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Bundling and downstream entry

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ABSTRACT

We investigate the incentives of an upstream producer to enter the downstream market where the alternative is to sell via a downstream platform who offers all products as a bundle. When consumers can multihome, following entry the producer faces increased downstream competition but benefits from greater price setting flexibility. We show that entry becomes relatively more profitable if the products are closer substitutes or the correlation between product valuations is weaker. Our results have important implications on recent developments in industries such as video and music streaming.

1. Introduction

An important strategic decision for any producer is the choice of the optimal distribution channel. At its core lies the decision between active participation in the retail market (i.e., a vertically integrated supply structure or a direct channel) and selling the product through independent retailers (i.e., a retail channel). For example, in the video streaming industry, a content producer like Disney can offer its shows via an independent video streaming service provider (such as Netflix) or establish its own streaming platform to distribute them. In recent years, the industry witnessed a substantial level of entry of streaming platforms, most of which are video content producers themselves.[1]

A large body of literature has identified several factors that influence this decision, including the strategic interactions in the downstream market (Katz, 1991), types of vertical contracts (Arya and Mittendorf, 2011; Meyn et al., 2023), and pricing strategies (Jullien et al., 2023). In this paper, we highlight an important aspect which may shift the producers' decision towards becoming active in the downstream market. Almost without exception, streaming platforms offer all video or music content, self produced or licensed, as a bundle. For example, Netflix offers plans that differ in features like higher video quality, but they all give consumers access to its entire library.[2] In such scenarios, by entering the downstream market and selling its product directly, a producer brings competition into the market but gains flexibility in its price setting. Such flexibility provides an advantage to the producer, particularly when consumer tastes are sufficiently heterogeneous and products from different producers are sufficiently substitutable.

In order to show this incentive, we build a theoretical model that studies the entry and subsequent pricing decisions of a producer. The producer first decides whether to sell its product via a retailer, which already sells the other product in the market, or to enter downstream and sell directly to consumers. Consumers have heterogeneous and independent valuations for the two products and may buy both of them (i.e., they can multihome). We consider products which are substitutes as in Armstrong (2013), i.e., the utility from the joint consumption of two products is lower than the sum of utilities from the separate consumption of the two products. If downstream entry occurs, the producer and the retailer compete in prices. If the producer sells via the retailer, they negotiate on a fixed licensing fee and the vertically integrated retailer sells both products as a bundle. To differentiate our insights from supply side factors such as economies of scale, which would favor bundling over entry, we assume away fixed costs of entry.

For the producer, by selling via the retailer's bundle, it can reach consumers with relatively low values. By selling directly, it forgoes such gains from bundling and engages in downstream competition. However, it can thus target those consumers who have a strong preference for

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[1] https://www.ibisworld.com/industry-statistics/number-of-businesses/video-streaming-services-united-states/ documents that the number of video streaming businesses in the US increases rapidly.

[2] See, for example, https://www.netflix.com/signup/planform.

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its product with a higher price, which partially or completely offsets the downward pressure on its price arising from increased downstream competition. As the products become more substitutable, the producer's product adds less value to the bundle when it is sold through the retailer, and hence the gains from bundling diminish. Therefore, downstream entry is more likely if the joint consumption of the products is less desirable. In such cases, both the producer and the retailer are better off selling separately and targeting consumers who like their product much more than the rival's.[3]

We then allow the consumer tastes to be positively correlated across the products, which is common across the examples that we discuss (e.g., music or video streaming, academic journals, ebooks), as consumers can arguably be sorted to some degree according to their valuations for the general product category. The correlation of tastes is higher when there is a higher level of similarity between the products offered by the retailer and the producer (e.g., similar genres of movies and TV shows for video streaming, similar fields of study for academic journals). Correlated tastes are extensively studied in the bundling literature, and generally, a positive correlation leads to lower benefit from bundling (e.g., Schmalensee (1982), McAfee et al. (1989)). We show, however, that a stronger correlation of consumer tastes favors bundling over direct selling. This is because when the products are positively correlated, the two firms are fighting for a similar group of consumers under direct selling, which intensifies competition, and thus, negatively impacts industry profits.

Our theoretical model is closest to those in the literature on product bundling. The literature has mainly studied the bundling of products with additive values, independent or correlated (see, for example, Adams and Yellen (1976), McAfee et al. (1989), and Chen and Riordan (2013)). A few recent papers also explore the case of non-additive values ((Armstrong, 2013) and (Ghili, 2023)). Most of these papers consider optimal bundling strategies from the perspective of an individual firm, either a monopolist or a symmetric duopoly. One exception is Armstrong (2013) who considers separate selling by different firms, but there the focus is on the profitability of a joint discount offered by both sellers instead of a comparison to pure bundling. Furthermore, we consider how the degree of substitutability affects the relative profitability of pure bundling to direct selling.

Our analysis is related to the literature on vertical contracting. One strand of this literature studies the strategic use of vertical contracts between upstream and downstream firms (e.g., Bonanno and Vickers (1988)) or incentive contracts between owners and managers (e.g., Fershtman and Judd (1987), Sklivas (1987)) as a response to market competition. Our results show how the decision to vertically integrate is influenced by bundling and downstream competition. Another related strand is the literature on supplier encroachment. A key question in this literature is if it is beneficial for a producer to establish its direct retailing channel to compete with an independent retailer which also sells its product (Chiang et al., 2003; Hotkar and Gilbert, 2021), and (Jullien et al., 2023), and how this may affect the independent retailer (Arya et al., 2007). Our study considers a similar decision but with the added element of bundling. In addition, we show that supplier encroachment where both direct and indirect channels are active does not arise in our setup.

The rest of the paper is organized as follows. The next section introduces the basic model and solves for the equilibrium outcomes under no entry (bundling) and under entry (direct selling). In Section 3, we extend the model by allowing consumer valuations for the products to be correlated. Section 4 concludes. All proofs are relegated to the Appendix.

[3] Unsurprisingly, the highest profits are achieved if the retailer can offer both products via mixed bundling—selling both products separately while offering them as a bundle at a discount—in which case downstream entry does not take place. Yet, this is not a common practice in the video or music streaming industries, perhaps owing to large transaction costs or consumer aversion to variable pricing.

2. Model: Independent values

Two firms produce imperfectly substitutable products at zero marginal costs. Firm 1 is vertically integrated and has its own distribution channel in the downstream market.[4] Firm 2 can either enter the downstream market itself at no cost and sell its product directly to the consumers, or it can sell its product to Firm 1, who then makes the sales of both products to the consumers.

If Firm 2 enters the downstream market, the two firms compete by setting their prices. If Firm 2 decides to sell through the retail outlet of Firm 1, it is without loss of generality to assume that Firm 1 pays a fixed fee to Firm 2 as the efficient vertical contracting requires the wholesale price being equal to the marginal cost. In this case, Firm 1 offers both products (its own and that of Firm 2) as a bundle only, as stated in the following assumption.

Assumption 1. If Firm 2 does not enter the downstream market, Firm 1 offers both products as a pure bundle.

This assumption is consistent with the industry practice: apart from Amazon, major streaming platforms, such as Netflix, offer their entire library as a bundle to consumers.[5] A simple pricing scheme saves on menu costs and reduces consumers' search costs, particularly when the number of products is as large as it is in the video streaming industry.[6] Some recent research also shows that pure bundling can be an optimal pricing scheme under various circumstances. For example, Deb and Roesler (2024) show that pure bundling can be robustly optimal in a setup with consumer learning. Given its prevalence in practice, we proceed with this assumption and focus on the implication of bundling on content providers' entry decisions.

There is a unit mass of consumers with heterogeneous tastes for the two products. Consumers perceive the two products as partial substitutes. As such, they may choose to buy both of them if Firm 2 enters the downstream market. In the rest of the paper we will refer to this consumption behavior as multihoming.

Specifically, a consumer obtains a utility of V_i from consuming the product of Firm i only, where V_i is distributed uniformly in the interval $[0, 1]$, for $i = 1, 2$. A consumer's tastes for the two products are independently distributed.[7] The utility of consuming both products, either as a bundle or when multihoming, equals $v_1 + v_2 - \delta$, where $\delta \in (0, 1)$ is the substitution penalty, or what Armstrong (2013) calls the disutility of joint consumption.[8]

The timing of the game is as follows: In stage 1, Firm 2 offers to sell its product to Firm 1 in return for a fixed fee. If Firm 1 rejects this offer, in stage 2 Firm 2 will enter the downstream market. If Firm 1 accepts the offer, Firm 2 remains an upstream producer. In stage 3, if downstream entry of Firm 2 occurred, the firms will set their respective prices. If

[4] This is mainly for the purpose of streamlining our analysis. If Firm 1 is an independent retailer which can source its product from a producer, then this producer would face the same problem as in our analysis when Firm 2 enters in a vertically integrated way. Moreover, in a general model of interlocking relationship with vertically separated producers and retailers, Nocke and Rey (2018) show that vertical integration or exclusivity naturally arise in equilibrium. Hence, without delving into the details of vertical contracting or losing much insight, we assume that one firm is vertically integrated and focus on the entry incentives of the other firm.

