the outset. By contrast, via increasing its product variety, a firm's goal is to convince consumers who were satisfied with their previous product or those who would like to try out a different one to buy one of its products. A larger product variety implies an increase in the probability that one of the firm's products is aligned with a consumer's preference. This increases the firm's demand.

We can now determine the relationship between the two instruments. Using the Implicit Function Theorem yields

$$\text{sign}\left\{\frac{dm_i}{dq_i}\right\} = \text{sign}\left\{-\frac{(1-\alpha)vm_{i0}\sum\limits_{j=1,\, i\neq j}^{M} m_j}{\left(\sum\limits_{j=1}^{M} m_{j0}\right)\left(\sum\limits_{j=1}^{M} m_j\right)^2}\right\},$$

which is strictly negative. It follows that larger product variety and higher consumer satisfaction in are substitutes (i.e., the optimal $m_i$ is falling in $s_i$). The intuition is as follows: a larger investment in consumer satisfaction induces a smaller mass of consumers to switch to a different product. However, the reason to increase product variety for a firm is to attract switching consumers (i.e., 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 level of consumer satisfaction of a firm's products is higher. This induces the firm to lower its product variety.

We can solve the two first-order conditions for the Nash equilibrium. Focusing on symmetric firms, that is, $m_{i0}$ is the same for all firms $i = 1, ..., M$, we obtain that there is a unique symmetric equilibrium, in which all firms $i = 1, ..., M$ choose a product variety of

$$m_i^\star = \frac{(1-\alpha)(M-1)v(2cM^2 - v(M-1)(1-\alpha))}{2cfM^4} \tag{1}$$

and a consumer satisfaction level of

$$s_i^\star = \frac{(1-\alpha)(M-1)v}{2cM^2}.^6 \tag{2}$$

Having derived the equilibrium, we can now move to the question of how a firm's product variety is affected by the market environment. To analyze this, we perform comparative-static analyzes on the equilibrium product variety $m_i^\star$.

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

$$\frac{\partial m_i^\star}{\partial v} = \frac{(1-\alpha)(M-1)v(cM^2 - v(M-1)(1-\alpha))}{cfM^4}. \tag{3}$$

It is easy to check that this derivative is negative if

$$v \geq \frac{cM^2}{(M-1)(1-\alpha)}.^7$$

Therefore, we obtain our first result:

**Result 1.** *The equilibrium number of products of each firm falls in the per-consumer value $v$ 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 segment is more valuable (i.e., the consumers' willingness-to-pay is relatively high), firms usually find it more profitable to offer a larger number of products. 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.[8]

However, in our model there is a countervailing effect. In a market segment, which is very valuable, each firm has an increased incentive to retain its buyers. It will do so by investing more in consumer satisfaction, thereby inducing fewer consumers to switch to rival firms' products. It is easily seen from Equation (2) that $s_i^\star$ increases in $v$. Because all firms invest more, the number of dissatisfied consumers falls, implying that each firm can only attract

[6]We show that our assumption on $c$ implies that $s_i^\star < 1$ in Appendix B.

[7]It is easy to check that this condition is compatible with our assumption. In fact, the assumption to guarantee quasi-concavity of the profit function implies $v < 4M^3c/\left((M-1)(2M+1)(1-\alpha)\right)$, where the right-hand side of this inequality is strictly larger than $cM^2/\left((M-1)(1-\alpha)\right)$.

[8]We will indeed confirm this intuition in a classic model of product variety, that we present in Section XX.

fewer of these consumers with its product variety. As a consequence, firms respond with a reduction in the number of products they offer. The counter-intuitive effect therefore results from the interplay between investment in consumer satisfaction and in product variety. In fact, if $s_i$ was fixed, an increase in $v$ would unambiguously lead to an increase in the number of products. However, since both investments are substitutes, this result no longer holds.

Result 1 shows that this effect dominates if $v$ is particularly large. The reason is that with a large $v$, the satisfaction level provided by firms is high, thereby inducing most consumers to stick to their choice. As a consequence, investing in new product variety does not pay off much. By contrast, if $v$ increases starting from a low level, the direct effect that the market segment becomes more valuable dominates, implying that each firm optimally increases its product variety. As we argue in the empirical section, it is plausible that $v$ must be relatively high in each segment in which several firms are active. The reason is that fixed costs from entry into a segment are usually high, implying that segments with $v$ close to zero or small will not be covered.

Second, we turn to the number of firms $M$. The number of firms reflects the degree of competition for switching consumers. The more firms are active in a particular segment, the lower the probability that a dissatisfied consumer will buy one of the products from a firm. Taking the derivative of $m_i^\star$ with respect to $M$ yields

$$\frac{\partial m_i^\star}{\partial M} = -\frac{(1-\alpha)(M-2)v(cM^2 - v(M-1)(1-\alpha))}{cfM^5}, \tag{4}$$

which is positive if

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

We can then state our second result:

**Result 2.** *The equilibrium number of products of each firm increases in the number of firms $M$ in a segment for sufficiently large $v$.*

Result 2 demonstrates that an increase in competition caused by a larger number of firms might induce firms to expand their number of products. The intuition behind this result is rooted in the interplay between investment in consumer satisfaction 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 consumers with its products. Because the costs of investing in product variety is unchanged, each firm optimally reduces the number of product it offers.

At the same time, an increase in the number of firms also implies that each firm has a lower market share of its existing products. Consequently, providing high-quality products that lead to high satisfaction levels pays off less because fewer consumers experience the products. As a consequence, investment in consumer satisfaction falls. This in turn leads to a larger number of switching consumers, which renders an increased product variety profitable for each firm. This indirect 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 $s_i^\star$ caused by an increase in the number of firms is high if $v$ is large.

Third, we study how the share of loyal consumers, denoted by $\alpha$, affects equilibrium product variety. Loyal consumers stick with the product they previously bought, regardless of the satisfaction level. Since an increasing share of loyal consumers implies that firms can attract fewer consumers with their products, this share will affect the optimal number of products offered by a firm in equilibrium. To show that the relationship between the product variety and the share of loyal consumers is non-monotonic, we differentiate $m_i^\star$ twice with respect to $\alpha$ to get

$$\frac{\partial^2 m_i^\star}{\partial(\alpha)^2} = -\frac{v^2(M-1)^2)}{cfM^4} < 0. \tag{5}$$

In addition, the first derivative is positive if and only if

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

We therefore obtain the following result:

**Result 3.** *The relationship between the equilibrium number of products and the share of loyal consumers $\alpha$ is concave, with the number of products increasing for low values of $\alpha$ but decreasing for high values of $\alpha$.*

The decreasing part of the non-monotonicity is not surprising. The optimal number of products 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 effect of the share of loyal consumers on the investment in consumer satisfaction. As loyal consumers do not react to changes in the satisfaction level, firms find it optimal to lower their 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 of such consumers. If the share of non-loyal consumers is large (i.e., if $\alpha$ is small), this effect dominates and leads to a positive relationship between $m_i^\star$ and $\alpha$.

Finally, we turn to the interaction effects between the three variables. Here, we obtain the following result whose derivation is relegated to Appendix C.

