Two at the Top: Quality Differentiation in Markets with Switching Costs*

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We explore the effects of switching costs on the subgame perfect quality decisions of oligopolists and the dynamics of price competition. We establish a strong strategic quality premium. We show that competition for the establishment of customer relationships will eliminate low-quality firms in period 1 and that low-quality firms can survive only based on poaching profits. The equilibrium configuration is characterized by an agglomeration of two providers of top-quality as soon as switching cost heterogeneity is sufficiently significant.

Keywords: quality choice, switching costs, poaching, natural oligopoly.

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1. Introduction

In existing models of vertical product differentiation firms typically relax price competition by choosing different levels of quality (Shaked and Sutton (1982)). Nevertheless in many industries it appears that several competing firms simultaneously supply products located at the highest available level of the quality spectrum. The rating industry is dominated by the rivals Standard & Poors and Moodys. The auction houses Sotheby's and Christie's are the dominant auction houses for art auctions and these rivals exhibit a roughly similar economic performance. The aircraft industry is characterized by fairly symmetric duopoly competition between Airbus and Boeing and it is indeed hard to find evidence of systematic quality differences between their products. In these examples, rivalry between the two leading firms is intense, but yet no single firm seems to clearly dominate its rival(s) in terms of quality. Similarly, in the micro-processor industry each generation of microprocessors is clearly dominated by two firms, Intel and AMD (American Microprocessor Devices). Finally, the United States General Accounting Office's (US-GAO) report to a Senate committee (2003) documents in great detail that the accounting and audit services industry has a structure with two dominant accounting firms when the client firms are classified according to their industrial sector. In fact, for a spectrum of different investigated industrial sectors the two dominant accounting firms have a joint market share in the range between 70 % and 95 %.

These observations are at striking variance with the predictions of the existing literature on vertical product differentiation based on income heterogeneity across consumers. Virtually all these models of vertical product differentiation, where firms offer quality-differentiated products, have the property that only one firm provides the highest quality product, and all other firms offer products representing distinctly lower qualities. In these models the top-quality firm typically enjoys the highest mark-up, market share and profit.[1] None of these models generates market structures where there could be any agglomeration of competitors offering similar (or even identical) vertical characteristics.[2]

On a more general level, the idea of firms offering identical commodities and competing in prices has virtually no theoretical basis in industrial economics. In equilibrium firms will typically offer differentiated, and hence different products.

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[1] See, for example, Gabszewicz and Thisse (1979), Shaked and Sutton (1982), (1983) or Gehrig (1996).

In this paper we argue that the traditional vertical differentiation literature has neglected switching costs as a crucial characteristic of many industries, where quality competition is an important dimension. If an airline demands an extra set of jets of a given size class, it might have strong incentives to stay with the incumbent provider in order to economize on the cost of training new crews and mechanics as well as spare parts and maintenance. In other words, switching the aircraft may be quite expensive for an airline. Likewise accountants or rating agencies familiar with a company from previous encounters will cause less of a burden to management time than a new accounting team. Again, switching accountants imposes potentially significant switching costs on management.[3] Sellers of valuable pieces of art might face substantial costs of switching from one auction house to another as the auction house has to convince itself of the authenticity in order to maintain its reputation.[4]

In the presence of switching costs, incumbents have an interest to exploit their monopoly power on those captive clients with an established customer relationship. On the other hand, the very same firm may aggressively poach for the rival's current customers. Hence, switching costs also invite price discrimination between attached and unattached consumers. Moreover, in anticipation of expected loyalty rents from captive customers firms compete aggressively for new customers. In fact, the examples provided above seem to be characterized by aggressive poaching activities.[5]

In this paper we analyze the impact of quality differentials on the intertemporal pricing structure as well as on the poaching activities. In particular, we show that the high-quality firm can afford higher introductory discounts, and therefore it can poach more effectively for the low-quality captive clientele and it can protect more easily its own captive clientele.

Moreover, we analyze the equilibrium quality choice. We show that switching costs and the possibility to price discriminate generate systematic and interesting interactions with product

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[2] As we will discuss below, minimal differentiation in location models (e.g. Neven and Thisse (1990)) can only be shown in models with at least two dimensions, and hence two choice variables.

[3] A survey of 147 chief financial officers (CFO's) of major firms reports that switching to another auditor is very difficult (38%) or at least somewhat difficult (54%) on a scale of five possible answers (US-GAO 2003, p. 95). In the same survey, CFO´s asses a very great importance (76%) or great importance (23%) to the qualities of services offered, on a scale of five possible answers (US-GAO 2003, p. 96).

[4] We should hasten to say that the industries mentioned in this introduction serve illustrative purposes. Of course, empirically many features in addition to switching costs contribute to the industrial structure of these industries. Likewise, it should be emphasized that we do not want to advocate the feature with two top quality providers as a general empirical regularity. However, these industries exhibit regularities that cannot be easily explained by standard models of product differentiation based on income differences across consumers.

[5] While the US-GAO (2003) report does not provide information about pricing structures, it provides average fees across industries. These have been relatively low and basically unaffected by changes in the industrial structure.

choice. In particular, switching costs will help to segment the market. Hence, even in a duopoly two high-quality firms are able to share the market and still earn positive profits in the presence of switching costs. While intense ex ante price competition reduces any advantages to incumbency, competition for poaching revenues is limited when the top quality is offered by only two firms. Entry of further top quality competitors is effectively impeded, since Bertrand type competition among two (or more) poachers would effectively compete away any poaching rents, and hence eliminate the ability of financing any sunk quality investments.

We focus on vertically differentiated markets where consumers are heterogeneous with respect to their switching costs. When the dispersion of switching costs is sufficiently strong, we show that low-quality producers have a particularly strong incentive to close the quality gap to high-quality producers despite the bite of price competition. Under such circumstances the equilibrium configuration will be characterized by an agglomeration of two firms at the top of the quality spectrum. With sufficiently strong dispersion of the switching costs the incentives created by poaching profits dominate relative to the competition-relaxing effects of quality differentiation. This holds true as long as the poaching profits survive, i.e. as long as no more than two firms produce the top quality. When dispersion is small, the market can sustain only one active firm.

While our results differ from the implications of standard vertical differentiation models, they do not invalidate the property of a natural oligopoly found in earlier models of vertical product differentiation (for example, Shaked and Sutton (1982) and (1983)). Entry by competitors is limited by the prospect to earn positive poaching revenues. Hence, in equilibrium there cannot be identical (by quality) competitors poaching for the clients of some other rival. In particular, our theory predicts that there will never be more than two firms at the top of the quality spectrum. This particular generalization of the finiteness property is specific for vertical product differentiation based on switching cost heterogeneity.[6]

Our analysis is structured as follows. Section 2 presents the basic two-period model of consumers with switching costs. Sections 3 and 4 analyze price and quality competition for duopolistic industries where the consumers have a fixed income level. Section 5 explores some

[6] Neven and Thisse (1990) have also designed a duopoly model where quality agglomeration at the highest available quality may occur under certain conditions. However, our mechanism is very different from theirs. In Neven and Thisse (1990) firms commit to a two-dimensional product choice described by a vertical as well as a horizontal characteristic in the long run and they subsequently compete in price. However, their analysis is restricted to a duopoly. In our model we can show that at most two firms will offer top quality.

implications of our theory for industrial structure. Section 6 discusses limitations and some potential extensions of our results. Finally, Section 7 offers concluding comments.

