Quantitative Marketing and Economics (2023) 21:381–435
https://doi.org/10.1007/s11129-023-09266-9

Price commitment and the strategic launch of a fighter brand

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Received: 28 November 2022 / Accepted: 2 May 2023 / Published online: 1 July 2023

Abstract
We consider a vertically differentiated market where an incumbent strategically wants to launch a fighter brand to thwart a new entrant. Without a credibly commitment this launch is ineffective because the incumbent always has an incentive to price the fighter brand ex-post out of the market. Endogenous price leadership with fixed or list price announcement, and dual channeling with an intermediary retailer to distribute the fighter brand are analyzed as commitment devices. The optimal mode then depends on customers' sensitivities to a deviation from the price announcement as well as on the attractiveness of the underlying market.

Keywords Fighter brand · Endogenous price leadership · Dual channeling

JEL Classification C72 · D43 · L15 · M31

1 Introduction

In the late 1960 s, one of every two watches in the world was made in Switzerland - almost all mechanical. Ten years later, by the end of the 1970 s, the Swiss share of the world market has plummeted to 15%. US watchmakers like Timex, and Japanese companies like Citizen and Hattori-Seiko, took advantage of the new quartz and LED technologies to offer watches at considerably lower prices. Still, Swiss watchmakers continued to dominate the upper end of the watch market with brands like Omega, Longines, or Tissot. To protect these highly valuable premium brands from encroachment by its competitors, the SMH Group, formed by a merger of the two largest

The author thanks two anonymous referees and Anna Ressi for helpful comments and suggestions. All errors remain my own.

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watchmaking groups in the country, launched the Swatch brand in 1983 as a low-cost, high-tech line plastic-cased watches. This launch was so successful that not only did the Swatch sales and exports grow at double-digit rates through the 1980 s, but also its premium brands could maintain a stronghold in the higher end market, see Mudambi (2005) and Barrett (2000).

Swatch is a typical example of a so-called fighter brand that a brand manufacturer under competitive pressure can use to respond to potential entry. Positioning a second product lower in quality than the existing premium brand targets directly against low-price competitors. Many brand manufacturers have used such fighter brands against low-cost entrants[1]: Qantas, for example, dominating the Australian airspace, launched JetStar to attack Virgin Blu; British Airways launched GO to take on Ryanair and EasyJet in the UK; General Motors launched Saturn to fight against Japanese imports into America; Nestle created a fighter brand called Khrutka to compete in the Russian market directly with the local corn flakes producers; or Philip Morris has used L&M, Basic and Chesterfield as fighter brands to flank its brand Marlboro. In some cases, fighter brands might even open up a new lower-end market segment for the brand manufacturer. For example, 3 M created a low-price version called Highland of its Post-it Notes to compete with its cheaper rivals. And, Anheuser-Busch promoted Busch Bavarian against regional breweries to protect its premium brands Budweiser and Michelob, see Ritson (2009). In both cases, it turned out that these fighter brands were so profitable that 3 M, as well as Anheuser-Busch, left them in their portfolio long after their cheaper rivals had left the market.

However, positioning a fighter brand confronts a brand manufacturer with a dual challenge: On the one hand, this second brand should weaken the market position of potential entrants, should drive them out of the market, or, ideally, prevent their entry at all. On the other hand, introducing a fighter brand should not end up competing with the manufacturer's premium brand. Such cannibalization would imply that current premium brand customers switch to buy the new fighter brand, although they would have never switched to the rival's low-price product. To cope with this dual challenge, the incumbent has two different strategies to position a fighter brand successfully[2]:

- The firewall strategy is the most common response to launch a fighter brand. The idea is to position the second product below the quality of the top product but without moving below the expected quality of the low-price competitor. In this sense, the fighter brand should fend off rival firms to directly compete with the premium brand. As a response to private labels, Procter & Gamble, for example, repositioned some well-known products as higher-grade alternatives, such as Luvs disposable diapers or Camay beauty soap. In the U.S. airspace, the established

[1] For Qantas, see Ritson (2009); for British Airways, see "New BA Low-Cost Airline Meets Legal Threat," BBC News 1997-11-17 (http://news.bbc.co.uk/2/hi/business/31921.stm); for General Motors see "Behind the hype at GM's Saturn" FORTUNE Magazine 1985-11-11 (http://money.cnn.com/magazines/fortune/fortune_archive/1985/11/11/66593/index.htm); for Nestle see "How to Create a Fighting Brand", Global Brand Building 2009-12-06 (http://www.globalbrandbuilding.com/blog/2009/12/6/how-to-create-a-fighting-brand.html).

[2] The term firewall strategy is used by Pierce and Moukanas (2002) and D'Aveni (2004) in the context of a company's brand portfolio. See Berry and Schiller (1994) and Hilleke and Butscher (1997) for the following examples on the firewall strategy. The term sandwich strategy was coined by Jain (2006). See Jain (2006) and Ikrama (2008) for the following examples on the sandwich strategy.

airlines countered Southwest Airlines' no-frills concept with low-frills sub-airlines such as Shuttle by United Airlines, Delta Express by Delta Airlines, or Continental Lite by Continental Airlines.

- The sandwich strategy is another way to position a fighter brand. Instead of launching the second product in the middle market segment to fight low-price competitors, the manufacturer differentiates the offerings by launching the fighter brand as a low-price, low-quality product. By doing so, the rival's positioning is sandwiched and locked into the middle market segment. After the patent expiry of its blockbuster proton pump inhibitor drug Prilosec and the entry of several generics, AstraZeneca, for example, introduced a non-prescription, over-the-counter offering Prilosec OTC and sandwiched the generics on price and quality. Or, in the parcel delivery market in the U.S., market leader FedEx launched a second brand called FedEx standard delivery to sandwich United States Postal Service (USPS), which introduced an air courier service with a price significantly below the rate of its brand service called FedEx Priority.

The purpose of the present paper is to analyze the strategic role of a fighter brand to accommodate entry in a vertically differentiated market. In our setup, we consider an incumbent firm that already produces a product of high quality. The incumbent, foreseeing market entry, positions a fighter brand before the entrant's product launch. Then both firms set prices, and customers decide which product to buy. Two aspects of this modeling are essential to note: First, in the absence of market entry, the incumbent never finds it optimal to have a second product. This one-product strategy follows because customers are uniformly distributed according to their willingness to pay for quality which implies that marginal revenues are decreasing.[3] However, in the presence of market entry, introducing a fighter brand might be beneficial because it allows the incumbent to influence the positioning of the entrant's product and protect the high-quality product. And second, note that the timing of the launch of the fighter brand is essential for its strategic role: By launching the fighter brand before the competitor entered, the incumbent tries to influence the quality positioning of the entrant. If the launch would be simultaneously or after the entrant's product launch, it would never be optimal for the incumbent to offer a second product because this would not influence the quality decision of the entrant.[4]

Not in all the examples mentioned above does the incumbent use the launch of a fighter brand for such preemptive reasons. Take, for example, the fighter brands of the SMH Group, 3 M, or Anheuser-Busch. They launched their fighter brands after the entrant's product choice. Hence, introducing a second, lower-positioned product to the brand product was not to influence the entrant's quality choice but to weaken the entrant's market position or drive them out of the market.

[3] The one-product strategy as well as the following commitment problems for the incumbent can be established even under a more general distribution assumption. See the discussion in Sect. 5 as well as Appendix 4.

[4] Note that this argumentation implicitly assumes that the entrant is perfectly informed about the incumbent's intention to influence his quality decision. If, however, the entrant is unsure about the incumbent's intention, the entrant's quality choice might be affected even if the possible launch of the fighter might happen after the entrant decides its quality, see the discussion in Sect. 5.

There are, however, examples in which firms launch their fighter brands for preemption, either to influence the quality decision of the entrant or even to prevent them from entering into existing home markets.[5] In the example above on the U.S. airline industry, the established airlines introduced low-fare sub-airlines not only to fight back for market share ex-post after the entry of Southwest Airlines but also to prevent Southwest Airlines from entering into other existing home markets. These fighter brands flew on routes with head-to-head competition with no-frills carriers like Southwest Airlines but also on routes where low-price competitors were not yet offering services. A brand manufacturer of electronic goods used a similar two-product strategy to counter and prevent the entry of Chinese manufacturers which low-quality products. By launching a fighter brand, the brand manufacturer stopped the decrease of profits in already entered markets and used this strategy worldwide in countries where the low-priced competitors have not yet tried to enter the market.

As a first result, we show that the launch of a fighter brand is ineffective without any commitment by the incumbent. Two commitment problems might arise: First, the incumbent might have an incentive to withdraw the fighter brand after the entrant chose a quality level. In our model, two reasons might induce this temptation. First, introducing a second product does not open up new market segments with high growth potential, as in the examples mentioned above of 3 M and Anheuser-Busch. This possibility is excluded since we consider a market with one homogeneous market segment only. Second, we do not consider exit costs for the incumbent in our model. As first discussed by Judd (1985), preempting new entrants by product proliferation then is not credible because the incumbent can always withdraw the new product. Such a behavior happened, for example, in the match industry in both Canada and the United Kingdom.[6] Here, the monopolist introduced a locally marketed brand of lower quality as a fighter brand to deter or limit new entry and withdrew the brand as soon as the entrant left the market or was sold out to the monopolist. In our model, the entrant would foresee such behavior by the incumbent and then launch a higher quality product.

The second commitment problem, however, is more severe. Even if the incumbent has no incentive to withdraw the fighter brand, it always has an incentive to price the fighter brand out of the market to increase the profits with the premium product. Such behavior can occur independently of whether the incumbent positions the fighter brand using the firewall or the sandwich strategy:

- When using the firewall strategy, the incumbent can set the price for the fighter brand so high that the price-quality ratios of the premium and fighter brand are identical. No customer would buy the second new product, and the resulting market demand is zero. By doing so, the incumbent avoids any cannibalization with the premium product.
- When using the sandwich strategy, the incumbent can set the price for the fighter brand so high that the resulting market demand is zero. Although this reduces the incumbent's profits with the fighter brand, it relaxes price competition with the entrant's product. Such behavior is beneficial for the incumbent because it also

[5] See Hilleke and Butscher (1997) for the following examples.

[6] See Bolton et al. (1999) and, in particular, Yamey (1972, p.136f) for further references.

relaxes price competition with the premium product with higher profit margins than those with the fighter brand.

Of course, in both cases the entrant anticipates the incumbent's pricing behavior and is better off by launching a product directly in the higher market segment. Hence, the strategic role assigned to the fighter brand is lost without any commitment by the incumbent to the pricing strategy for the fighter brand.

To resolve both commitment problems, we consider two commitment devices, endogenous price leadership with a price announcement and dual channeling with price delegation, and analyze their trade-offs:

- Under endogenous price leadership, the incumbent can send out a catalog or leaflet to consumers or use TV or Internet to advertise the price for the new product. In principle, such an advertisement is possible in two ways. The incumbent can announce to offer the fighter brand either for a specific fixed price or for a particular list price with the possibility to sell the fighter brand for a discounted price that is less than or equal to the announced list price.[7] The incumbent's investment in advertisement indicates the degree of commitment not to price the fighter brand higher than announced. Deviating from this announcement implies a loss in the incumbent's reputation in the entire market and influences the premium product sales. The extent of this reputation loss thereby depends on customers' reaction in case of a deviation and the incumbent's advertising investments for the new product. If these investments are sufficiently high, the incumbent credibly commits to its price announcement and has no incentive to withdraw the fighter brand ex-post.
- Under dual channeling, the incumbent uses an intermediary retailer to distribute the fighter brand. By offering a franchise contract to the retailer, the incumbent delegates the sales of the fighter brand to a third party. Dual channeling, therefore, solves both commitment problems of the incumbent. However, since cannibalization concerns do not influence the retailer's pricing decision, the retailer intensifies competition with the entrant. Hence, using a dual-channel as a commitment device comes with some costs for the incumbent.

We then show the following four results: First, although both commitment devices entail costs, it is always beneficial for the incumbent to use one of them. Second, independent of the commitment device used, the incumbent always positions the fighter brand to defend the premium product strategically. That is, a firewall strategy is always better than a sandwich strategy. The reason is as follows: When using the firewall strategy, the incumbent will optimally choose prices to cover the upper half of the entire market by the premium product. To reduce the negative effect of cannibalization, the incumbent tries to position the quality level of the fighter brand as low as possible. Of course, if this quality level is too low, the fighter brand loses its purpose as a firewall, and the competitor launches the product in the middle market segment. Although this eliminates any cannibalization, the sandwich strategy leads to more price competition,

[7] For the use of fixed pricing and how firms can commit to not offering discounts, see Harrington (2011) for practical examples. For the use of list pricing and examples in business, see Diaz et al. (2009) or Ning (2021).

which reduces the demand for the fighter brand and the premium product. Third, we show that a list price leads to higher profits than a fixed price announcement. Under the fixed price commitment, the entrant introduces a product identical to the quality of the fighter brand but priced slightly below its fixed price. Consequently, the incumbent makes no profits with the fighter brand, and the entrant's product competes directly with the premium product. Although the incumbent can strategically use the entrant's reaction to position the fighter brand even lower in the market and for a higher price than the list price, this does not compensate for the loss of profits with the fighter brand. Note that such an imitation of the fighter brand is not beneficial for the entrant under a list price commitment because the incumbent can react to the entrant's price cut with a discount. Price competition then sparks a continuous undercutting mechanism that leads to zero profits for the entrant. And fourth, the optimal commitment device depends on the reputation elasticity and the attractiveness of the market. Suppose customers' sensitivity to a deviation from the incumbent's price announcement is low or the market is very attractive. In that case, dual channeling is the only commitment device for the incumbent because the necessary advertising investments for an endogenous price leadership would be too high. Suppose customers' sensitivity increases or the market attractiveness is in an intermediate range. In that case, advertising in a fixed price commitment becomes possible and optimal. In contrast, an endogenous price commitment with a list price becomes optimal if the reputation elasticity is sufficiently high or the market is relatively unattractive.

The paper proceeds as follows: Sect. 2 reviews the related literature. Section 3 introduces the basic model of a vertically differentiated market in which an incumbent can use a fighter brand as a response to entry and solves for the optimal behavior. Section 4 extends the basic model to analyze two commitment devices; endogenous price leadership and dual channeling. We conclude with some final remarks in Sect. 5. Proofs of the results are presented in the Appendix.

2 Related literature

This paper mainly contributes to the economic literature on strategic entry deterrence with product proliferation.[8] The idea that incumbent firms can deter entry by product proliferation goes back to Hay (1976), Prescott and Visscher (1977), Schmalensee (1978), Eaton and Lipsey (1979), and Omori and Yarrow (1982). They argue that launching additional products and thereby crowding the product spectrum, incumbents leave potential entrants no niche for entry. Such a product proliferation strategy is beneficial for the incumbent even though it leads to inefficiencies in the absence of possible entry.[9]

[8] Besides product proliferation, the incumbent might also use other strategic options to react to potential entry. Since the seminal papers by Spence (1977) and Dixit (1979, 1980), most articles study the use of limit pricing in price competition or limit quantity in quantity competition. More recent articles are Noh and Moschini (2006), where the incumbent relies on limit qualities, Jost (2014) and Kurokawa and Matsubayash (2018), where the incumbent adjusts the quality and price of the premium product, Wang et al. (2016) where the incumbent uses a branding strategy or Baron (2021) where the incumbent uses product innovation.

[9] There are, of course, other non-strategic reasons for firms to apply multiproduct strategies, see, e.g., Kim and Kim (1996) for cost spill-overs, or Gabszewicz et al. (1986) for demand side characteristics.

Judd (1985) emphasized the importance of commitment in determining whether product proliferation can serve as a credible entry deterrent. He argued that an incumbent might have an incentive to withdraw some products once the entrant entered the market to prevent competition.[10] In the context of a multi-market model, he then showed that crowding the product spectrum will not credibly deter entry when goods are substitutes, exit costs are low, or competition for the same good is intense. This result is different in a market with horizontal product differentiation. Depending on the costs for launching an additional product, an incumbent always has an incentive to crowd the product spectrum to increase profits even in the absence of potential entry. Indeed, suppose the incumbent faces the threat of entry. In that case, Bonanno (1987) shows that the incumbent better uses an entry-deterring strategy by changing the specification of its products instead of increasing the number of products.

In a market with vertical product differentiation, however, the problem of commitment becomes even more severe than in the multi-market model as in Judd (1985), for the following reason[11]: An incumbent protected by market entry would, as a monopolist, only offer one product, namely the one with the highest quality. Hence, in the presence of potential entry, an incumbent launches a second product only for strategic reasons like entry deterrence. Therefore, the incumbent's incentives to withdraw the second product after successful entry deterrence are high. This temptation is independent of whether the market is covered or uncovered. Suppose the market is covered because all customers have an income such that they are willing to buy always one product. Then Donnenfield and Weber (1992) show that the incumbent chooses the highest quality and the entrant offers the lowest quality if both firms apply a one-product strategy. If, in addition, the incumbent can launch a second product, Bonnisseau and Lahmandi-Ayed (2006) show that the incumbent has no incentive to do so to prevent entry in the low-quality segment. Müller and Götz (2017) show that if there are two incumbents in the market as in Donnenfield and Weber (1992) and the high-quality incumbent can launch a second product to prevent entry, launching a fighter brand as a firewall is always optimal. However, they neglect the commitment problem in their analysis and discuss only interior solutions. Suppose the market is uncovered because some customers do not buy. Then the model of Choi and Shin (1992) shows that quality differentiation between the incumbent and an entrant is not maximal if both can offer only one product. Hence, price competition is fiercer than in a market that is covered. If the incumbent applies a multi-product strategy, Jost (2014) shows that the high-quality incumbent also positions a second product as a firewall. However, he circumvents the commitment problem by assuming that the incumbent can credibly introduce a second product quality. In the model by Li (2019), which also studies vertical line extension in the context of preemption, the

[10] For empirical support of this commitment problem, see Piazzai and Wijnberg (2019), who study sequential product introductions in the U.S. recording industry. They show that product complexity increases the deterrent power of product proliferation.

[11] Vertical differentiation and product line strategies have been extensively researched after the classical papers from the early 1980 s by Gabszewicz and Thisse (1979, 1980) and Shaked and Sutton (1982, 1983), see, e.g., Moorthy (1988, 1991), Motta (1993), Lehmann-Grube (1997), Jones and Mendelson (2011), or Siebert (2015). However, most of this literature does not investigate entry deterrence. Consequently, the strategic launch of a fighter brand and the commitment problem discussed in this paper is not an issue in this literature.

problem of commitment does not arise due to status preferences of customers. She considers an incumbent selling a premium good to customers with an additional status utility derived from the average status (willingness to pay) of all buyers when buying this product. Launching a fighter brand might be profitable for the incumbent if customers exhibit such preferences. The status preferences increase the differentiation between the premium product and the fighter brand because it alleviates cannibalization.

The basic model of our analysis then is similar to Jost (2014) and Müller and Götz (2017) with the following modifications. Unlike Jost (2014), we do not consider a two-period setup where customers make purchases from the incumbent in both periods while purchasing from the entrant only in the second period. Instead, we follow Müller and Götz (2017), assuming that the incumbent's highest quality product is exogenously given. Unlike Müller and Götz (2017), we do not consider two incumbents offering products when entry occurs, and the market is not covered. Instead, we follow Jost (2014) in assuming that only one incumbent is active in the market and that customers have the option not to buy a product.

The contribution of the present paper is to solve the incumbent's commitment problems when launching a fighter brand for strategic reasons. Our paper contributes to the literature on endogenous price leadership concerning the first commitment device where the incumbent announces a fixed or list price. This stream of literature investigates under which conditions it is optimal for a dominant or more efficient firm to act as a price leader in an oligopolistic market. See, for example, Deneckere and Kovenock (1992), Deneckere et al. (1992), Tasnádi (2004), or Pastine and Pastine (2004) for models where the timing of moves is endogenously derived. Li (2014) analyzes the case in which two firms already offer a product, one firm a high-quality product, and its competitor a low-quality product. The competitive setup is different in our model since the entrant endogenously chooses the quality level of its product before price competition takes place. Consequently, the entrant would have a second-mover advantage in his quality and price-setting behavior if the incumbent announces a specific fixed price when launching the fighter brand. For this reason, we also consider endogenous price leadership, where the incumbent offers a special list price for selling its second product.[12] Concerning the second commitment device, the idea to use a retailer as a commitment device for launching and pricing a fighter brand goes back to Hadfield (1991). He shows that the delegation of pricing authority to an independent third party through a franchise contract can deter entry. However, his analysis is not in a framework of vertical but horizontal differentiation.