**Result 4.**
*(a) The absolute effect of the per-consumer value $v$ on the equilibrium number of products $m_i^\star$ becomes smaller if the number of firms $M$ is larger.*
*(b) The absolute effect of the per-consumer value $v$ on the equilibrium number of products $m_i^\star$ becomes smaller if the share of loyal consumers $\alpha$ is larger. In addition, the absolute value of this effect is larger than the absolute value of the effect in (a).*
*(c) The absolute effect of the number of firms $M$ on the equilibrium number of products $m_i^\star$ becomes smaller if the share of loyal consumers $\alpha$ increases.*

The intuition behind these results is as follows: If the number of firms increases, competition gets fiercer, which implies that each firm's profit falls. The effect of a change in the consumer valuation on the firms' choices of their product variety becomes less important. This explains Result 4(a). The result holds regardless of whether product variety increases or decreases with the value of the market. In other words, if $v$ is small, the positive effect of $v$ on product variety gets diminished whereas if $v$ is large, the negative effect gets diminished.

A similar explanation applies for the first part of Result 4(b) and Result 4(c). As loyal consumers are immune to changes in the product variety, if more loyal consumers are present, each firm reacts less in its product variety to a change in consumer valuations and the number of competitors. Again, this holds regardless of whether $v$ and $M$ have a positive or a negative effect on product variety.

Finally, the second part of Result 4(b) states that the moderating effect of loyal consumers is stronger than the one of competing firms. The reason is that loyal consumers affect a firm's demand and therefore the product variety directly whereas the competitors do so only indirectly via their choice of product variety and customer satisfaction level.

# 4 Robustness and Extensions

In this Section, we consider several extensions of the baseline model. First, we show that the model's predictions are robust to a situation in which investment in the customer satisfaction level do not spill over to all products but most be done for each product separately (Section 4.1). Second, we analyze the case in which the choice of customer satisfaction and product variety is a sequential one (Section 4.2). Third, we demonstrate that our results carry over to the case in which firms are asymmetric at the outset, that is, some firms have a big product variety and others a small one (Section 4.3). Finally, we show how price competition can be included in our model and how it affects the results (Section 4.4).

## 4.1 No Economies of Scale

In the baseline model, we considered the situation in which investment in the customer satisfaction level must only be done once by firms and then applies to all firm's products. In this respect, there are strong economies of scale. In this section, we consider the opposite case without economies of scale. This implies that for each existing product, the firm decides about the satisfaction level.

Denoting by $k$ the product of firm $i$, with $k = 1, ..., m_{i0}$, the overall cost of firm $i$ from investing in customer satisfaction are given by $c \sum_{k=1}^{m_{i0}} s_{ki}^2$, where $s_{ki}$ is the the customer satisfaction level of product $k$ of firm $i$. The resulting profit function is then given by

$$\Pi_i(\mathbf{s}, \mathbf{m}) = \frac{\alpha v m_{i0}}{\sum\limits_{j=1}^{M} m_{j0}} + \frac{(1-\alpha)v \sum\limits_{k=1}^{m_{i0}} s_{ki}}{\sum\limits_{j=1}^{M} m_{j0}} + \left( \frac{(1-\alpha)v \sum\limits_{k=1}^{m_{i0}} (1 - s_{ki})}{\sum\limits_{j=1}^{M} m_{j0}} \right) \left( \frac{m_i}{\sum\limits_{j=1}^{M} m_j} \right)$$

$$+ \left( \frac{(1-\alpha)v \sum\limits_{j=1,\, i \neq j}^{M} \sum\limits_{k=1}^{m_{j0}} (1 - s_{kj})}{\sum\limits_{j=1}^{M} m_{j0}} \right) \left( \frac{m_i}{\sum\limits_{j=1}^{M} m_j} \right) - f m_i - c \sum_{k=1}^{m_{i0}} s_{ki}^2.$$

We can then proceed in the same way as in Section 3 to solve for the equilibrium product variety and customer satisfaction level. Again, assuming that firms are symmetric and have the same product variety to start with, that is, $m_{10} = m_{20} = \cdots = m_{M0} = m_0$, we obtain that in the unique symmetric equilibrium

$$m_i^\star = \frac{(1-\alpha)(M-1)v(2cM^2 - v(M-1)(1-\alpha))}{2cfm_0M^4} \quad \text{and} \quad s_i^\star = \frac{(1-\alpha)(M-1)v}{2cm_0M^2}.$$

It is evident that the only difference between these equilibrium values and the ones in (1) and (1) is that now $m_0$ shows up the denominator. Because $m_0$ is a parameter, it dos not affect the sign of the derivatives of the equilibrium values with respect to $v$, $M$, and $\alpha$. As a consequence, all results derived in Section 3 carry over to the case in which no economies of scale are present.

## 4.2 Sequential Choices

In the baseline model, we considered the case in which the product variety and the customer satisfaction level are chosen simultaneously. This is a reasonable assumption as the product spectrum of a firm requires some planning which is done in parallel to choosing the quality and thereby the satisfaction level of existing products. However, as the customer satisfaction level refers to the products that a firm offers at the outset and may also be a longer-term choice, a sequential timing in which the satisfaction level of existing products is chosen before the product variety is also conceivable. In this section, we analyze such a sequential scenario.

We solve the game by backward induction. Assuming symmetry of firms at the outset, we obtain that in the unique subgame perfect equilibrium, the customer satisfaction level is[9]

$$s_i^{\star\star} = \frac{v(1-\alpha)(M+1)(M-1)}{2cM^3} \tag{6}$$

and the product variety

$$m_i^{\star\star} = \frac{v(1-\alpha)(M-1)\left(M^2(2cM - v(1-\alpha)) + v\right)}{2cfM^5} \tag{7}$$

for each firm $i = 1, ..., M$.

Comparing these equilibrium levels with the ones of the simultaneous game, we obtain

$$s_i^\star - s_i^{\star\star} = -\frac{v(1-\alpha)(M-1)}{2cM^3} < 0$$

and

$$m_i^\star - m_i^{\star\star} = \frac{v^2(1-\alpha)^2(M-1)^2}{2cfM^5} > 0.$$

Therefore, the equilibrium customer satisfaction level is higher in the sequential game compared to the simultaneous one, whereas the opposite result holds for the product variety (i.e., it is smaller in the sequential game than in the simultaneous one). The intuition behind the result is as follows: If a firm invests more in the customer satisfaction level, less consumers as willing to switch to a new product, which implies that investment into the product variety pays off to a smaller extent for each firm. As the customer satisfaction level is chosen before the product variety in the sequential game, each firm can induce the rivals to choose a smaller product variety by investing more in customer satisfaction. As a smaller product variety of rivals is beneficial because it implies that the firm obtains a larger fraction of the switching consumers, each firm will do so in equilibrium. This leads to a higher level of customer satisfaction and a smaller product variety.

We can determine whether the results of the baseline model carry over. Taking the

[9]The assumption on $c$ made in Section 3 guarantees that the customer satisfaction level is below 1 also in the sequential case.

derivative of $m_i^{\star\star}$ with respect to $v$ yields that it is negative if

$$v > \frac{cM^3}{(1-\alpha)(M+1)(M-1)}.$$

Comparing this threshold with the one of the simultaneous game, we obtain that $\partial m_i^{\star\star}/\partial v < 0$ for an even smaller value of $v$. This implies that Result 1 of the previous section carries over and now holds for an even larger parameter range. In addition, the absolute value of $\partial m_i^{\star\star}/\partial v$ is smaller the larger are $M$ and $\alpha$, which confirms Results 4(a) and 4(b), first part.