2. A Model of Quality Choice with Switching Costs

We consider a market with repeat purchases of non-durable commodities or services in two periods. The commodities can be offered at different quality levels $q \in [\upsilon, \omega]$, where ω (υ) denotes the highest (lowest) available quality ($\upsilon > 0$).

Consumers value quality, the valuation of which varies with income y. Following the standard approach in the literature on vertical product differentiation, the per-period preferences are quasi-linear in the composite good z_t and are represented by

$$U_t(q_t, y, z_t) \;=\; q_t\, y \;-\; z_t\,, \quad t = 1{,}2. \tag{1}$$

Furthermore, consumers are assumed to buy exactly one unit of the differentiated good.

Aggregate inter-temporal utility is separable across time periods. Future consumption is discounted at the rate $0 < \delta \le 1$ according to

$$U(q_1, y_1, z_1, q_2, y_2, z_2) \;=\; U_1(q_1, y_1, z_1) \;+\; \delta U_2(q_2, y_2, z_2). \tag{2}$$

Consumers are assumed to face consumer-specific switching costs. Extending Chen (1997)[7] we assume that the switching costs s of a consumer with income y are uniformly distributed on $[\underline{s}, \bar{s}]$ with a lower bound $\underline{s}$ such that $0 \le \underline{s} < \bar{s}$. We find it useful to employ the following convention: $\underline{s} = \tilde{s} - \sigma$ and $\bar{s} = \tilde{s} + \sigma$. With this formulation $\tilde{s}$ can be interpreted as the mean of the switching cost, and σ as a measure of its dispersion. We assume that in period 1 the consumer knows the probability distribution from which their switching costs are drawn, but does not know the consumer-specific switching cost realization until period 2.

The switching costs s can be justified by, for example an inspection cost, which has to be paid each time a new product is acquired. This inspection cost may, for example, capture a learning cost, e.g. the opportunity cost of getting acquainted with a new piece of software or a new operating system. As another example, the switching cost could capture the initial x-ray a dentist typically takes before starting any operation. It has to be paid each time another dentist is

[7] Chen (1997) focuses on uniform switching costs on intervals of the type $[0, \bar{s}]$.

selected. Likewise a consultant supplying accounting or audit services needs to be familiarized with the economic situation and business environment for each new client firm.

The literature on vertical product differentiation has typically emphasized income heterogeneity as the source for quality differentiation. This literature has generated important insights regarding the price equilibrium and the associated configuration of market shares with vertical product differentiation (see, for example, Shaked and Sutton (1982, 1983)). In this paper we assume that income is fixed at y in order to instead analyze the effects of switching costs on the equilibrium incentives for pricing and vertical differentiation in an oligopolistic industry.

The timing of decisions is as follows: With an established industry structure firms select product quality. Then for given and mutually observed qualities the competing firms determine prices in two rounds of competition. In the second round of price competition we allow for history-dependent pricing in the form of behavior-based pricing. In particular, firms can discriminate between their own customers and those consumers with an established customer relationship with a rival. Thus firms are allowed to poach the rivals' customers, while they typically treat their loyal customers differently. In period 1 firm *i*'s price is denoted by p_1^i, whereas the period-2 price to loyal customers is denoted by p_2^i and the period-2 poaching price to customers with an established business relationship with a rival is denoted by r_2^i.

For most of the analysis we are interested in the set of subgame perfect Nash equilibria of this three-stage game. Section 3 analyses the price equilibrium in periods 1 and 2 before section 4 presents the analysis of the quality choice. Section 5 subsequently explores some implications for market structure.

3. Price Competition with Fixed Qualities

In this section we analyze price competition for fixed quality choices. Let us concentrate on the case of fixed income y. We will first analyze the case of duopoly and subsequently discuss the general case with more than 2 firms in Section 5. Let $q_L \leq q_H$.[8]

[8] At this stage it does not matter which firm, 1 or 2, provides the higher quality. We also consider identical qualities.

3.1 Duopolistic Price Competition in Period 2

In period 2 firms can price discriminate on the basis of customer purchase histories. Firms are tempted to charge particularly attractive prices to rivals' customers in order to poach them, while at the same time they would like to exploit locked-in customers. However, the poaching prices of rivals pose a competitive threat to the exploitation of locked-in customers and for that reason there is a limit to the extent incumbent firms can benefit from established customer relationships.

Poaching will induce switching only if the poaching offers undercut incumbent prices by more than the switching cost. In period 2 a former buyer of the high-quality product (q_H) will switch to a low-quality product (q_L) if and only if [9]

$$q_H y - p_2^H \; < \; q_L y - r_2^L - s \tag{3a}$$

and a former buyer of a low-quality product will switch if and only if

$$q_L y - p_2^L \; < \; q_H y - r_2^H - s. \tag{3b}$$

Consequently, switching will occur for consumers with sufficiently low switching costs, whereas consumers with sufficiently high switching costs tend to be loyal.

Denote the quality differential by $\Delta = q_H - q_L$. Then the critical level of switching costs, below which the customer finds it optimal to switch to the competitor, is given by

$$\hat{s}_H = p_2^H - r_2^L - \Delta y \tag{4a}$$

for former customers of the high-quality product, whereas the critical switching cost is

$$\hat{s}_L = p_2^L - r_2^H + \Delta y \tag{4b}$$

for customers belonging to the inherited market share of the low-quality firm.

Let us consider price competition in period 2 for consumers with an inherited customer relationship with the high-quality supplier first. Both the incumbent and the poaching firm maximize expected profits given by

$$\max_{p_2^H} \quad p_2^H \cdot \frac{\tilde{s} + \sigma - \hat{s}_H}{2\sigma} \quad , \tag{5a}$$

[9] We have introduced switching costs in the additive way for reasons of simplicity. In an earlier version (Gehrig and Stenbacka (2005)) we focused on a multiplicative specification so as to keep the model as close to Shaked and Sutton (1982). This specification has also been used by, for example, Gabszewicz and Thisse (1979, 1980). Strictly speaking, the multiplicative structure imposes the structure that the effective switching costs increase with the quality of the product one switches to. However, this is not a critical assumption from the point of view of our qualitative results.

$$\max_{r_2^L} \quad r_2^L \cdot \frac{\hat{s}_H - \tilde{s} + \sigma}{2\sigma} \quad , \tag{5b}$$

respectively. Likewise the objective functions in the market segment of former customers of the low-quality firm read as:

$$\max_{r_2^H} \; r_2^H \cdot \frac{\hat{s}_L - \tilde{s} + \sigma}{2\sigma} \tag{6a}$$

$$\max_{p_2^L} \; p_2^L \cdot \frac{\tilde{s} + \sigma - \hat{s}_L}{2\sigma} \quad . \tag{6b}$$

Due to price discrimination the period-2 market is separated into segments of former buyers of the high-quality product and former buyers of the low-quality product. Competition for former buyers of the high-quality product involves the high-quality incumbent and the low-quality poacher, while competition for the former buyers of the low-quality product involves the low-quality incumbent and the high-quality poacher, as long as both are actively poaching. Propositions 3.1 – 3.3 characterize incumbency prices and poaching prices in equilibrium for different levels of switching costs. We refer to the Appendix for the formal proof of Propositions 3.1 – 3.3.