[5] These platforms also offer plans that differ in terms of streaming quality, the number of connected devices, and so on. In this model, we focus on the role of bundling and abstract away from these price discrimination motives.

[6] Theoretically, Chu et al. (2011) show that simple pricing schemes based on bundle size can achieve a profit similar to that from mixed bundling.

[7] In Section 3 we allow for positively correlated tastes.

[8] The parameter δ taking negative values would imply complementary products, whereas $\delta > 1$ would violate free disposal.

entry did not occur, then Firm 1 sets a price for the bundle consisting of the products of the two firms.

In the following, we first analyze the equilibrium of the subgames with and without Firm 2 entering the downstream market, and then we determine the entry incentives of Firm 2. Note that downstream entry can only be profitable under licensing with a fixed fee or a two-part tariff if it leads to an increase in the sum of the profits of the two firms. Therefore, it is sufficient to compare the total industry profits in those two subgames.

Remark: In Appendix 5.5, we consider the scenario in which Firm 2 can enter the downstream market and simultaneously sell its product to Firm 1, although this does not seem to arise in the markets we mentioned earlier. We nevertheless show that, in our model, the industry profit is always lower in this case than when Firm 2 enters without selling to Firm 1. Thus, Firm 2 does not benefit from selling to Firm 1, once it decides to enter the downstream market. In other words, supplier encroachment does not arise with bundling in our model.[9] This is also consistent with the observation that exclusivity seems to be the norm in video streaming.[10]

This also implies that the assumption of Firm 1 being vertically integrated is without loss of generality for our analysis. As under fixed fee licensing, the only possible equilibrium outcome is either one firm selling a bundle or two firms, vertically integrated or under an exclusive agreement, each selling one product.[11] The market outcome could potentially be different if per-unit royalties are allowed, as producers could use wholesale prices strategically to influence downstream competition. However, royalties are not common in practice. For example, Netflix offers licensing payments which involve a fixed fee that is independent of viewership.[12]

2.1. No downstream entry: bundling

In this subgame Firm 1 is the only seller of both goods and offers them as a pure bundle at a price of p_B. The net utility of a consumer with taste draws v_1 and v_2 is given by

$$U_B = v_1 + v_2 - p_B - \delta,$$
$$U_\emptyset = 0,$$

from purchasing the bundle and not purchasing, respectively. The share of consumers who demand the bundle at p_B depends on the joint distribution of the taste variables:

$$S_B = P(v_1 + v_2 - \delta \geq p_B).$$

The density of $Z \equiv v_1 + v_2 - \delta$ is shown in Fig. 1.

Firm 1 chooses p_B to maximize $\Pi_B(p_B) = p_B \cdot S_B$. The optimal price is presented in the following theorem.

Theorem 1. *The optimal bundle price is given by*

$$p_B = \begin{cases} \frac{2-\delta}{3}, & \frac{1}{2} < \delta < 1, \\ \frac{\sqrt{6+\delta^2}-2\delta}{3}, & \delta \leq \frac{1}{2}. \end{cases}$$

The optimal bundle price monotonically decreases in δ—with a kink at $\delta = \frac{1}{2}$, as the increased substitutability of the products makes the bundle less attractive for the consumers.

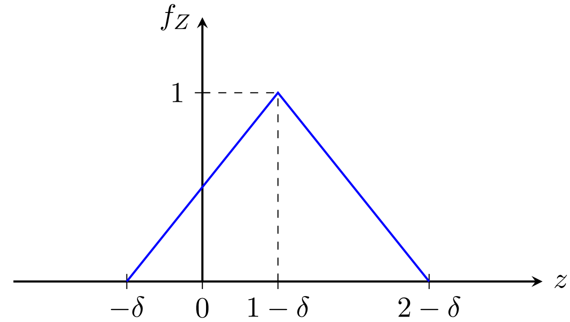

Fig. 1. The pdf of $Z = v_1 + v_2 - \delta$.

2.2. Downstream entry: Competition

Now suppose that Firm 2 entered the downstream market and offers its product at p_2, whereas Firm 1 sets p_1 for its own product. The consumers have the option of buying either product, both of them (multihoming, indicated by subscript M), or neither of them. The net utilities are given by

$$U_1 = v_1 - p_1,$$
$$U_2 = v_2 - p_2,$$
$$U_M = v_1 + v_2 - p_1 - p_2 - \delta,$$
$$U_\emptyset = 0,$$

with corresponding market shares of

$$S_1 = P(v_1 > p_1 \quad \& \quad v_2 < p_2 + \delta \quad \& \quad v_1 - p_1 > v_2 - p_2),$$
$$S_2 = P(v_2 > p_2 \quad \& \quad v_1 < p_1 + \delta \quad \& \quad v_1 - p_1 < v_2 - p_2),$$
$$S_M = P(v_1 + v_2 - p_1 - p_2 - \delta > v_1 - p_1 \quad \& \quad v_1 + v_2 - p_1 - p_2 - \delta > v_2 - p_2),$$
$$= P(v_1 - p_1 - \delta > 0 \quad \& \quad v_2 - p_2 - \delta > 0).$$

The demands for each firm's product are illustrated in Fig. 2.

Note that, as the substitution penalty increases the area corresponding to multihoming (S_M) shrinks, and for high enough values of δ there will be no consumers who multihome. The next theorem summarizes the equilibrium of this subgame.

Theorem 2. *In the subgame when Firm 2 enters downstream, the equilibrium prices are given by*

$$p_1^* = p_2^* = \begin{cases} \frac{1+(1-\delta)^2}{2(2-\delta)}, & \delta < 2 - \sqrt{2}, \\ \sqrt{2} - 1, & 2 - \sqrt{2} \leq \delta \leq 1, \end{cases}$$

with corresponding equilibrium profits of

$$\Pi_1^* = \Pi_2^* = \begin{cases} \frac{(2-2\delta+\delta^2)^2}{4(2-\delta)^2}, & \delta < 2 - \sqrt{2}, \\ 3 - 2\sqrt{2}, & 2 - \sqrt{2} \leq \delta \leq 1. \end{cases}$$

2.3. Subgame perfect nash equilibrium

The comparison of industry profits across the two subgames is presented in Fig. 3. Once again, note that the entry incentives of Firm 2 are perfectly aligned with the industry profits.

For sufficiently low values of the substitutability parameter δ, industry profits are higher when the two products are bundled together and Firm 2 does not enter. When the substitutability between the products is stronger, Firm 2 no longer wants to license its product to Firm 1, and it prefers to enter the downstream market itself. The next theorem provides the exact threshold value of δ.

Theorem 3. *Downstream entry by the independent producer Firm 2 is profitable for $\delta > \hat{\delta} \approx 0.206$.*

[9] See Hotkar and Gilbert (2021) who analyze this problem with linear wholesale contracts and no bundling. We thank an anonymous referee for pointing out this possibility.

[10] Yuan (2025) shows that, as of 2022, 87% of titles appear only on one streaming platform.

[11] Note that the outcome where both downstream firms sell a bundle won't arise as the industry profit would be zero in this case.

[12] https://www.cnbc.com/2018/08/15/netflix-cost-plus-model-tv-shows-revenue-upside.html.

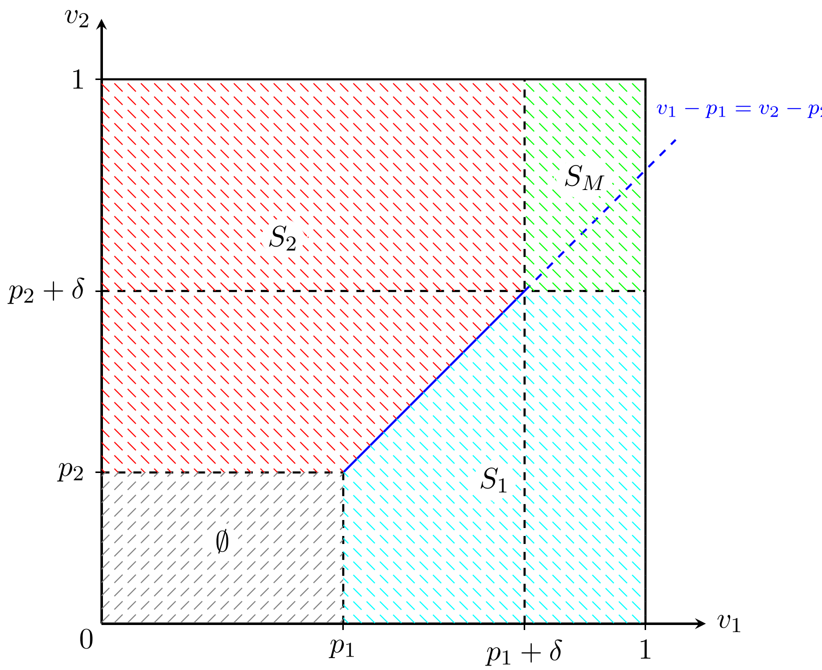

Fig. 2. Consumer choices.