Similarly, the derivative of $m_i^{\star\star}$ with respect to the number of firms $M$ is negative if

$$v > \frac{2cM^3(M-2)}{(1-\alpha)(M-1)(2M^2-M-5)}.$$[10]

Again, the threshold value for $v$ is smaller than in the simultaneous game, which shows that also Result 2 of the previous section holds for a larger parameter range. The absolute value of $\partial m_i^{\star\star}/\partial M$ is also smaller the larger is $\alpha$ and $|\partial m_i^{\star\star}/\partial v| < |\partial m_i^{\star\star}/\partial M|$, whenever $\partial m_i^{\star\star}/\partial v < 0$ and $\partial m_i^{\star\star}/\partial M > 0$ which confirms Results 4(c) and 4(b), second part.

Finally, taking the derivative of $m_i^{\star\star}$ with respect to the consumer loyalty level $\alpha$ yields that it is positive if $\alpha < (v(M^2-1) - cM^3)/[v(M-1)(M+1)]$, negative at $\alpha = 1$, and strictly concave due to the fact that

$$\frac{\partial^2 m_i^{\star\star}}{\partial\left(\alpha\right)^2} = -\frac{v^2(M-1)^2(M+1)}{cfM^5} < 0.$$

Therefore, also Result 3 of the previous section carries over to the sequential timing.

## 4.3 Asymmetric Firms

We solved the baseline model for the case of symmetric firms, that is, all firms offer the same product variety at the outset (i.e., $m_1 0 = m_{20} = \cdots = m_{M0}$). In this Section, we show that our results carry over to the case of asymmetric firms. To simplify the exposition, we consider a situation with two different types of firms. As will become clear after the analysis, the situation with $M$ different firm can be tackled in the same way and delivers qualitatively the same results.[11]

[10] The right-hand side is (weakly) positive for all $M \geq 2$.

[11] Firms may also differ in other dimensions. For example, that may have different costs to offer an additional product (i.e., different $f$) or differ in their investment cost of consumer satisfaction (i.e., different $c$). Solving for the equilibrium in these situations can be achieved in the same way as in case firm differ in their product variety at the outset and leads to similar results.

Suppose that, among the $M$ firms, $K < M$ firms offer a product variety $\underline{m}_0$ at the outset, whereas $M - K$ firms offer a variety of $\overline{m}_0$ a the outset, with $\underline{m}_0 \neq \overline{m}_0$. The profit function of firm $i$ offering a product variety of $\underline{m}_0$ at the outset is then given by

$$\frac{\alpha v \underline{m}_0}{K\underline{m}_0 + (M-K)\overline{m}_0} + \frac{(1-\alpha)v\underline{m}_0 s_i}{K\underline{m}_0 + (M-K)\overline{m}_0} + \left(\frac{(1-\alpha)v\underline{m}_0(1-s_i)}{K\underline{m}_0 + (M-K)\overline{m}_0}\right)\left(\frac{m_i}{\sum\limits_{j=1}^{M} m_j}\right)$$

$$+\left(\frac{(1-\alpha)v\left(\sum\limits_{j=1,\, i\neq j}^{K}\underline{m}_0(1-s_j) + \sum\limits_{j=K+1}^{M}\overline{m}_0(1-s_j)\right)}{K\underline{m}_0 + (M-K)\overline{m}_0}\right)\left(\frac{m_i}{\sum\limits_{j=1}^{M} m_j}\right) - fm_i - cs_i^2.$$

The structure of this profit is equivalent to the one of the baseline model, taking into account that there are only two types of firms (i.e., some with a variety of $\underline{m}_0$ at the outset and some with a variety $\overline{m}_0$).

Proceeding in the same way as in the baseline model to solve for the equilibrium customer satisfaction levels and the product varieties yields that in the unique equilibrium[12]

$$\underline{s}^\star = \frac{v\underline{m}_0(M-1)(1-\alpha)}{2c\left(K\underline{m}_0 + (M-K)\overline{m}_0\right)}, \quad \overline{s}^\star = \frac{v\overline{m}_0(M-1)(1-\alpha)}{2c\left(K\underline{m}_0 + (M-K)\overline{m}_0\right)} \tag{8}$$

and

$$\underline{m}^\star = \overline{m}^\star = \frac{v(M-1)(1-\alpha)\psi}{2fcM^3\left(K\underline{m}_0 + (M-K)\overline{m}_0\right)^2}, \tag{9}$$

with

$$\psi \equiv 4Mc\underline{m}_0\overline{m}_0K(M-K) + 2cM\left(K^2\underline{m}_0 + (M-K)^2\overline{m}_0\right) - v(M-1)(1-\alpha)\left(K\underline{m}_0 + (M-K)\overline{m}_0\right).$$

It is evident from (8) and (9) that the equilibrium consumer satisfaction levels for the two types of firms differ but not the equilibrium variety. We first explain the intuition for the former result. From (8), $\overline{s}^\star \geq \underline{s}^\star$ if and only if $\overline{m}_0 \geq \underline{m}_0$, that is, the group of firms which has a larger product variety at the outset, will invest more in customer satisfaction. This is intuitive: Because this group has more consumers, it benefits to a greater extent from retaining its consumers, and is therefore willing to invest more. We now turn to the result that both types of firms offer the same product variety in equilibrium. The intuition for this

[12]Here, $\underline{q}^\star$ and $\underline{m}^\star$ are the equilibrium levels for firms with a product variety of $\underline{m}_0$ at the outset and $\overline{q}^\star$ and $\overline{m}^\star$ are those for firms with product variety $\overline{m}_0$ at the outset.

result is that the mass of dissatisfied consumers who are willing to buy a new product is the dame for all firms. Because firms choose their product varieties to attract these consumers and face the same costs for offering an additional product, the equilibrium product variety is the same for both firms.[13]

Before providing the comparative static analyses, we note that considering more than just two types of firms leads to very similar results. The model is then more complicated to solve, as, given that there $k$ different types of firms, with $2 \leq k \leq M$, there are $2 \times K$ unknowns, but the method is the same and the results are qualitatively similar.

We can show that the results of the baseline model also hold in case of asymmetric firm. First, denoting $\underline{m}^\star = \overline{m}^\star$ by $\hat{m}^\star$ and taking the derivative of $\hat{m}^\star$ with respect to $v$ we obtain that the equilibrium product variety is increasing in the consumer valuation if and only if

$$v > \frac{Mc\left(K\underline{m}_0 + (M-K)\overline{m}_0\right)^2}{(1-\alpha)(M-1)\left(K\left(\underline{m}_0\right)^2 + (M-K)\left(\overline{m}_0\right)\right)}. \tag{10}$$

Similarly, taking the derivative of $\hat{m}^\star$ with respect to $M$ yields that the equilibrium product variety is decreasing in the number of firms if

$$v > \frac{cM(M-2)\left(K\underline{m}_0 + (M-K)\overline{m}_0\right)^3}{(M-1)(1-\alpha)\rho}, \tag{11}$$

with

$$\begin{aligned} \rho \equiv\ & K^2(M-3)\underline{m}_0 + (M-K)\left(2M(M-2) + K(M-3)\right)\overline{m}_0 \\ & -\overline{m}_0\underline{m}_0 K\left((3M^2 - M(K+5) - 3K)\underline{m}_0 + (M(K+2) - 3K)\overline{m}_0\right). \end{aligned}$$

Therefore, as in the baseline model, if $v$ is large enough $\partial\hat{m}^\star/\partial v < 0$ and $\partial\hat{m}^\star/\partial M > 0$.