Proposition 3.1 (high dispersion)

When switching costs are sufficiently dispersed, i.e. when $\sigma \geq \frac{1}{3}(\tilde{s} + \Delta y)$, *both firms can earn positive mark-ups on poaching and the equilibrium prices are*

$$\begin{pmatrix} p_2^H \\ r_2^L \end{pmatrix} = \frac{1}{3} \begin{pmatrix} \tilde{s} + 3\sigma + \Delta y \\ -\tilde{s} + 3\sigma - \Delta y \end{pmatrix} \tag{7a}$$

$$\begin{pmatrix} r_s^H \\ p_2^L \end{pmatrix} = \frac{1}{3} \begin{pmatrix} -\tilde{s} + 3\sigma + \Delta y \\ \tilde{s} + 3\sigma - \Delta y \end{pmatrix} \quad . \tag{7b}$$

While poaching is profitable for sufficiently dispersed switching costs, the low-quality supplier will abstain from poaching when the dispersion of the switching costs declines below the threshold $\frac{1}{3}(\tilde{s} + \Delta y)$.

Proposition 3.2 (intermediate dispersion)

When the dispersion of the switching costs is in an intermediate range, i.e. when $\frac{1}{3}(\tilde{s} - \Delta y) < \sigma < \frac{1}{3}(\tilde{s} + \Delta y)$, *only the high-quality firm can earn positive mark-ups on poaching and the equilibrium prices are*

$$\begin{pmatrix} p_2^H \\ r_2^L \end{pmatrix} = \frac{1}{2}\begin{pmatrix} \tilde{s} + \sigma + \Delta y \\ 0 \end{pmatrix} \tag{7c}$$

$$\begin{pmatrix} r_2^H \\ p_2^L \end{pmatrix} = \frac{1}{3}\begin{pmatrix} -\tilde{s} + 3\sigma + \Delta y \\ \tilde{s} + 3\sigma - \Delta y \end{pmatrix} . \tag{7d}$$

When the dispersion of the switching costs is sufficiently low, even the high-quality producer will refrain from poaching.

Proposition 3.3 (low dispersion)

When the dispersion of the switching costs is sufficiently small, i.e. when $\sigma < \frac{1}{3}(\tilde{s} - \Delta y)$, *no positive mark-ups can be earned on poaching and the equilibrium prices are*

$$\begin{pmatrix} p_2^H \\ r_2^L \end{pmatrix} = \frac{1}{2}\begin{pmatrix} \tilde{s} + \sigma + \Delta y \\ 0 \end{pmatrix} \tag{7e}$$

$$\begin{pmatrix} r_s^H \\ p_2^L \end{pmatrix} = \frac{1}{2}\begin{pmatrix} 0 \\ \tilde{s} + \sigma - \Delta y \end{pmatrix} . \tag{7f}$$

Based on Proposition 3.1 we can conclude that both firms are able to achieve positive poaching profits when the dispersion of the switching cost is sufficiently large. When the switching cost dispersion is belongs to the intermediate interval characterized in Proposition 3.2, the low-quality producer can no longer earn positive poaching rents. Finally, if the dispersion is sufficiently small as characterized in Proposition 3.3, no firm can sustain positive poaching rents. Propositions 3.1 – 3.3 provide a full characterization of price equilibrium in period 2.

The dispersion of the switching costs, measured by σ, relaxes price competition, and, hence, has similar implications as product differentiation. When switching costs are sufficiently dispersed, both firms will engage in active and profitable poaching. Moreover, in this case equations (7a) and (7b) establish that period-2 prices are unambiguously increasing functions of switching cost dispersion. Interestingly, higher switching costs per se, as measured by the mean $\tilde{s}$, inhibit poaching, and, thus, endow incumbents with better protection against poaching. As the dispersion of switching costs declines, so does also the profitability of poaching. With sufficiently small dispersion poaching will neither be profitable nor effective, despite the fact that switching costs are present per se.

Proposition 3.1 implies that the lock-in effects of business relationships are quality-contingent. This is formulated in the following Corollary.

Corollary 3.4 *When* $\sigma \geq \frac{1}{3}(\tilde{s} + \Delta y)$ *poaching and equilibrium switching take place in both directions. Customers belonging to firm H's market segment switch if* $s < \hat{s}_H = \frac{1}{3}[2\tilde{s} - \Delta y]$, *while customers belonging to firm L's market segment switch if* $s < \hat{s}_L = \frac{1}{3}[2\tilde{s} + \Delta y]$. *In particular, we establish* $\hat{s}_L > \hat{s}_H$.

Proof: Straightforward and omitted.

Corollary 3.4 states that the switching cost threshold required to prevent a customer of a low-quality firm from switching is higher than the threshold required to keep a customer of a high-quality firm loyal. Thus, high-quality producers tend to have more loyal customers. In this respect, the production of a high-quality product is associated with a strategic premium as it is structurally more resistant to switching compared with a low-quality product.[10] Moreover, regardless of the switching cost dispersion, the high-quality product never faces a lower switching threshold. The switching threshold is always higher for the high-quality product except for the case with sufficiently low switching cost dispersion, for which there is no switching at all.

We next calculate the profits associated with the equilibrium prices. These profits are reported in Propositions 3.5 – 3.7 below.

Proposition 3.5 (high dispersion)

When the switching costs are sufficiently dispersed, i.e. when $\sigma \geq \frac{1}{3}(\tilde{s} + \Delta y)$, *incumbency profits are:*

$$\Pi_2^H = \frac{(\tilde{s} + 3\sigma + \Delta y)^2}{18\sigma} \qquad \textit{for the high-quality firm,} \qquad (9a)$$

$$\Pi_2^L = \frac{(\tilde{s} + 3\sigma - \Delta y)^2}{18\sigma} \qquad \textit{for the low-quality firm.} \qquad (9b)$$

Both firms achieve positive poaching profits according to

$$\tilde{\Pi}_2^H = \frac{(-\tilde{s} + 3\sigma + \Delta y)^2}{18\sigma} \qquad \textit{for the high-quality poacher,} \qquad (9c)$$

$$\tilde{\Pi}_2^L = \frac{(-\tilde{s} + 3\sigma - \Delta y)^2}{18\sigma} \qquad \textit{for the low-quality poacher.} \qquad (9d)$$

While in the case of a sufficiently high degree of dispersion poaching is always profitable, in the intermediate range the low-quality producer refrains from poaching.

Proposition 3.6 (intermediate dispersion)

When the dispersion of the switching costs is in an intermediate range, i.e. when $\frac{1}{3}(\tilde{s} - \Delta y) < \sigma < \frac{1}{3}(\tilde{s} + \Delta y)$, *incumbency profits are:*

$$\Pi_2^H = \frac{(\tilde{s} + \sigma + \Delta y)^2}{8\sigma} \qquad \textit{for the high-quality firm,} \qquad (10a)$$

$$\Pi_2^L = \frac{(\tilde{s} + 3\sigma - \Delta y)^2}{18\sigma} \qquad \textit{for the low-quality firm.} \qquad (10b)$$

Only the high-quality firm earns positive poaching profits

$$\tilde{\Pi}_2^H = \frac{(-\tilde{s} + 3\sigma + \Delta y)^2}{18\sigma} \qquad \textit{for the high-quality poacher,} \qquad (10c)$$

$$\tilde{\Pi}_2^L = 0 \qquad \textit{for the low-quality poacher.} \qquad (10d)$$

When the dispersion of switching costs is sufficiently low, poaching is not profitable any more.