3 The commitment problem when launching a fighter brand

This section first introduces the basic model of vertical differentiation with entry. We then show that if the incumbent cannot credibly commit to launching the fighter brand, product proliferation has no strategic role for entry deterrence.

[12] Note that the incumbent's commitment to a specific price serves as a device to influence the entrant's product positioning. Loginova (2016) and Dai (2017) discuss price commitment as a mechanism to influence consumers' consumption choices.

3.1 The basic model

Consider a vertically differentiated market where products can be produced in different qualities $q \in [0, \overline{q}]$ where $\overline{q} > 0$ is the highest possible quality level. We assume that a customer buys no more than one unit of the product from the qualities available in the marketplace. Customers' preferences are described by a parameter θ which is uniformly distributed on the interval $\left[0, \overline{\theta}\right]$ with unit density, where $\overline{\theta} \geq 1$. The parameter θ of a customer can be interpreted as the willingness to pay for a product. The net surplus when buying a product with quality q for price p then is

$$u\left(q, p\right) = q\theta - p.$$

Customers who do not purchase receive zero utility.

On the supply side, we presume that an incumbent - henceforth, she - already developed and produces one product of highest quality $q_H = \overline{q}$. This product is the incumbent's premium product.[13] Before a competitor enters the market, the incumbent can launch a second product as fighter brand with lower quality. Let $q_L > 0$ be the quality of this fighter brand, with $q_L < \overline{q}$. To focus on the incumbent's commitment problem, we assume that she has no further development costs and can costlessly develop a lower quality product. Being aware of both product qualities $q_L,\ q_H$, the entrant - henceforth, he - enters the market. The basic model assumes that the entrant has free access to the incumbent's technology and no development costs for a lower quality level. Since market entry is without costs, the market becomes a duopoly.[14] The entrant then competes for customers by offering a product with quality q_E with $q_E > 0$. We assume in the basic model that introducing or withdrawing a fighter brand is without costs for the incumbent. As it is standard in literature on vertical differentiation, marginal costs of production are normalized to zero for both firms.[15]

The incumbent observes the entrant's quality choice q_E and both firms then set prices $p_H,\ p_L$ and p_E conditional on the qualities offered in the market. This choice then determines firms' demands $x_H,\ x_L$ and x_E. Since production is without costs, the entrant's profits are

$$\pi_E\left(q_H, q_L; q_E\right) = p_E x_E,$$

and the total profits of the incumbent are

$$\pi_I\left(q_H, q_L; q_E\right) = p_H x_H + p_L x_L.$$

[13] This assumption is without loss of generality. Assuming that the incumbent has some convex development costs $c(q) = \gamma q^2/2$ to produce a quality q as in Jost (2014), it is easy to show that she chooses a quality level $q_H = \overline{\theta}^2/4\gamma$. And if the incumbent has production costs $c\left(q, x\right) = \gamma q^2 x/2$ for producing x units of quality q as in Noh and Moschini (2006), calculation shows that the premium product has quality $q_H = 2\overline{\theta}/3\gamma$. In either case, the incumbent faces a commitment problem when launching a fighter brand. As a consequence, the central insights of our analysis carry over to a more general setting with development and production costs.

[14] See Section 4.1 to discuss how fixed cost of entry or quality development cost affects our results.

[15] Under the assumption of constant marginal production cost for quality and quantity, all our results are extended by an obvious price translation; see, for example, Bonnisseau and Lahmandi-Ayed (2006).

In sum, we consider the following sequence of events[16]:

Stage 1 The incumbent, already producing a product with quality level $q_H = \overline{q}$, can introduce a second product quality q_L with $q_L \in (0, \overline{q})$.

Stage 2 The entrant enters the market and offers a product of quality $q_E > 0$.

Stage 3 Having observed the product qualities offered in the market, the two firms compete by simultaneously choosing prices $p_H,\ p_L$ respectively, p_E, in the product market.

Stage 4 Customers decide whether to buy from the firm that offers the best price-quality combination or whether not to buy at all.

3.2 The incumbent's commitment problem

Before we solve the basic model, note that the incumbent would never introduce a second quality into the market without the threat of entry, see, e.g., Mussa and Rosen (1978), Moorthy (1984), or Tirole (1988, pp. 296–297). In fact, for a given quality level q_H of her product, the incumbent always uses a one-product strategy which leads to monopoly profits $\pi_I = \overline{\theta}^2 q_H/4$ and a monopoly price $p = \overline{\theta} q_H/2$.[17] As noted before, the incumbent would then prefer the highest possible quality level, $q_H = \overline{q}$, if she could also choose the quality level q_H of her product.

To solve the basic model of Sect. 3.1, we use backward induction. Suppose that the incumbent has launched the second product of quality q_L in Stage 1 and that the entrant entered by offering a product of quality q_E in Stage 2. Market competition in Stage 3 then depends on where the entrant located his product quality. Two product quality orderings can be distinguished. In the firewall scenario, the entrant positions his product q_E in the low quality area and $q_E < q_L < q_H$. In the sandwich scenario, the entrant offers a new product q_E in an intermediate quality range between the incumbent's two products and $q_L < q_E < q_H$. Customers in Stage 4 can choose between three different products in both cases.

To discuss the incumbent's commitment problem, suppose that the incumbent offers the high-quality product for a price p_H and that the entrant offers his product for a price p_E. The consumption decisions in Stage 4 then depend on the price p_L for the fighter brand, which determines whether the fighter brand is active in the market with positive demand. To see this in more detail, consider first the firewall scenario, then the sandwich scenario.

Stage 4 - Firewall scenario Suppose that the fighter brand has positive demand such that three indifferent customers exist in the market. One type of customer θ_1 is indifferent between buying the product with the highest quality q_H or the fighter brand with quality q_L, that is, $\theta_1 q_H - p_H = \theta_1 q_L - p_L$. One type of customer θ_2 is indifferent

[16] Note that we assume here that the incumbent's introduction of the fighter brand at Stage 1 is carried out before the entrant's product launch at Stage 2. Of course, we could have also assumed that introducing the fighter brand is only an announcement to launch a fighter brand at a later stage. However, the driving force behind the incumbent's commitment problems does not alter.

[17] In case the incumbent would offer two product qualities with $q_H > q_L$, profit maximization leads to identical price-quality ratios of both products, $p_H/q_H = p_L/q_L = \overline{\theta}/2$. However, the demand for low-quality products then is zero.

between buying the fighter brand from the incumbent or the entrant's product with quality q_E, that is, $\theta_2 q_L - p_L = \theta_2 q_E - p_E$. And one type of customer θ_3 is indifferent between buying the lowest quality product q_E or nothing at all, that is, $\theta_3 q_E - p_E = 0$. Hence, any customer with $\theta \geq \theta_1$ will prefer to buy product q_H, any customer with intermediate parameter $\theta \in (\theta_2, \theta_1)$ will buy product q_L, any customer with intermediate parameter $\theta \in (\theta_3, \theta_2)$ will buy product q_E, and any consumer $\theta \leq \theta_3$ will not buy at all. This consumption behavior results in market demands,

$$x_H = \overline{\theta} - \frac{p_H - p_L}{q_H - q_L},\ x_L = \frac{p_H - p_L}{q_H - q_L} - \frac{p_L - p_E}{q_L - q_E},\ x_E = \frac{p_L - p_E}{q_L - q_E} - \frac{p_E}{q_E},$$

and the incumbent's profits $p_H x_H + p_L x_L$ are

$$\pi_{IF}\left(q_H, q_L; q_E\right) = p_H\left(\overline{\theta} - \frac{p_H - p_L}{q_H - q_L}\right) + p_L\left(\frac{p_H - p_L}{q_H - q_L} - \frac{p_L - p_E}{q_L - q_E}\right).$$

Note that the demand x_L for the fighter brand is strictly positive, $\theta_2 < \theta_1$, only if p_L is sufficiently low, that is, lower than the weighted average of p_H and p_E,

$$p_L < p_H \frac{(q_L - q_E)}{(q_H - q_E)} + p_E\left(1 - \frac{(q_L - q_E)}{(q_H - q_E)}\right). \tag{PC$_F$}$$

This price constraint (PC$_F$) has to be fulfilled for a fighter brand to be active in the market. If the constraint holds in equilibrium, price competition in Stage 3 leads to optimal prices p_H^*, p_L^* and p_E^* and implies profits $\pi_{IF}^*\left(q_H, q_L; q_E\right)$ for the incumbent.

Alternatively, the incumbent also can price the fighter brand out of the market; that is, the fighter brand is not active, and the price constraint (PC$_F$) is violated. In this case, only two indifferent customers exist in the market: One type of customer θ_1 is indifferent between buying the product q_H or the entrant's product with quality q_E, that is, $\theta_1 q_H - p_H = \theta_1 q_E - p_E$. And, as before, type θ_3 customer is indifferent between buying the lowest quality product q_E or nothing at all, that is, $\theta_3 q_E - p_E = 0$. The market demands in this case then are

$$x_H = \overline{\theta} - \frac{p_H - p_E}{q_H - q_E},\ x_E = \frac{p_H - p_E}{q_H - q_E} - \frac{p_E}{q_E},$$

and the incumbent's profits are

$$\pi_I\left(q_H; q_E\right) = p_H\left(\overline{\theta} - \frac{p_H - p_E}{q_H - q_E}\right).$$

Price competition between the incumbent and the entrant then leads to optimal prices p_H^* and p_E^* in Stage 3, which results in profits $\pi_I^*\left(q_H; q_E\right)$ for the incumbent.

If we now compare the incumbent's optimal profits in these two cases, a simple calculation shows that the incumbent is always better off when pricing the fighter brand out of the market, that is,

$$\pi_I^*(q_H; q_E) > \pi_{IF}^*(q_H, q_L; q_E)$$

for all quality combinations $(q_H, q_L; q_E)$.

Stage 4 - Sandwich scenario Like the firewall scenario, suppose first that the incumbent prices the fighter brand to have a positive demand. Then there exist three indifferent customers in the market: The customer indexed by θ_1 is now given by $\theta_1 q_H - p_H = \theta_1 q_E - p_E$, customer θ_2 is indifferent between buying the entrant's product with quality q_E or the fighter brand from the incumbent, that is, $\theta_2 q_E - p_E = \theta_2 q_L - p_L$ and the customer indexed by θ_3 is given by $\theta_3 q_{1\,L} - p_L = 0$. Market demands then are

$$x_H = \overline{\theta} - \frac{p_H - p_E}{q_H - q_E}, \; x_E = \frac{p_H - p_E}{q_H - q_E} - \frac{p_E - p_L}{q_E - q_L}, \; x_L = \frac{p_E - p_L}{q_E - q_L} - \frac{p_L}{q_L}.$$

The demand x_L for the fighter brand is strictly positive, $\theta_3 < \theta_2$, only if the price-quality ratio of the fighter brand is lower than the one of the entrant's product,

$$p_L < p_E \frac{q_L}{q_E}. \qquad (\mathrm{PC}_S)$$

This price constraint (PC_S) is necessary for a fighter brand to be active in the market. If it is satisfied in equilibrium, the corresponding optimal prices leads to equilibrium profits $\pi_{IS}^*(q_H, q_L; q_E)$ for given product qualities $(q_H, q_L; q_E)$.

As in the firewall scenario, the incumbent can also price the fighter brand out of the market. In this case, the price constraint (PC_S) is violated, and p_L is sufficiently high. Of course, the incumbent's optimal profits are identical to those in the firewall scenario.

If we then compare the incumbent's profits in both cases, note that her profits when the fighter brand is active in market are identical to the ones when she prices the fighter brand out of the market, if she sets $q_L = 0$. Moreover, the higher the quality of the fighter brand, the higher the quality of the entrant's product in the sandwich scenario, which implies that price competition between the entrant's and the incumbent's products becomes fiercer. Hence, the incumbent's profits decrease in the quality level of the fighter brand. In sum, for every quality level $q_L > 0$,

$$\pi_I^*(q_H, q_E) > \pi_{IS}^*(q_H, q_E; q_L),$$

and the incumbent is always better off when pricing the fighter brand sufficiently high such that its demand is zero.

Proposition 1 *In the basic model, the incumbent cannot credibly launch a fighter brand. Instead, she offers the premium product $q_H = \overline{q}$ for an equilibrium price $p_H^* = \overline{\theta}\overline{q}/4$. The entrant chooses an equilibrium quality $q_E^* = 4\overline{q}/7$ and a price*

$p_E^* = \overline{\theta}\overline{q}/14$. *The resulting equilibrium profits are*

$$\pi_I^*\left(\overline{q};\frac{4}{7}\overline{q}\right) = \frac{7}{48}\overline{\theta}^2\overline{q},\ \pi_E^*\left(\overline{q};\frac{4}{7}\overline{q}\right) = \frac{1}{48}\overline{\theta}^2\overline{q}.$$

Proof See Appendix 1. □

The proposition shows that the incumbent has a commitment problem when launching a fighter brand, independent of whether she uses a firewall or sandwich strategy. In both cases, after introducing the second product into the market to thwart the entrant, she always has an incentive to price the product out of the market in the subsequent price competition stage. Of course, the entrant will forego such a pricing behavior so that the quality decision when introducing his product will not be affected by the incumbent's fighter brand. As a result, the entrant enters the market with a product whose quality level is identical to one without a fighter brand.

4 The optimal commitment to launch a fighter brand

In the following, we will show how the incumbent can credibly launch her fighter brand into the market. In particular, we extend the basic model of Sect. 3 to analyze two different commitment devices: Endogenous price leadership, where the incumbent has the possibility to announce a certain price behavior when introducing the fighter brand.[18] And dual channeling, where the incumbent has the possibility to delegate the pricing decision for the fighter brand to a third party. In the third subsection, we then compare these commitment devices.

4.1 Endogenous price leadership

Suppose the incumbent can introduce a second product before the entrant enters the market and, simultaneously, announces a price for which the fighter brand is active in the market. Our discussion in the last section then implies that the incumbent has to announce a price for the fighter brand that either satisfies the price constraint (PC_F) or the price constraint (PC_S), depending on whether the subsequent quality choices lead to a firewall or sandwich scenario.

Of course, without any commitment device to follow such a price strategy in the subsequent price competition stage, the incumbent's announcement would be useless since she would price the fighter brand out of the market after known qualities. We, therefore, assume that the incumbent can advertise her price strategy when launching the fighter brand. In practice, such an advertisement is usually in the form of a catalog or a leaflet sent to consumers or by TV or Internet ads. The advertised price then serves as a commitment by the incumbent not to price the fighter brand higher than announced.

[18] Note that the incumbent can not only commit to the price of the fighter brand but also to one of the premium product. See Footnote 22 for a discussion of this case.

Whether the incumbent's commitment to the advertised price is binding in the price competition stage depends on the number of consumers reached by the advertisement and her loss in reputation in the market when charging a higher price for her fighter brand than announced. This reputation loss might, for example, occur because customers retract their decision to buy the incumbent's premium product.[19] To model this endogenous degree of commitment, we assume that the incumbent can choose an investment $i \geq 0$ in advertising her price strategy. This advertising investment implicitly determines the incumbent's loss in reputation $R(i)$ when pricing the fighter brand higher than announced. In this sense, $R(i)$ serves as deviation costs the incumbent has to pay if she deviates from her announcement. It constitutes her degree of commitment. We assume that the reputation loss $R(i)$ increases in the advertising investment i, but with decreasing marginal reputation loss, that is $R' > 0$ and $R'' < 0$.

Our discussion in the last section then implies that the incumbent can credibly commit to the pricing of the fighter brand if the loss $R(i)$ is sufficiently high such that she has no incentive to deviate from her announcement. Depending on the quality ordering, such a credible commitment requires sufficiently high advertising investment. In case of a firewall scenario, the advertising investment i_F has to ensure the following commitment constraint (CC$_F$):

$$R\left(i_F\right) \geq \pi_I^*\left(q_H; q_E\right) - \pi_{IF}^*\left(q_H, q_L; q_E\right). \qquad (\mathrm{CC}_F)$$

And in the case of a sandwich scenario, the advertising investment i_S has to be sufficiently high such that the following commitment constraint (CC$_S$),

$$R\left(i_S\right) \geq \pi_I^*\left(q_H; q_E\right) - \pi_{IS}^*\left(q_H, q_L; q_E\right). \qquad (\mathrm{CC}_S)$$

is satisfied.

Similar to Diaz et al. (2009), we assume that the incumbent has two possibilities when advertising her price strategy for the following analysis. She announces either to offer the fighter brand for a specific list price which she can lower by offering discounts in the price competition stage. Or, she announces to offer the fighter brand for a fixed price without any discounts. In the following, we analyze the incumbent's commitment to a list price and delegate the discussion on how to commit to a fixed price to Appendix 2.

To analyze the list price commitment game, we modify the basic model from Sect. 3 as follows[20]:

[19] The incumbent's loss in reputation if she prices the fighter brand higher than announced is explained in the marketing literature with consumer preferences that allow for sensitivity to reference dependence and loss-aversion: By assuming that the advertised price of the fighter brand serves as a reference point for a customer's purchase, an incumbent which subsequently charges a higher price may stipulate a feeling of dissatisfaction, see Bronnenberg and Wathieu (1996). In this case, the incumbent loses those customers who would otherwise buy her premium product. See also Ho et al. (2006) and Lim and Ho (2008), who argue that this reputation loss includes loss in the credibility of future claims, negative word-of-mouth, withholding of demand, or defection of customers to the entrant.

[20] Note that if the introduction of the fighter brand would only be an announcement to launch a fighter brand at a later stage, the advertising investment would not only be a commitment device for making the pre-announced price credible at Stage 3 but also to make the pre-announced launch credible at this stage.

Stage 1 The incumbent, already producing her premium product with quality level $q_H = \overline{q}$, introduces a fighter brand of quality q_L and simultaneously chooses an advertising investment i, $i \geq 0$, to announce that she will offer the fighter brand for a list price $\bar{p}_L$, with $\bar{p}_L > 0$.

Stage 2 The entrant enters the market and offers a product of quality q_E.

Stage 3 Having observed the product qualities offered in the market, the two firms compete by simultaneously choosing prices p_H, p_L and p_E in the product market. In case the incumbent deviates from her announced price strategy, $p_L > \bar{p}_L$, she has a reputation loss of $R(i)$; otherwise, for $p_L \leq \bar{p}_L$, there is no additional cost.

Stage 4 Customers decide whether to buy from the firm that offers the best price-quality combination or whether not to buy at all.

Note that the incumbent's commitment problem is solved only if both commitment constraints are satisfied, either for the firewall or sandwich scenarios. Consider, for example, the firewall scenario. Suppose the advertising investment i_F is too low such that the commitment constraint (CC_F) is violated. In that case, the incumbent will price the fighter brand out of the market, independent of the list price $\bar{p}_L$ announced in Stage 1, because the reputation loss $R(i_F)$ is not sufficiently high to prevent her from doing so. If, on the other hand, the list price $\bar{p}_L$ announced in Stage 1 is not sufficiently low to satisfy the price constraint (PC_F), the incumbent charges $p_L = \bar{p}_L$ without any reputation loss, independent of her investment i_F. In both cases, no customer demands the fighter brand, and the equilibrium of Proposition 1 results.

Because of this remark, we analyze the list price commitment game as follows: We first assume that the commitment constraints are both satisfied for the firewall and sandwich scenarios. Under this assumption, we then discuss whether the incumbent should better use the firewall or sandwich strategy to launch the fighter brand. This analysis determines the equilibrium qualities, prices, and profits for the commitment case. Given these results, we then consider the question, under which conditions the incumbent's announcement are credible ex-post.