Taking the derivative of $\hat{m}^\star$ with respect to $\alpha$ yields that the equilibrium product variety is concave in the share of loyal consumers because

$$\frac{\partial^2\hat{m}^\star}{\partial\left(\alpha\right)^2} = -\frac{v^2(M-1)^2\left(K\left(\underline{m}_0\right)^2 + (M-K)\left(\overline{m}_0\right)^2\right)}{cfM^3\left(K\underline{m}_0 + (M-K)\overline{m}_0\right)^2} < 0.$$

and strictly increasing if $\alpha$ is small enough:

$$\alpha < 1 - \frac{cM\left(K\underline{m}_0 + (M-K)\overline{m}_0\right)^2}{v(M-1)\left(K\left(\underline{m}_0\right)^2 + (M-K)\left(\overline{m}_0\right)^2\right)}.$$

[13] If firms differed in their costs for offering variety $f$, the result would be different and firms with a lower $f$ offer a larger variety.

Therefore, all Results 1-3 carry over to the case of asymmetric firms. The intuition is very similar as outlined in the last Section. Finally, it is also straightforward to verify that also Result 4 (a)-(c) holds with asymmetric firms.

## 4.4 Price Competition

In this Section, we extend our baseline model to account for price competition between firms. This implies that firms do not only choose the customer satisfaction level and the product variety but also set a price for each product they offer. Consumers are more likely to buy a cheaper product, capturing the standard effect of price competition.

Our aim is to capture in a simple way that a lower price increases the probability that a consumer buys the firm's product but the price is not the only dimension a consumer cares about (e.g., due to product differentiation or imperfect information), implying that the product with the lowest price does not obtain the entire demand. Formally, the probability that a consumer buys product $k$ of firm $i$, with $k = 1, ..., m_i$, given that prices of all products denoted by $p_{ki}$, $i = 1, ..., M$, is

$$\frac{(v - p_{ki})^\beta}{\sum_{j=1}^{M} \sum_{k=1}^{m_j} (v - p_{kj})^\beta}. \tag{12}$$

As consumers obtain a gross utility of $v$ from each product, the net utility of product $k$ of firm $i$ is $v - p_{ki}$. Therefore, from (12), consumers are more likely to buy a product that yields a higher net utility (i.e., a product with a cheaper price). The extent by which the price influences the buying probability is determined by the parameter $\beta \in [0, \infty)$. If $\beta = 0$, we are in the baseline model, as (12) boils down to $1/\sum_{j=1}^{M} m_j$; the product price then does not influence the buying probability and all consumers decide on a random basis. By contrast, of $\beta \to \infty$, only the product that provides he highest net utility to consumers will be bought by unsatisfied consumers. The model is then one of perfect Bertrand competition. For any intermediate value of $\beta$, the model can be interpreted as one in which firms offer differentiated products and consumers decide according to the price and partly according to their preferences.[14]

We note that the formulation is a variant of a standard urn-ball matching function (see e.g., Petrongolo and Pissarides, 2001), where the products of the firms take the role of balls. However, in contrast to the classical urn-ball matching function, the balls have different matching probabilities and firms can influence the matching probability with the prices they

[14] Another interpretation is that some consumers decide on a random basis whereas others decide only on the basis of the price.

set for their products.[15]

Given (12), and denoting by $\mathbf{p} = \{p_{11}, ..., p_{m_M M}\}$ the vector of price of all firms' products, the profit function of firm $i$ is

$$\Pi_i(\mathbf{s}, \mathbf{m}, \mathbf{p}) = \left( \frac{\alpha m_{i0} + (1-\alpha) m_{i0} s_i}{\sum\limits_{j=1}^{M} m_{j0}} \right) \left( \frac{\sum\limits_{k=1}^{m_i} p_{ki}(v - p_{ki})^\beta}{\sum\limits_{k=1}^{m_i} (v - p_{ki})^\beta} \right) + \left( \frac{(1-\alpha) m_{i0}(1 - s_i)}{\sum\limits_{j=1}^{M} m_{j0}} \right) \left( \frac{\sum\limits_{k=1}^{m_i} p_{ki}(v - p_{ki})^\beta}{\sum\limits_{j=1}^{M} \sum\limits_{k=1}^{m_j} (v - p_{kj})^\beta} \right)$$

$$+ \left( \frac{(1-\alpha) \sum\limits_{j=1,\, i \neq j}^{M} m_{j0}(1 - s_j)}{\sum\limits_{j=1}^{M} m_{j0}} \right) \left( \frac{\sum\limits_{k=1}^{m_i} p_{ki}(v - p_{ki})^\beta}{\sum\limits_{j=1}^{M} \sum\limits_{k=1}^{m_j} (v - p_{kj})^\beta} \right) - f m_i - c s_i^2.$$

As in the baseline model, the first two term represents the profit from loyal consumers and from non-loyal consumers who are satisfied with the product from firm $i$. They buy a product from firm $i$ again and choose one of firm $i$'s products according to the probability given by (12), taking into account that only products of firm $i$ are relevant for these consumers. It is evident that the firm does no longer receive a revenue of $v$ but the price that it charges for the product bought by the consumer. The third and the fourth term represent the profit from non-loyal consumers who are dissatisfied either with a product of firm $i$ (third term) or with a product from a competitor (fourth term). The probability of buying is now modified according to (12), and firm $i$ receives the respective price instead of $v$. Finally, the fourth and fifth term represent the costs from investing into product variety and customer satisfaction, respectively.

We can now solve the model in the same way as in the baseline model.[16] Focusing on a symmetric equilibrium (i.e., $m_{10} = m_{20} = \cdots = m_{M0}$), we obtain that the equilibrium price, customer satisfaction level, and product variety are given

$$\tilde{p}^\star = \frac{M\left(cM\left(M + (M-1)(1-\alpha)\beta\right) - \sqrt{\xi}\right)}{(M-1)^2(1-\alpha)^2\beta}, \quad \tilde{s}^\star = \frac{cM\left(M + (M-1)(1-\alpha)\beta\right) - \sqrt{\xi}}{2cM(M-1)(1-\alpha)\beta},$$

and

$$\tilde{m}^\star = \frac{\left(cM\left(M + (M-1)(1-\alpha)\beta\right) - \sqrt{\xi}\right)\left(\sqrt{\xi} - cM\left(M(1-\beta) + \beta + \alpha\beta(M-1)\right)\right)}{2cfM^2(M-1)^2(1-\alpha)^2\beta^2},$$

[15]See Fainmesser and Galeotti (2018) for a similar formulation in a different context (i.e., influencers in social media choose the quality a follower obtains, and an influencer probabilistically gains more followers with higher quality).

[16]As in the baseline model, we assume that $c$ is sufficiently large to guarantee quasi-concavity of the profit function and that the customer satisfaction level is below 1 in equilibrium.

where

$$\xi \equiv c^2M^2\left(M+(M-1)(1-\alpha)\beta\right)^2 - 2vcM(M-1)^2(1-\alpha)^2\beta.$$

Due to the additional strategic variable of the price, the formulas are more complicated than in the baseline model. However, applying the rule of L'Hospital, it is easy to show that $\tilde{p}^\star = v$ when $\beta = 0$. Then, also $\tilde{s}^\star = s^\star$ and $\tilde{m}^\star = m^\star$; hence, the solution is continuous. The larger is $\beta$—i.e., the more weight is on price competition—the lower are the equilibrium customer satisfaction level and product variety, as investment is no longer as valuable as without price competition.

We note that the analysis allows to determine a positive relation between $v$ and $\tilde{p}^\star$, that is, the larger is the consumers' willingness-to-pay, the higher is the equilibrium price.[17] The result is very intuitive because firms exploit that consumers have higher reservation values by setting higher prices. In the empirical analysis, we will measure the value of a market by the product prices, and the relationship derived in this section provides a justification for this measurement.