[10] This seems to be consistent with observations from, for example, the car industry, where high-quality brands

Proposition 3.7 (low dispersion)

When the dispersion of the switching costs is sufficiently small, i.e. when $\sigma < \frac{1}{3}(\tilde{s} - \Delta y)$ *, incumbency profits are:*

$$\Pi_2^H = \frac{(\tilde{s} + \sigma + \Delta y)^2}{8\sigma} \qquad \textit{for the high-quality firm,} \qquad (11a)$$

$$\Pi_2^L = \frac{(\tilde{s} + \sigma - \Delta y)^2}{8\sigma} \qquad \textit{for the low-quality firm.} \qquad (11b)$$

Poaching is unprofitable for both firms as

$$\tilde{\Pi}_2^H = 0 \qquad \textit{for the high-quality poacher,} \qquad (11c)$$

$$\tilde{\Pi}_2^L = 0 \qquad \textit{for the low-quality poacher.} \qquad (11d)$$

In light of Propositions 3.5 – 3.7 the high-quality producer enjoys a competitive advantage as it earns higher incumbency and poaching profits than the low-quality rival. Qualitatively, this conclusion is in line with the standard literature on vertical differentiation based in income heterogeneity (see Gabscewicz and Thisse (1979, 1980) and Shaked and Sutton (1982, 1983)). Incumbency profits, however, do not necessarily universally outweigh poaching profits. Poaching profits of a high-quality producer may exceed incumbency revenues of a low-quality producer.

It is worth observing already at this stage that, regardless of the dispersion of the switching costs, the quality differential $\Delta = q_H - q_L$ favors the high-quality producer at the detriment of the low-quality producer, both for incumbency and for poaching revenues. Ultimately, as we will find out later on, with sufficiently large switching cost dispersion this effect induces the low-quality producer to minimize the quality gap to the high-quality producer.

Finally, when switching costs are sufficiently differentiated, i.e. when $\sigma \geq \frac{1}{3}(\tilde{s} + \Delta y)$, dispersion will promote both incumbency and poaching profits. In this case increased differentiation in the switching costs tends to reduce the intensity of price competition to benefit both firms. The average level of switching costs $\tilde{s}$ will also increase both incumbency and poaching profits under the same condition.

typically have a higher degree of customer loyalty.

3.2 Duopolistic Price Competition in Period 1

We next proceed to analyze price competition in period 1. At this stage the competing firms rationally anticipate the period-2 equilibrium and internalize these effects into the decision making in period 1.

In period 1, consumers do not yet know the realization of their switching costs. For that reason consumers with identical incomes will exhibit identical purchasing behavior in period 1.[11] The consumers simply select the product that yields the highest discounted expected utility to them. They are indifferent between the high-quality product offered at price p_1^H and the low-quality product at price p_1^L if

$$q_L y - p_1^L \quad + \quad \delta \left[(q_L y - p_2^L) \frac{\tilde{s} + \sigma - \hat{s}_L}{2\sigma} \quad + \int_{\tilde{s}-\sigma}^{\hat{s}_L} (q_H y - r_2^H - s) \frac{ds}{2\sigma} \right] \quad =$$

$$q_H y - p_1^H \quad + \quad \delta \left[(q_H y - p_2^H) \frac{\tilde{s} + \sigma - \hat{s}_H}{2\sigma} \quad + \int_{\tilde{s}-\sigma}^{\hat{s}_H} (q_L y - r_2^L - s) \frac{ds}{2\sigma} \right] \quad . \qquad (12)$$

Through re-arrangement of the indifference condition (12) we find that

$$p_1^H \quad = \quad p_1^L \quad + \quad \Delta y \quad + \quad \delta \left[(q_H y - p_2^H) \frac{\tilde{s} + \sigma - \hat{s}_H}{2\sigma} - (q_L y - p_2^L) \frac{\tilde{s} + \sigma - \hat{s}_L}{2\sigma} \right]$$

$$+ \delta \left[(q_L y - r_2^L) \frac{\hat{s}_H - \tilde{s} + \sigma}{2\sigma} - (q_H y - r_2^H) \frac{\hat{s}_L - \hat{s} + \sigma}{2\sigma} \right] + \frac{\delta}{2\sigma} \left[\int_{\tilde{s}-\sigma}^{\hat{s}_L} s\,ds \quad - \int_{\tilde{s}-\sigma}^{\hat{s}_H} s\,ds \right] . \quad (13)$$

Formulation (13) provides a decomposition of the premium the typical consumer is prepared to pay for the high-quality product in period 1 into four components: The first component Δy is the immediate utility gain from higher quality. The second component denotes the utility gain from maintaining a customer relationship with the high-quality firm relative to the low-quality firm. This difference is positive and adds to the premium for the high-quality product. The third component is negative and measures the relative utility losses that arise since a consumer

[11] In a world where switching costs were already known ex ante, consumers would be heterogeneous in period 1. Under such circumstances expectations about switching costs would have to be replaced by realized switching costs. This additional fragmentation would significantly add to the complexity of the analysis without qualitatively changing the underlying trade-offs. We have chosen to follow the modeling approach of Chen (1997) by assuming

belonging to the high-quality segment in period 1 can only face low-quality poaching offers, whereas a consumer belonging to the low-quality segment can attract high-quality poaching offers. Finally, the last component adds the differential in expected switching costs to the quality premium, which according to Corollary 3.4 is positive.

It should be emphasized that the quality premium described by (13) approaches the premium familiar from traditional models of vertical differentiation as the discount factor approaches zero, i.e. as the consumers turn completely myopic. Consistent with this observation, the quality premium differs more significantly from the traditional one the higher is the discount factor.

Firms maximize expected intertemporal profits. These intertemporal profits consist of the period-1 profits and the discounted incumbency and poaching profits achieved in period 2. Let μ_H denote the period-1 market share of the high-quality firm and μ_L the market share of the low-quality firm, such that $\mu_L = 1 - \mu_H$. The intertemporal profits can then formally be expressed as follows

$$\Pi^H = \mu_H p_1^H + \delta\left(\mu_H \Pi_2^H + (1-\mu_H)\tilde{\Pi}_2^H\right) \tag{14a}$$

$$\Pi^L = \mu_L p_1^L + \delta\left(\mu_L \Pi_2^L + (1-\mu_L)\tilde{\Pi}_2^L\right). \tag{14b}$$

Equations (14a) and (14b) imply that the intertemporal profits are linear as functions of the market shares acquired in period-1. Therefore, in period 1, the low-quality firm can offer introductory discounts up to a limit determined by the return on its captive period-1 clients. At this discount the low-quality firm breaks even. The high-quality firm just needs to match this price using the indifference relation (12) (or equivalently, (13)) and at that price the high-quality firm can still make a positive intertemporal profit on captive clients. Thus, in equilibrium, the high-quality firm will attract all consumers in period 1. The low-quality firm can only hope to poach consumers with low switching costs in period 2.

Consequently, in line with the argument developed above, the equilibrium price in period 1 is determined by $p_1^L = -\delta\, \Pi_2^L$ for the low-quality firm and condition (13) for the high-quality firm. Propositions 3.8 – 3.10 characterize the period-1 equilibrium prices for the different relevant

that the switching costs are not yet realized in period 1, or alternatively that the consumers do not yet know their idiosyncratic switching costs until the end of period 1.

segments of the dispersion of the switching costs. For the proofs of Propositions 3.8 – 3.10 we refer to the Appendix.