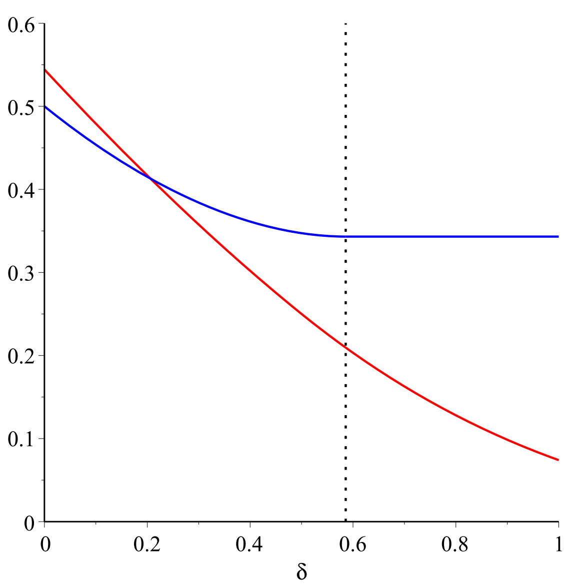

Fig. 3. Industry profits with licensing in red, with entry in blue.

At first glance this result may seem counter-intuitive. When the products are closer substitutes, entering the downstream market is clearly less profitable for Firm 2. The alternative of licensing its product to Firm 1, however, becomes even less attractive with increased substitutability. Without an option of buying either good separately, more consumers opt out of the market and bundling profits decline sharply in δ. When multihoming doesn't arise under entry, which occurs in our model for $\delta > 2 - \sqrt{2}$, the industry profits are independent of δ and always higher than those under bundling, which suffer from the increased substitution penalty.

This result highlights the benefits from the price setting flexibility when the products are closer substitutes. By entering the downstream market and setting its own price for its own good, Firm 2 will be able to sell to those consumers who have higher individual valuations for its own product and relatively lower valuations for the rival product.

When products are poor substitutes on the other hand, bundling is the superior alternative. The argument is simple. Bundling enables the monopolist seller (Firm 1) to extract additional surplus from consumers who value one product highly and the other product slightly more than the substitution penalty. These consumers would not multihome if the products were offered separately, but they do buy the bundle.

3. Correlated values

Whereas in our model δ measures the joint consumption penalty[13], it does not say anything about the distribution of tastes across the consumer population. We now consider the case where the valuations of consumers are positively correlated.

We introduce the correlation of values by assuming that v_1 and v_2 are jointly distributed according to the following joint density function:

$$f(v_1, v_2) = \begin{cases} \frac{1}{1-\rho^2}, & \text{for } 0 \le v_1 \le 1, 0 \le v_2 \le 1, |v_2 - v_1| \le 1 - \rho, \\ 0, & \text{otherwise.} \end{cases}$$

Graphically, the joint density takes positive values in the shaded area in the below graph (Fig. 4). The parameter ρ captures the correlation between the two valuations. As ρ approaches zero, the products become more independent and the joint pdf covers the entire area of the unit square at the limit and we are back to the base model. As ρ approaches one, the product valuations become highly correlated, with $v_1 = v_2$ at the limit of $\rho = 1$.

Note that δ and ρ capture different aspects of consumers' preferences for the two products. The parameter ρ is related to the similarity of the two products. For example, when two video streaming platforms offer a similar genre of shows (e.g. thriller), the correlation, and thus ρ, is high. The substitution penalty, δ, can also be related to the similarity. For example, δ is higher when the libraries of the two video streaming platforms overlap more. However, δ can also capture features beyond the characteristics of products. For instance, when consumers are more time constrained, the substitution penalty will be higher and the joint consumption of the products will yield lower aggregate value.

[13] Another interpretation of δ would be consumers' taste for variety. A higher value of δ would then imply a lower taste for variety.

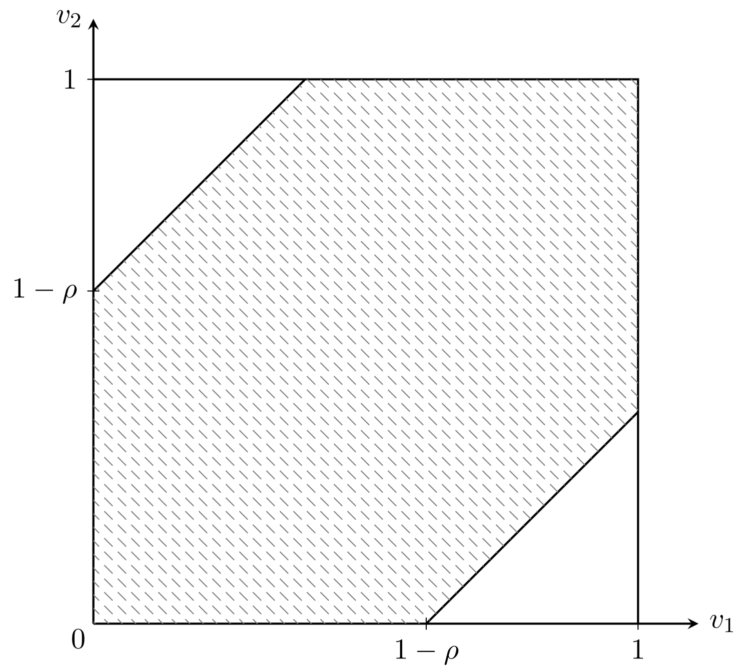

Fig. 4. Joint distribution of v_1 and v_2.

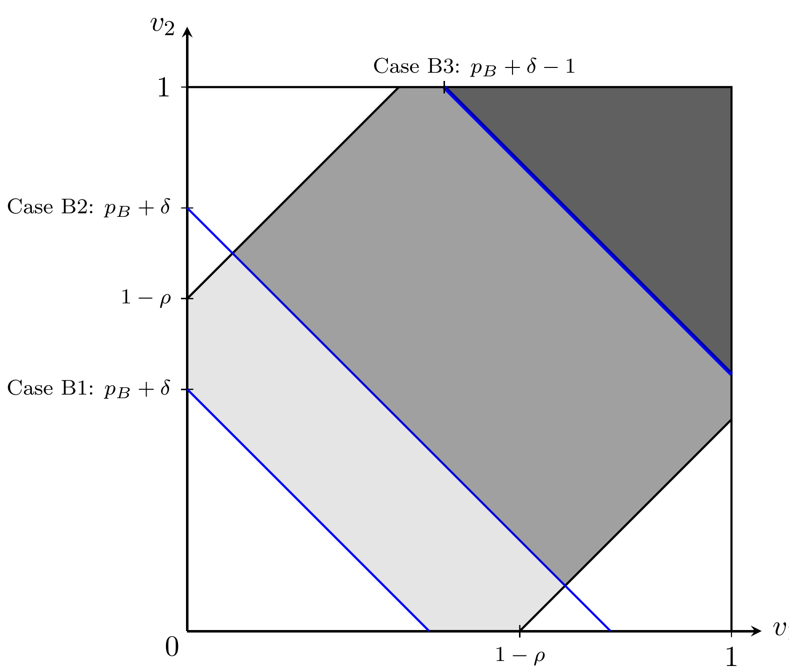

Fig. 5. The three cases of bundling.

3.1. No downstream entry: bundling

The net utilities of an individual consumer from consuming the bundle or from not buying are given by

$$U_1 = v_1 + v_2 - p_B - \delta,$$
$$U_\emptyset = 0,$$

and the share of consumers who demand the bundle at p_B becomes

$$S_B(p_B) = P(v_1 + v_2 > p_B + \delta) = P(v_2 > p_B + \delta - v_1).$$

The share of consumers who choose to buy the bundle depends on the comparison of $p_B + \delta$ and $1-\rho$.

There are three cases to consider as shown in Fig. 5. In each case, the shaded area above the blue line represents the corresponding demand. The optimal bundling price is presented in the next theorem.