We can turn to the comparative-static analyses and check whether our results carry over to the case of price competition. First, we obtain that $\partial\tilde{m}^\star/\partial v$ and $\partial\tilde{m}^\star/\partial M$ are both positive if and only if

$$v > \frac{cM^2}{(M-1)(1-\alpha)} + \frac{\beta cM}{2}. \tag{13}$$

Therefore, we obtain the same qualitative results as Results 1 and 2 of the baseline model, that is, the equilibrium product variety is falling in the consumers' valuation and the increasing in the number of firms if $v$ is large enough. The threshold value for $v$ is larger than in the baseline model; however, it is never in conflict with the assumption guaranteeing an interior solution and the range for which (13) holds is always sizable. Turning to consumer loyalty, we can also confirm Result 3 of the baseline model. In fact $\partial\tilde{m}^\star/\partial\alpha$ is positive if and only if

$$\alpha < 1 - \frac{2cM^2}{(M-1)(2v-Mc\beta)}, \tag{14}$$

and the second derivative is strictly negative. Again, the threshold given by the right-hand side of (14) is tighter than the one in the baseline model but there is always a sizable parameter range such that (14) can be fulfilled. As a consequence, also Result 3 of the baseline model carries over. In the same way as in the baseline model, we can also show that Result 4 (a) - (c) holds in the case of price competition.

[17] Formally, $\tilde{p}^\star$ falls with $\xi$ and $\xi$ falls with $v$, which implies $\partial\tilde{p}^\star/\partial v > 0$.

# 5 Empirical Predictions

## 5.1 Hypotheses

We test our results on German magazine data. Results 1-3 all depend on consumer valuation $v$ to be sufficiently large. It is likely that magazine publishers are only active in market segments with a sufficiently high consumer valuation due to large fixed costs. In these segment, firms can charge a sufficiently high price to profitable offer at least one product—recall that in Section 4.4 we showed a positive relation between product prices and market value. Segments comprised of readers with only a low willingness-to-pay will not be served since fixed costs cannot be recovered. We therefore assume that $v$ indeed is sufficiently large. Therefore, the first prediction from our model, capturing Result 1, is formulated in the first hypothesis.

**Hypothesis 1.** *The effect of a higher revenue per consumer on a firm's number of products is negative.*

Similarly, we can formulate our hypothesis about the number of firms (Result 2).

**Hypothesis 2.** *The effect of a larger number of firms on a firm's number of products is positive.*

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 effect of increasing loyalty on a firm's number of products is positive for low levels of loyalty and negative for high levels of loyalty.*

We now turn to Result 4, which allows us to formulate hypotheses on the moderating effect of the variables. The first contingency, capturing Result 4(a), describes the moderating effect of the number of firms.

**Contingency 1.** *An increase in the number of competing firms weakens the negative effect of revenue per consumer on the equilibrium number of products; i.e. the interaction between the two variables is positive.*

The second contingency, derived in Result 4(b), describes the moderating effect of consumer loyalty.

**Contingency 2.** *An increase in consumer loyalty weakens the negative effect of revenue per consumer on the equilibrium number of products; i.e. the interaction between the two* *variables is positive. In addition, the absolute effect on consumer loyalty on the revenue per consumer is larger than the absolute effect of the number of firms on the revenue per consumer.*

Finally, Contingency 3, which is captured by Result 4(c), describes how consumer loyalty moderates the effect of the number of firms on product variety.

**Contingency 3.** *An increase in consumer loyalty weakens the positive effect of the number of competing firms on the equilibrium number of products; i.e. the interaction between the two variables is negative.*

## 5.2 Difference to Standard Models

Before turning to the empirical analysis, we briefly discuss that the hypotheses derived in the previous Section are genuinely due to the interaction between customer satisfaction and product variety—as emphasized by our model—and differ from the hypotheses that classical models of imperfect competition deliver.

Consider for example a model of horizontal product differentiation, such as a representative consumer model (e.g., Bowley, 1924, or Singh and Vives, 1984) or a location model (e.g., Salop, 1979). In both types of models, if consumer valuations increase, equilibrium prices will rise, which implies that investments in product variety become more profitable as well. Therefore, the relation between the revenue per consumer and the number of products is positive—contrary to our Hypothesis 1.

This result obtains if the number of firms is exogenous. If there is free entry by firms and the market becomes more valuable, more firms may enter. In these type of models, this leads to a reduction in the product variety of each firm under some parameter constellations.[18] However, at the same time, it implies a positive relationship between per consumer revenue and the number of firms, which is in contrast to our Hypothesis 2.

Similar predictions are in models of vertical product differentiation, such as Shaked and Sutton (1982). An upward shift in the distribution of consumer taste parameters also leads either to a increase in product variety and/or an increase in the number of active firms. Therefore, obtaining Hypotheses 1 and 2 jointly in one model is not possible in these classical frameworks. In fact, these frameworks are not concerned with firms owning an existing stock of consumers and therefore do not consider customer management by investment in satisfaction levels. This is the novelty of our model, which allows for such investment together with variety choice, thereby leading to novel hypotheses.

[18]Details of the analysis are available from the authors upon request.

# 6 Data

## 6.1 Dataset

To test the predictions of our theoretical model, we use data from the German magazines industry. These data stem 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 cover prices, advertising rates (which we both convert into 2000 prices), the total number of copies sold, subscriber shares and identifiers for magazine segments. These core data have been collected quarterly since 1972.[19] We supplement them with 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. These data are the same as the ones used by advertisers willing to place ads in the magazines in our data. They are available on an annual basis for the years 1998 to 2010.

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 and topic (like TV, cars, politics). It is a very broadly accepted industry standard and used by, for example, AG.MA as well as in all "factsheets" that are prepared by each publisher to describe the key reader and magazine characteristics to potential advertising clients.[20].

Our data consist of 6002 observations on 179 magazines tracked over 49 time periods between 1998/I and 2010/I. These magazines are published by 30 unique publishing groups. 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 3444 segment-publisher-period observations.

[19] Chandra and Kaiser (2014) also use this data set to study targeted advertising and its relationship to an increasingly internet-affine audience.

[20] The publisher Bauer Verlag for example maintains an easy to navigate website for factsheet downloads: `http://www.baueradvertising.de/marken/zeitschriften/?tx_bmmediafinder_brandlisting[back]=1&cHash=d27b19f8ade95678744573011d7cdea6`

## 6.2 Descriptive evidence

We measure "value" by copyprices that we in turn calculate as the weigthed sum of newsstand prices and subscription rates, where we use the share of copies sold via subscriptions as weights. The number of competing firms in a segment is directly observed in our data while we proxy the third key variable of our theoretical model, consumer loyalty, by the share of subscribers in total sold copies. As Table 1 shows, the mean (subscription-adjusted) copyprice is 2.7 Euros with a minimum of 0.51 Euro and a maximum of 7.3 Euros. There are 2.22 other publishers per segment on average with a minimum of zero (i.e., some publishers are monopolists in a particular segment) and a maximum of five. A quarter of all copies are sold through subscriptions on average. In a robustness check, we consider *total* revenue per reader, which is the sum of copyprice and advertising revenue per reader, as an alternative measure of "value". This alternative proxy has an average of 18.6 Euros and varies between 1.9 and 200 Euros. Finally, we directly observe the dependent variable—the number of titles that a publishers offers in each segment. Its mean is 1.67 with a minimum number of one and a maximum number of eleven.

Table 1 here!