Proposition 3.8 (high dispersion)

When switching costs are sufficiently dispersed, i.e. when $\sigma \geq \frac{1}{3}(\tilde{s} + \Delta y)$, *the period-1 prices are given by*

$$p_1^L = -\delta \frac{(\tilde{s} + 3\sigma - \Delta y)^2}{18\sigma} \quad \text{for the low-quality firm,} \tag{15a}$$

and

$$p_1^H = p_1^L - \Delta y \left(1 - \delta \frac{\tilde{s}}{3\sigma} \right) \quad \text{for the high-quality firm.} \tag{15b}$$

While the low-quality firm bids its potential incumbency revenues in order to enter the market the high-quality firm prices its product just as to deny profitable entry for the low-quality rival and thereby attract the entire market in period 1. In the case of intermediate dispersion the low-quality firm refrains from poaching, which affects the high quality firm's limit pricing strategy.

Proposition 3.9 (intermediate dispersion)

When the dispersion of the switching costs is in an intermediate range, i.e. when $\frac{1}{3}(\tilde{s} - \Delta y) < \sigma < \frac{1}{3}(\tilde{s} + \Delta y)$, *the period-1 prices are given by*

$$p_1^L = -\delta \frac{(\tilde{s} + 3\sigma - \Delta y)^2}{18\sigma} \quad \text{for the low-quality firm,} \tag{16a}$$

and

$$p_1^H = p_1^L + \Delta y + \delta \left(\frac{\sigma}{4} - \frac{(\tilde{s} - \Delta y)^2}{36\sigma} \right) \quad \text{for the high-quality firm.} \tag{16b}$$

When the switching cost dispersion is sufficiently low both firms abstain from poaching in period 2. This also affects the incumbency value for the low-quality firm.

Proposition 3.10 (low dispersion)

When the dispersion of the switching costs is sufficiently small, i.e. when $\sigma < \frac{1}{3}(\tilde{s} - \Delta y)$ *, the period-1 prices are given by*

$$p_1^L = -\delta \frac{(\tilde{s} + \sigma - \Delta y)^2}{8\sigma} \quad \textit{for the low-quality firm and} \tag{17a}$$

and

$$p_1^H = p_1^L + \Delta y \quad \textit{for the high-quality firm.} \tag{17b}$$

Together Propositions 3.1 – 3.3 and Propositions 3.8 – 3.10 reveal a typical intertemporal pattern of equilibrium prices. A phase of introductory offers with price discounts is succeeded by a phase of higher prices where incumbent firms exploit locked-in customers, with whom the customer relationship was formed in the first phase. Such an intertemporal pricing structure is typical for models with switching costs (see, for example, the survey models of Klemperer (1995), Varian (2003), Farrell and Klemperer (2004) or the general analysis of Fudenberg and Tirole (2000) and Taylor (2003)). In any of the equilibrium configurations characterized by Propositions 3.8 – 3.10 the introductory discount of the high-quality firm is just sufficient to deny the low-quality firm any positive market share in period 1. Thus, in equilibrium the high-quality firm captures the whole market in period 1. In period 1 the low-quality firm cannot provide a more attractive introductory offer than the price at which period-1 profits outweigh the period-2 incumbency profits for the low-quality firm. In period 2 the high-quality firm can exploit its incumbency advantage, even though the low-quality firm may successfully poach some of its clients. Based on this line of arguments we conclude that the intertemporal discounted profit of the low-quality firm is determined by the discounted value of the poaching profits in period 2. We formulate these insights in a more formal way in Proposition 3.11 and 3.12 below.

Proposition 3.11

If $\sigma \geq \frac{1}{3}(\tilde{s} + \Delta y)$ *and* $q_H \geq q_L$ *the intertemporal discounted profit of the low-quality firm is*

$$\Pi^L = \delta\, \tilde{\Pi}_2^L = \delta \cdot \frac{(3\sigma - \tilde{s} - \Delta y)^2}{18\sigma}.$$

Proposition 3.11 incorporate as a special case the configuration where the duopolists offer identical qualities. Namely, if the firms offer identical qualities, i.e. if $\Delta = 0$, the intertemporal profit for both firms is $\Pi^i = \delta \tilde{\Pi}_2^j = \frac{\delta}{18\sigma}(3\sigma - \tilde{s})^2$ (i = H,L) if the dispersion of the switching costs is sufficiently large. The feature with positive intertemporal profits for the case with identical qualities is a striking finding as it highlights the divergence of our results from the standard literature on product differentiation. In the presence of differentiated switching costs the equilibrium profits are positive even when the competing firms offer identical product characteristics. In our setting with competing duopolists each firm is a monopolist on the poaching revenues associated with those consumers who have a customer relationship with the rival. For that reason it is profitable to poach the competitor in period 2 even when ex-ante competition for market shares is so intense that all profits, which are related to market shares acquired in period 1, are effectively eliminated through the introductory discount at the stage when the firms compete for the formation of customer relationships. Hence, the intertemporal discounted profits are strictly positive despite identical product choices by the firms. This result, however, does not survive the entry of additional equal quality competitors, as Section 5 demonstrates.

On the basis of the present analysis one might also be tempted to inquire about the dynamics of the poaching process in a more general structure with several rounds of competition. What would be the ultimate distribution of prices? On the basis of our analysis we would conjecture that the answer should depend on the type of information about the history of purchases available to the competitors. If firms can only observe current consumer attachment, and if they have no records about past purchasing behavior, the steady state actually coincides with our period-2 prices. If firms keep more detailed records about past purchasing behavior, further possibilities to segment the market will be exploited in equilibrium.

If the dispersion of the switching costs is not sufficiently large Propositions 3.6 and 3.7 imply:

Proposition 3.12

If $\sigma < \frac{1}{3}(\tilde{s} + \Delta y)$ *the intertemporal discounted profit of the low-quality firm is* $\Pi^L = 0$.

Proposition 3.12 implies that in the presence of (small) entry costs the market cannot sustain a duopoly configuration with asymmetric qualities when the dispersion of the switching costs is below the threshold specified ($\sigma < \frac{1}{3}(\tilde{s} + \Delta y)$).

4. Quality Competition

The quality decision serves as a long-run commitment relative to the subsequent stage of price competition. We assume the available range of qualities to be given by the interval $[\upsilon, \omega]$, where $\omega\,(\upsilon)$ denotes the highest (lowest) available quality ($\upsilon > 0$). Suppose, for the purpose of analyzing the strategic incentives for quality provision as opposed to quality decisions determined by cost considerations, that the establishment of a production line of quality q imposes "low" costs, which are independent of the quality.[12]

Suppose that the two rival firms operate with different quality levels so that the high-quality firm produces q_H, whereas the low-quality firm produces q_L. As we have shown in the previous section, in period 1 the high-quality firm captures all the market and the intertemporal discounted equilibrium profits of the low-quality firm are given by its discounted poaching profits in period 2, more precisely $\delta \cdot \tilde{\Pi}_2^L = \delta \cdot \frac{(-\tilde{s} + 3\sigma - \Delta y)^2}{18\sigma}$ (see 9.d)). Consequently, the duopolists determine their qualities so as to solve the optimization problems

$$\max_{q_L} \quad \delta\, \tilde{\Pi}_2^L(q_L, q_H) \tag{18a}$$

and

$$\max_{q_H} \quad p_1^H \quad + \quad \delta\left[\Pi_2^H(q_H, q_L) + \tilde{\Pi}_2^H(q_H, q_L)\right] \quad . \tag{18b}$$

The optimization problems (18a) and (18b), where the relevant period-2 profits are characterized in Proposition 3.5 ((9a) – (9d)), determine the subgame perfect quality equilibrium.