Theorem 4. *The optimal bundle price is given by*

$$p_B = \begin{cases} \frac{\sqrt{\delta^2+6(1-\rho^2)}-2\delta}{3}, & 5\rho+2\delta<1, \\ \frac{2-\delta}{3}, & 2\delta-3\rho\geq 1, \\ \frac{3+\rho-2\delta}{4}, & 5\rho+2\delta\geq 1 \quad \& \quad 2\delta-3\rho<1. \end{cases}$$

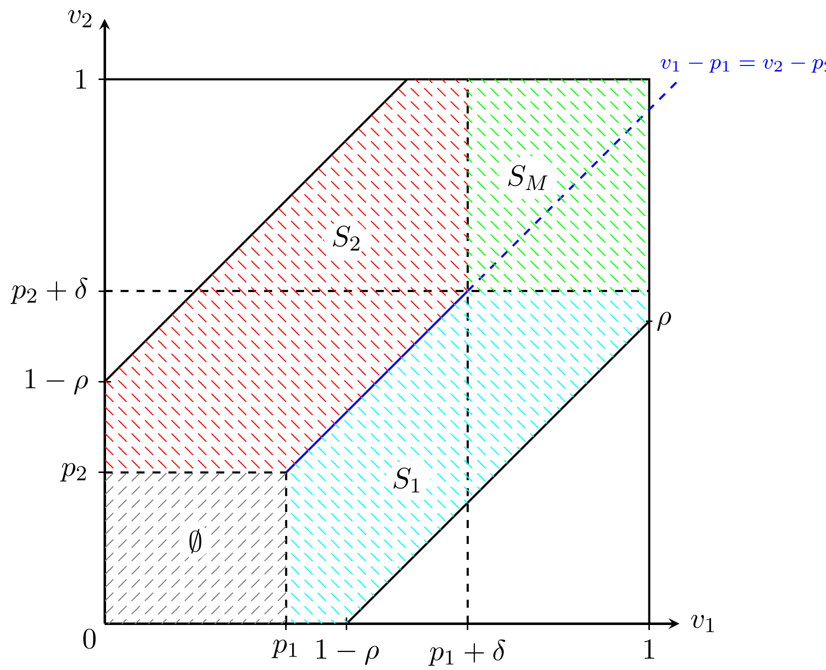

Fig. 6. Consumer choices for $p_1 + \delta > p_2 + \delta > \rho > 1 - \rho > p_1$.

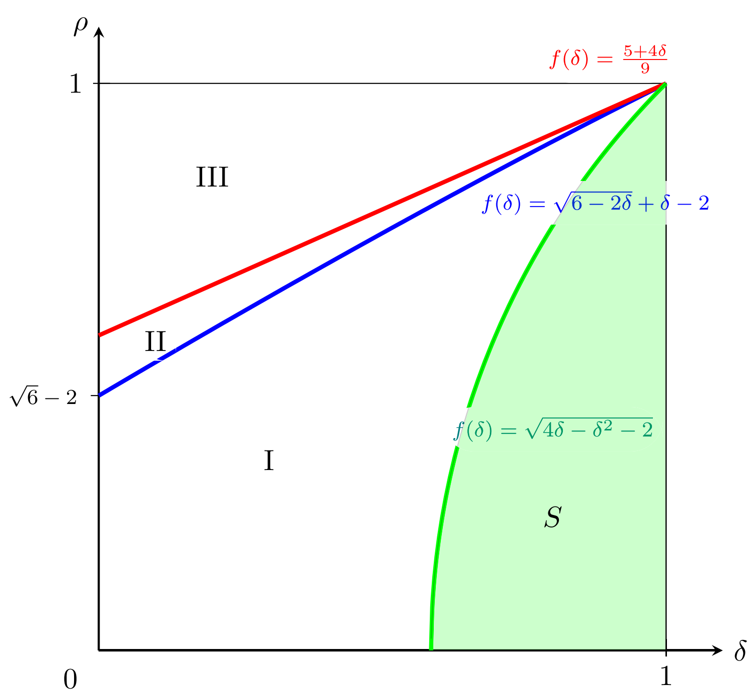

Fig. 7. Parameter regions for the equilibrium under entry.

3.2. Downstream entry: Competition

The consumer choice problem remains unchanged from the previous section, however the added dimension of correlation complicates the calculation of market shares for given prices. Depending on the relative magnitudes of δ, ρ, and the prices, different constellations may arise. Fig. 6 shows one such possible case.

The following theorem presents the equilibrium price under downstream entry for different parameter ranges of ρ and δ.

Theorem 5. *The equilibrium price under downstream entry can be one of four cases, as summarized in Fig. 7:*

1. *Region I:* $\max\{0, \sqrt{4\delta - \delta^2 - 2}\} \le \rho < \sqrt{6 - 2\delta} + \delta - 2$,
$$p^* = \frac{1 + (1-\delta)^2 - \rho^2}{2(2-\delta)}.$$
2. *Region II:* $\sqrt{6 - 2\delta} + \delta - 2 \le \rho < \frac{5+4\delta}{9}$,
$$p^* = \frac{-(2 - 2\rho + \delta) + \sqrt{(2 - 2\rho + \delta)^2 + 6(1-\rho)(1+\rho-\delta)}}{3}.$$
3. *Region III:* $\frac{5+4\delta}{9} \le \rho \le 1$,
$$p^* = \frac{(1-\rho)(3+\rho-2\delta)}{2(4(1-\rho)+\delta)}.$$

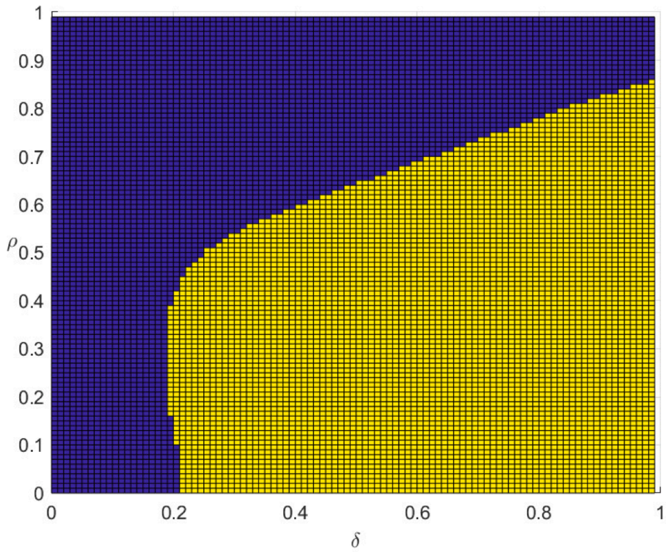

Fig. 8. Profit comparison between direct selling and indirect selling.

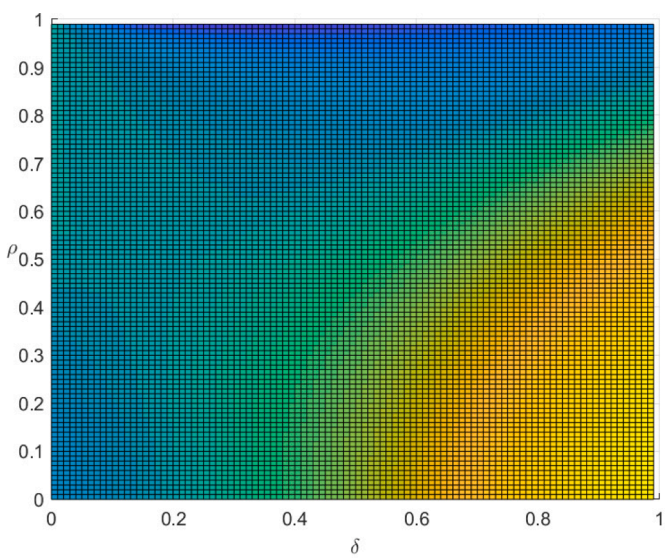

Fig. 9. Relative profitability of bundling vis-à-vis direct selling.

4. *Region S:* $\rho < \sqrt{4\delta - \delta^2 - 2}$,

   $p^* = \sqrt{2 - \rho^2} - 1$.

Note that, similar to the case of independently distributed values, when δ is relatively large, multihoming does not occur in equilibrium (in this case in region S).

3.3. Subgame perfect nash equilibrium

Given the complex nature of the equilibria with bundling and especially under entry, an analytical comparison of equilibrium profits in the two subgames is not tractable. Therefore, we conduct a numerical comparison of the profits and present the results in Fig. 8, where in the yellow area entry is more profitable than licensing/bundling.

To illustrate how the relative profitability of entry changes with the parameters, Fig. 9 shows the difference between the profits under entry and under licensing. The area with darker blue color is where bundling becomes more profitable, and the area with brighter yellow is where entry becomes more profitable.

As can be seen from the figures, entry is more profitable as products become more substitutable, i.e., as δ increases, and if the valuations are not too positively correlated. This extends the result for independent valuations in Section 2 to the entire range of positive correlations. The intuition remains the same: as products become more substitutable, each product contributes less to the value of the bundle, and hence, Firm 2 finds it more profitable to enter to cater to the high value consumers of its own product. However, this is no longer the case when valuations are sufficiently positively correlated. A strong positive correlation means that the consumers who value a product higher are also the ones who value the rival product more. This makes firms compete for the same group of consumers which intensifies the competition under entry.

4. Conclusion

We consider the decision of a producer between selling via an independent retailer and establishing its own downstream retail outlet, when the independent retailer exclusively offers bundles. We show that when the joint consumption of the products is less valuable, the industry profit is higher when the content provider enters the downstream market and distributes directly to consumers. This is because separate selling offers firms the flexibility in pricing and allows them to focus on consumers who primarily value their products. This flexibility is particularly valuable when product valuations are less correlated, as a higher correlation between the product valuations intensifies downstream competition when entry takes place, and therefore, makes licensing followed by bundling relatively more attractive.