With these three proxies of our key variables at hand, we provide a first descriptive assessment of our three hypotheses in Figure 1. We Figure 1 displays scatterplots (left panel) and the results of fitted regressions of the number of magazine titles per publisher per segment (right panel) and (i) copyprices (top), (ii) the number of other publishers in the segment (middle), as well as (iii) subscriber shares (bottom). We annualize the data by taking the means (across segments and time) of each variable. The fitted regressions use linear regressions for copyprices as well as the number of other publishers in a segment and quadratic regressions for subscriber shares, which is consistent with our hypotheses.

The association between the number of titles per publisher is negative as indicated by the associated scatterplot. This is also reflected by our fitted regressions, providing support for Hypothesis 1. The scatterplot and the associated fit for the mapping between the number of titles per publisher in a segment and the number of titles by other publishers indicates a positive relationship, which is consistent with Hypothesis 2. Finally, the relationship between the number of titles and the share of subscribers is inversely u-shaped which is in line with Hypothesis 3.

Figure 1 here!

## 6.3 Additional control variables

In addition to the three key variables of our model and their interactions, our empirical model contains a set of additional control variables. These variables are not theory-driven but nonetheless likely to affect the number of titles which is why to control for them in order to mitigate possible omitted variable bias: (i) reader heterogeneity, (ii) potential market size, (iii) returns to scope, (iv) readers' Internet affinity, (v) presence of companion websites, (vi) a set of magazine periodicity dummies, (vii) a set of variables depicting printing cost and (viii) a set of time dummies. We describe these additional controls in detail in Appendix D.

Appendix E displays the pairwise correlations of the variables used in our main models. We find the correlations among the variables to be low. Moreover, the mean variance inflation factors is 4.97 for our most general model which is well below the critical value of 10 as suggested by Belsley et al. (1980).

# 7 Empirical results

## 7.1 Main results

Our dependent variable is the number of products per publisher and time period. It is a count variable; hence, we model it by a count data approach. Since our estimation results do not provide any indication for overdispersion, we use a Poisson model instead of the more popular negative binomial count data model.

We lag our explanatory variables by one period and include, apart from our key variables copyprice, number of titles by other publishers, subscriber share and its square as well as the interactions, the set of control variables listed in Subsection 6.3. Key estimation results are shown in Table 2 while we relegate the results of the full model to Appendix F. We display the results for a model testing Hypotheses 1 to 3 without contingencies (left column, Model I) and a model testing all hypotheses, that is, direct effects and contingencies (right column, Model II). Standard errors are robust.

Table 2 here!

Both models provide strong evidence for a negative direct relationship between copyprices and the number of titles. The coefficient estimate for Model I is -.09 and -.19 for Model II that includes interactions with copyprice. Given that both are also statistically highly significant, Hypothesis 1 is fully supported. Since the Poisson model has an exponential conditional mean function, the corresponding marginal effects are -0.09 and -0.19 times the number of titles by the own publisher in the own segment, respectively. If, for example, the own publisher has only one title, an increase in average copyprices within the segment by one Euro is associated with a decrease in the number of titles by 0.09 for the hypotheses-only model (the marginal effects of the contingencies model additionally depend on the interactions so that the corresponding coefficients do not have a direct interpretation).

The top part of Figure 2 displays the expected absolute effects of changes in copyprices on the number of titles by a publisher in a segment as calculated based on the hypotheses–only model. To calculate the figures, we set all variables but the ones whose absolute effect we want to study equal to their means. It shows that the number of titles by the own publisher in a segment decreases with increasing copy prices and that these effects are statistically significant over all copyprices as the confidence band, the gray areas in Figure 2, indicates. Appendix G explains in detail how we generate the figures.

Figure 2 here

The coefficient estimate on the non-interacted number of titles by other publishers in the own segment is positive as predicted by our theory in both models but statistically only weakly significant in the hypotheses-only model (Model I) while statistically insignificant in the contingencies model (Model II) . We trace the statistically weak significance back to too little variation in the number of titles by other publishers in the own segment across time and segment. The coefficient estimate for the hypotheses-only model is 0.02 which translates into a marginal effect of the same size for a publisher with just one title in the respective segment. This combined with the statistically weak significance, provides weak evidence for Hypothesis 2. The middle panel of Figure 2 provides a visualization of the absolute effects and shows that if there is one title by another publisher in the own segment, the expected number of own titles is 1.46. It increases to 1.6 titles if five publishers are active in the own segment, the highest value we observe in our data.

Hypothesis 3 predicts an inverted u-shaped relationship between subscriber share, our measure of reader loyalty, and the number of titles. Consistent with our hypothesis, the linear term on subscriber share is positive while the quadratic term is negative in both models. The coefficient estimates are jointly and separately statistically highly significant, which is fully consistent with Hypothesis 3. The number of titles is maximized for subscriber shares of around 45 percent for both specifications. Figure 2 (bottom) displays the concave relationship by mapping subscriber share to the expected number of titles.

We now turn to the interaction results, which are summarized in Hypothesis 4. Contingency 1 predicts a positive but weak interaction between the copyprice and the number of competing firms in a segment. Model II of Table 2 indeed suggests a positive relationship which is statistically insignificant. This provides weak support for our result that the interaction effect of the copyprice and the number of competitors on the product portfolio is relatively small.

In contrast to the first contingency, the interaction effect between copy price and subscriber share (i.e., Contingency 2) and the interaction effect between subscriber share and the number of other publishers (i.e., Contingency 3) are predicted to be large and should therefore be statistically significant. Indeed, we find strong evidence for these contingencies to hold. Contingency 2 suggests a positive coefficient on the interaction between copyprice and subscriber share. We in fact estimate a statistically significant positive interaction term. Contingency 3 predicts a negative term on the subscriber share/number of other publishers interaction. As Table 2 shows, the interaction coefficient is negative and statistically highly significant as it is consistent with our model. In addition, the second part of Contingency 2 suggested the moderating effect discussed in Contingency 1 to be smaller than the moderating effect of Contingency 2. A $T$-test of this result cannot reject its validity: the moderating effect of Contingency 1 is statistically significantly smaller than that of Contingency 2 with a $p$-value of 0.0002. The joint contingency cannot be rejected with a $p$-value of 0. Hence, Contingencies 2 and 3 are fully supported by our data while Contingency 1 finds weak empirical backing.

Finally, we note that the control variables have the expected sign. For example, a larger potential market size leads to an increase in the number of titles. A similar effect holds for the total number of magazines by a publisher, which was our proxy for economies of scope. Also, if readers in a segment are more heterogeneous, each publisher active in the segment sells a larger number of titles. Online affluency of readers as well as the physical size of magazines within a segment both have the expected negative effects of the number of magazines per publisher in a segment.

## 7.2 Robustness checks

We submit our main estimation results to four robustness checks. These are (i) period-by-period instead of panel Poisson estimation, (ii) IV estimation and (iii) total revenue per reader as an alternative measure for "value". We (iv) consider alternative estimation techniques.

**(i) Period-by-period estimation**

A major inconsistency between our theoretical and empirical model is that we use panel data in our econometrics while our theoretical model is static. This is potentially a critical issue since the German magazine industry has been characterized by substantial entry and exit as well as by mergers and acquisitions in the period under study. Of the 179 magazines our dataset comprises of, 21 changed hands, while 67 magazines entered the market and 50 exited.[21] To align our theoretical model with our empirical setup, we additionally estimate our main model period-by-period as a robustness check. This leads to 49 period-specific estimates. To aggregate these period-specific results, we apply Pooled Mean Group Estimation (PMGE, Pesaran et al. 1999) by averaging across the estimates and providing the associated standard errors.