When switching costs are sufficiently dispersed so that $3\sigma > \tilde{s} + \Delta y$ equation (9(d)) implies that the poaching profits of the low-quality supplier are a strictly decreasing function in the quality produced by the high-quality producer, q_H, and a strictly increasing function in the

[12] In this respect our analysis of quality provision follows the approach developed by Shaked and Sutton (1982, 1983). We return to a discussion of the modifications induced by quality-contingent costs in section 6.

firm's own quality, q_L. Thus, for sufficiently dispersed switching costs the low-quality firm always has an incentive to increase its quality q_L until it approaches the high quality level q_H. In other words, the low-quality supplier has a strategic incentive to close the quality gap to the high-quality supplier, and, thus, minimize distance. Likewise, the profit of the high-quality firm is increasing in q_H.

If on the other hand switching costs are insufficiently dispersed, such as $3\sigma < \tilde{s}$, at most one firm can be active in equilibrium. Overall we can characterize the equilibrium quality choice in the next proposition.

Proposition 4.1

a) *Two at the top*: If $\sigma \geq \frac{1}{3}\tilde{s}$ the subgame perfect equilibrium combination of qualities induces agglomeration at the top, i.e. $q_H = q_L = \varpi$.

b) *One at the top*: If $\sigma < \frac{1}{3}\tilde{s}$ in a subgame perfect equilibrium only one firm is active and produces top quality, i.e. $q_H = \varpi$.

Proof: See Appendix.

Accordingly, depending on the degree of dispersion of switching costs, two firms or one firm will actively compete for customers. When the dispersion of switching costs is sufficiently high, two firms will offer the highest quality, otherwise a single firm will do so.

When the dispersion of the switching costs is sufficiently large the equilibrium quality of the low-quality firm is determined by the achievable poaching profits. Competition based on quality commitments implies a race to the top in our model, since superior quality conveys a strong strategic advantage. Due to sufficiently dispersed switching costs, price competition is relaxed and both firms can earn positive rents. Hence we find agglomeration at the top. When the degree of dispersion is too low, profitable poaching is no longer possible.

Hence we conclude that switching cost dispersion has very different implications for quality choice than income differences across consumers. Models of vertical differentiation based on income differences (for example, Shaked and Sutton (1982)) tend to predict configurations with a positive degree of quality differentiation as a mechanism to soften subsequent price competition. With sufficiently dispersed switching costs the intertemporal features of price equilibrium allow two firms to share the market and, thus, relax price competition. Since higher quality provides a competitive advantage, a race to the top results in the case of duopoly.

With regard to the agglomeration in product space, our results resemble those of earlier papers on product differentiation. Models of location choice in multi-characteristics space with quadratic transportation costs tend to generate location equilibria with minimal differentiation in one dimension. E.g. Irmen and Thisse (1998) provide a model, where equilibrium location choice involves maximal differentiation in the dominant dimension and minimal differentiation in all other characteristics. Also, somewhat more closely related to our model, in a model with horizontal and vertical differentiation Neven and Thisse (1990) find equilibria with agglomeration at the top quality and maximal differentiation in location. Neven and Thisse (1990) typically also find equilibria with clustering in location and maximal differentiation in quality. However, the common feature of all these contributions is the presence of a multidimensional characteristics space. In relationship to this literature the remarkable feature about our model is that the equilibrium with agglomerated qualities emerges within the framework of a one-dimensional model of product characteristics, if there is a sufficient degree of heterogeneity across consumers. Furthermore, our model predicts a unique equilibrium with clustering at top quality.

It is also worth noting that for sufficiently large dispersion of the switching costs the equilibrium quality choice in a duopoly is identical to the monopoly choice of quality. In both market structures, only top quality will be offered. This mechanism reminds of Swan's (1970a and 1970b) argument that a monopoly firm and a price-setting competitive industry will offer products of the same quality (i.e. durability in Swan's wording).

We have seen that higher dispersion (or a higher mean) of the switching costs stimulate poaching profits. Within the framework of our model increased poaching profits will make entry more attractive even at identical qualities. This, in turn, promotes competition in the vertically differentiated industry. In this respect more dispersed switching costs tend to make the industry more competitive from the point of view of a long-term perspective with free entry. This prediction seems to modulate the common view according to which higher switching costs would increase the market power of incumbent firms. Clearly, this popular view is restricted to a short-term perspective with already established customer relationships and with a given market structure.

5. Endogenous Market Structure

As we have demonstrated in the previous sections, switching costs open up the possibility of poaching, and poaching is increasingly profitable as a function of the dispersion of the switching costs. Furthermore, as we showed in section 4, clustering of firms takes place at the top of the quality spectrum in a duopolistic market. What can be said about further entry? Can even more firms enter at the top, once we allow for endogenous entry with sufficiently small entry costs $F>0$?

The answer is no. When three firms offer identical quality, competition for poaching revenues eliminates any poaching rents. Since ex-ante competition eliminates any incumbency rents, overall revenues will not cover any positive sunk cost of entry (see Taylor (2003)). This is stated in Lemma 5.1

Lemma 5.1 (*Competition for poaching revenues*)

Consider a market with at least three (or more) firms, $i=1,2,3$ all offering the top quality, $q_i = \omega$. (There may be further firms offering the same or lower quality.) In any subgame perfect equilibrium period-2 prices are then characterized by the poaching prices $r_2^i = 0$ and incumbency prices $p_2^i = \frac{1}{2}(\tilde{s} + \sigma + \Delta y)$. Intertemporal profits are then $\Pi^i = 0$ for all firms and these cannot cover any positive entry costs.

Proof: Since $i=1,2,3$ are identical competitors, the argument developed by Taylor (2003) applies. Accordingly, in equilibrium Bertrand competition eliminates any poaching profits. Further, ex-ante competition eliminates any incumbency profits. In this setting firms with lower quality cannot even attract positive market shares.

Q.E.D.

Accordingly, in any industry equilibrium with costly entry no more than two firms can offer the highest quality and still earn positive revenues. This argument is essentially true also for any quality level below top quality. Each quality level can be offered by at most two firms.

Proposition 5.2 (*Two at the Top*)

In any equilibrium with a small cost of market entry each quality level is provided by at most two firms. In particular, at most two firms offer the highest quality.

Hence, our model has the clear prediction that in markets with moderate entry costs and a sufficient degree of switching cost dispersion exactly two firms enter. Moreover, this industry structure is independent of market size, provided markets are mature enough to allow profitable entry of at least two top quality firms. This finding contrasts with the literature on multi firm location models, which either predicts existence problems (e.g. under linear transportation costs), or agglomeration of more firms than two firms, if agglomeration occurs at all. For example, de Palma, Ginsburgh, Papageorgiou and Thisse (1985) and Gehrig (1998) establish the emergence of agglomeration in multi-characteristics space under search externalities. However, in those models agglomeration is not limited to two firms. As markets grow, in those models typically increasingly more firms will agglomerate. Hence, these models cannot predict, why exactly two firms dominate certain industries.