Our results shed light on recent developments in the media sector. Notably, multiple content providers in the video streaming industry have started their own streaming platforms. In contrast, the music streaming industry is much more concentrated, where major producers refrain from entering the downstream market and instead choose to license their content to active streaming platforms. Our results imply that a driving force could be the extent to which the joint consumption of products is desirable. Arguably, video content is much more time consuming than music, making joint consumption more costly / less valuable. Consequently, video content providers are more likely to enter the consumer market and establish their direct sales channels, while catering to groups of consumers who value their contents highly.[14]

On a related note, since the wholesale contracts we consider involve a fixed fee, the strategic decision we analyze is equivalent to that faced by a producer who must decide whether to establish a direct sales channel or to merge with an existing retailer. Our results therefore imply that vertical mergers are more likely when the joint consumption of products is more desirable.

CRediT authorship contribution statement

Firat Inceoglu: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization; **Xingyi Liu:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization.

Data availability

No data was used for the research described in the article.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

[14] For example, Amazon Prime offering live UEFA Champions League games, Youtube offering NBA games, Netflix offering celebrity documentaries.

Appendix A.

A.1. Proof of Theorem 1

Firm 1 chooses the bundle price p_B to maximize $\Pi_B(p_B) = p_B \cdot S_B$.

Given the density of consumer valuations for the bundle, the price could be greater than or less than $1-\delta$.

1. $p_B > 1-\delta$:

   $$\Pi_B(p_B) = p_B \cdot \frac{1}{2} \cdot (2-\delta-p_B)^2$$

   with the first-order-condition yielding

   $$p_B = \frac{2-\delta}{3}$$

   which is greater than $1-\delta$ and optimal for $\delta > \frac{1}{2}$.
2. $p_B \le 1-\delta$:

   $$\Pi_B(p_B) = p_B \cdot \left(1 - \frac{(p_B+\delta)^2}{2}\right)$$

   with the first-order-condition yielding

   $$p_B = \frac{\sqrt{6+\delta^2} - 2\delta}{3}$$

   which is less than $1-\delta$ and optimal for $\delta \le \frac{1}{2}$.

A.2. Proof of Theorem 2

To start with, suppose that δ is low enough, such that some consumers multihome in equilibrium. Then the market shares of the four options (buy product 1, buy product 2, buy both, buy none) are given by the areas shown in Fig. 2. The corresponding market share functions are

$$S_1(p_1,p_2) = \frac{1}{2}\delta\big(2p_2+\delta\big) + (1-p_1-\delta)(p_2+\delta)$$

$$S_2(p_1,p_2) = \frac{1}{2}\delta\big(2p_1+\delta\big) + (1-p_2-\delta)(p_1+\delta)$$

$$S_M(p_1,p_2) = (1-p_1-\delta)(1-p_2-\delta).$$

Maximization of the profit functions,

$$\Pi_1(p_1) = p_1 \cdot (S_1 + S_M) = p_1\Big(\frac{1}{2}\delta\big(2p_2+\delta\big) + 1 - p_1 - \delta\Big)$$

$$\Pi_2(p_2) = p_2 \cdot (S_2 + S_M) = p_2\Big(\frac{1}{2}\delta\big(2p_1+\delta\big) + 1 - p_2 - \delta\Big)$$

yields

$$p_1^* = p_2^* = \frac{1+(1-\delta)^2}{2(2-\delta)}$$

with corresponding equilibrium profits of

$$\Pi_1^* = \Pi_2^* = \frac{(2-2\delta+\delta^2)^2}{4(2-\delta)^2}.$$

For multihoming to arise in equilibrium we need $p^* + \delta < 1$, which is satisfied for $\delta < 2-\sqrt{2}$.

Now consider the range $\delta \ge 2-\sqrt{2}$. Looking at the market shares in Fig. 2, one can notice that starting from a symmetric price pair $p_1 = p_2$, a price reduction has a potentially different impact than a price increase. (Fig. A.10)

In the symmetric price equilibrium that we search for, neither a price increase nor a price reduction should be profitable. The market shares of, say, Firm 1, in consideration of these respective changes are given by

$$\hat{S}_1 = \frac{1}{2}(2p_2+1-p_1)(1-p_1)$$

$$\tilde{S}_1 = \frac{1}{2}(p_2+1)(1-p_2) + p_2 - p_1$$

In the symmetric equilibrium, there are two conditions that need to be satisfied:

$$\frac{\partial(p_1 \cdot \hat{S}_1)}{\partial p_1} \le 0$$

$$\frac{\partial(p_1 \cdot \tilde{S}_1)}{\partial p_1} \ge 0$$

yielding the unique equilibrium price

$$p_1^* = p_2^* = \sqrt{2} - 1$$

with corresponding equilibrium profits of

$$\Pi_1^* = \Pi_2^* = 3 - 2\sqrt{2}.$$

Since no consumer multihomes in this case, the substitution penalty does not enter the profit functions.

A.3. Proof of Theorem 4

Case B1: $p_B + \delta < 1-\rho$

The share of consumers who buy the bundle is given by:

$$S_B(p_B) = \Big(1-\rho^2 - \frac{1}{2}(p_B+\delta)^2\Big) \cdot \frac{1}{1-\rho^2}$$

The downstream retailer that offers the bundle maximizes its profit of

$$\Pi_{B1}(p_B) = p_B \cdot S_B(p_B)$$

yielding the optimal bundle price

$$p_B = \frac{\sqrt{\delta^2 - 6\rho^2 + 6} - 2\delta}{3}.$$

The condition for Case B1 is satisfied for $5\rho + 2\delta < 1$

Case B2: $1+\rho > p_B + \delta \ge 1-\rho$

Note that the intersection of the blue line with $v_2 = 1-\rho+v_1$ occurs at $v_1 = \frac{p_B+\delta-1+\rho}{2}$. The share of consumers who buy the bundle is then given by

$$S_B(p_B) = \Big(1-\rho^2 - \frac{1}{2}(p_B+\delta)^2 + 2\cdot\frac{1}{2}(p_B+\delta-1+\rho)^2\cdot\frac{1}{2}\Big)\cdot\frac{1}{1-\rho^2}$$
$$= \Big(1-\rho^2 - \frac{1}{2}(p_B+\delta)^2 + \frac{(p_B+\delta-1+\rho)^2}{2}\Big)\cdot\frac{1}{1-\rho^2}$$

yielding the optimal bundle price of

$$p_B = \frac{3+\rho-2\delta}{4}.$$

The condition for Case B2 is then satisfied for $5\rho + 2\delta \ge 1$ and $1+3\rho > 2\delta$.

Case B3: $p_B + \delta \ge 1+\rho$

In this case, the demand for the bundle equals

$$S_B = \frac{(2-p_B-\delta)^2}{2} \cdot \frac{1}{1-\rho^2}$$

The optimal price is given by

$$p_B = \frac{2-\delta}{3},$$

which satisfies $p_B + \delta \ge 1+\rho$ for $1+3\rho \le 2\delta$.

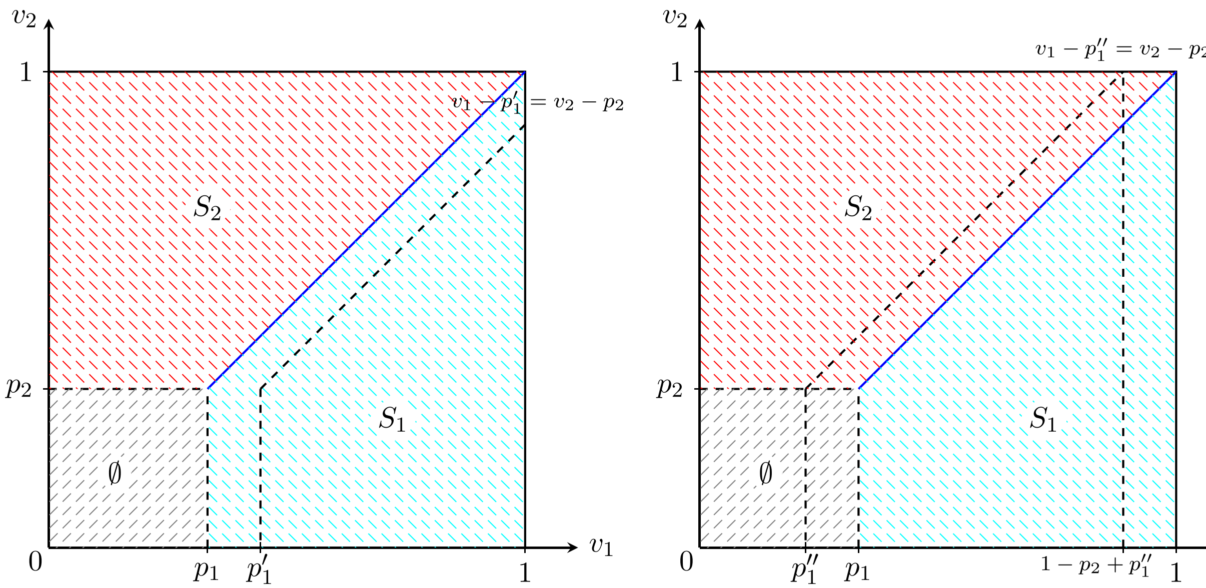

Fig. A.10. Change in the demand for Firm 1 with a price increase and with a price reduction.