The PMGE model supports our initial findings for Hypothesis 1 and Hypothesis 3 as shown in Table 3 (left column): the coefficient on copyprice is statistically and economically negative while the coefficient on the linear subscriber share is positive and the quadratic term is negative. Both are statistically highly significant. Hypothesis 2 is, however, unsupported. This is unsurprising since the empirical identification of the PMGE model solely hinges upon cross-segment variation (instead of both cross-segment and across time variation as in the main model) which accentuates the problem of little variation in the number of competing firms even further. More generally and as a consequence of the period-by-period estimation, all PMGE coefficients are estimated with less precision than in the main model.[22]

Table 3 here!

**(iii) 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 as a first instrument. Our intuition behind this 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 share of magazines with companion websites by the own publisher in other segments as an additional instrument. The

[21] We define magazine exit as the event when a magazine is no longer listed in the AG.MA data, which implies that it no longer pays off for the publisher to have reader level characteristics collected for advertising clients.

[22] The contingencies (not reported in Table 3) also have the same sign as in the main estimation. However, due to the small variation in the number of other publishers, the ones including this variable are not statistically significant.

intuition here is that market entry by competing firms is less likely to occur if incumbent publishers bundle print and online versions while the own online behavior is unlikely to affect how many magazines a competing publisher produces in a given segment. We display the Poisson IV regression results in the middle column of Table 3. 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 a "first stage" auxiliary OLS regression of all exogenous variables and the instruments on the number of titles by other publishers in the own segment and find that all instruments are separately and jointly highly significant. The $F$-statistic associated with the joint test is 313 which is substantially higher that the critical value of 10 (Staiger and Stock, 1997). The second property is tested by a Hansen $J$-test, which cannot reject orthogonality of the instruments at any conventional confidence level (the $p$-value is 0.53). Hence, both tests indicate that our instruments are statistically valid.

Our IV Poisson estimation results indeed show that the coefficient on the number of competing firms in a segment stays positive and becomes larger in absolute magnitude suggesting that not using instruments may bias the coefficient estimates towards 0 (i.e., not instrumenting works against our hypothesis). The precision with which it is estimated decreases, generating a statistically highly significant and positive effect, which is consistent with Hypothesis 2. Hypothesis 1 and Hypothesis 3 are supported as well by this robustness check.

**(ii) Total revenue per reader**

We consider total revenue per reader—the sum of copyprices and advertising revenues per reader—as an alternative measure of "value". Table 3 (right column) shows that this alternative measure also has a statistically and economically negative effect on portfolio size, which provides additional support for Hypothesis 1. In addition, we also find support for Hypotheses 3 but again do not find statistically significant effects for the number of competing magazines in a segment (Hypothesis 2).

**(iv) Alternative estimation models**

Our estimation results so far rely on a single main econometric approach only, the Poisson count data model. In a final robustness check we explore three alternative estimation models: simple OLS, a Tobit model which accounts for left-censoring at 1 (most publishers produce one title per segment only) and a probit model for having one or more than one title per segment. The associated estimation results are displayed in Appendix H. The main difference to our main model is that the coefficient on the number of competing publishers in a segment is statistically significant (and positive) throughout which is in line with Hypothesis 2 that received somewhat mixed support in our Poisson models. Appendix H else shows that the results are qualitatively very similar to the ones displayed in Table 2.[23]

### 7.3 Results summary

Our empirical results are well in line with our theoretical model. As predicted by Hypothesis 1, we find a statistically and economically highly significant negative effect of copyprices on portfolio size. Similarly, Hypothesis 2 which predicted a positive effect of the number of competing firms in a segment also finds empirical support. It is, however, statistically somewhat weaker. Finally, all estimations indicate an inverted u-shaped relationship between subscriber shares and the number of titles by the own publisher in a segment. The corresponding parameters are estimated with high precision, which is perfectly in line with Hypothesis 3.

Contingency 1 that predicted a small increase in the positive effect of the number of competing firms on product variety due to an increase in subscriber share is weakly supported empirically: the corresponding parameter estimate is positive as predicted but is statistically insignificant. Contingency 2 that predicted a lower negative effect of consumer valuation on product variety as the share of loyal consumers increases, and Contingency 3 that predicted a fall in the positive effect of the number of competing firms on product variety as the share of loyal consumers increases, receive both strong empirical support.

## 8 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

[23]Quantitative differences in coefficient sizes cannot be interpreted since the results from the different models are not comparable.

investment on profits. Our empirical analysis of the German magazine market lends strong empirical support to these predictions.

[**Markus: diese reader differentiation Sache wird hier nicht erwähnt. Und so richtige mabagerial implications sind das ja nicht. Ich denke in Bezug auf die Implication könnten wir vielleicht was schreiben dass unser Modell Märkte wie Zeitschriften, Bier und so beschreiben kann. Die Implication wäre dann dass Manager zwei State Variablen haben und dass die eine besser workt als die andere. Mal sehen ob wir das so aufschreiben können dass es nicht total trivial erscheint.**

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.

[**Markus: das ist wahnsinnig lang geworden. Ich habe es recht gekürzt.** 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] Belsley, DA, Kuh E, Welsch RE (1980) *Regression Diagnostics: Identifying Influential Data and Sources of Collinearity*, Wiley & Sons, New York, New York.

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

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

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

[5] Bresnahan 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.

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

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

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

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

[10] Fainmesser IP, Galeotti A (2018) The Market for Influence. *American Economic Journal: Microeconomics* forthcoming.

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

[12] Greene, WH (2003) *Econometric Analysis*, Prentice Hall, New York, New York.

[13] Hamilton S (2009) Excise Taxes with Multiproduct Transactions. *American Economic Review* 99(1), 458–471.

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

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

[16] Kekre S, Srinivasan K (1990) Broader Product Line: A Necessity to Achieve Success. *Management Science* 36(9) 1216–1231.

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

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

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

[20] Pasaran HM, Shin Y, Smith RP (1999) Pooled Mean Group Estimation of Dynamic Heterogeneous Panels. *Journal of the American Statistical Association* 94 (4), 621-634.

[21] Petrongolo B, Pissaridis M (2001) Looking into the Black Box: A Survey of the Matching Function. *Journal of Economic Literature* 34 (2), 390-431.

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

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

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

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

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

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

Table 1: **Summary statistics of main variables**

| | Mean | Std. dev. | Min. | Max. |
|---|---|---|---|---|
| **Dependent variable** | | | | |
| # of titles per publisher per segment | 1.67 | 1.37 | 1 | 11 |
| **Key explanatory variables** | | | | |
| Mean copyprice in segment (in Euros) | 2.70 | 1.19 | 0.51 | 7.30 |
| # other publishers in segment | 2.22 | 1.27 | 0 | 5 |
| Mean subscriber share in segment | 0.25 | 0.18 | 0 | 1 |
| **Alternative dependent variable (Subsection 7.2)** | | | | |
| Total revenue per reader (in Euros) | 18.61 | 19.50 | 1.88 | 200.14 |

Note: 3444 observations.