Finally, note that in industry equilibrium there may be additional firms offering lower than top quality in order to compete away some of the poaching benefits. Since switching costs are continuously distributed depending on the cost of market entry, several lower quality providers may enter, each selecting different quality levels strictly below the top quality. This structure, however, implies that equilibrium prices will largely be determined by the two top firms. It will not be very sensitive to the number of further active firms in the industry. Already in duopolistic markets competition forces poaching and incumbency prices down to relatively low levels. Additional competition by additional lower-quality poachers will therefore restrain poaching (and incumbency) prices by some albeit small extent. In line with this implication the US-GAO report provides information that the fee structure of the US accounting industry did not change materially in the aftermath of the industry restructuring caused by the dissolution of Arthur Anderson and the merger of Coopers&Lybrand and Pricewaterhouse (US-GAO (2003)). This report cannot find any evidence for any significant increase in average fees in any market segment after the US market for accounting services was restructured from six (“Big Six”) to four (“Big Four”) large firms.

6. Discussion and Extensions

Throughout the analysis we have focused on analyzing the strategic incentives associated with the quality choice in isolation from considerations related the potential costs implied by quality improvements. Suppose, for the purpose of generalizing our analysis to incorporate also realistic cost considerations that the establishment of a production line of quality q imposes increasing and convex costs $F(q)$ so that $F'(q) > 0$ and $F''(q) > 0$. Under such circumstances the duopolists determine their qualities so as to solve the optimization problems

$$\max_{q_L} \quad \delta\, \tilde{\Pi}_2^L(q_L, q_H) \quad - \quad F(q_L)$$

and

$$\max_{q_H} \quad p_1^H\, M \quad + \quad \delta\left[\Pi_2^H(q_H, q_L) + \tilde{\Pi}_2^H(q_H, q_L)\right] \quad - \quad F(q_H).$$

Under these generalized circumstances the common strategic incentive, which implies an agglomeration at the top quality in the absence of cost considerations, does not generalize unless the marginal revenues associated with quality improvements are equal for the high-quality and the low-quality firm. In general we have no reason to expect this to be the case. Thus, in the presence of cost considerations each of the duopolists would supply the quality which equalizes its marginal revenues with the marginal costs of quality provision. In the case of sufficiently dispersed switching costs this would lead to a configuration of differentiated qualities, but neither necessarily maximal nor minimal differentiation. The precise degree of quality differentiation would depend on the particular features of the cost function *F(q)*. One might also conjecture that for lower marginal costs of quality improvements symmetric equilibria in quality may still be feasible, while high marginal costs of quality improvement are more likely to generate asymmetric quality choices.

The symmetry of quality choices is also a direct consequence of our assumption that switching costs are not related to quality differentials. When larger quality differentials imply larger switching costs, minimum differentiation will correspond to maximal intensity of price competition. In the extreme case of Bertrand competition this implies that identical quality choice will no longer occur in equilibrium. In such a variant of our model, similarly to Gehrig and Stenbacka (2004), an additional incentive to differentiate products would tend to generate differentiated quality outcomes.

In order to render our results more comparable to the literature on quality differentiation based on income heterogeneity alone we could generalize our model and introduce income heterogeneity in period 2 in addition to the differentiation in switching costs. Is agglomeration at the top quality a robust property with respect to such a generalization?

Assume that in period 2 consumers are represented by their combination of switching cost and income *(s,y)* and that the consumers *(s,y)* are uniformly distributed on $[\tilde{s}-\sigma, \tilde{s}+\sigma] \times [\underline{y}, \bar{y}]$.[13] In line with our earlier analysis, we assume that only period 2 income is differentiated due to some form of income shocks. This means that consumers (still) are identical in period 1.[14] Within such a framework we have shown in an earlier version of this study (Gehrig and Stenbacka, 2005) that in duopoly the subgame perfect equilibrium exhibits agglomeration at the highest quality level if the dispersion of the switching costs is sufficiently significant compared with the income dispersion, i.e. if $\sigma > \frac{1}{3}\left[\tilde{s} + (\varpi - v)(2\bar{y} - \underline{y})\right]$. It confirms that our central theme "two at the top" also applies to an economic environment that more closely resembles Shaked and Sutton (1982) with sufficiently significant switching cost differentiation as an additional crucial feature. We can easily see that for $\sigma = 0$ any equilibrium will imply a configuration with different quality levels. By continuity this property extends to cases with a small degree of switching cost dispersion.

Let us conclude with a comment on welfare for the case with sufficiently dispersed switching costs. From Corollary 3.4 we can also directly conclude that the welfare loss induced by switching costs is independent of the quality level in all symmetric equilibria where firms supply identical qualities, because under such circumstances the proportion $\frac{\sigma - \frac{1}{3}\tilde{s}}{2\sigma}$ of the customers switch. Interestingly, the ratio of switching consumers is increasing (decreasing) as a function of the variance (mean) of the switching costs. Thus, the welfare loss from switching is increasing (decreasing) as a function of the variance (mean) of the switching costs. Furthermore,

[13] The literature reports fairly few attempts to analyze multi-dimensional product differentiation. Important exceptions are Irmen and Thisse (1998) for an analysis of competition in general multi-characteristics spaces, Neven and Thisse (1990) and Ireland (1987) (Chapter 7) for combinations of horizonal and vertical product differentiation and Dos Santos Ferreira and Thisse (1996) for an analysis of the Launhardt model.

[14] Allowing for income heterogeneity already in period 1 renders the analysis slightly more complex, since individual histories at various income levels need to be tracked. However, the same basic economic forces are at play.

as observed in Proposition 3.1, the poaching prices are increasing (decreasing) as functions of the variance (mean) of the switching costs in equilibria with identical qualities.[15]

7. Conclusion

In this study we have established that the distribution of switching costs across consumers may be an important determinant of quality choice. In vertically differentiated markets where switching cost heterogeneity is sufficiently significant low-quality producers have an incentive to close the quality gap to high-quality producers despite the bite of price competition. Under such circumstances the equilibrium configuration will be characterized by an agglomeration of two firms at the top of the quality spectrum. In this sense our result differs strongly from standard vertical differentiation models based on income differences between consumers. In such types of models the degree of differentiation is always strictly positive. In our model the incentives created by poaching profits dominate relative to the competition-relaxing effects of quality differentiation. This holds true as long as the poaching profits survive in equilibrium, i.e. as long as no more than two firms produce the top quality. Our results do not invalidate the finiteness property found in models of vertical product differentiation, since entry is limited by the profitability of poaching revenues. In particular, our theory predicts that there will never be more than two firms at the top of the quality spectrum.

Our results add important insights regarding the effects of switching costs on quality choice and industry structure. Most importantly, our model shows that a concentrated industrial structure with minimal quality differentiation is compatible with price competition in an intertemporal model of competition with switching cost heterogeneity. Furthermore, the industrial structure and the equilibrium configuration of qualities are determined by the dispersion of the switching costs rather than by their mean.

Our framework lends itself to quite a number of extensions. One could, for example, model switching costs to be quality-dependent or dependent on how different the available products are. Such considerations would introduce additional strategic effects like those analyzed by Gehrig and Stenbacka (2004) in a model of differentiation-induced switching costs within the framework of horizontal product differentiation.