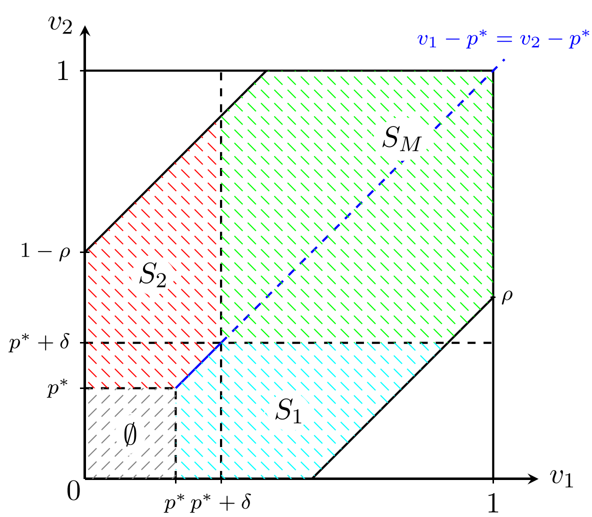

Fig. A.11. Case L1: $p^* < p^* + \delta < \rho$.

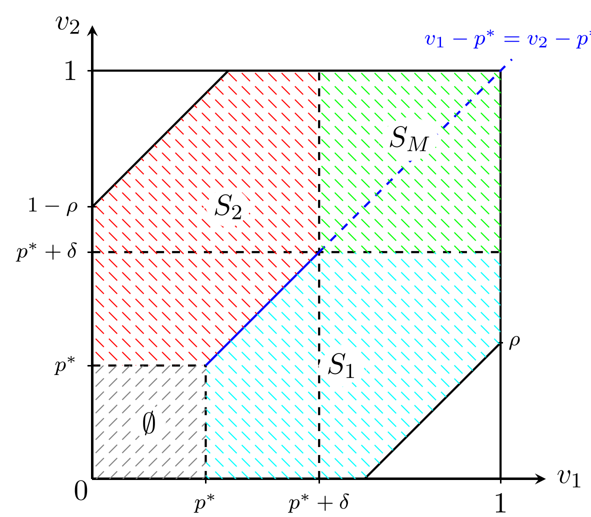

Fig. A.12. Case L2: $\rho < p^* < p^* + \delta < 1 - \rho$ or $p^* < \rho < p^* + \delta < 1 - \rho$.

A.4. Proof of Theorem 5

Depending on the relative values of the prices and the model parameters, several demand constellations will arise. Below, we will analyze these case by case. When multihoming occurs, there are two groups of cases corresponding to "Low ρ" ($\rho < \frac{1}{2}$), denoted by the prefix 'L', and "High ρ" ($\rho > \frac{1}{2}$), denoted by the prefix 'H'. The equilibrium situations without multihoming are analyzed at the very end. (Fig. A.11)

■ **Case L1:** $p^* < p^* + \delta < \rho$

In this case, the total demand for good 1 is

$$S_1 + S_M = \left(\frac{1}{2}\delta(2p_2 + \delta) + 1 - p_1 - \delta - \frac{1}{2}\rho^2 - \frac{1}{2}(\rho - p_1 - \delta)^2\right) \cdot \frac{1}{1 - \rho^2}.$$

The unique symmetric equilibrium price is equal to

$$p_1^* = p_2^* = p^* = \frac{-(2 - 2\rho + \delta) + \sqrt{(2 - 2\rho + \delta)^2 + 6(1 - \rho)(1 + \rho - \delta)}}{3},$$

and we have $p^* + \delta < \rho$ if

$$\rho > \sqrt{6 - 2\delta} + \delta - 2.$$

■ **Case L2:** $\rho < p^* < p^* + \delta < 1 - \rho$ or $p^* < \rho < p^* + \delta < 1 - \rho$

In this case, it does not matter whether p^* is smaller or greater than ρ. (Fig. A.12)

The market shares can again be written in terms of the areas in the consumer taste distribution.

$$S_1 = \left(\frac{1}{2}\delta(2p_2 + \delta) + (1 - p_1 - \delta)(p_2 + \delta) - \frac{1}{2}\rho^2\right) \cdot \frac{1}{1 - \rho^2}$$

$$S_2 = \left(\frac{1}{2}\delta(2p_1 + \delta) + (1 - p_2 - \delta)(p_1 + \delta) - \frac{1}{2}\rho^2\right) \cdot \frac{1}{1 - \rho^2}$$

$$S_M = (1 - p_1 - \delta)(1 - p_2 - \delta) \cdot \frac{1}{1 - \rho^2}$$

Maximization of the profit functions,

$$\Pi_1(p_1, p_2) = p_1 \cdot (S_1 + S_M)$$

$$\Pi_2(p_1, p_2) = p_2 \cdot (S_2 + S_M)$$

yields

$$p_1^* = p_2^* = \frac{1 + (1 - \delta)^2 - \rho^2}{2(2 - \delta)},$$

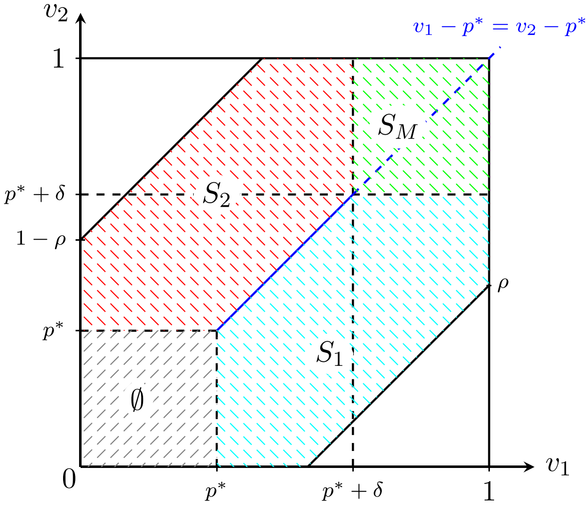

Fig. A.13. Case L3: $p^* + \delta > 1 - \rho > p^* > \rho$ or $p^* + \delta > 1 - \rho > \rho > p^*$.

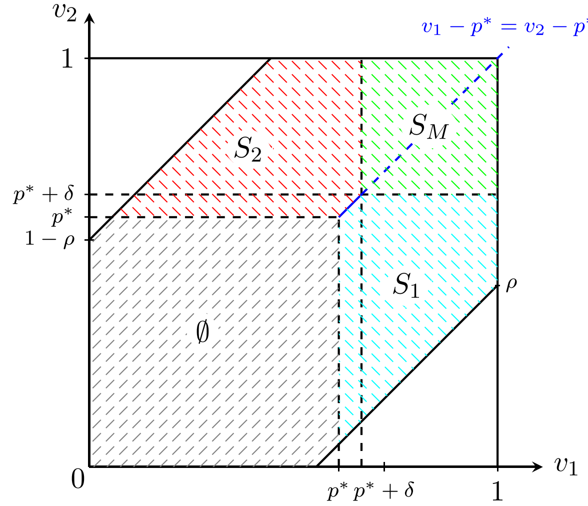

Fig. A.14. Case L4: $p^* + \delta > p^* > 1 - \rho$.

which satisfies $p^* + \delta < 1 - \rho$ for $\rho + \delta < 2 - \sqrt{2}$, and $p^* + \delta > \rho$ if $\rho < \sqrt{6 - 2\delta} + \delta - 2$. Thus, Case L2 arises if

$$\rho < \min\{2 - \sqrt{2} - \delta, \sqrt{6 - 2\delta} + \delta - 2\}.$$

The corresponding equilibrium profits are

$$\Pi_1^* = \Pi_2^* = \frac{(1 + (1 - \delta)^2 - \rho^2)^2}{4(1 - \rho^2)(2 - \delta)^2}$$

■ **Case L3:** $p^* + \delta > 1 - \rho > p^* > \rho$ or $p^* + \delta > 1 - \rho > \rho > p^*$

In this case, it does not matter whether p^* is smaller or greater than ρ.