Table 2: **Poisson estimation results**

| | **Hypotheses** **Coeff.** **(std. err.)** | **Contingencies** **Coeff.** **(std. err.)** |
|---|---|---|
| Copyprice | -0.091*** | -0.183*** |
| | (0.014) | (0.036) |
| # other publishers in own segment | 0.021* | 0.052 |
| | (0.012) | (0.036) |
| Subscriber share | 3.172*** | 3.262*** |
| | (0.264) | (0.354) |
| Subscriber share squared | -3.534*** | -3.750*** |
| | (0.339) | (0.394) |
| # other publishers * copy price | | 0.005 |
| | | (0.013) |
| Copyprice*subscriber share | | 0.193*** |
| | | (0.052) |
| Subscriber share * # other publishers | | -0.174*** |
| | | (0.067) |
| $R^2$ | 0.593 | 0.598 |

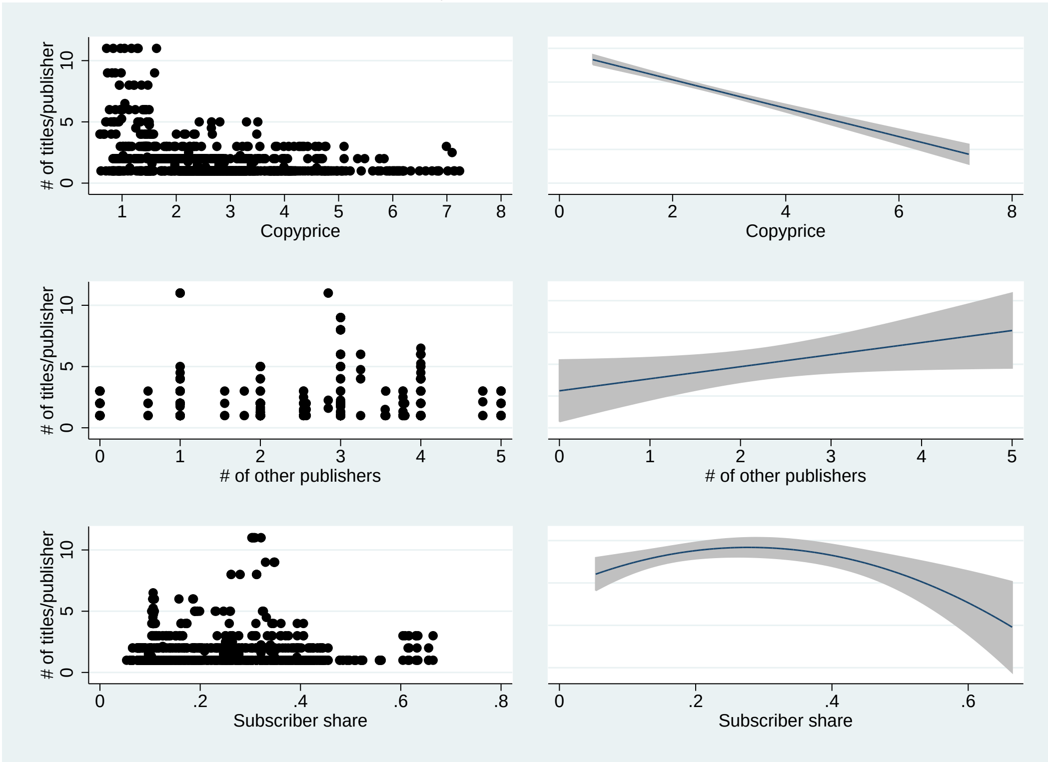
Notes: The dependent variable is the number of titles produced by the own publisher in a given segment. The specifications additionally includes controls for reader heterogeneity, potential market size, returns to scope, readers' Internet affinity, the presence of companion websites, a set of periodicity dummies, time dummies and proxies for printing cost. A fuller estimation results table is relegated to Appendix F. The number of observations is 3444. $*\ p < 0.10$, $**\ p < 0.05$, $***\ p < 0.01$."

Table 3: **Robustness checks - Poisson estimation results**

| | **MGE** **Coeff.** **(std. err.)** | **IV** **Coeff.** **(std. err.)** | **Plain** **Coeff.** **(std. err.)** |
|---|---|---|---|
| Copyprice | -0.182** | -0.029*** | |
| | (0.078) | (0.011) | |
| Total revenue per reader | | | -1.668*** |
| | | | (0.293) |
| # other publishers in own segment | 0.528 | 0.075*** | 0.017 |
| | (8.518) | (0.024) | (0.011) |
| Subscriber share | 3.220*** | 2.285*** | 3.222*** |
| | (0.670) | (0.162) | (0.265) |
| Subscriber share squared | -3.676*** | -2.322*** | -3.710*** |
| | (1.273) | (0.203) | (0.352) |
| Pearson $R^2$ | 0.541 | 0.541 | 0.578 |

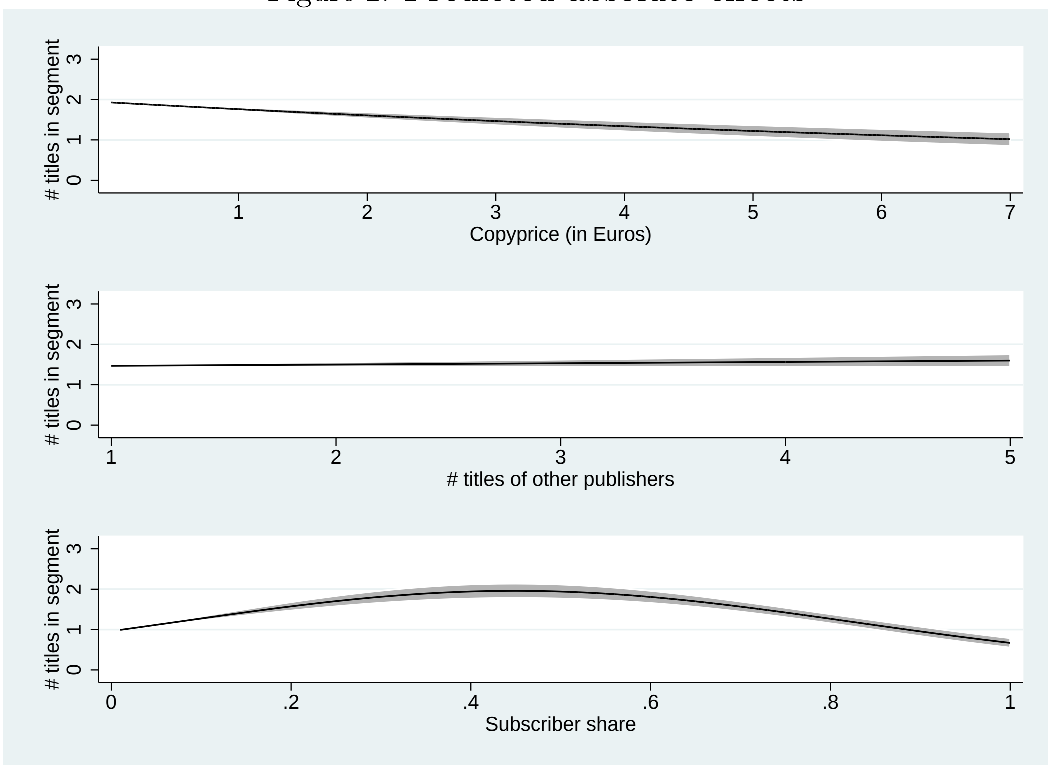
Notes: The dependent variable is the number of titles produced by the own publisher in a given segment. The specifications additionally includes a large set of additional controls as listed in Subsection 6.3. The number of observations is 3444. $* \ p < 0.10$, $** \ p < 0.05$, $*** \ p < 0.01$.

Figure 1: **Scatterplots and predictions of the number of titles per publisher per segment and the main explanatory variables**




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

Figure 2: **Predicted absolute effects**




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