[15] Of course, in our model where each consumer purchases precisely one unit of the product the price effect represents nothing but a transfer between the consumers and the producers with no impact on total welfare.

Moreover, one might also be interested in the market structure with a longer time time horizon with more rounds of price competition, and hence more occasions for switching, and possibly re-switching. The availability of more extensive customer histories would there would enable more precise forms of behaviour-based price discrimination. It would be interesting to explore the effects of such more precise form of price discrimination for equilibrium qualities and industrial structure.

Appendix

Proof of Propositions 3.1 – 3.3:

The first-order conditions of (5a) and (5b) read

$$\begin{pmatrix} 2 & -1 \\ -1 & 2 \end{pmatrix} \begin{pmatrix} p_2^H \\ r_2^L \end{pmatrix} = \begin{pmatrix} \tilde{s} + \sigma + \Delta y \\ -\tilde{s} + \sigma - \Delta y \end{pmatrix}. \tag{A.1a}$$

Moreover the first order conditions of (6a) and (6b) read

$$\begin{pmatrix} 2 & -1 \\ -1 & 2 \end{pmatrix} \begin{pmatrix} r_2^H \\ p_2^L \end{pmatrix} = \begin{pmatrix} -\tilde{s} + \sigma + \Delta y \\ \tilde{s} + \sigma - \Delta y \end{pmatrix}. \tag{A.1b}$$

Hence the interior segments of the reaction functions are given by:

$$\begin{pmatrix} p_2^H \\ r_2^L \end{pmatrix} = \frac{1}{2} \begin{pmatrix} \tilde{s} + \sigma + \Delta y + r_2^L \\ -\tilde{s} + \sigma - \Delta y + p_2^H \end{pmatrix} \tag{A.2a}$$

$$\begin{pmatrix} r_2^H \\ p_2^L \end{pmatrix} = \frac{1}{2} \begin{pmatrix} -\tilde{s} + \sigma + \Delta y + p_2^L \\ \tilde{s} + \sigma - \Delta y + r_2^H \end{pmatrix} \tag{A.2b}$$

(a) When $\sigma \geq \frac{1}{3}(\tilde{s} + \Delta y)$, both firms price on their interior reaction functions. In this case an interior price equilibrium exists. It reads:

$$\begin{pmatrix} p_2^H \\ r_2^L \end{pmatrix} = \frac{1}{3}\begin{pmatrix} \tilde{s} + 3\sigma + \Delta y \\ -\tilde{s} + 3\sigma - \Delta y \end{pmatrix} \tag{A.3a}$$

$$\begin{pmatrix} r_s^H \\ p_2^L \end{pmatrix} = \frac{1}{3}\begin{pmatrix} -\tilde{s} + 3\sigma + \Delta y \\ \tilde{s} + 3\sigma - \Delta y \end{pmatrix} . \tag{A.3b}$$

(b) When $\frac{1}{3}(\tilde{s} - \Delta y) < \sigma < \frac{1}{3}(\tilde{s} + \Delta y)$, the low-quality firm selects the corner solution $r_2^L = 0$, while the high-quality firm produces according to its reaction correspondence (A.2a)

$$\begin{pmatrix} p_2^H \\ r_2^L \end{pmatrix} = \frac{1}{2}\begin{pmatrix} \tilde{s} + \sigma + \Delta y \\ 0 \end{pmatrix} \tag{A.4a}$$

$$\begin{pmatrix} r_s^H \\ p_2^L \end{pmatrix} = \frac{1}{3}\begin{pmatrix} -\tilde{s} + 3\sigma + \Delta y \\ \tilde{s} + 3\sigma - \Delta y \end{pmatrix} . \tag{A.4b}$$

(c) When $\sigma < \frac{1}{3}(\tilde{s} - \Delta y)$, both firms select minimal poaching prices $r_2^L = r_2^H = 0$, while incumbency prices are determined by the reaction correspondences (A.2a) and (A.2b).

$$\begin{pmatrix} p_2^H \\ r_2^L \end{pmatrix} = \frac{1}{2}\begin{pmatrix} \tilde{s} + \sigma + \Delta y \\ 0 \end{pmatrix} \tag{A.5a}$$

$$\begin{pmatrix} r_s^H \\ p_2^L \end{pmatrix} = \frac{1}{2}\begin{pmatrix} 0 \\ \tilde{s} + \sigma - \Delta y \end{pmatrix} . \tag{A.5b}$$

Q.E.D.

Proofs of Propositions 3.8 – 3.10:

For the low-quality supplier the competitiveness of the period-1 discount is limited by the value of low quality incumbency in each case. Hence p_1^L is determined by the corresponding incumbency profits given by (9b).

The indifference relation (12), or equivalently the quality premium relation (13,) can be used to determine p_1^H. When $\sigma \geq \frac{1}{3}(\tilde{s} + \Delta y)$, according to Corollary 3.4 the switching thresholds are given by $\hat{s}_H = \frac{1}{3}[2\tilde{s} - \Delta y]$ and $\hat{s}_L = \frac{1}{3}[2\tilde{s} + \Delta y]$. Substituting these as well as the period-2 equilibrium prices (7a) and (7b) into (13) yields the period-1 prices (15a) and (15b) after some algebraic manipulations.

The proofs of Propositions 3.9 and 3.10 are analogous. When $\frac{1}{3}(\tilde{s} - \Delta y) < \sigma < \frac{1}{3}(\tilde{s} + \Delta y)$, the the switching cost thresholds are $\hat{s}_H = \tilde{s} - \sigma$ and $\hat{s}_L = \frac{1}{3}[2\tilde{s} + \Delta y]$. Similarly, when $\sigma < \frac{1}{3}(\tilde{s} - \Delta y)$, the switching cost thresholds are $\hat{s}_H = \tilde{s} - \sigma = \hat{s}_L$.

Q.E.D.

Proof of Proposition 4.1:

(a) First we focus on the case with sufficiently dispersed switching costs so that $\sigma \geq \frac{1}{3}\tilde{s}$. Differentiation of the low-quality firm's objective function shows that

$$\frac{\partial\, \delta\, \tilde{\Pi}_2^L(q_L, q_H)}{\partial\, q_L} = \frac{2\,\delta\, M\, (-\tilde{s} + 3\sigma - \Delta y)}{18\sigma}\, y \quad > \quad 0 \quad \text{when} \quad \sigma > \frac{1}{3}(\tilde{s} + \Delta y),$$

which means that the low-quality firm has an incentive to close the gap to the high-quality firm. Through straightforward calculations it can further be verified that the profit of the high-quality firm is increasing in q_H since

$$\frac{\partial \left(p_1^H\ M \quad + \quad \delta \left[\Pi_2^H(q_H, q_L) + \tilde{\Pi}_2^H(q_H, q_L)\right]\right)}{\partial\, q_H} \quad > \quad 0\,.$$

Consequently, in equilibrium both duopolists make identical quality decisions at the highest available quality level. In other words, in equilibrium there will be agglomeration at the top of the available quality spectrum.

(b) In the case of low dispersion of switching costs $\sigma < \frac{1}{3}\tilde{s}$ the low quality firm cannot profitably poach. Moreover, in this case even matching top quality cannot generate positive revenues.

Q.E.D.

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