The demands are the same as in Case L2. Hence, the equilibrium prices are still given by

$$p_1^* = p_2^* = p^* = \frac{1 + (1 - \delta)^2 - \rho^2}{2(2 - \delta)}.$$

We have $p^* + \delta > 1 - \rho$ if $\rho + \delta > 2 - \sqrt{2}$, and $p^* < 1 - \rho$ if $\rho < 2 - \sqrt{2} + (\sqrt{2} - 1)\delta$. Note that $2 - \sqrt{2} + (\sqrt{2} - 1)\delta$ is always higher than $\frac{1}{2}$. Hence, Case L3 arises when $\rho \in (2 - \sqrt{2} - \delta, 1/2)$. (Fig. A.13)

Moreover, Case L2 and L3 have the same price and profit functions, and they arise if

$$\rho \leq \min\{1/2, \sqrt{6 - 2\delta} + \delta - 2\}.$$

■ **Case L4:** $p^* + \delta > p^* > 1 - \rho$

In this case, the demand for seller 1 is

$$S_1 + S_M =$$

$$\left((1 - p_1) \cdot (1 - p_1 + p_2 - \rho) + \frac{1}{2}(p_1 - p_2 + 1 - p_2 - \delta) \cdot (1 - p_1 - \delta)\right) \cdot \frac{1}{1 - \rho^2}. \tag{A.1}$$

At the symmetric equilibrium we have

$$p_1^* = p_2^* = p^* = \frac{4 - 2\rho - \delta - \sqrt{(4 - 2\rho - \delta)^2 - 6(1 - \rho) - 3(1 - \delta)^2}}{3},$$

which is higher than $1 - \rho$ if

$$\rho > 2 - \sqrt{2} + (\sqrt{2} - 1)\delta.$$

Note that the right hand side is higher than $1/2$. Hence, for small $\rho \leq 1/2$, Case L4 actually cannot occur. (Fig. A.14, A.15, A.16, A.17)

■ Case H1: $p^* + \delta < 1 - \rho$ or $p^* < 1 - \rho < p^* + \delta < \rho$

In both cases, the demands are the same as in Case L1, given by

$$S_1 + S_M = \left(\frac{1}{2}\delta(2p_2 + \delta) + 1 - p_1 - \delta - \frac{1}{2}\rho^2 - \frac{1}{2}(\rho - p_1 - \delta)^2\right) \cdot \frac{1}{1 - \rho^2}.$$

Therefore, the symmetric equilibrium price is

$$p_1^* = p_2^* = p^* = \frac{-(2 - 2\rho + \delta) + \sqrt{(2 - 2\rho + \delta)^2 + 6(1 - \rho)(1 + \rho - \delta)}}{3},$$

and we have $p^* < 1 - \rho$ if

$$\rho < \frac{5 + 4\delta}{9}.$$

As above, we have already shown that $p^* + \delta < \rho$ if

$$\rho > \sqrt{6 - 2\delta} + \delta - 2.$$

■ Case H2: $\rho > p^* + \delta > p^* > 1 - \rho$

The equilibrium situation is illustrated in the below figure.

The market shares can once again be written in terms of the areas in the consumer taste distribution.

$$S_1 + S_M$$

$$= \left((p_2 - p_1 + 1 - \rho)(1 - p_1) + \frac{1}{2}(1 - p_2 - \delta)^2 - \frac{1}{2}(p_1 - p_2)^2 - \frac{1}{2}(\rho - p_1 - \delta)^2\right)$$

$$\cdot \frac{1}{1 - \rho^2}$$

The unique symmetric equilibrium is given by

$$p_1^* = p_2^* = p^* = \frac{(1 - \rho)(3 + \rho - 2\delta)}{2(4(1 - \rho) + \delta)}.$$

We have $p^* > 1 - \rho$ if $\rho > \frac{5+4\delta}{9}$, and $p^* + \delta < \rho$ if $\rho \in (\frac{5+4\delta-\sqrt{2(\delta^2-\delta+2)}}{7}, \frac{5+4\delta+\sqrt{2(\delta^2-\delta+2)}}{7})$. Note that for $\delta \in [0, 1]$, we always have $\frac{5+4\delta}{9} \geq \frac{5+4\delta-\sqrt{2(\delta^2-\delta+2)}}{7}$, and $\frac{5+4\delta+\sqrt{2(\delta^2-\delta+2)}}{7} \geq 1$. Therefore, Case H2 arises if

$$\rho \in (\frac{5 + 4\delta}{9}, 1).$$

■ Case H3: $p^* + \delta > \rho > p^* > 1 - \rho$ or $p^* + \delta > p^* > \rho$

The equilibrium situation is illustrated in the below figure.

In this case, the demands are the same as in Case L4, given by

$$S_1 + S_M$$

$$= \left((1 - p_1) \cdot (1 - p_1 + p_2 - \rho) + \frac{1}{2}(p_1 - p_2 + 1 - p_2 - \delta)\right.$$

$$\left.\cdot(1 - p_1 - \delta)\right) \cdot \frac{1}{1 - \rho^2}.$$

The equilibrium prices are given by

$$p_1^* = p_2^* = p^* = \frac{4 - 2\rho - \delta - \sqrt{(4 - 2\rho - \delta)^2 - 6(1 - \rho) - 3(1 - \delta)^2}}{3},$$

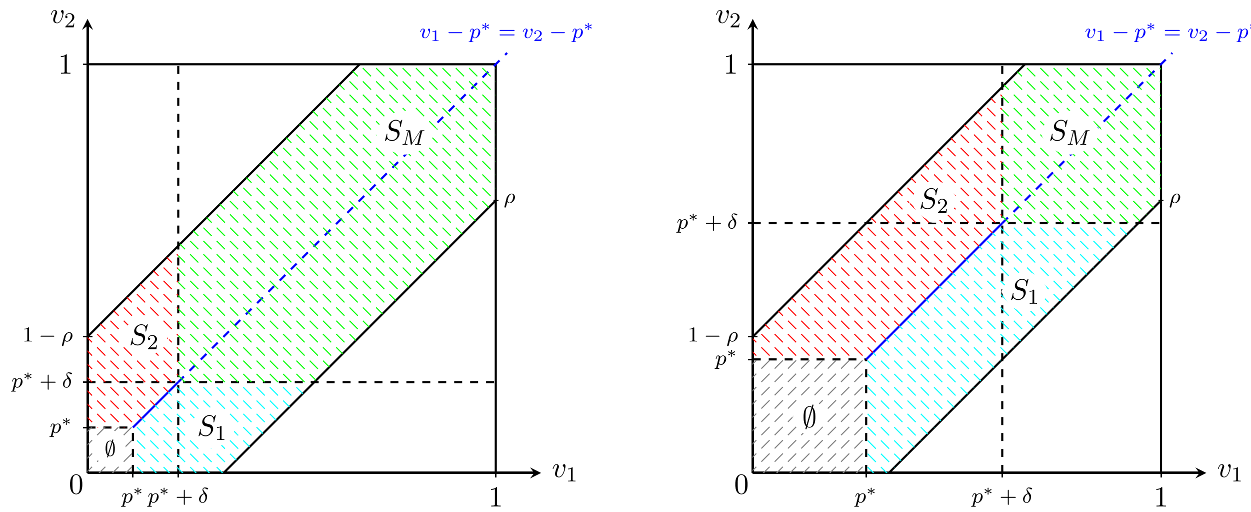

Fig. A.15. Case h1: $p^* + \delta < 1 - \rho$ or $p^* < 1 - \rho < p^* + \delta < \rho$.

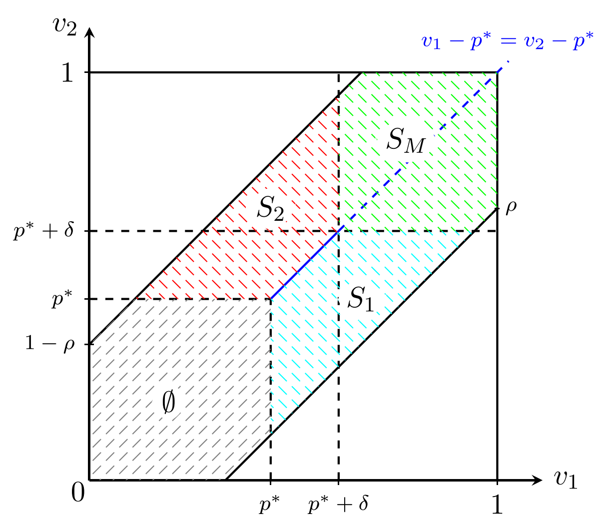

Fig. A.16. Case h2: $\rho > p^* + \delta > p^* > 1 - \rho$.

which is higher than $1 - \rho$ if

$$\rho > 2 - \sqrt{2} + (\sqrt{2} - 1)\delta.$$

Furthermore, we have $p^* + \delta > \rho$ if

$$\rho < \frac{5 + 4\delta - \sqrt{2\delta^2 - 2\delta + 4}}{7} \text{ or } \rho > \frac{5 + 4\delta + \sqrt{2\delta^2 - 2\delta + 4}}{7}.$$

Note that, for $\delta \in (0, 1)$, $\frac{5+4\delta-\sqrt{2\delta^2-2\delta+4}}{7} < 2 - \sqrt{2} + (\sqrt{2} - 1)\delta$, and $\frac{5+4\delta+\sqrt{2\delta^2-2\delta+4}}{7} > 1$. Therefore, Case H3 cannot occur for $\rho > 1/2$. (Fig. A.18)

■ Case H4: $p^* + \delta > \rho > 1 - \rho > p^*$

The equilibrium situation is illustrated in the below figure.