Suppose that the incumbent has credibly solved her commitment problem in equilibrium. That is, by announcing a list price $\bar{p}_L^*$ and choosing an advertising investment i^* she has no incentive to price the fighter brand out of the market. To discuss how the incumbent should position the fighter brand given these assumptions, we build on the consumption decisions derived in the basic model in case the incumbent will not price the fighter brand out of the market. Market competition then determines the optimal equilibrium prices, and the equilibrium demand functions in the firewall and the sandwich scenario. At Stage 2, the entrant can then decide whether to position his product q_E in the low-quality area, $q_E = q_{EF} < q_L$ (firewall scenario), or in an intermediate quality area between the incumbent's two products, $q_E = q_{ES} > q_L$ (sandwich scenario), when entering the market. In the first case, the optimal product positioning is similar to the result in Choi and Shin (1992), $q_{EF}^* = 4q_L/7$, and results in profits $\pi_{EF}^* = \overline{\theta}^2 q_L/48$. In the second case, the entrant's optimal positioning $q_{ES}^* \in (q_L, q_H)$ is given by the first-order condition for maximizing profits π_{ES}. In sum, the entrant then positions his product below the incumbent's product if the resulting equilibrium profits exceed those in the sandwich scenario. Otherwise, the entrant chooses a sandwich position.

What position q_L is then optimal for the incumbent's fighter brand in Stage 1? To answer this question, suppose that the incumbent would contemplate introducing a fighter brand as a firewall and q_L just below her high-quality product q_H such that the entrant will enter the market with a quality q_{EF}^* below q_L. Inspecting the total derivative of her reduced-form profits then gives an intuition of the incumbent's incentives to offer such a fighter brand as a firewall[21]:

$$\frac{d\pi_{IF}}{dq_L} = \overbrace{\underbrace{\frac{\partial \pi_{IF}}{\partial x_L}}_{>0}\underbrace{\frac{\partial x_L}{\partial q_L}}_{>0}}^{\text{demand effect}} + \overbrace{\underbrace{\frac{\partial \pi_{IF}}{\partial x_L}}_{>0}\underbrace{\frac{\partial x_L}{\partial p_E}}_{>0}\underbrace{\frac{\partial p_E}{\partial q_L}}_{>0}}^{\text{1. strategic effect}} + \overbrace{\underbrace{\frac{\partial \pi_{IF}}{\partial x_L}}_{>0}\underbrace{\frac{\partial x_L}{\partial q_{EF}}}_{<0}\underbrace{\frac{\partial q_E}{\partial q_L}}_{>0}}^{\text{2. strategic effect}} + \overbrace{\underbrace{\frac{\partial \pi_{IF}}{\partial x_H}}_{>0}\underbrace{\frac{\partial x_H}{\partial q_L}}_{<0}}^{\text{cannibalization effect}}$$

We can decompose the total derivative into four effects; the demand effect, the first and second strategic effect, and the cannibalization effect. The demand effect is positive, which implies that decreasing the quality q_L leads to fewer profits for the incumbent through lower demand for the fighter brand. The first strategic effect is also positive saying that decreasing quality q_L leads to less price competition in the market. A lower price p_E of the entrant's product then reduces the demand for the fighter brand and thus implies fewer profits. However, the second strategic effect is negative, indicating that a lower quality of the fighter brand increases profits. This follows because a lower quality also reduces the entrant's quality choice, expanding the fighter brand's demand. Moreover, the cannibalization effect is also negative because a lower quality of her fighter brand cannibalizes the demand for her high-quality product to a lower extent. The analysis shows that the last two adverse effects dominate the first two positive effects. Hence, the incumbent prefers to position her firewall with quality as low as possible.

Of course, this strategy has its limits because the entrant's profits successively diminish when he responds to a lower quality q_L of the fighter brand with a lower quality $q_{EF}^*(q_L)$. If the incumbent sets $q_L = 0$, the entrant's best response when following this strategy would be $q_{EF}^*(0) = 0$, resulting in zero profits. But for $q_L = 0$, the entrant optimally chooses a product quality above q_L by setting $q_{ES}^*(0) = 4q_H/7$ while earning profits $\pi_{ES} = \overline{\theta}^2 q_H/48$. On the other hand, the entrant's profits strictly decrease when he responds to a higher quality of the fighter brand with an even higher quality q_{ES}^* in the immediate quality area (q_L, q_H). Continuity then implies that there exists a critical value q_L^* such that the entrant is indifferent between positioning in the low-quality range or an intermediate quality range. Then the entrant chooses his product quality q_E below q_L as long as the fighter brand's quality q_L is greater than q_L^* and he positions q_E in an intermediate range (q_L, q_H) otherwise.

Hence, to analyze the incumbent's optimal positioning strategy, it is necessary to consider her profits in the sandwich scenario. Note first that for $q_L = 0$, the incumbent's

[21] Since the incumbent optimally sets her prices p_L and p_H in the product market, that is $d\pi_{IF}/dp_L = d\pi_{IF}/dp_H = 0$, the effect of q_L on her profits π_{IF} through price changes can be ignored by applying the envelope theorem.

profits are $\pi_{IS} = 7\bar{\theta}^2 q_H/48$ given the entrant optimally chooses $q_{ES}^*(0) = 4q_H/7$. Inspecting the total derivative of its reduced-form profits then shows that this is the highest profit the incumbent can earn under the sandwich scenario:

$$\frac{d\pi_{IS}}{dq_L} = \overbrace{\underbrace{\frac{\partial \pi_I}{\partial x_L}}_{>0}\underbrace{\frac{\partial x_L}{\partial q_L}}_{>0}}^{\text{demand effect}} + \overbrace{\underbrace{\frac{\partial \pi_I}{\partial x_L}}_{>0}\underbrace{\frac{\partial x_L}{\partial p_E}}_{>0}\underbrace{\frac{\partial p_E}{\partial q_L}}_{<0}}^{\text{1. strategic effect on } x_L} + \overbrace{\underbrace{\frac{\partial \pi_I}{\partial x_H}}_{>0}\underbrace{\frac{\partial x_H}{\partial p_E}}_{>0}\underbrace{\frac{\partial p_E}{\partial q_L}}_{<0}}^{\text{1. strategic effect on } x_H}$$
$$+ \overbrace{\underbrace{\frac{\partial \pi_I}{\partial x_L}}_{>0}\underbrace{\frac{\partial x_L}{\partial q_{ES}}}_{<0}\underbrace{\frac{\partial q_{ES}}{\partial q_L}}_{>0}}^{\text{2. strategic effect on } x_L} + \overbrace{\underbrace{\frac{\partial \pi_I}{\partial x_H}}_{>0}\underbrace{\frac{\partial x_H}{\partial q_{ES}}}_{<0}\underbrace{\frac{\partial q_{ES}}{\partial q_L}}_{>0}}^{\text{2. strategic effect on } x_H}$$

In this case, the total derivative can be decomposed into five effects, the demand effect and two first and second strategic effects. The demand effect is positive as before, implying that a lower quality q_L leads to fewer profits for the incumbent through lower demand for the fighter brand. The first strategic effect on the demand for the fighter brand now is negative because sandwiching the entrant with increasing quality q_L leads to more price competition in the market. A lower price p_E of the entrant's product then reduces demand for the fighter brand and thus implies fewer profits. For the same reason, a lower price p_E also reduces demand for the premium product and also means fewer profits. Moreover, both strategic effects are negative since a higher quality of the fighter brand sandwiches the entrant's quality choice on a higher level which implies less demand for the fighter brand and the premium product. Note that the direct cannibalization effect is zero since the quality of her fighter brand in the sandwich scenario has no direct impact on the demand for the incumbent's high-quality product. The analysis shows that the last two negative effects dominate the first two positive effects.

Figure 1 shows the optimal positioning for the incumbent's fighter brand: First, the incumbent's profits are always higher in the firewall scenario than in the sandwich scenario. Hence, she prefers that the entrant positions his product below her fighter brand. Second, her profits in the firewall scenario are decreasing in the quality level of the fighter brand. Hence, she prefers to position the fighter brand slightly above q_L^* where the entrant is indifferent between the firewall and sandwich scenario.[22]

Proposition 2 *Suppose that the incumbent has credibly solved her commitment problem by announcing a list price $\bar{p}_L^*$ and investing i^* in advertising this announcement. Then the incumbent will always launch a fighter brand as a firewall. In particular, she*

[22] Note that the incumbent can not only commit to the price of the fighter brand but also to one of the premium product. Unlike the incumbent's commitment not to price the fighter above a particular price ceiling, such a commitment would require not pricing the premium product below a specific price floor. If this announcement is made credible by appropriate advertising investments of the incumbent, the resulting outcome, however, would be identical to the one in the case of a price commitment for the fighter brand. A higher price for the premium product is only profitable for the incumbent if she introduces the fighter brand, and the resulting equilibrium in Proposition 2 is unique. I thank an anonymous reviewer who brought this point to my attention.

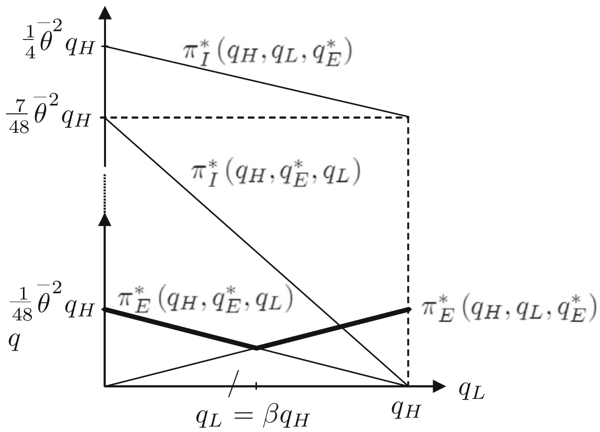

Fig. 1 Sandwich versus firewall strategy under endogenous price leadership

offers the premium product $q_H = \overline{q}$ *for an equilibrium price* $p_H^* = (2 - \beta_L)\,\overline{\theta}\overline{q}/4$ *and sells the fighter brand with quality* $q_L^* = \beta_L \overline{q}$ *for a price* $p_L^* = \beta_L \overline{\theta}\overline{q}/4$*. The entrant chooses an equilibrium quality* $q_E^* = \gamma_L \overline{q}$ *and a price* $p_E^* = \gamma_L \overline{\theta}\overline{q}/8$ *with* $\beta_L = 0.548$ *and* $\gamma_L = 4\beta_L/7$*. The resulting pre-advertising equilibrium profits are*

$$\pi_I^*(\overline{q}, \beta_L\overline{q}; \gamma_L\overline{q}) = \frac{1}{48}(12 - 5\beta_L)\,\overline{\theta}^2\overline{q}, \;\; \pi_E^*(\overline{q}, \beta_L\overline{q}; \gamma_L\overline{q}) = \frac{1}{48}\beta_L\overline{\theta}^2\overline{q}.$$

Proof See Appendix 1. □

In this equilibrium, the ideal positioning of the three products shows a familiar structure (see Fig. 2):

The price-quality positions of the three products exhibit a decreasing ratio in equilibrium. In fact, the relationships

$$\frac{p_H^*}{q_H} = \frac{1}{4}(2 - \beta_L)\,\overline{\theta} > \frac{p_L^*}{q_L^*} = \frac{1}{4}\overline{\theta} > \frac{p_E^*}{q_E^*} = \frac{1}{8}\overline{\theta}$$

show that the premium product can maintain the best price-quality ratio in the market, supported by the fighter brand that effectively keeps with its price-quality ratio competition off the backs of the premium product. The entrant only remains in the position as a low price-low quality competitor. The figure also shows the price-quality positioning in the following case in point, see Dolan and Simon (1996, p.213f): A leading incumbent of lighting products introduced a second product to defend its premium product against the attack of highly cheap imports from China. Compared to the premium brand, the fighter brand was slightly modified while its price was about 40% below the one of the premium brand. The Chinese product was priced 60-70% below the premium brand's price.

How effectively the incumbent uses her fighter brand under endogenous price leadership to protect the high-quality brand can be seen by consulting the market demands

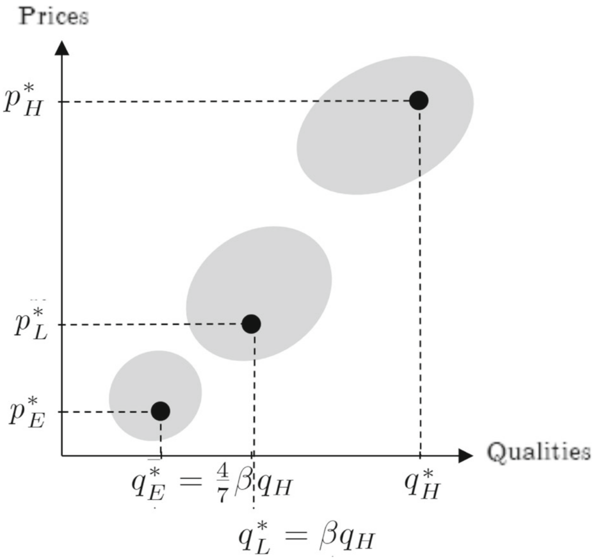

Fig. 2 Positioning structure in equilibrium and practice under endogenous price leadership

of the three products,

$$x_H^* = \frac{1}{2}\overline{\theta} > x_E^* = \frac{7}{24}\overline{\theta} > x_L^* = \frac{1}{12}\overline{\theta}.$$

The target of the fighter brand, to compete with the low-price entrant while still serving the high price segment with the premium product, is met. Compared to the monopoly situation, the incumbent still covers the upper half of the entire market with the premium product. Of course, the price of the premium product is now lower than its monopoly price.

Given these insights, we can now answer the question under which circumstances the incumbent actually has an incentive to commit to her fighter brand credibly. Consider first the list price $\bar{p}_L^*$ in Stage 1. Of course, the incumbent will always set $\bar{p}_L^*$ higher than or equal to the equilibrium price p_L^* of the fighter brand to maximize her profits. Moreover, the upper bound for the list price results from the price constraint (PC_F). Using the equilibrium qualities and prices from Proposition 2, the demand for the fighter brand is positive as long as

$$\bar{p}_L^* \leq \frac{8 - 5\beta_L}{7 - 4\beta_L} p_L^* = \beta_L p_L^*,$$

with $\beta_L = 1.094$. To make her price announcement $\bar{p}_L^* \in \left[p_L^*, \beta_L p_L^*\right]$ binding ex-post, the incumbent's commitment constraint (CC_F) then has to be satisfied. Note that if the incumbent would price her fighter brand out of the market given the entrant has chosen a quality level $q_E^* = \gamma_L \overline{q}$, the incumbent's profit would increase to

$$\pi_I^*\left(\overline{q}; q_E^*\right) = \frac{7\,(7-4\beta_L)}{4\,(7-\beta_L)^2}\overline{\theta}^2\overline{q}.$$

Hence, the commitment constraint is satisfied, if

$$R\,(i) \geq R_M^* = \frac{(1-\beta_L)\,(77-5\beta_L)}{48\,(7-\beta_L)^2}\beta_L\overline{\theta}^2\overline{q}.$$

When her investment i at Stage 1 of the model and the corresponding reputation loss $R\,(i)$ is sufficiently high, $R\,(i) \geq R_M^*$, she has no incentive to price the fighter brand out of the market. Compared to the basic model without endogenous price leadership, the credible launch of her fighter brand then increases her profits by

$$\Delta_M^* = \frac{5}{48}\,(1-\beta_L)\,\overline{\theta}^2\overline{q},$$

which defines the value of her commitment. Let $\bar{\imath}_M$ be the critical investment such that $R\,(\bar{\imath}_M) = R_M^*$. Since the reputation loss is increasing in her investment and investments in advertising reduce her profits, the incumbent optimally either chooses $i^* = \bar{\imath}_M$ to make the list price credible ex-post, or she invests nothing, and her announcement is not binding. As a consequence, the entrant forms a belief about whether the incumbent would later have an incentive to price her fighter brand out of the market or not. In the first case, the entrant then chooses a quality level $q_E = 4\overline{q}/7$ according to Proposition 1. In the second case, he chooses a quality level $q_E = \gamma_L\overline{q}$ according to Proposition 2.

Proposition 3 *Let $\bar{\imath}_M$ be defined by $R\,(\bar{\imath}_M) = R_M^*$.*

1. *If $\bar{\imath}_M \leq 5\,(1-\beta_L)\,\overline{\theta}^2\overline{q}/48$, the incumbent acts as a price leader. She announces a list price $\bar{p}_L^* \in \left[p_L^*, \beta_L p_L^*\right]$ and chooses an advertising investment $i_M^* = \bar{\imath}_M$ to credibly commit to her fighter brand as characterized in Proposition 2. The incumbent's post-advertising profits then are*

$$\pi_I^*\,(\overline{q}, \beta_L\overline{q}; \gamma_L\overline{q}) - \bar{\imath}_M.$$

2. *If $\bar{\imath}_M > 5\,(1-\beta_L)\,\overline{\theta}^2\overline{q}/48$, the incumbent chooses not to invest, $i_M^* = 0$, and her profits are the same as in Proposition 1.*

Proof See Appendix 1. □

The interpretation of this result is straightforward: Depending on the incumbent's loss in reputation when she deviates from the announced price strategy, she uses a price commitment whenever the benefits exceed the costs, that is, whenever the value of commitment is higher than the necessary investment in advertising. In the first case, the loss in reputation as a function of her advertising investment is relatively steep which makes the investment i^* necessary for not deviating from her announcement beneficial. In the second case, the function $R(i)$ is less steep so that the investment i^* necessary for a credible commitment exceeds the difference in profits R_M^* from doing so.

The fact that the incumbent's list price is not unique in equilibrium is due to the rationality of customers. They know in equilibrium that the incumbent will sell the fighter brand for p_L^* and discount it by $\left(\bar{p}_L^* - p_L^*\right)$. Hence, the list price announced is irrelevant for their decision. The finding would be different if we would assume that the incumbent could influence customers' buying decisions by the announced posted price $\bar{p}_L^* \in \left[p_L^*, \beta_L p_L^*\right]$. In this case, the list price serves as a reference point, and the size of the discount adds to the willingness to buy. Then that $\bar{p}_L^* = \beta_L p_L^*$ and the list price is uniquely determined.

Concerning the entrant's cost when entering the market, the following remarks are worth noting:

Remark 1 Suppose the quality positioning of the entrant requires some investment. That is, let $c_E(q)$ be the entrant's cost in developing a specific quality q, with $c_E(q) = \delta_E q^2/2$ where the cost parameter δ_E reflects the efficiency of the entrant's investments into quality development. The entrant's decision whether to position his product below the quality of the fighter brand, $q_E = q_{EF} < q_L$, or between the incumbent's products $q_E = q_{ES} \in (q_L, q_H)$ then is not only affected by corresponding marginal revenues but also by the marginal quality costs of these two options. Of course, the higher the cost parameter δ_E, the lower the optimal quality positioning of his product, independent of the underlying firewall or sandwich scenario. That is, $\partial q_{EF}^*/\partial\delta_E < 0$ as well as $\partial q_{ES}^*/\partial\delta_E < 0$.[23] However, the cost effect is more significant in the sandwich scenario than in the firewall scenario. To see this, consider the critical value $q_L^*(\delta_E)$ such that the entrant is indifferent between positioning his product in the low-quality range or the intermediate quality range. Since his quality positioning is higher in the sandwich scenario than in the firewall scenario, $q_{ES}^*(\delta_E) > q_{EF}^*(\delta_E)$, his quality cost in the first case is higher than in the second case. But then the critical value $q_L^*(\delta_E)$ for which the entrant is indifferent between both scenarios is decreasing in the entrant's efficiency of quality development, that is, $\partial q_L^*/\partial\delta_E < 0$.

Remark 2 Suppose the entrant has to bear entry costs $F_E \geq 0$ when entering the market. If these costs are sufficiently high, the entrant will never enter, and the incumbent does not need to launch a second product while offering the maximal quality $q_H = \overline{q}$. Using the equilibrium payoffs from Proposition 1, this happens whenever $F_E \geq \pi_E^*(\overline{q}; 4\overline{q}/7) = \overline{\theta}^2\overline{q}/48$. Suppose the entrant's entry costs are lower than this critical value. In that case, our analysis above shows that the incumbent can block entry by offering a fighter brand if endogenous price leadership is beneficial. According to Proposition 2, this happens when $F_E \geq \pi_E^*(\overline{q}, \beta_L\overline{q}; \gamma_L\overline{q}) =$

[23] In the firewall scenario, for example, the entrant's optimal quality choice is characterized by

$$\frac{\partial\pi_{EF}}{\partial q_{EF}} = \frac{\overline{\theta}^2 q_L (4q_L - 7q_{EF})}{(4q_L - q_{EF})^3} - \delta_E q_{EF} = 0$$

and the envelope theorem implies that $\partial q_{EF}^*/\partial\delta_E < 0$.

$\beta_L \overline{\theta}^2 \overline{q}/48$. If the entrant's entry costs are even lower than this critical value, the incumbent may follow two different strategies under endogenous price leadership: she may accommodate or deter entry. In the first case, her pre-advertising profits are $\pi_I^* (\overline{q}, \beta_L \overline{q}; \gamma_L \overline{q}) = (12 - 5\beta_L) \overline{\theta}^2 \overline{q}/48$ according to Proposition 2. For deterrence, note that the incumbent cannot use her fighter brand q_L since any reduction in this quality level would encourage the entrant to position his product between the incumbent's products $q_E \in (q_L, q_H)$. Hence, the incumbent can pursue a deterrence strategy only by re-positioning her premium product. Let $q_H = 48F_E/\beta_L \overline{\theta}^2$ be the quality of the premium product such that the entrant breaks even, $\pi_E^* (q_H, \beta_L q_H; \gamma_L q_H) - F_E = \beta_L \overline{\theta}^2 q_H/48$. Then the incumbent earns pre-advertising profits $\pi_I^* (q_H, \beta_L q_H; \gamma_L q_H) = (12 - 5\beta_L) F_E/\beta_L$ which are lower than $\pi_I^* (\overline{q}, \beta_L \overline{q}; \gamma_L \overline{q})$ since $\beta_L \overline{\theta}^2 \overline{q}/48 > F_E$. Hence, re-positioning is never optimal for the incumbent, and entry occurs.

4.2 Dual channeling

Another possibility for the incumbent to commit to the pricing of her fighter brand is to delegate this decision to another party, see Hadfield (1991). In the context of our model, the incumbent can, for example, give the sale of the fighter brand to an independent retailer or sales force - henceforth, she. Such a strategy was, for example, chosen by Anheuser-Busch, see Ritson (2009). In the sixties, the company introduced a new fighter brand called Busch Bavarian with a separate sales force and distinct distribution to distance it from its other two premium brands, Budweiser and Michelob.

We analyze how such dual channeling can serve as a commitment device in the following. The sequence of events in this modified interaction is as follows:

Stage 1a The incumbent, already producing a product with quality level $q_H = \overline{q}$, can introduce a fighter brand with quality q_R. If she does so, she delegates the sale of this second product to an independent retailer by offering a contract (w, x_R, L), where w denotes the wholesale price for selling a product of quality q_R to the retailer, x_R denotes the quantity she supplies, and L denotes the franchise fee the retailer pays to the incumbent for doing her business.

Stage 1b The retailer decides whether to accept this contract or not. She accepts whenever her profits are non-negative.

Stage 2 The entrant enters the market and offers a product of quality q_E.

Stage 3 Having observed the product qualities offered in the market, the three firms choose prices: The incumbent sets p_H, the retailer sets p_R, and the entrant sets p_E.

Stage 4 Customers decide whether to buy from the firm that offers the best price-quality combination or whether not to buy at all. The incumbent and the retailer both honor the contract signed.[24]

[24] That is, the incumbent supplies the retailer with x_R products of quality q_R for price w and the retailer pays the franchise fee L. Note that we implicitly assume here that a breach of contract is not possible for either party.

Different from the basic model, the incumbent now maximizes her profits $\pi_I(q_H, q_R; q_E) = p_H x_H + w x_R + L$, whereas the retailer chooses the price p_R of the fighter brand to maximize

$$\pi_R(q_H, q_R; q_E) = (p_R - w)\, x_R - L.$$

The entrant still maximizes his profits $\pi_E(q_H, q_R; q_E) = p_E x_E$.

How does the equilibrium behavior change in this dual channeling setup compared to the extended model in Sect. 4.1? First, we immediately see that the optimal price competition in the sandwich scenario is identical in both models. The incumbent's maximization problem in the sandwich scenario consists of two subproblems - choosing the optimal price for the premium product and the one for the fighter brand. Both subproblems, however, are independent of each other since no cannibalization occurs, so it does not matter whether the retailer or the incumbent sets the price for the fighter brand.

Second, however, market competition in the firewall scenario is now different: Since the retailer, when setting his optimal price p_R does not care about the cannibalization effect with the incumbent's brand product, the optimal price reactions differ. In particular, price competition between the premium and the fighter brand is lower but price competition between the fighter brand and the entrant's product more fierce. To see this more clearly, note that the incumbent's optimal price setting for her premium and fighter brand in the basic model is characterized by

$$p_H^* - p_L^* = \frac{1}{2}\overline{\theta}\,(q_H - q_L)\,.$$

To avoid cannibalization with her premium product, she always keeps the price difference between her two products constant. Hence, the price competition between the fighter brand and the entrant's product has direct feedback on the price of her premium product, and the incumbent is less willing to lower the price for the fighter brand. This feedback then is less strict in case the retailer is in charge of pricing the fighter brand:

$$p_H^* - \frac{1}{2}p_R^* = \frac{1}{2}\overline{\theta}\,(q_H - q_R) + \frac{1}{2}w.$$

In this case, price competition between the retailer and the entrant does not influence the incumbent's premium product price as much as when the incumbent competes with the entrant. But this implies that the incumbent is less restricted in setting the price p_H and she will therefore choose in equilibrium a higher price for her premium product. On the other side of the market, the retailer's price for the fighter brand is less dependent on the incumbent's price, and she will therefore intensify competition with the entrant.

Moreover, the wholesale price w influences the feedback of price competition between the retailer and the entrant on the price of the incumbent's premium product. In fact, the higher the wholesale price, the larger the price spread between the premium product and fighter brand. Hence, by not charging any wholesale price, $w = 0$, the incumbent can increase the market demand for her premium product, which is higher than the one in the monopoly market. Note that $w = 0$ does not imply a loss in profits for the incumbent because she optimally sets $L^* = (p_R - w)\,x_R$ such that the retailer always breaks even. Doing so still ensures that the retailer accepts contracting and results in profits for the incumbent equal to $\pi_M = p_H x_H + p_R x_R$.

Another consequence of the intensified price competition under dual channeling is a lower quality of the fighter brand in equilibrium. The reasoning for this observation is the following. The lower prices imply that the entrant's profits in the presence of a retailer are smaller than without delegation in the firewall scenario by a factor

$$\frac{q_H - q_L}{4q_H - q_L} < 1.$$

Since her profits in the sandwich scenario are unchanged, and the optimal quality level of the fighter brand follows from equalizing her profits in both scenarios, see Sect. 4.1, a lower profit in the firewall scenario directly implies that $q_R^* < q_L^*$.

Proposition 4 *If the incumbent uses dual channeling to commit to the launch of her fighter brand credibly, she offers the premium product $q_H = \overline{q}$ for an equilibrium price $p_H^* = (0.276)\,\overline{\theta}\overline{q}$ and chooses a quality level $q_R^* = (0.486)\,\overline{q}$ for the fighter brand. She offers a contract with $w^* = 0$, $x_R^* = (0.308)\,\overline{\theta}$ and $L^* = (0.005)\,\overline{\theta}^2\overline{q}$ which the retailer accepts who offers the fighter brand for a price $p_L^* = (0.003)\,\overline{\theta}\overline{q}$. The entrant chooses an equilibrium quality $q_E^* = (0.337)\,\overline{q}$ and a price $p_E^* = (0.001)\,\overline{\theta}\overline{q}$. The resulting equilibrium profits are $\pi_R^*\left(\overline{q}, q_R^*; q_E^*\right) = 0$ and*

$$\pi_I^*\left(\overline{q}, q_R^*; q_E^*\right) = (0.152)\,\overline{\theta}^2\overline{q},\ \pi_E^*\left(\overline{q}, q_R^*; q_E^*\right) = (0.001)\,\overline{\theta}^2\overline{q}.$$

Proof See Appendix 1. □

Of course, in equilibrium, the incumbent loses profits by delegating the pricing of her fighter brand to an independent retailer. The positioning of the three products compared to the basic model shows the following structure (see Fig. 3):

The price-quality positions of the three products in dual channeling exhibits a decreasing ratio in equilibrium,

$$\frac{p_H^*}{q_H^*} = (0.276)\,\overline{\theta} > \frac{p_R^*}{q_R^*} = (0.073)\,\overline{\theta} > \frac{p_E^*}{q_E^*} = (0.03)\,\overline{\theta}$$

as in the basic model. However, the market's price-quality ratios are lower than those in a market, where the incumbent can commit herself to the pricing of her fighter brand by endogenous price leadership.

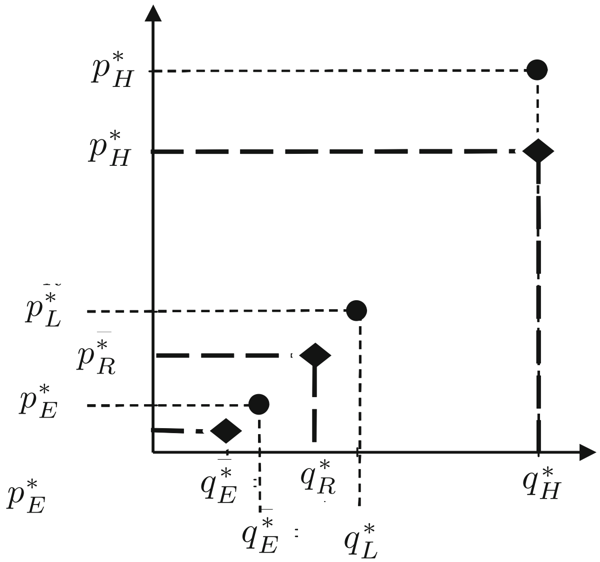

Fig. 3 Positioning structure in equilibrium with and without a dual channeling

4.3 The optimal commitment device

Proposition 4 shows that the incumbent always benefits from dual channeling compared to the non-commitment scenario,

$$\pi_I^* \left(\overline{q}, q_R^*; q_E^*\right) > \pi_I^* \left(\overline{q}; \frac{4}{7}\overline{q}\right).$$

Hence, she prefers to commit herself to launch a fighter brand credibly. In the following, we consider her decision whether to use endogenous price leadership or dual channeling as a commitment device. We consider two influencing variables, the reputation elasticity

$$\rho_R(i) = R'(i)\,\frac{i}{R(i)},$$

which measures how customers react to a deviation from the incumbent's price announcement and the attractiveness of the market,

$$\alpha = \overline{\theta}^2\overline{q},$$

as a measure of the quality level $\overline{q}$ of the incumbent's premium product and customers' maximal willingness $\overline{\theta}$ to pay for quality.

Proposition 5 *The incumbent always commits to the launch of the fighter brand. Depending on the attractiveness α of the market, the optimal commitment device is as follows: There exists a critical value α^* such that*

- *if $\alpha \leq \alpha^*$, the incumbent prefers an endogenous price commitment with a list price, and*
- *if $\alpha \geq \alpha^*$, she favors dual channeling.*

Moreover, the critical value α^* is increasing in the reputation elasticity ρ_R.

Proof See Appendix 3 and the proof of Proposition 8 for the more general case including an endogenous price commitment with a fixed price. □

The interpretation of this result follows directly from our previous discussions: On the one hand, the incumbent's profit gains from a commitment are highest for a list price commitment and lowest for dual channeling. On the other hand, the necessary advertising investments for a credible commitment are reverse: no investments for dual channeling, some investments for a price leadership with a list price commitment.

To discuss how the reputation elasticity and the market attractiveness influence the optimality of these commitment devices, consider first the sensitivity of customers to a deviation from the incumbent's price announcement. If the reputation elasticity is low, the incumbent cannot credibly commit herself not to price the fighter brand out of the market, and dual channeling is the only option. If the reputation elasticity is sufficiently high, an endogenous price commitment with a list price becomes possible. In this case, the higher advertising investments by the incumbent necessary to make her announcement credible are worthwhile due to the increased commitment value.

Concerning the market attractiveness, note that the higher α, the higher the commitment value, making higher investments in advertising necessary. Suppose the market is not very attractive. Then the investment in advertising necessary for endogenous price leadership is small for a list price commitment and the incumbent prefers the list price commitment with the highest profits. If the market's attractiveness increases, this commitment device is not possible anymore because the investment necessary for its credibility is too high. In this case, the incumbent prefers dual channeling as a commitment device since her reduced profits when cooperating with a retailer are independent of any investment in her reputation.

5 Conclusion

The present paper considered the optimal launch of a fighter brand to thwart a new entrant. Starting with the observation that the incumbent will always price such a second product out of the market, we showed that the price policy for the fighter brand is crucial for its success. We, therefore, analyzed two commitment devices, endogenous price commitment with a list price and dual channeling with price delegation to a retailer. We showed that the incumbent always prefers to use a commitment device and that endogenous price announcements are optimal if the market is not attractive and customers react sufficiently sensitive to a deviation.

The incumbent's ability to set up a commitment device enables him to act like a Stackelberg leader. However, different from the conventional wisdom that a Stackelberg pricing leader wants to raise prices, the incumbent in the present model is trying to use her first-mover advantage to commit to lowering the price. At first sight, such a paradoxical behavior seems to be odd. At second sight, however, the rationality for this behavior is grounded on the timing of moves: In a standard Stackelberg pricing game with given differentiated products, the Stackelberg leader takes the price response of the follower into account when deciding on her pricing. In our model of vertical differentiated products q_H and q_E with $q_H > q_E$, the incumbent's optimal price p_H^S when acting as price leader is

$$p_H^S = \frac{\overline{\theta} q_H (q_H - q_E)}{(2q_H - q_E)},$$

which is higher than the optimal price p_H^* in the simultaneous pricing game.[25] The difference to the present model then lies in the fact that product qualities are not fixed when the incumbent commits to her pricing strategy. In particular, the entrant can perfectly imitate the incumbent's fighter brand in quality and price, thus driving the fighter out of the market.

A key ingredient of our model is the uniform distribution of customers. While this is a common assumption in the literature on vertical differentiation and makes our analysis tractable, it is not without loss of generality. For suppose customers have bimodally distributed preferences. Then the incumbent might be incentivized to offer a second, low-quality product in addition to the premium product without a threat of entry. An entrant can then offer his product in the intermediate range of the market between the two modes, leading to a sandwich instead of a firewall scenario. However, the incumbent then faces no commitment problem since the low-quality product will generate positive profits, regardless of whether the entrant entered the market. On the other hand, the commitment problem is not an artifact of the uniform distribution of customers but can be established even under a more general distribution assumption.[26] For suppose, customers' preferences are log-concave distributed. Building on the analysis by Benassi et al. (2019), it is easy to show that the incumbent would never launch a second product without the threat of entry.[27] Hence, when launching a fighter brand to influence the positioning of the entrant's product, the incumbent faces a similar commitment problem as in our basic model with a uniform distribution of customers. As a consequence, the central insights of our analysis carry over to more general distribution assumptions.

Another key ingredient of our model is the assumption that the entrant is perfectly informed about the incumbent's commitment device. As argued in the introductory section, this assumption implies that if the launch of the fighter brand would not preemptive, its quality will not influence the quality decision of the entrant's product

25 As in the proof of Proposition 1, Part 1b, the entrant optimally chooses $p_E^*\left(p_H^S\right) = \frac{1}{2} p_H^S \frac{q_E}{q_H}$ and the incumbent's first-order condition with respect to price p_H^S becomes

$$\frac{\partial \pi_I}{\partial p_H^S} = \frac{\overline{\theta} q_H (q_H - q_E) - p_H^S (2q_H - q_E)}{q_H (q_H - q_E)} = 0.$$

26 I thank an anonymous reviewer who brought this point to my attention.

27 We prove this statement in Appendix 4, Proposition 9.

launch. Under asymmetric information, however, the quality decision of the entrant could still be affected even if the launch of the fighter brand may happen after the entrant decides its quality.[28] To see this suppose that the entrant is unsure about the credibility of the incumbent's commitment to introduce a fighter brand after his quality choice q_E. In the case of endogenous price leadership, for example, the advertising investments might be private information of the incumbent so that the entrant is unsure about the degree of commitment that her announcement is binding ex-post. Consequently, the entrant has to form some belief about the credibility of the incumbent's commitment. Now suppose that her price commitment is not binding ex-post but that the entrant expects the announcement to be credible. If this case happens, it will lead to a two-product market constellation in which the entrant positions his product in the lower market segment and the incumbent prices the fighter brand out of the market, $q_E^* = \frac{4}{7}\beta_L\overline{q} < q_H^* = \overline{q}$. Hence, the possibility of a launch would influence the entrant's quality choice even if this launch of the fighter brand might happen after the entrant decides on quality.[29]

Our analysis assumed that customers were aware of the differences in product quality. In particular, we implicitly assumed that customers have perfect knowledge that the fighter brand is simply a lower quality product at a lower price than the premium brand, which is, however, not necessarily the case, see Ritson (2009, p.88). In 1994 Kodak's best-selling Gold Plus film lost market share as many of its customers switched to Fujicolor's Super G film, priced 20% lower. To combat its competitor, Kodak launched a fighter brand called Funtime. This product had lower quality than its premium brand - Kodak manufactured Funtime with an older, less effective technology than Gold Plus - and was sold at the same price as Fuji's offering. However, since most customers were unaware of the quality differences, they saw Funtime as a high-quality Kodak film at a lower price. This consumption behavior seriously damaged Kodak's reputation for high quality, and Gold Plus sales were more damaged than Fuji's. Two years later, in 1996, Kodak then withdrew Funtime from the market. The story shows that the success of a fighter brand also depends crucially on how the incumbent brands her products. The incumbent would label the premium product and the second, lower-quality product with a single brand name using umbrella branding. On the other hand, the incumbent may also sell her two products under different names. In the context of this paper, one would expect that if customers are uncertain about product characteristics, umbrella branding might play an informational role and increase the cannibalization of the premium brand.

Another key assumption of our model that might influence the results of this paper is the nature of competition between the firms. We assumed that market competition is in prices. Consequently, the qualities of the fighter brand and the entrant's product are strategic complements in our model. Aoki (1988), however, shows in a vertical

[28] I thank an anonymous reviewer who brought this point to my attention.

[29] Note that under asymmetric information, a market constellation could arise, characterized by a sandwich scenario: Suppose that the incumbent's price commitment is binding ex-post but that the entrant expects that the incumbent will price the fighter brand out of the market. In this case, the incumbent sets the quality of the fighter brand as before, $q_L^* = \beta_L q_H$, but the entrant does not take the price announcement for the fighter brand as binding and positions his product as in the model of Choi and Shin (1992) so that $q_E^* = \frac{4}{7}q_H$. The resulting market constellation then is $q_L^* = \beta_L\overline{q} < q_E^* = \frac{4}{7}\overline{q} < q_H^* = \overline{q}$.

differentiation model with a sequential quality choice that qualities are strategic complements for the high-quality firm but strategic substitutes for the low-quality firm if the market is characterized by Cournot competition. In our model, this result suggests that under quantity competition, the incumbent has to increase the quality of her fighter brand to reduce the quality of the entrant's product. This, however, makes the firewall strategy less attractive due to the cannibalization effect. In turn, one might expect that the sandwich strategy becomes more profitable for the incumbent.

And finally, we assumed that the incumbent has no launching costs when introducing a second product. Hence, it is always optimal to launch a fighter brand to thwart new entrants. In general, however, an incumbent has different responses available to face new competition, see Jost (2014). For example, the incumbent could lower the price for her premium product or decrease, respectively, increase her premium product quality. The analysis shows that these strategies might be optimal under different extensions of our basic model. Suppose, for example, that the incumbent has to bear some costs when launching a second product and, in addition, is uncertain about the entry. Investing in such a situation in a product launch imposes costs that might be worthless if the entrant does not enter. Instead of making such a risky long-term decision implying sunk costs, it might be more beneficial for the incumbent to wait until the entrant enters the market. She could then use a price defense to defend the premium product as a short-term tactical decision.

Funding Open Access funding enabled and organized by Projekt DEAL.

Declarations

Conflict of interest The author has no competing interests to declare that are relevant to the content of this article.

Appendix 1

Proof of Proposition 1 Let $(q_H, q_L; q_E)$ be the qualities chosen in Stage 1 and 2 by the incumbent and the entrant. Depending on the quality levels, we distinguish between two scenarios.

1. Consider first the firewall scenario with $q_H > q_L > q_E$ and let p_H, p_L, p_E be the corresponding prices in Stage 3. We distinguish two cases: either p_L is sufficiently

low such that $\theta_1 > \theta_2$, that is,

$$p_L < p_H \frac{(q_L - q_E)}{(q_H - q_E)} + p_E \frac{(q_H - q_L)}{(q_H - q_E)},$$

or p_L is higher than this critical value such that $\theta_1 = \theta_2$, with $\theta_1 = (p_H - p_L) / (q_H - q_L)$ and $\theta_2 = (p_L - p_E) / (q_L - q_E)$. In the first case, the fighter brand is active in the market and we index prices by p_{HF}, p_{LF}, p_{EF} as well as profits by (π_{IF}, π_{EF}). In the second case, the fighter brand is inactive and and its quality level is irrelevant for profits.

(a) $\theta_1 > \theta_2$: Given $q_H > q_L > q_E$, the entrant maximizes profits π_{EF} with respect to its product price p_{EF}. This leads to the first-order condition

$$\frac{\partial \pi_{EF}}{\partial p_{EF}} = \frac{p_L q_E - 2 p_{EF} q_L}{q_E (q_L - q_E)} = 0,$$

hence $p_{EF} = \frac{1}{2} p_L \frac{q_E}{q_L}$. Similarly, the incumbent maximizes her overall profits π_{IF} with respect to prices p_{LF} and p_{HF} and the first-order conditions are

$$\frac{\partial \pi_{IF}}{\partial p_{HF}} = \frac{\overline{\theta} (q_H - q_L) - 2 (p_{HF} - p_{LF})}{q_H - q_L} = 0,$$
$$\frac{\partial \pi_{IF}}{\partial p_{LF}} = \frac{2 p_{HF} (q_L - q_E) - 2 p_{LF} (q_H - q_E) + p_{EF} (q_H - q_L)}{(q_H - q_L)(q_L - q_E)} = 0$$

Note that the first-order condition with respect to p_{LF} is binding, since $\theta_1 > \theta_2$ ensures that the optimal $p^*_{LF} (p_{HF}; p_{EF})$ is an interior solution,

$$\begin{aligned} p^*_{LF} (p_{HF}; p_{EF}) &= p_{HF} \frac{(q_L - q_E)}{(q_H - q_E)} + \frac{1}{2} p_{EF} \frac{(q_H - q_L)}{(q_H - q_E)} \\ &< p_{HF} \frac{(q_L - q_E)}{(q_H - q_E)} + p_{EF} \frac{(q_H - q_L)}{(q_H - q_E)}. \end{aligned}$$

Solving the three first-order conditions above for p_{HF}, p_{LF}, and p_{EF} then gives optimal prices

$$\begin{aligned} p^*_{HF} &= \frac{1}{2} \overline{\theta} \frac{q_H (q_L - q_E) + 3 q_L (q_H - q_E)}{4 q_L - q_E}, \\ p^*_{LF} &= 2 \overline{\theta} \frac{q_L (q_L - q_E)}{4 q_L - q_E}, \\ p^*_{EF} &= \overline{\theta} \frac{q_E (q_L - q_E)}{4 q_L - q_E}. \end{aligned}$$

Of course, $p^*_{HF} > p^*_{LF}$ and $p^*_{LF} > p^*_{EF}$. Substituting these optimal prices into the demand function leads to the following profits π^*_{IF} for the incumbent in the optimum,

$$\pi_{IF}^{*}\left(q_H, q_L; q_E\right) = \frac{\overline{\theta}^2}{4} \frac{\left(16 q_H q_L^2 - q_L q_E^2 - 8 q_L^2 q_E - 8 q_H q_L q_E + q_H q_E^2\right)}{\left(4 q_L - q_E\right)^2}.$$

(b) $\theta_1 = \theta_2$: Given $q_H > q_E$, the entrant maximizes profits π_E with respect to the product price p_E. As in Case 1a, the first-order condition now leads to $p_E = \frac{1}{2} p_H \frac{q_E}{q_H}$. Simultaneously, the incumbent then maximizes her overall profits π_I with respect to price p_H. The first-order condition now is,

$$\frac{\partial \pi_I}{\partial p_H} = \frac{\overline{\theta}\left(q_H - q_E\right) - 2 p_H + p_E}{q_H - q_E} = 0,$$

which implies $p_H = \frac{1}{2}\left(p_E + \overline{\theta}\left(q_H - q_E\right)\right)$. Solving both first-order conditions then leads to optimal prices

$$p_H^{*} = \frac{2\overline{\theta} q_H \left(q_H - q_E\right)}{4 q_H - q_E} \text{ and } p_E^{*} = \frac{\overline{\theta} q_E \left(q_H - q_E\right)}{4 q_H - q_E},$$

and the incumbent's profits are now

$$\pi_I^{*}\left(q_H; q_E\right) = \frac{4\overline{\theta}^2 q_H^2 \left(q_H - q_E\right)}{\left(4 q_H - q_E\right)^2}.$$

If we compare the incumbent's profits in these two cases, then

$$\pi_I^{*}\left(q_H; q_E\right) > \pi_{IF}^{*}\left(q_H, q_L; q_E\right)$$

since $\frac{\partial}{\partial q_L} \pi_{IF}^{*}\left(q_H, q_L; q_E\right) = \frac{\overline{\theta}^2 q_E^2 (7 q_L - q_E)}{2(4 q_L - q_E)^3} > 0$ and $\pi_{IF}^{*}\left(q_H, q_H; q_E\right) = \pi_I^{*}\left(q_H, q_E\right) - \frac{3\overline{\theta}^2 q_H q_E (q_H - q_E)}{4(4 q_H - q_E)^2}$. Hence, in the firewall scenario, the interior solution derived for the optimal prices in Case 1(a) is not the global maximum. Instead, the interior solution derived for the optimal prices in Case 1(b) constitutes the equilibrium prices. As a result, the incumbent always prices the fighter brand out of the market.

2. Consider next the sandwich scenario with $q_H > q_E > q_L$ and let p_H, p_L, p_E the corresponding prices in Stage 3. We distinguish two cases: either p_L is sufficiently low such that $\theta_2 > \theta_3$, that is,

$$p_L < p_E \frac{q_L}{q_E},$$

or p_L is higher than this critical value such that $\theta_2 = \theta_3$, with $\theta_2 = \left(p_H - p_E\right) / \left(q_H - q_E\right)$ and $\theta_3 = \left(p_E - p_L\right) / \left(q_E - q_L\right)$. In the first case, the fighter brand is again active in the market and we index prices by p_{HS}, p_{LS}, p_{ES} as well as profits by $\left(\pi_{IS}, \pi_{ES}\right)$. The second case is identical to Case 1(b).

(a) $\theta_2 > \theta_3$: Given $q_H > q_L > q_E$, the entrant's profits π_{ES} are maximized with respect to the product price p_{ES} if the first-order condition is satisfied:

$$\frac{\partial \pi_{ES}}{\partial p_{ES}} = \frac{p_{HS}(q_E - q_L) + p_{LS}(q_H - q_E) - 2p_{ES}(q_H - q_L)}{(q_H - q_E)(q_E - q_L)} = 0.$$

The best response function of the entrant then is

$$p_{ES} = \frac{1}{2} p_{HS} \frac{q_E - q_L}{q_H - q_L} + \frac{1}{2} p_{LS} \left(1 - \frac{q_E - q_L}{q_H - q_L}\right).$$

Maximizing the incumbent's overall profits π_{IS} with respect to prices p_{LS} and p_{HS} gives the first-order conditions

$$\begin{aligned} \frac{\partial \pi_{IS}}{\partial p_{HS}} &= \frac{p_{ES} - 2p_{HS} + \overline{\theta}(q_H - q_E)}{q_H - q_E} = 0, \\ \frac{\partial \pi_{IS}}{\partial p_{LS}} &= \frac{p_{ES} q_L - 2p_{LS} q_E}{q_L (q_E - q_L)} = 0. \end{aligned}$$

Note that the first-order condition with respect to p_{LS} is binding, since $\theta_3 < \theta_2$ ensures an interior solution,

$$p_{LS}^* (p_{HS}; p_{ES}) = p_{ES} \frac{q_L}{2q_E} < p_{ES} \frac{q_L}{q_E}.$$

Solving all three first-order conditions for optimal prices yields

$$\begin{aligned} p_{HS}^* &= \frac{\overline{\theta}(q_H - q_E)(q_H(q_E - q_L) + 3q_E(q_H - q_L))}{2(q_E(q_H - q_E) + q_H(q_E - q_L) + 2q_E(q_H - q_L))}, \\ p_{ES}^* &= \frac{\overline{\theta} q_E (q_E - q_L)(q_H - q_E)}{(q_E(q_H - q_E) + q_H(q_E - q_L) + 2q_E(q_H - q_L))}, \\ p_{LS}^* &= \frac{\overline{\theta} q_L (q_E - q_L)(q_H - q_E)}{2(q_E(q_H - q_E) + q_H(q_E - q_L) + 2q_E(q_H - q_L))}. \end{aligned}$$

Note that $p_{HS}^* > p_{ES}^*$ and $p_{ES}^* > p_{LS}^*$. Substituting these optimal prices into the demand function gives us the optimal profits π_{IS}^* for the incumbent as

$$\pi_{IS}^* (q_H, q_L; q_E) = \frac{\overline{\theta}^2}{4} \frac{(q_H - q_E) A}{\left(q_E^2 + q_H q_L - 4q_H q_E + 2q_E q_L\right)^2},$$

with $A = q_H^2 q_L^2 - 8q_H^2 q_L q_E + 16q_H^2 q_E^2 + 5q_H q_L^2 q_E - 23q_H q_L q_E^2 + 10q_L^2 q_E^2 - q_L q_E^3$.

(b) $\theta_2 = \theta_3$: This case is identical to Case 1 (b) in the firewall scenario, so that optimal profits for the incumbent are again

$$\pi_I^* (q_H; q_E) = \frac{4\overline{\theta}^2 q_H^2 (q_H - q_E)}{(4q_H - q_E)^2}.$$

If we compare the incumbent's optimal profits in these two cases, then

$$\pi_I^* (q_H; q_E) - \pi_{IS}^* (q_H, q_L; q_E) > 0$$

Hence, the optimal solution derived in Case 2 (a) is not the global maximum and the optimal prices in Case 2 (b) constitute the equilibrium prices. Hence, in the sandwich scenario the incumbent also prices the fighter brand out of the market.

It remains to show how the entrant sets the quality level of his product at Stage 2, given that he knows the incumbent prices the fighter out of the market. Given the equilibrium prices in Stage 3, the entrant's equilibrium profits are

$$\pi_E^* (q_H; q_E) = \frac{\overline{\theta}^2 q_H q_E (q_H - q_E)}{(4q_H - q_E)^2}.$$

Given $q_H = \overline{q}$, the entrant's optimal product quality maximizes π_E^* and leads to $q_E^* = 4\overline{q}/7$.
Q.E.D. □

Proof of Proposition 2 Suppose that the incumbent announces a list price $\bar{p}_L^*$ and chooses an advertising investment i^* in Stage 1 of the list price commitment game such that the price constraint (PC$_F$) as well as the commitment constraint (CC$_F$) for the firewall scenario are satisfied in equilibrium. We first show that this announcement and her investment also ensures that the price constraint (PC$_S$) and the commitment constraint (CC$_S$) for the sandwich scenario are satisfied: Consider first the commitment constraint and suppose the qualities $(q_H, q_L; q_E)$ chosen in Stage 1 and 2 by the incumbent and the entrant imply a firewall scenario. If (CC$_F$) is satisfied, the incumbent's profits then are lowest for $q_L = q_H$, that is

$$\pi_{IF}^* (q_H, q_L; q_E) \geq \frac{4\overline{\theta}^2 q_H^2 (q_H - q_E)}{(4q_H - q_E)^2},$$

according to the proof of Proposition 1, Part 1 (a). If, on the other hand, the qualities $(q_H, q_L; q_E)$ would induce a sandwich scenario, her profits are highest for $q_L = 0$, hence,

$$\pi_{IS}^* (q_H, q_L; q_E) \leq \frac{4\overline{\theta}^2 q_H^2 (q_H - q_E)}{(4q_H - q_E)^2},$$

according to the proof of Proposition 1, Part 2 (a). But then i^* also ensures

$$R\left(i^*\right) \geq \pi_I^* (q_H; q_E) - \pi_{IS}^* (q_H, q_L; q_E)$$

since $\pi_{IF}^{*}(q_H, q_L; q_E) \geq \pi_{IS}^{*}(q_H, q_L; q_E)$. To see that if $\bar{p}_L^{*}$ satisfies the price constraint (PC_F), this price announcement also ensures the price constraint (PC_S), let $(q_H, q_L; q_E)$ be the qualities in the market, with $q_L = \beta_L q_H$ and $q_E = q_{ES} = \alpha_M q_H$ in case of the sandwich scenario and $q_E = q_{EF} = \gamma_L q_H$ in case of the firewall scenario. That is, with $1 > \alpha_M > \beta_L > \gamma_L > 0$. Then the proof of Proposition 1 implies $\gamma_L = 1/4$ and

$$p_{LF}^{*} = \frac{1}{4}\beta_L \overline{\theta} q_H, \;\; p_{LS}^{*} = \frac{(\alpha_M - \beta_L)(1 - \alpha_M)}{2(\alpha_M(1 - \alpha_M) + (\alpha_M - \beta_L) + 2\alpha_M(1 - \beta_L))}\beta_L \overline{\theta} q_H.$$

Simple calculation then shows that $p_{LF}^{*} > p_{LS}^{*}$.[30]

Given $\left(\bar{p}_L^{*}, i^{*}\right)$, we now solve the list price commitment game via backwards induction.

- S3 Suppose that the incumbent in Stage 1 introduced a fighter brand of quality q_L, that the entrant in Stage 2 entered with a product of quality q_E. Then the demand for the fighter brand is positive and market competition in Stage 3 leads to equilibrium prices as in the proof of Proposition 1.
- S2 Taking these equilibrium prices into account, consider the entrant's decision where to position his product at Stage 2. Given $q_H > q_L$ the entrant can either choose q_{EF} with $q_{EF} < q_L$ - the firewall scenario - or with $q_{ES} \in [q_L, q_H]$ - the sandwich scenario. If the entrant chooses $q_{EF} < q_L$, then using equilibrium prices, the first-order condition for profit maximization gives

$$\frac{\partial \pi_{EF}}{\partial q_{EF}} = \frac{\partial}{\partial q_{EF}}\left(\frac{\overline{\theta}^2 q_{EF} q_L (q_L - q_{EF})}{(4q_L - q_{EF})^2}\right) = \frac{\overline{\theta}^2 q_L (4q_L - 7q_{EF})}{(4q_L - q_{EF})^3} = 0$$

and he optimally chooses $q_{EF}^{*} = 4q_L/7$. Hence,

$$\pi_{EF}^{*}\left(q_H, q_L; q_{EF}^{*}\right) = \frac{1}{48}\overline{\theta}^2 q_L, \pi_{IF}^{*}\left(q_H, q_L; q_{EF}^{*}\right) = \frac{1}{48}\overline{\theta}^2 (12q_H - 5q_L).$$

If, on the other hand, $q_{ES} \in (q_L, q_H)$, then using equilibrium prices, the entrant's profits read as

$$\pi_{ES}(q_H, q_L; q_{ES}) = \frac{\overline{\theta}^2 q_{ES}(q_H - q_L)(q_H - q_{ES})(q_{ES} - q_L)}{(q_{ES}(q_H - q_{ES}) + q_H(q_{ES} - q_L) + 2q_{ES}(q_H - q_L))^2}.$$

In this case, the first-order condition is

$$\frac{\partial \pi_{ES}}{\partial q_{ES}} = \frac{\overline{\theta}^2 q_{ES}(q_H - q_L) A}{(q_{ES}(q_H - q_{ES}) + q_H(q_{ES} - q_L) + 2q_{ES}(q_H - q_L))^3}$$

[30] Rearranging this inequality leads to

$$\beta_M(1 - \alpha_M) + \alpha_M(\alpha_M - \beta_M) + 2\alpha_M(1 - \beta_M) > 0,$$

which is always satisfied.

with $A = -7q_{ES}^3 q_H + 5q_{ES}^3 q_L + 4q_{ES}^2 q_H + 4q_{ES}^2 q_H q_L - 2q_{ES}^2 q_L - 3q_{ES} q_H q_L - 3q_{ES} q_H q_L + 2q_H^2 q_L$. Note that for $q_{ES} = q_H$ we have $A = -3q_H (q_H - q_L)^2 < 0$ whereas for $q_{ES} = q_L$ we have $A = 3q_L (q_H - q_L)^2 > 0$. Continuity then requires that the entrant optimally chooses $q_{ES}^* \in (q_L, q_H)$ such that $A = 0$, that is,[31]

$$\frac{\left(3q_H q_{ES}^* - 4\left(q_{ES}^*\right)^2 - 2q_H q_L + 3q_{ES}^* q_L\right)}{2\left(2q_{ES}^* - 4q_H + 2q_L\right)} = \frac{q_{ES}^*\left(q_H - q_{ES}^*\right)\left(q_{ES}^* - q_L\right)}{\left(2q_{ES}^* q_L - 4q_{ES}^* q_H + q_H q_L + \left(q_{ES}^*\right)^2\right)} \tag{C1}$$

In sum, the entrant chooses $q_{EF}^* < q_L$ if $\pi_{EF}^*\left(q_H, q_L; q_{EF}^*\right) > \pi_{ES}^*\left(q_H, q_L; q_{ES}^*\right)$ and otherwise $q_{ES}^* \in (q_L, q_H)$.

S1 Consider now the incumbent's optimal quality level q_L of the fighter brand. Note that $\pi_{EF}^*\left(q_H, q_L, q_{EF}^*\right)$ is monotone increasing in q_L, $\partial \pi_{EF}/\partial q_L = \overline{\theta}^2/48 > 0$, with $\pi_{EF}^* = 0$ for $q_L = 0$ and $\pi_{EF}^* = \overline{\theta}^2 q_H/48$ for $q_L = q_H$. Moreover, $\pi_{ES}^*\left(q_H, q_L; q_{ES}^*\right)$ is monotone decreasing in q_L,

$$\frac{\partial \pi_{ES}^*}{\partial q_L} = -\overline{\theta}^2 \left(q_{ES}^*\right)^2 \left(q_H - q_{ES}^*\right)^2 \times \frac{2q_{ES}^*\left(q_H - q_L\right) + q_L\left(q_H - q_{ES}^*\right) + q_{ES}^*\left(q_{ES}^* - q_L\right)}{\left(2q_{ES}^*\left(q_H - q_L\right) + q_H\left(q_{ES}^* - q_L\right) + q_{ES}^*\left(q_H - q_{ES}^*\right)\right)^3} < 0$$

with $\pi_{ES}^* = 0$ for $q_L = q_H$ and $\pi_{ES}^* = \overline{\theta}^2 q_H/48$ for $q_L = 0$. Let q_L be the critical value such that the entrant's profits in the firewall and sandwich scenario are identical, that is, $\pi_{EF}^*\left(q_H, q_L; q_{EF}^*\right) = \pi_{ES}^*\left(q_H, q_L; q_{ES}^*\right)$. Then q_L satisfies

$$\frac{1}{48}\overline{\theta}^2 q_L = \overline{\theta}^2 \left(q_{ES}^*\right)^2 \frac{\left(q_H - q_L\right)\left(q_H - q_{ES}^*\right)\left(q_{ES}^* - q_L\right)}{\left(2q_{ES}^* q_L - 4q_H q_{ES}^* + q_H q_L + \left(q_{ES}^*\right)^2\right)^2}. \tag{C2}$$

Condition (C1) and (C2) then uniquely determine the optimal pair $\left(q_L^*, q_{ES}^*\right)$ with $q_L^* < q_{ES}^*$: Using (C1) and solving for q_L then gives a quadratic equation with two roots

$$q_{L\pm}^* = \frac{q_{ES}^*\left(3q_H^2 - 5\left(q_{ES}^*\right)^2 - 4q_H q_{ES}^* \pm \left(q_H - q_{ES}^*\right)\sqrt{X}\right)}{4q_H^2 - 4\left(q_{ES}^*\right)^2 - 6q_H q_{ES}^*}$$

[31] Note that $\partial^2 \pi_{ES}^2/\partial q_{ES}^2 < 0$ requires $6q_H q_L^3 (q_H - q_L)^2 + q_{ES}^2 A > 0$ which is always satisfied in the optimum.

with $X = 25\left(q_{ES}^*\right)^2 + 34q_H q_{ES}^* - 23q_H^2$. Note that in equilibrium $X > 0$ since otherwise, (C2) would not have a solution. Moreover note that $q_{L-}^* \in \left(0, q_{ES}^*\right)$, but q_{L-}^* is always strictly greater than q_{ES}^*.[32] Hence, $q_L^* = q_{L+}^*$. Substituting this q_L^* in condition (C2) and rearranging terms then yields

$$q_H\left(q_H - q_{ES}^*\right)^2\left(3q_H q_{ES}^* + 2\left(q_{ES}^*\right)^2 - 2q_H^2\right)^3$$
$$\left(73q_H^3 - 192q_H^2 q_{ES}^* + 57q_H\left(q_{ES}^*\right)^2 + 89\left(q_{ES}^*\right)^3\right) = 0$$

Hence, the optimal q_{ES}^* is linear in q_H, $q_{ES}^* = \alpha_M q_H$ and solution of

$$\left(3\alpha_M + 2\alpha_M^2 - 2\right)\left(73 - 192\alpha_M + 57\alpha_M^2 + 89\alpha_M^3\right) = 0.$$

Since $\left(3\alpha_M + 2\alpha_M^2 - 2\right) = \left(\alpha_M + 2\right)\left(2\alpha_M - 1\right)$, the only solution with $\alpha_M > 4/7$ then is $\alpha_M = 0.777$ as a root of $\left(73 - 192\alpha_M + 57\alpha_M^2 + 89\alpha_M^3\right)$. The optimal q_L^* then is

$$q_L^* = \frac{\alpha_M\left((1-\alpha_M)\sqrt{25\alpha_M^2 + 34\alpha_M - 23} + 3 - 5\alpha_M^2 - 4\alpha_M\right)}{4 - 4\alpha_M^2 - 6\alpha_M} q_H$$
$$= \beta_L q_H = (0.548)\, q_H.$$

To see that the incumbent positions her fighter brand quality slightly above q_L^* such that the entrant's best response is $q_{EF}^* = 4q_L^*/7 = 4\beta q_H/7$, note that

$$\frac{\partial \pi_{IF}^*}{\partial q_L} = -\frac{5}{48}\overline{\theta}^2 < 0$$

with $\pi_{IF}^* = \overline{\theta}^2 q_H/4$ for $q_L = 0$ and $\pi_{IF}^* = 7\overline{\theta}^2 q_H/48$ for $q_L = q_H$. Moreover, in the sandwich scenario,

$$\frac{\partial \pi_{IS}^*}{\partial q_L} = -\frac{q_{ES}\left(q_H - q_L\right) Y}{\left(q_{ES}\left(q_H - q_{ES}\right) + q_H\left(q_{ES} - q_L\right) + 2q_{ES}\left(q_H - q_L\right)\right)^3} < 0$$

with $Y = \left(q_{ES}\left(q_{ES} - q_L\right) + 20q_{ES}\left(q_H - q_L\right) + q_L\left(q_H - q_{ES}\right)\right) q_E$ $\left(q_H - q_{ES}\right) + q_{ES} q_H\left(q_{ES} - q_L\right)\left(8q_{ES} + 12q_H - 15q_L\right) + 7q_{ES}^2 q_L\left(q_{ES} - q_L\right) + q_H\left(q_{ES} + q_L\right)\left(q_{ES} - q_L\right) + 3q_{ES}^2\left(q_H - q_L\right)^2 > 0$. Note that $\pi_{IS}^* = 7\overline{\theta}^2 q_H/48$ for $q_L = 0$ and $\pi_{IS}^* = 0$ for $q_L = q_H$. Hence, if the incumbent positions her fighter brand slightly below q_L^* such that the entrant's best response is in the intermediate

[32] For $q_{ES}^* > q_H/2$ we have $q_{L-}^* < q_{ES}^*$ iff $0 < 12\left(2q_{ES}^* - q_H\right)\left(2q_H + q_{ES}^*\right)$ and for $q_{ES}^* < q_H/2$ we have $q_{L-}^* < q_{ES}^*$ iff $0 > 12\left(2q_{ES}^* - q_H\right)\left(2q_H + q_{ES}^*\right)$ which is true in both cases.

range, her resulting profits would be strictly lower. The resulting pre-advertising profits then are

$$\pi^*_{EF} = \frac{1}{48}\overline{\theta}^2 \beta_L q_H,\ \pi^*_{IF} = \frac{1}{48}\overline{\theta}^2 (12 - 5\beta_L) q_H$$

Q.E.D. □

Proof of Proposition 3 Let $\bar{p}_L$ be the incumbent's list price announced and i be her advertising investment chosen in Stage 1. Using $p^*_L = \beta_L \overline{\theta}\overline{q}/4$ and $\beta_L = 1.094$, we consider the following three cases:

1. $\bar{p}_L < p^*_L$: Suppose first that i is sufficiently high such that the commitment constraint (CC_F) is satisfied and let $(q_H, q_L; q_E)$ be the quality choices in Stage 1 and 2. Then the incumbent optimally prices the fighter brand for the highest possible price $\bar{p}_L$ and the optimal prices $p^*_{HF}(\bar{p}_L)$ and $p^*_{EF}(\bar{p}_L)$ following according to the best response function in the proof of Proposition 1. Note that the incumbent's resulting profit $\pi^*_{IF}(q_H, q_L; q_E)\ \bar{p}_L)$ is strictly lower for every quality combination $(q_H, q_L; q_E)$ than her profit $\pi^*_{IF}(q_H, q_L; q_E)$ since she would prefer to price the fighter brand for p^*_L. But this implies that the advertising investment i to make the commitment constraint (CC_F) binding ex-ante also ensures that the commitment constraint for an announcement p^*_L would be satisfied, that is,

$$R(i) \geq \pi^*_I(q_H; q_E) - \pi^*_{IF}((q_H, q_L; q_E)|\bar{p}_L) > \pi^*_I(q_H; q_E) - \pi^*_{IF}(q_H, q_L; q_E).$$

   Hence, the incumbent prefers to announce the higher list price p^*_L. Of course, if i is not sufficiently high to satisfy the commitment constraint (CC_F) the incumbent will price the fighter brand out of the market.
2. $\bar{p}_L \in \left[p^*_L, \beta_L p^*_L\right]$: Then (PC_F) is satisfied. Suppose that i is sufficiently high such that the commitment constraint is satisfied when the incumbent launches a fighter brand of quality q_L. If $q_L < \beta_L q_H$, three qualities then are in the market and the entrant's product is sandwiched by the incumbent's products according to the proof of Proposition 2. However, the incumbent then is better off by launching the fighter brand with quality $q_L = \beta_L q_H$ since this leads to a firewall scenario with higher profit π^*_{IF}. Note that a higher profit π^*_{IF} implies that the corresponding commitment constraint is still satisfied with i, that is,

$$R(i) \geq \pi^*_I(q_H; q_E) - \pi^*_{IS}\left((q_H, q_L; q^*_{ES})\right) > \pi^*_I(q_H; q_E) - \pi^*_{IF}\left(q_H, \beta_L q_H; q^*_{EF}\right).$$

   If, on the hand, $q_L > \beta_L q_H$, the entrant positions his product below the incumbent's fighter brand according to the proof of Proposition 2. As in the case before, the incumbent then is better off by launching the fighter brand with quality $q_L = \beta_L q_H$ since this leads to higher profit π^*_{IF} and the corresponding commitment constraint is still satisfied with i, that is,

$$R(i) \geq \pi^*_I(q_H; q_E) - \pi^*_{IF}\left((q_H, q_L; q^*_{EF})\right) > \pi^*_I(q_H; q_E) - \pi^*_{IF}\left(q_H, \beta_L q_H; q^*_{EF}\right).$$

As a conclusion, the incumbent chooses $q_L = \beta_L q_H$ in equilibrium, if the commitment constraint (CC$_F$) is satisfied. Note that she decides not to deviate from her announced list price in Stage 3, whenever

$$R(i) \geq R^* = \pi^*_{IF}\left(q_H, \beta_L q_H; q^*_E(i)\right) - \pi^*_I\left(q_H, q^*_E(i)\right),$$

where $q^*_E(i)$ denotes the entrant's optimal product quality given the advertising investment i. According to the proof of Proposition 2, the entrant chooses in Stage 2 an optimal quality level $q^*_{EF}(i) = \gamma_L q_H$ if the incentive compatibility condition (CC$_F$) is satisfied, otherwise, he chooses $q^*_E(i) = 4q_H/7$. Using Proposition 1 and the results above, the critical reputation loss then is $R^* = 5(1-\beta_L)\overline{\theta}^2 q_H/48$. The incumbent's investment decision in Stage 1 then depends on the reputation loss function $R(i)$. In case, $R(i) < R^*$ for all investment levels i, she cannot credibly commit herself to deviate from her announcement and chooses $i^* = 0$. In case, $R(i) \geq R^*$ for some $i > 0$, let i^* be the lowest investment such that $R(i^*) = R^*$.[33] Then the incumbent invests i^* in Stage 1 whenever

$$\pi^*_{IF}(\overline{q}, \beta_L\overline{q}; \gamma_L\overline{q}) - i^* \geq \pi^*_I\left(\overline{q}; \frac{4}{7}\overline{q}\right),$$

otherwise, she invests $i^* = 0$. Hence, if $i^* \leq R(i^*) = R^*$, the incumbent chooses an optimal investment i^*, whereas she chooses not to invest if $i^* > R(i^*) = R^*$. The monotonicity of $R(\cdot)$ then implies investment that she invests i^* for $R^* = R(i^*) \leq R(R(i^*)) = R(R^*)$ and otherwise not.

3. $\bar{p}_L > \beta_L p^*_L$: In this case, the price constraint (PC$_F$) is not satisfied and, according to the proof of Proposition 1, the incumbent will always price the fighter brand out of the market, independent of her advertising investment i.
Q.E.D. □

Proof of Proposition 4 In solving the game, we use backward induction and distinguish two cases, the firewall scenario where $q_H > q_R > q_E$ and the sandwich scenario with $q_H > q_E > q_R$.

S3.1 Consider first the firewall scenario. Given prices p_{HF}, p_{RF}, p_{EF}, market demands are

$$x_{HF} = \overline{\theta} - \frac{p_{HF} - p_{RF}}{q_H - q_R}, x_{RF} = \frac{p_{HF} - p_{RF}}{q_H - q_R} - \frac{p_{RF} - p_{EF}}{q_R - q_E},$$
$$x_{EF} = \frac{p_{RF} - p_{EF}}{q_R - q_E} - \frac{p_{EF}}{q_E}.$$

The entrant then maximizes profits π_{EF} with respect to its product price p_{EF}. This leads to the first-order condition

$$\frac{\partial \pi_{EF}}{\partial p_{EF}} = \frac{2p_{EF}q_R - q_E p_{RF}}{q_E(q_E - q_R)} = 0,$$

[33] Note that $R(i) > R^*$ for all $i > i^*$ since $R(\cdot)$ is monotone increasing in i.

hence $p_{EF}=\frac{1}{2}p_{RF}\frac{q_E}{q_R}$. The retailer maximizes profits π_{RF}, yielding the first-order condition

$$\frac{\partial \pi_{RF}}{\partial p_{RF}}=\frac{p_{EF}\left(q_H-q_R\right)-\left(2p_{RF}-w\right)\left(q_H-q_E\right)+p_{HF}\left(q_R-q_E\right)}{\left(q_H-q_R\right)\left(q_R-q_E\right)}=0.$$

And third, the incumbent maximizes her overall profits π_{IF} with respect to its price p_{HF} and the first-order condition reads as

$$\frac{\partial \pi_{IF}}{\partial p_{HF}}=\frac{\overline{\theta}\left(q_H-q_R\right)-2p_{HF}+p_{RF}+w}{q_H-q_R}=0.$$

The best response functions are obtained from these conditions as $p_{EF}=\frac{1}{2}\frac{q_E}{q_R}p_{RF}$ and

$$\begin{aligned}
p_{RF}&=\frac{p_{EF}\left(q_H-q_R\right)+p_{HF}\left(q_R-q_E\right)}{2\left(q_H-q_E\right)}+\frac{1}{2}w,\\
p_{HF}&=\frac{1}{2}\overline{\theta}\left(q_H-q_R\right)+\frac{1}{2}\left(p_{RF}+w\right).
\end{aligned}$$

Solving for p_{HF}, p_{RF}, and p_{EF} then gives equilibrium prices

$$\begin{aligned}
p_{HF}^{*}&=\frac{1}{2}\overline{\theta}\left(q_H-q_R\right)\left(1+\frac{q_R\left(q_R-q_E\right)}{\left(q_H\left(q_R-q_E\right)+2q_R\left(q_H-q_E\right)+q_R\left(q_H-q_R\right)\right)}\right)\\
&\quad+\frac{1}{2}w\left(1+\frac{q_R\left(2\left(q_H-q_E\right)+\left(q_R-q_E\right)\right)}{\left(q_H\left(q_R-q_E\right)+2q_R\left(q_H-q_E\right)+q_R\left(q_H-q_R\right)\right)}\right)\\
p_{RF}^{*}&=\overline{\theta}\frac{q_R\left(q_H-q_R\right)\left(q_R-q_E\right)}{\left(q_H\left(q_R-q_E\right)+2q_R\left(q_H-q_E\right)+q_R\left(q_H-q_R\right)\right)}\\
&\quad+w\frac{q_R\left(2\left(q_H-q_E\right)+\left(q_R-q_E\right)\right)}{\left(q_H\left(q_R-q_E\right)+2q_R\left(q_H-q_E\right)+q_R\left(q_H-q_R\right)\right)},\\
p_{EF}^{*}&=\frac{1}{2}\overline{\theta}\frac{q_E\left(q_H-q_R\right)\left(q_R-q_E\right)}{\left(q_H\left(q_R-q_E\right)+2q_R\left(q_H-q_E\right)+q_R\left(q_H-q_R\right)\right)}\\
&\quad+\frac{1}{2}w\frac{q_E\left(2\left(q_H-q_E\right)+\left(q_R-q_E\right)\right)}{\left(q_H\left(q_R-q_E\right)+2q_R\left(q_H-q_E\right)+q_R\left(q_H-q_R\right)\right)}.
\end{aligned}$$

Note that

$$\frac{\partial}{\partial w}\left(p_{HF}^{*}-p_{RF}^{*}\right)=\frac{1}{2}\frac{\left(2q_R-q_E\right)\left(q_H-q_R\right)}{q_H\left(q_R-q_E\right)+2q_R\left(q_H-q_E\right)+q_R\left(q_H-q_R\right)}>0.$$

Substituting the equilibrium prices into the demand function gives us the equilibrium demands, and shows that for $w=0$, the market demand for the premium product is higher than the one in the monopoly case $x_{HF}^{*}>\overline{\theta}/2$. Moreover, the retailer's market demand for the fighter brand is decreasing in the wholesale price,

$$\frac{\partial}{\partial w}x_{RF}^{*}=-\frac{2q_L\left(q_H-q_E\right)-q_E\left(q_H-q_E\right)}{\left(q_R-q_E\right)\left(q_H\left(q_R-q_E\right)+2q_R\left(q_H-q_E\right)+q_R\left(q_H-q_R\right)\right)}\overline{\theta}<0,$$

hence, by setting $w=0$ the retailer's market demand is greatest and equal to

$$x_{RF}^{*}=\frac{q_R\left(q_H-q_E\right)}{\left(q_H\left(q_R-q_E\right)+2q_R\left(q_H-q_E\right)+q_R\left(q_H-q_R\right)\right)}\overline{\theta}.$$

S3.2 Consider now the sandwich scenario. Given $q_H > q_E > q_R$ and prices p_{HS}, p_{ES}, p_{RS}, market demands are

$$x_{HS}=\overline{\theta}-\theta_1, x_{ES}=\theta_1-\theta_2, x_{RS}=\theta_2-\theta_3.$$

where $\theta_1 = (p_{HS}-p_{ES})/(q_H-q_E)$ is the customer who is indifferent between the premium product and the entrant's product, $\theta_2 = (p_{ES}-p_{RS})/(q_E-q_R)$ is the one indifferent between buying the product from the entrant or the retailer, and the customer indexed by θ_3 is given by $\theta_3 q_R - p_{RS} = 0$. The entrant's profit function π_{ES} then is maximized with respect to his product price p_{ES} if the first-order condition is satisfied:

$$\frac{\partial\pi_{ES}}{\partial p_{ES}}=\frac{p_{HS}\left(q_E-q_R\right)+p_{RS}\left(q_H-q_E\right)-2p_{ES}\left(q_H-q_R\right)}{\left(q_H-q_E\right)\left(q_E-q_R\right)}=0.$$

The best response function of the entrant then is

$$p_{ES}=\frac{1}{2}p_{HS}\frac{q_E-q_R}{q_H-q_R}+\frac{1}{2}p_{RS}\frac{q_H-q_E}{q_H-q_R}.$$

The retailer's profits π_{RS} are maximized if

$$\frac{\partial\pi_{RS}}{\partial p_{RS}}=\frac{1}{q_R\left(q_E-q_R\right)}\left(wq_E-2p_{RS}q_E+q_Rp_{ES}\right)=0,$$

hence,

$$p_{RS}=\frac{1}{2}w+\frac{1}{2}p_{ES}\frac{q_R}{q_E}.$$

And the incumbent maximizes π_{IS} with respect to p_{HS}, hence

$$\frac{\partial\pi_{IS}}{\partial p_{HS}}=\frac{1}{q_H-q_E}\left(-2p_{HS}+p_{ES}+\overline{\theta}\left(q_H-q_E\right)\right)=0$$

and

$$p_{HS}=\frac{1}{2}p_{ES}+\frac{1}{2}\theta\left(q_H-q_E\right).$$

Rearranging the three first order conditions then gives

$$
\begin{aligned}
p_{HS}^{*} &= \frac{1}{2}q_E\frac{w\left(q_H-q_E\right)+\theta\left(q_E-q_R\right)\left(q_H-q_E\right)}{q_E\left(q_H-q_E\right)+q_H\left(q_E-q_R\right)+2q_E\left(q_H-q_R\right)}+\frac{1}{2}\theta\left(q_H-q_E\right),\\
p_{ES}^{*} &= q_E\frac{w\left(q_H-q_E\right)+\theta\left(q_E-q_R\right)\left(q_H-q_E\right)}{q_E\left(q_H-q_E\right)+q_H\left(q_E-q_R\right)+2q_E\left(q_H-q_R\right)},\\
p_{RS}^{*} &= \frac{1}{2}w+\frac{1}{2}q_R\frac{w\left(q_H-q_E\right)+\theta\left(q_E-q_R\right)\left(q_H-q_E\right)}{q_E\left(q_H-q_E\right)+q_H\left(q_E-q_R\right)+2q_E\left(q_H-q_R\right)}.
\end{aligned}
$$

and equilibrium demands follow.

S2 Given $q_H > q_R$ the entrant can either choose q_E such that $q_E < q_R$ or such that $q_E \in [q_{RL}, q_H]$. If the entrant chooses $q_E < q_R$, the entrant's profits are

$$
\pi_{EF}^{*}\left(q_H,q_R;q_{EF}\right)=\frac{\overline{\theta}^2 q_R q_{EF}\left(q_R-q_{EF}\right)\left(q_H-q_R\right)^2}{4\left(q_H\left(q_R-q_{EF}\right)+q_R\left(q_H-q_R\right)+2q_R\left(q_H-q_{EF}\right)\right)^2}
$$

given equilibrium prices and $w = 0$. Then

$$
\frac{\partial\pi_{EF}^{*}}{\partial q_{EF}}=\frac{1}{4}\overline{\theta}^2\frac{q_R^2\left(q_H-q_R\right)^2\left(4q_{EF}q_R+4q_Hq_R-q_R^2-7q_{EF}q_H\right)}{\left(q_H\left(q_R-q_{EF}\right)+q_R\left(q_H-q_R\right)+2q_R\left(q_H-q_{EF}\right)\right)^3}=0
$$

for

$$
q_{EF}^{*}=q_R\frac{4q_H-q_R}{7q_H-4q_R}.
$$

His equilibrium profits then are

$$
\pi_{EF}^{*}=\frac{1}{48}\overline{\theta}^2 q_R\frac{q_H-q_R}{4q_H-q_R}.
$$

If the entrant chooses a sandwich position, $q_{ES} \in [q_L, q_H]$, the corresponding price equilibrium leads to profits

$$
\begin{aligned}
&\pi_{ES}^{*}\left(q_H,q_R;q_{ES}\right)\\
&\quad=\overline{\theta}^2 q_{ES}^2\frac{\left(q_H-q_R\right)\left(q_H-q_{ES}\right)\left(q_{ES}-q_R\right)}{\left(q_E\left(q_H-q_{ES}\right)+q_H\left(q_{ES}-q_R\right)+2q_{ES}\left(q_H-q_R\right)\right)^2}
\end{aligned}
$$

for $w = 0$. The first order condition then reads as

$$
\frac{\partial\pi_{ES}^{*}}{\partial q_{ES}}=\overline{\theta}^2\frac{q_{ES}\left(q_H-q_R\right)A}{\left(q_{ES}\left(q_H-q_{ES}\right)+q_H\left(q_{ES}-q_R\right)+2q_{ES}\left(q_H-q_R\right)\right)^3},
$$

with $A = 2q_H^2q_R^2-3q_H^2q_Rq_{ES}+4q_H^2q_{ES}^2-3q_Hq_R^2q_{ES}+4q_Hq_Rq_{ES}^2-7q_Hq_{ES}^3-2q_R^2q_{ES}^2+5q_Rq_{ES}^3$. Note that for $q_{ES} = q_H$ we have $A = -3q_H^2\left(q_H-q_R\right)^2 < 0$ whereas for $q_{ES} = q_R$ we have $A = 3q_R^2\left(q_H-q_R\right)^2 > 0$. Continuity then requires that the entrant optimally chooses $q_{ES}^* \in (q_R, q_H)$ such that $A = 0$, that is,

$$2q_H^2 q_R^2 - 3q_H^2 q_R q_{ES} + 4q_H^2 q_{ES}^2 - 3q_H q_R^2 q_E + 4q_H q_R q_{ES}^2 - 7q_H q_{ES}^3 - 2q_R^2 q_{ES}^2 + 5q_R q_{ES}^3 = 0 \tag{C5}$$

Note that this condition for q_{ES}^* is independent of whether the retailer or the incumbent sets the price for the fighter brand. This is due to the fact, that in the sandwich scenario the incumbent's maximization problem consists of two subproblems - choosing the optimal price for the premium product and the one for the fighter brand - which are independent of each other.

S1 Note that $\pi_{EF}^*(q_H, q_R; q_{EF})$ is monotone increasing in q_R for $q_R < \overline{q}_R$ with $\pi_{EF}^*(q_H, q_R; q_{EF}) = 0$ for $q_R = 0$, and monotone decreasing in q_R for $q_R > \overline{q}_R$ with $\pi_{EF}^*\left(q_H, q_R; q_{EF}^*\right) = 0$ for $q_R = q_H$ with $\overline{q}_R = \left(4 - 2\sqrt{3}\right) q_H = 0.535\,90 q_H$:

$$\frac{\partial \pi_{EF}^*}{\partial q_R} = \frac{1}{48}\overline{\theta}^2 \frac{((q_H - 2q_R)(4q_H - q_R) + q_R(q_H - q_R))}{(4q_H - q_R)^2}$$

Moreover, $\pi_{ES}^*\left(q_H, q_R; q_{ES}^*\right)$ is monotone decreasing in q_R,

$$\frac{\partial \pi_{ES}^*}{\partial q_R} = -\overline{\theta}^2 \left(q_{ES}^*\right)^2 \left(q_H - q_{ES}^*\right)^2 \times \frac{2q_{ES}^*(q_H - q_R) + q_R\left(q_H - q_{ES}^*\right) + q_{ES}^*\left(q_{ES}^* - q_R\right)}{\left(2q_{ES}^*(q_H - q_R) + q_H\left(q_{ES}^* - q_R\right) + q_{ES}^*\left(q_H - q_{ES}^*\right)\right)^3} < 0$$

with $\pi_{ES}^*\left(q_H, q_R; q_{ES}^*\right) = 0$ for $q_R = q_H$ and $\pi_{ES}^*\left(q_H, q_R; q_{ES}^*\right) = \overline{\theta}^2 q_H/48$ for $q_R = 0$. Let q_R^* be the critical value given by $\pi_{EF}^*\left(q_H, q_R^*; q_{ES}^*\right) = \pi_{ES}^*\left(q_H, q_R^*; q_{ES}^*\right)$, that is,

$$\frac{1}{48}\theta^2 q_R^* \frac{q_H - q_R^*}{4q_H - q_R^*} = \theta^2\left(q_{ES}^*\right)^2 \frac{\left(q_H - q_R^*\right)\left(q_H - q_{ES}^*\right)\left(q_{ES}^* - q_R^*\right)}{\left(\left(q_{ES}^*\right)^2 + q_H q_R^* - 4q_H q_{ES}^* + 2q_R^* q_{ES}^*\right)^2}. \tag{C6}$$

Then condition (C5) and (C6) uniquely determine the optimal pair $\left(q_R^*, q_{ES}^*\right)$ with $q_R^* < q_{ES}^*$: Using (C5) and solving for q_R^* then gives a quadratic equation with two roots

$$q_{R\pm}^* = \frac{q_{ES}^*\left(5\left(q_{ES}^*\right)^2 + 4q_H q_{ES}^* - 3q_H^2 \pm \left(q_H - q_{ES}^*\right)\sqrt{X}\right)}{4\left(q_{ES}^*\right)^2 + 6q_H q_{ES}^* - 4q_H^2}$$

with $X = 25\left(q_{ES}^*\right)^2 + 34 q_H q_{ES}^* - 23q_H^2$. Note that in equilibrium $X > 0$ since otherwise (C6) would not have a solution. Moreover note that $q_{R-}^* \in \left(0, q_{ES}^*\right)$, but q_{R+}^* is always strictly greater than q_{ES}^*. Hence, $q_R^* = q_{R-}^*$. Substituting this q_R^* in condition (C6) and rearranging terms then yields

$$q_H \left(q_H - 2q_{ES}^*\right)^3 \left(2q_H + q_{ES}^*\right)^4 \times \\ \left(522q_H^4 - 2129q_H^3 q_{ES}^* + 2097q_H^2 \left(q_{ES}^*\right)^2 + 465q_H \left(q_{ES}^*\right)^3 - 631 \left(q_{ES}^*\right)^4\right) = 0$$

Hence, the optimal q_{ES}^* is linear in q_H, $q_{ES}^* = \alpha_R q_H$ and $\alpha_R = 1/2$ since $522 - 2129\alpha_R + 2097\alpha_R^2 + 465\alpha_R^3 - 631\alpha_R^4 > 0$ for all $\alpha_R \in [0, 1]$. Since the nominator and denominator of (C5) are both zero for $q_{ES}^* = \frac{1}{2} q_H$, the optimal $q_R^* = \beta_R q_H$ results from (C6) as solution of

$$\frac{1}{16}\beta_R (7 - 8\beta_R)^2 = 6 (4 - \beta_R) \left(\frac{1}{2} - \beta_R\right),$$

hence, $\beta_R = 0.486\,05$.

The optimal q_R^* then determines the optimal quality of the entrant's product according to Stage 2 as

$$q_E^* = \beta_R \frac{4 - \beta_R}{7 - 4\beta_R} q_H = \gamma_R q_H,$$

with $\gamma_R = 0.337\,82$. With $q_H = \overline{q}$, the entrant's profits then are

$$\pi_E^* \left(q_H, q_R^*; q_{EF}^*\right) = \frac{\gamma_R (1 - \beta_R)^2 (\beta_R - \gamma_R) \overline{\theta}^2 \overline{q}}{36\beta_R (1 - \gamma_R)^2}$$

and the incumbent's profits are

$$\pi_I^* \left(q_H, q_R^*; q_{EF}^*\right) = \frac{(1 - \beta_R) (\gamma_R - 4\beta_R + 3\beta_R\gamma_R)^2}{4 \left(\gamma_R - 4\beta_R + \beta_R^2 + 2\beta_R\gamma_R\right)^2} \overline{\theta}^2 \overline{q} + L^* = (0.146\,87)\, \overline{\theta}^2 \overline{q} + L^*$$

where $L^* = \pi_R^*$ are the retailer's profits

$$\pi_R^* \left(q_H, q_R^*; q_E^*\right) = \frac{\beta_R^2 (\beta_R - 1) (\gamma_R - 1) (\beta_R - \gamma_R)}{\left(\gamma_R - 4\beta_R - \beta_R^2 + 2\beta_R\gamma_R\right)^2} \overline{\theta}^2 \overline{q} = \left(5.197\,7 \times 10^{-3}\right) \overline{\theta}^2 \overline{q}.$$

Note that the retailer's demand in equilibrium is

$$x_{RF}^* = \frac{\beta_R (1 - \gamma_R)}{((\beta_R - \gamma_R) + 2\beta_R (1 - \gamma_R) + \beta_R (1 - \beta_R))} \overline{\theta} = 0.308\,96\overline{\theta}.$$

Q.E.D. □

Appendix 2

In the following, we consider the fixed price commitment game. Suppose we modify the list price commitment game from Sect. 4.1 by assuming that the incumbent would advertise to launch the fighter brand of quality q_L for a fixed price p_L in Stage 1. Suppose that the incumbent chooses an advertising investment i which credibly solves her commitment problem in the fixed price commitment game.

How does the entrant react to this announcement? And what does his reaction imply for the optimal launch of the fighter brand? To discuss the first questions, note that the entrant in Stage 2 still has two possibilities to position his product; either below the fighter brand or between the incumbent's products. In the firewall scenario, he would then optimally choose the quality level identical to the incumbent's fighter brand, $q_{EF}^{**} = q_L$ and offer it in the price competition stage with a price p_{EF}^{**} (slightly) below p_L. But this implies that now the entrant prices the incumbent's fighter brand out of the market. Consequently, the incumbent then would make no profits with her second product, and only two products would be active in the market. In the sandwich scenario, the entrant would either choose the positioning of his product strictly between the incumbent's products, $q_{EF}^{**} \in (q_L, q_H)$, or he would imitate the incumbent's fighter brand, $q_{EF}^{**} = q_L$, with a price p_{EF}^{**} (slightly) below p_L. The first case is optimal if the quality of the fighter brand is too low, and it is beneficial for the entrant to choose a strict sandwich position. The second case is optimal if the quality of the fighter brand is close to the one of the incumbent's premium product.

To discuss the optimal reaction of the incumbent to this behavior, suppose she would advertise to launch the optimal fighter brand of the list price commitment game, that is, a second product of quality q_L^* for a fixed price p_L^* as defined in Proposition 2. Then it is easy to see that the entrant decides to match the incumbent's fighter brand q_L^* with a price slightly below p_L^*, independent of whether he pursues the firewall or sandwich scenario. In both scenarios, he alone captures the lower part of the market, and his profits would be higher than those from Proposition 2. But this implies that the incumbent can either lower the quality of her fighter brand or increase the price announcement. With the first strategy, she weakens the market positioning of the entrant's product quality; and with the second strategy, she relaxes price competition with the entrant's product. In both cases, she obtains higher profits with her premium product. Whether this advantage of a fixed price commitment counterbalances her loss in profits from the fighter brand is answered in the following proposition.

Proposition 6 *Suppose that the incumbent has credibly committed to launching a fighter brand of quality q_L^{**} with a fixed price p_L^{**} by investing i^{**} in advertising this announcement. As in the list price commitment game, she will always launch the fighter brand as firewall. Different from the list price commitment game, she offers the premium product $q_H = \overline{q}$ for a higher equilibrium price, $p_H^{**} \geq p_H^*$ and launches the fighter brand with a lower quality $q_L^{**} = \beta_F \overline{q} \leq q_L^*$ and a higher price $p_L^{**} \geq p_L^*$. The entrant chooses an equilibrium quality $q_E^{**} = q_L^{**}$ and a price $p_E^{**} = p_L^{**}$. Compared to the list price commitment game, the resulting pre-advertising equilibrium profits of* *the incumbent are lower in the fixed price commitment game,*

$$\pi_I^{**}\left(\overline{q}, \beta_F\overline{q}; \beta_F\overline{q}\right) < \pi_I^{*}\left(\overline{q}, \beta_L\overline{q}; \gamma_L\overline{q}\right),$$

but the ones of the entrant are higher,

$$\pi_E^{**}\left(\overline{q}, \beta_F\overline{q}; \beta_F\overline{q}\right) > \pi_E^{*}\left(\overline{q}, \beta_L\overline{q}; \gamma_L\overline{q}\right).$$

Proof See Appendix 3. □

Proposition 4 shows that the incumbent's pre-advertising profits are higher with a list price than with a fixed price. Intuitively, the advantage of the fixed price commitment game to earn higher profits with her premium brand does not compensate for the loss of profits with her fighter brand. In fact, suppose the incumbent would offer a fighter brand of quality $q_L = \gamma_L\bar{q}$, which just matches the entrant's optimal quality choice in the list price commitment game. As discussed above, the entrant then optimally chooses $q_E^{**} = \gamma_L\bar{q}$. Now let p_L' be the incumbent's announced price for the fighter brand such that her profits in the fixed price commitment game are equal to the ones in the equilibrium of Proposition 2, that is,

$$\pi_I^{*}\left(\overline{q}, \beta_L\overline{q}; \gamma_L\overline{q}\right) = \pi_I^{**}\left(\left(\overline{q}, \gamma_L\overline{q}; \gamma_L\overline{q}\right) \mid p_L'\right).$$

The question of whether the incumbent's equilibrium profits in the fixed price commitment game are higher or lower than the ones in the equilibrium in the list price commitment game then is answered by comparing the entrant's profits in the sandwich and the firewall scenario: If

$$\pi_{EF}^{**}\left(\left(\overline{q}, \gamma_L\overline{q}; \gamma_L\overline{q}\right) \mid p_L'\right) > \pi_{ES}^{**}\left(\left(\overline{q}, \gamma_L\overline{q}; \gamma_L\overline{q}\right) \mid p_L'\right),$$

the incumbent can either slightly lower the quality q_L of the fighter brand or slightly increase its price p_L' so that the entrant still positions his second quality with $q_E^{**} = q_L$. In both cases, the incumbent can increase her profits, and she prefers a fixed price commitment to a list price commitment. The conclusion is the opposite if the firewall scenario leads to lower profits for the entrant than the sandwich scenario. The incumbent then has to increase the fighter brand's quality or reduce the announced price to make the sandwich strategy less attractive for the entrant. Independent of her reaction, her profits are lower than those in the equilibrium of the list price commitment game. A simple calculation shows that this is indeed the case.

Using the results from Proposition 4, we can now discuss the conditions such that the incumbent has an incentive to credibly commit to her fighter brand in the fixed price commitment game. Consider first the price constraint (PC_F) in the firewall scenario, which should ensure that the incumbent's fighter brand has positive demand. But since the entrant always drives the incumbent's fighter brand out of the market, the incumbent's fighter brand always has zero demand. Hence, the incumbent does not need to ensure that the fighter brand in the firewall scenario is active ex-post in the market.

This conclusion, however, is different in the sandwich scenario when the entrant positions his product between the incumbent's two products. If the fixed price is too high in this case, the demand for the fighter brand in the sandwich scenario would be zero, which implies that the price constraint (PC$_S$) would be violated. The proof of Proposition 4 then shows that this implies the fixed price p_L has to be lower than the optimal price $p^*_{EF}(q_L)$ the entrant would choose in the absence of a price announcement in the firewall scenario. Hence, if this price constraint holds in equilibrium, the entrant optimally chooses a price slightly below the fixed price announced by the incumbent.

To ensure the credibility of this price announcement, the incumbent has to invest in advertisement. In particular, the advertising investment i^{**} has to be sufficiently high such that

$$R\left(i^{**}\right) \geq R_F^{**} = \pi_I^*\left(\overline{q}; \beta_F \overline{q}\right) - \pi_I^{**}\left(\overline{q}, \beta_F \overline{q}; \beta_F \overline{q}\right).$$

Note that if she would price her fighter brand out of the market given the entrant has chosen a quality level $q_E^* = \beta_F \overline{q}$, her profits would increase to

$$\pi_I^*\left(\overline{q}; \beta_F \overline{q}\right) = \frac{4\left(1-\beta_F\right)}{\left(4-\beta_F\right)^2} \overline{\theta}^2 \overline{q}.$$

Proposition 7 *Let $\bar{\imath}_F$ be defined by $R\left(\bar{\imath}_F\right) = R_F^{**}$.*

1. *If $\bar{\imath}_F \leq R_F^{**}$, the incumbent acts as price leader. She announces a fixed price p_L^{**} and chooses an advertising investment $i_F^* = \bar{\imath}_F$ to credibly commit to her fighter brand as characterized in Proposition 3. The incumbent's post-advertising profits then are*
$$\pi_I^{**}\left(\overline{q}, \beta_F \overline{q}; \beta_F \overline{q}\right) - \bar{\imath}_F.$$
2. *If $\bar{\imath}_M > R_F^{**}$, the incumbent chooses not to invest, $i_F^* = 0$, and her profits are the same as in Proposition 1.*

Note that the value of her commitment in case of a fixed price commitment is lower than in case of a list price commitment: If we compare the incumbent's profit increase when credibly launching the fighter brand with her profits without endogenous price leadership, the value of commitment amounts to

$$\Delta_F^{**} = \pi_I^{**}\left(\overline{q}, \beta_F \overline{q}; \beta_F \overline{q}\right) - \pi_I^*\left(\overline{q}; \frac{4}{7}\overline{q}\right).$$

Since her profits are lower with a fixed price commitment according to Proposition 3, the value of commitment is higher in the list price commitment game.

If we compare the fixed price commitment case with the other two commitment devices, the following propositione follows:

Proposition 8 *The incumbent always commits to the launch of the fighter brand. Depending on the attractiveness α of the market, the optimal commitment device is as follows: There exists two critical values α_L^* and α_F^* with $0 \leq \alpha_L^* \leq \alpha_F^*$, such that*

- *if* $\alpha \leq \alpha_L^*$, *the incumbent prefers an endogenous price commitment with a list price,*
- *if* $\alpha \in \left(\alpha_L^*, \alpha_F^*\right]$, *she prefers an endogenous price commitment with a fixed price announcement, and*
- *if* $\alpha \geq \alpha_F^*$, *she favors dual channeling.*

Moreover, the critical values α_L^* *and* α_F^* *are increasing in the reputation elasticity* ρ_R.

Proof See Appendix 3. □

The interpretation of this result follows directly from our previous discussion: The incumbent's profit gains from a commitment to a fixed price are lower than the ones for a list price commitment, but higher than the ones for dual channeling. The same is true for the necessary advertising investments for a credible commitment: some investments for a fixed price commitment, that is more than for dual channeling, less for a price leadership with a list price commitment.

To discuss how the reputation elasticity and the market attractiveness influence the optimality of a fixed price commitment, consider first the sensitivity of customers to a deviation from the incumbent's price announcement. If the reputation elasticity is sufficiently high, advertising investments make an endogenous price commitment with a fixed price attractive because the necessary investments are lower than the corresponding reputation loss in case of a deviation. However, a list price commitment in this intermediate range is not beneficial. If the reputation elasticity is even higher, an endogenous price commitment with a list price becomes possible. In this case, the higher advertising investments by the incumbent necessary to make her announcement credible are worthwhile due to the increased commitment value.

Concerning the market attractiveness, note that if the market is not unattractive, the investment in advertising necessary for endogenous price leadership with a list price is not possible anymore because the investment necessary for its credibility is too high. Hence, an endogenous price commitment with a fixed price becomes optimal because this commitment device requires less investment in advertising due to a lower value of commitment. Of course, if the market's attractiveness becomes too high, this commitment device is too expensive because the necessary advertising investment is too high and the incumbent prefers dual channeling.

Appendix 3

Proof of Proposition 7 Suppose that in the fixed price commitment game the incumbent announces a fixed price p_L and chooses an advertising investment i in Stage 1 such that the price constraint as well as the commitment constraint for the firewall and sandwich scenario are satisfied in equilibrium. Let q_L be the quality of the fighter brand she launches in Stage 1. Then we prove the proposition by backward induction as follows:

- In the firewall scenario, Stage 2.1, we first show that if the entrant chooses a quality q_{EF} below the one of the fighter brand, $q_{EF}^{**} = q_L$. Moreover, we show that he always prices his product slightly below p_L, that is, $p_{EF}^{**} = p_L$.

- In the sandwich scenario, Stage 2.2, we then characterize with condition $\left(C'1\right)$ the entrant's optimal quality choice q_{ES}^{**} in case, he positions his product between the incumbent's products.
- As in the proof of Proposition 2, we then characterize for a given price p_L in Stage 1 a condition $\left(C'2\right)$ on the optimal quality level q_L^{**} which keeps the entrant indifferent between positioning his product in the firewall or sandwich scenario.
- Finally, we show that in equilibrium the incumbent's profit π^{**} is greater than the equilibrium profit π^* she receives in the list price commitment game.

S2.1 Consider the firewall scenario in which the entrant in Stage 2 enters the market with a product of quality $q_{EF} < q_L$. Given $q_H > q_L > q_{EF}$, the entrant in Stage 3 then maximizes his profits with respect to product price p_{EF} given p_L. According to the first-order condition in the proof of Proposition 1, Case 1 (a), the optimal price response then is $p_{EF}^{**}(p_L) = \frac{1}{2} p_L \frac{q_{EF}}{q_L}$ and his equilibrium profits are

$$\pi_{EF}^{**}\left(\left(q_H, q_L; q_{EF}\right) | p_L\right) = \frac{p_L^2 q_{EF}}{4 q_L \left(q_L - q_{EF}\right)}.$$

Since $\partial \pi_{EF}^{**}\left(\left(q_H, q_L; q_{EF}\right) | p_L\right) / \partial q_{EF} = \left(p_L / 2\left(q_L - q_{EF}\right)\right)^2 > 0$, the entrant chooses q_{EF}^{**} as high as possible in Stage 2. Hence, $q_{EF}^{**} = q_L$. Price competition at Stage 3 then implies that the entrant only has positive profits, if he prices his product (slightly) lower than the announced price p_L for the incumbent's fighter brand which implies that $x_L = 0$ in equilibrium. Hence, $\theta_1 = \theta_2$.

To show that $p_{EF}^{**} = p_L$, let $p_{EF}^*(q_L)$ be the optimal price the entrant would choose in the absence of a price announcement. According to the proof of Proposition 1, Case 1 (b), $p_{EF}^*(q_L) = \overline{\theta} q_L \left(q_H - q_L\right) / \left(4 q_H - q_L\right)$. Of course, if $p_L > p_{EF}^*(q_L)$, slightly undercutting the incumbent's price p_L would not be optimal for the entrant. Hence, to show that $p_{EF}^{**} = p_L$ it is sufficient to show that the optimal p_L is always lower that $p_{EF}^*(q_L)$. To prove this claim, consider the price competition in the sandwich scenario. According to the proof of Proposition 1, Case 2 (a), the optimal prices $p_{HS}^{**}(p_L)$ and $p_{ES}^{**}(p_L)$ given p_L are

$$p_{HS}^*(p_L) = \frac{\left(q_H - q_E\right)}{4\left(q_H - q_L\right) - \left(q_E - q_L\right)} \left(p_L + 2\overline{\theta}\left(q_H - q_E\right)\right),$$

$$p_{ES}^*(p_L) = \frac{\left(q_H - q_E\right)}{4\left(q_H - q_L\right) - \left(q_E - q_L\right)} \left(\overline{\theta}\left(q_E - q_L\right) + 2 p_L\right).$$

Using these prices, $\theta_3 < \theta_2$ requires $p_L < p_{ES}^*(p_L) q_L / q_E$ which is equivalent to

$$p_L < \frac{\theta q_L \left(q_H - q_E\right)\left(q_E - q_L\right)}{\left(q_E\left(q_H - q_E\right) + 2 q_H\left(q_E - q_L\right) + q_E\left(q_H - q_L\right)\right)}.$$

But $p^*_{EF}(q_L)$ is greater than this critical value,[34]

$$\frac{\overline{\theta} q_L (q_H - q_L)}{(4q_H - q_L)} > \frac{\theta q_L (q_H - q_E)(q_E - q_L)}{(q_E (q_H - q_E) + 2q_H (q_E - q_L) + q_E (q_H - q_L))}.$$

Hence, if $p_L \geq p^*_{EF}(q_L)$, the price constraint in the sandwich scenario would be violated. As a result, $p_L < p^*_{EF}(q_L)$ and the entrant's optimal price is $p^{**}_{EF} = p_L$. According to the proof of Proposition 1, Case 1 (b), the incumbent then chooses $p^{**}_{HF} = \frac{1}{2}\left(p_L + \overline{\theta}(q_H - q_L)\right)$ and the entrant's profit are

$$\pi^{**}_{EF}(p_L) = p_L \left(\frac{q_L (q_H - q_L)\overline{\theta} - p_L (2q_H - q_L)}{2q_L (q_H - q_L)} \right).$$

S2.2 Consider now the sandwich scenario. Given p_L and the optimal prices $p^{**}_{HS}(p_L)$ and $p^{**}_{ES}(p_L)$ from Stage 2.1 above, the entrant's profits are

$$\pi^{**}_{ES}(p_L) = \frac{(q_H - q_E)\left(2p_L + \overline{\theta}(q_E - q_L)\right)\left(2p_L (q_H - q_L) + \overline{\theta}(q_E - q_L)(q_H + q_L - 2q_E)\right)}{(q_E - q_L)(4(q_H - q_L) - (q_E - q_L))^2}.$$

Maximizing his profits in Stage 2 with respect to the optimal quality choice $q^{**}_E(p_L)$ gives

$$\frac{\partial}{\partial q_E}\pi^{**}_{ES} = -\frac{A}{(q_E - q_L)^2 ((4(q_H - q_L) - (q_E - q_L)))^3}$$

with $A = 4p_L^2(q_H - q_L)((4q_H - q_E - q_L)(q_H - q_L) - 2q_L(q_E - q_L) - 2q_E(q_H - q_E)) + 24\overline{\theta} p_L(q_L - q_E)^2(q_H - q_E)(q_H - q_L) + \overline{\theta}^2(q_L - q_E)^2 X_1$ with $X_1 = (11q_H^2 - 3q_L^2 - 2q_H q_E)(q_E - q_L) + 2(q_H q_E + 5q_L^2 - q_E^2 - 2q_H^2)(q_H - q_E) + 6q_E(q_H + q_L - 6q_E)(q_H - q_L)$. As in the proof of Proposition 2, the optimal $q^{**}_E(p_L)$ is then characterized by $A = 0$, that is,

$$\begin{aligned} &4p_L^2 (q_H - q_L)\left(4q_H^2 - 5q_H q_L - 3q_H q_E + 3q_L^2 - q_L q_E + 2q_E^2\right) \\ &+ 24\overline{\theta} p_L (q_L - q_E)^2 (q_H - q_E)(q_H - q_L) = \overline{\theta}^2 (q_L - q_E)^2 X_2 \qquad (C1') \end{aligned}$$

with $X_2 = 4q_H^3 + 11q_H^2 q_L - 23q_H^2 q_E - 10q_H q_L^2 - 2q_H q_L q_E + 42q_H q_E^2 - 3q_L^3 + 19q_L^2 q_E - 36q_L q_E^2 - 2q_E^3$.

34 Rearranging this condition gives

$$2q_H q_E (q_E - q_L) + q_H (q_E - q_L)^2 + 2q_L (q_H (q_H - q_E) - q_E (q_H - q_L)) > 0$$

which is always satisfied.

S1.1 Similar to the proof of Proposition 1, the incumbent then chooses a quality level q_L^{**} for the fighter brand which keeps the entrant indifferent between positioning his product between her two products or below the fighter brand. Using the profits from Stage 2.1 and 2.2, this quality level is characterized by the following condition,

$$p_L\left(\frac{q_L\left(q_H-q_L\right)\overline{\theta}-p_L\left(2q_H-q_L\right)}{2q_L\left(q_H-q_L\right)}\right)$$
$$=\frac{\left(q_H-q_E^{**}\right)\left(2p_L+\overline{\theta}\left(q_E^{**}-q_L\right)\right)\left(2p_L\left(q_H-q_L\right)+\theta\left(q_E^{**}-q_L\right)\left(q_H+q_L-2q_E^{**}\right)\right)}{\left(q_E^{**}-q_L\right)\left(4\left(q_H-q_L\right)-\left(q_E^{**}-q_L\right)\right)^2} \tag{$C'2$}$$

for a given fixed price p_L.

S1.2 Instead of calculating the optimal fixed price p_L^{**} we now show that the incumbent's equilibrium profits in the fixed price commitment game are always lower than the ones in the list price commitment game. To see this, suppose the incumbent offer a fighter brand of quality $q_L = \gamma_L q_H$ for a price p_L' such that her profits are equal to the equilibrium profits in the list price commitment game,

$$\pi_I^*\left(\overline{q},\beta_L\overline{q};\gamma_L\overline{q}\right)=\frac{1}{48}\left(12-5\beta_L\right)\overline{\theta}^2\overline{q}=\pi_I\left(\overline{q},\gamma_L\overline{q};\gamma_L\overline{q}\right)$$
$$=\frac{\left(p_L'+\overline{\theta}\left(\overline{q}-\gamma_L\overline{q}\right)\right)^2}{4\left(\overline{q}-\gamma_L\overline{q}\right)}.$$

That is,

$$p_L'=\left(\sqrt{\frac{1}{12}\left(12-5\beta_L\right)\left(1-\gamma_L\right)}-\left(1-\gamma_L\right)\right)\overline{\theta}\overline{q}.$$

Given the fighter brand with $q_L = \gamma_L q_H$ and p_L', the entrant's profit in case of the firewall scenario - Stage 2.1 - are

$$\pi_{EF}^{**}\left(p_L'\right)=\frac{1}{24\gamma_L}\left(5\beta_L\left(2-\gamma_L\right)-12\left(4-3\gamma_L\right)+2\left(4-\gamma_L\right)\sqrt{3\left(\gamma_L-1\right)\left(5\beta_L-12\right)}\right)$$

which results in $\pi_{EF}^{**}\left(p_L'\right) = 1.393\,8\times 10^{-2}$. To calculate his profits in case of the sandwich scenario - Stage 2.2 - we first derive his optimal positioning $q_E^{**} = (\alpha_F q_H)$ as solution of condition $\left(C'1\right)$, that is, as roots of

$$2\alpha_F^3+36\alpha_F^2\gamma_L-42\alpha_F^2-19\alpha_F\gamma_L+2\alpha_F\gamma_L+23\alpha_F+3\gamma_L+10\gamma_L-11\gamma_L-4=0.$$

The optimal solution then is $\alpha_F = 0.249$ and his profits in the sandwich scenario are

$$\pi_{ES}^{**}\left(p_L'\right)=\frac{\left(1-\alpha_F\right)\left(2-\alpha_F-\gamma_L-\frac{1}{3}\sqrt{3\left(1-\gamma_L\right)\left(12-5\beta_L\right)}\right)B}{\left(\alpha_F-\gamma_L\right)\left(4-\alpha_F-3\gamma_L\right)^2}$$

with $B = 2(1-\alpha_F)^2 + 3(\alpha_F - \gamma_L)(1-\gamma_L) - \frac{1}{3}(1-\gamma_L)\sqrt{3(1-\gamma_L)(12-5\beta_L)}$, hence, $\pi_{ES}^{**}\left(p_L'\right) = 1.8276 \times 10^{-2}$. But this implies that $\pi_{EF}^{**}\left(p_L'\right) < \pi_{ES}^{**}\left(p_L'\right)$. Since the optimum is characterized by condition $\left(C'2\right)$ according to the discussion of Stage 1.1, the optimal fighter brand is characterized by $q_L^{**} \geq \gamma_L q_H$ and $p_L^{**} \geq p_L'$.
Q.E.D. □

Proof of Proposition 8 Consider the attractiveness of the market $\alpha = \overline{\theta}^2 \bar{q}$ and let $\alpha\delta_L = \pi_I^*(\overline{q}, \beta_L\overline{q}; \gamma_L\overline{q}) - \pi_I^*\left(\overline{q}; \frac{4}{7}\overline{q}\right)$ and $\alpha\delta_F = \pi_I^{**}(\overline{q}, \beta_F\overline{q}; \beta_F\overline{q}) - \pi_I^*\left(\overline{q}; \frac{4}{7}\overline{q}\right)$ be the value of commitment in the endogenous price leadership game with list price and with fixed price, respectively. Then $0 < \delta_F < \delta_L$ according to Proposition 4.

Consider the reputation elasticity $\rho_R(i) = R'(i)\, i / R(i)$ and let $\hat{\imath}$ be defined by $R\left(\hat{\imath}\right) = \hat{\imath}$. Note that if $R'(0) < 1$, then for all $i \geq 0$ we have $R(i) < i$. In this case, $\hat{\imath} = 0$, and dual channeling is the only option to credibly launch the fighter brand. A necessary condition for $\hat{\imath} > 0$ then is $R'(0) > 1$. Since the critical value $\hat{\imath}$ is the higher, the higher ρ_R is, endogenous price leadership with a fixed price is also an option for credibly launching the fighter brand, if $\alpha\delta_F \leq \hat{\imath}$.[35] And, if ρ_R is even higher such that $\alpha\delta_L \leq \hat{\imath}$, then an endogenous price leadership with a list price is a third option.

Now define $\hat{\alpha}_k > 0$, for $k = L, F$, such that

$$\hat{\alpha}_k \delta_k = \hat{\imath}$$

if possible. Since $\delta_L > \delta_F$, $\hat{\alpha}_L$ exists only if $\hat{\alpha}_F$ exists. We consider three cases:

1. Suppose that neither $\hat{\alpha}_F$ nor $\hat{\alpha}_L$ exists. Then the necessary investments to make an endogenous price leadership credible are higher than the corresponding commitment values. Hence, $\alpha_L^* = \alpha_F^* = 0$ and only dual channeling is possible to credibly launch the fighter brand.
2. Suppose that only $\hat{\alpha}_F$ exists. Then also endogenous price leadership with a fixed price becomes a possible commitment device. Note that for $\alpha = \hat{\alpha}_F$ the incumbent is indifferent whether to choose a fixed price commitment or not to launch the fighter brand at all. Hence, there exists $\alpha_F^* < \hat{\alpha}_F$ such that the incumbent is indifferent between dual channeling and endogenous price leadership with a fixed price. In this case, $\alpha_L^* = 0$.
3. Suppose finally that both $\hat{\alpha}_F$ and $\hat{\alpha}_L$ exist. Then both an endogenous price leadership with a list price ($k = L$) and a fixed price ($k = F$) are possible. Since for

[35] To see that the critical value $\hat{\imath}$ is increasing in ρ_R consider two functions $R_1(i)$ and $R_2(i)$ and let $\rho_{R1}(i) > \rho_{R2}(i)$ for all $i \geq 0$. Then $\rho_{R1}(0) = \rho_{R2}(0) = 0$ implies that $R_1'(0) > R_2'(0)$. Hence, there exists an $\varepsilon > 0$ such that $R_1\left(\varepsilon'\right) > R_2\left(\varepsilon'\right)$ for all $\varepsilon' < \varepsilon$. We now prove by contradiction that $R_1(i) > R_2(i)$ for all $i \geq 0$. For, suppose there exists an $\zeta > 0$ such that $R_1(\zeta) = R_2(\zeta)$, $\zeta = \min\{i > 0 : R_1(i) = R_2(i)\}$. Then there exists $\delta > 0$ such that $R_1\left(\zeta - \delta'\right) > R_2\left(\zeta - \delta'\right)$ and $R_1'\left(\zeta - \delta'\right) < R_2'\left(\zeta - \delta'\right)$ for all $\delta' < \delta$. But then

$$\rho_{R2}\left(\zeta - \delta'\right) = \left(\zeta - \delta'\right)\frac{R_2'\left(\zeta - \delta'\right)}{R_2\left(\zeta - \delta'\right)} > \left(\zeta - \delta'\right)\frac{R_1'\left(\zeta - \delta'\right)}{R_1\left(\zeta - \delta'\right)} = \rho_{R1}\left(\zeta - \delta'\right),$$

a contradiction. But then $R_1(i) > R_2(i)$ for all $i \geq 0$, hence $\hat{\imath}_1 > \hat{\imath}_2$.

$\alpha = \hat{\alpha}_L$ the incumbent is indifferent whether to choose a list price commitment or not to launch the fighter brand at all, there exists $\alpha_L^* < \hat{\alpha}_L$ such that the incumbent is indifferent between endogenous price leadership with a fixed price and a list price.

Q.E.D. □

Appendix 4

Proposition 9 *Suppose customers are distributed according to a density function $f(\theta)$ with $F(\theta)$ as the cumulative distribution function and assume that $f(\theta)$ satisfies the property that*

$$\eta(\theta) = \frac{\theta f(\theta)}{1 - F(\theta)}$$

is increasing in θ over the support $[0, \overline{\theta}]$. Then, in the absence of entry, the incumbent offers only one product $q_H^* = \bar{q}$.

Proof of Proposition 9 Note first, that the condition above on the density function is satisfied for most commonly used distributions, e.g., the normal, log-normal, or Beta distribution. To prove the proposition, suppose that the incumbent would offer two product qualities with $q_H > q_L$ and prices p_H and p_L. Let θ_H be the customer indifferent between buying the high- or the low-quality product, and θ_L be the customer indifferent between buying the low-quality product or not buying. Similar to the analysis in Sect. 3.2, we can calculate the indifferent customers as $\theta_H = (p_H - p_L) / (q_H - q_L)$ and $\theta_L = p_L / q_L$. Maximizing the incumbent's profits

$$\pi_I(q_H, q_L) = p_H\left(\overline{\theta} - F(\theta_H)\right) + p_L(F(\theta_H) - F(\theta_L))$$

with respect to prices then implies the following F.O.C.s:

$$\begin{aligned}
\frac{\partial}{\partial p_H}\pi_I &= \overline{\theta} - F(\theta_H) - \frac{p_H}{(q_H - q_L)} f(\theta_H) + \frac{p_L}{(q_H - q_L)} f(\theta_H) = 0, \\
\frac{\partial}{\partial p_L}\pi_I &= \frac{p_H}{(q_H - q_L)} f(\theta_H) + (F(\theta_H) - F(\theta_L)) \\
&\quad + p_L\left(-\frac{f(\theta_H)}{(q_H - q_L)} - \frac{f(\theta_L)}{q_L}\right) = 0
\end{aligned}$$

The first condition implies

$$\overline{\theta} - F(\theta_H) = \theta_H f(\theta_H),$$

hence, $\eta(\theta_H) = 1$. Substituting this condition into the second F.O.C. then implies

$$\overline{\theta} - F(\theta_L) = \theta_L f(\theta_L)$$

hence, $\eta(\theta_L) = 1$. But this contradicts the property that $\eta(\theta)$ is increasing in θ. Hence, as in our basic model, the incumbent as monopolist offers only one product with the highest quality $q_H = \bar{q}$.

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