The demands are the same as Case L2 and L3, given by

$$S_1 + S_M = \left(\frac{1}{2}\delta(2p_2 + \delta) + 1 - p_1 - \delta - \frac{1}{2}\rho^2\right) \cdot \frac{1}{1 - \rho^2}.$$

In the symmetric equilibrium we have

$$p_1^* = p_2^* = \frac{1 + (1 - \delta)^2 - \rho^2}{2(2 - \delta)}.$$

we have $p^* + \delta > \rho$ if $\rho < \sqrt{6 - 2\delta} + \delta - 2$, and $p^* < 1 - \rho$ if $\rho < 2 - \sqrt{2} + (\sqrt{2} - 1)\delta$.

Note that, for $\delta \in (0, 1)$, we have $2 - \sqrt{2} + (\sqrt{2} - 1)\delta > \sqrt{6 - 2\delta} + \delta - 2$. Therefore, Case H4 arises if $\rho \in (1/2, \sqrt{6 - 2\delta} + \delta - 2)$.

■ High δ, no multihoming:

Finally, note that when $p^* + \delta \le 1$ (possible only in cases L3 and H4), there will be no multihoming. This is equivalent to $\rho^2 + (2 - \delta)^2 \le 2$. Thus, in the green area in Fig. 7, multihoming does not occur in equilibrium.

The demands in cases L3 and H4 are the same, since in both cases $p^* < 1 - \rho$ and it does not matter whether $1 - \rho$ is greater or smaller than ρ. Note that starting from a symmetric price pair $p_1 = p_2$, a price reduction has a potentially different impact than a price increase (Fig. A.19).

In the symmetric price equilibrium that we search for, neither a price increase nor a price reduction should be profitable. The market shares of, say, Firm 1, in consideration of these respective changes are given by

$$S_1' = \left(\frac{1}{2}(2p_2 + 1 - p_1)(1 - p_1) - \frac{\rho^2}{2}\right) \cdot \frac{1}{1 - \rho^2}$$

$$S_1'' = \left(\frac{1}{2}(p_2 + 1)(1 - p_2) + p_2 - p_1 - \frac{\rho^2}{2}\right) \cdot \frac{1}{1 - \rho^2}$$

In the symmetric equilibrium, two conditions need to be satisfied:

$$\frac{\partial(p_1 \cdot S_1')}{\partial p_1} \le 0$$

$$\frac{\partial(p_1 \cdot S_1'')}{\partial p_1} \ge 0$$

These yield the unique equilibrium price

$$p_1^* = p_2^* = \sqrt{2 - \rho^2} - 1$$

with corresponding equilibrium profits of

$$\Pi_1^* = \Pi_2^* = \frac{1}{1 - \rho^2}(\sqrt{2 - \rho^2} - 1)^2.$$

Summary:

The separate cases arise in these regions given in Fig. 7:

1. Region I: Case L2, L3 & H4

$$p_1^* = p_2^* = \frac{1 + (1 - \delta)^2 - \rho^2}{2(2 - \delta)}$$

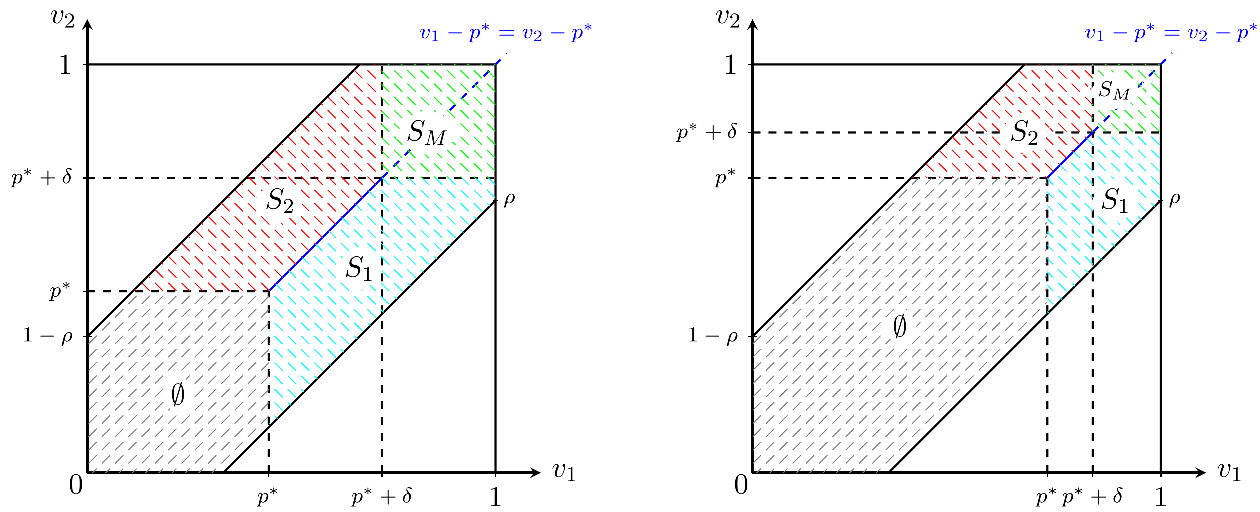

Fig. A.17. Case H3: $p^* + \delta > \rho > p^* > 1 - \rho$ or $p^* + \delta > p^* > \rho$.

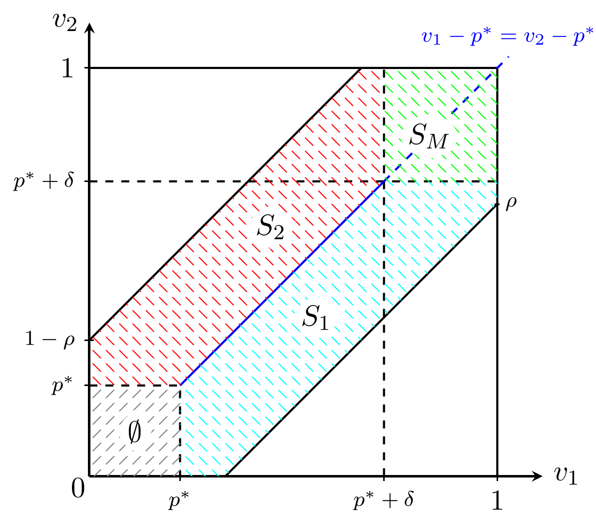

Fig. A.18. Case h4: $p^* + \delta > \rho > 1 - \rho > p^*$.

with

$$\pi_1 = \pi_2 = \frac{1}{1-\rho^2}(p^*)^2$$

2. Region II: Case L1, H1

$$p_1^* = p_2^* = p^* = \frac{-(2-2\rho+\delta) + \sqrt{(2-2\rho+\delta)^2 + 6(1-\rho)(1+\rho-\delta)}}{3}$$

with

$$\pi_1 = \pi_2 = \frac{1}{1-\rho^2}(1+\delta-\rho+p^*)(p^*)^2$$

3. Region III: Case H2

$$p_1^* = p_2^* = p^* = \frac{(1-\rho)(3+\rho-2\delta)}{2(4(1-\rho)+\delta)}$$

with

$$\pi_1 = \pi_2 = \frac{1}{1-\rho^2}(2+\delta-2\rho)(p^*)^2$$

4. Region S: Case L3, H4

$$p_1^* = p_2^* = \sqrt{2-\rho^2} - 1$$

with

$$\Pi_1^* = \Pi_2^* = \frac{1}{1-\rho^2}(\sqrt{2-\rho^2}-1)^2$$

A.5. Firm 2 licenses and enters

Suppose that after licensing its product to Firm 1, Firm 2 enters the downstream market and offers its product at p_2, while Firm 1 sells the bundle at p_B. The consumers have the option of buying product 2, the bundle, or nothing. Their net utilities are given by

$$U_2 = v_2 - p_2,$$

$$U_B = v_1 + v_2 - \delta - p_B,$$

$$U_\emptyset = 0,$$

with corresponding market shares of

$$S_2 = P(v_2 > p_2 \quad \& \quad v_2 - p_2 > v_1 + v_2 - p_B - \delta),$$

$$S_B = P(v_1 + v_2 - p_B - \delta > 0 \quad \& \quad v_1 + v_2 - p_B - \delta > v_2 - p_2)$$
$$= P(v_1 > p_B + \delta - v_2 \quad \& \quad v_1 > p_B + \delta - p_2).$$

The demands for the bundle and the product of firm 2 are illustrated below in Fig. A.20.

The corresponding profit functions are given by

$$\Pi_2(p_2) = p_2(1-p_2)(p_B + \delta - p_2)$$

$$\Pi_1(p_B) = p_B \frac{(1 - p_B - \delta + p_2)(1 - p_2 + 2 - p_B - \delta)}{2}$$

$p_B + \delta \geq 1$, and

$$\Pi_2(p_2) = p_2(1-p_2)(p_B + \delta - p_2)$$

$$\Pi_1(p_B) = p_B\left(1 + p_2 - p_B - \delta - \frac{p_2^2}{2}\right).$$

for $p_B + \delta < 1$.

The equilibrium prices are such that $p_B + \delta \geq 1$ for $\delta \geq 13/18$. As shown in Fig. A.21, for all $\delta \in [0, 1]$, the industry profit under entry is higher than that under entry and licensing. This implies that Firm 2 would be better-off not licensing to Firm 1, once it has entered the downstream market.

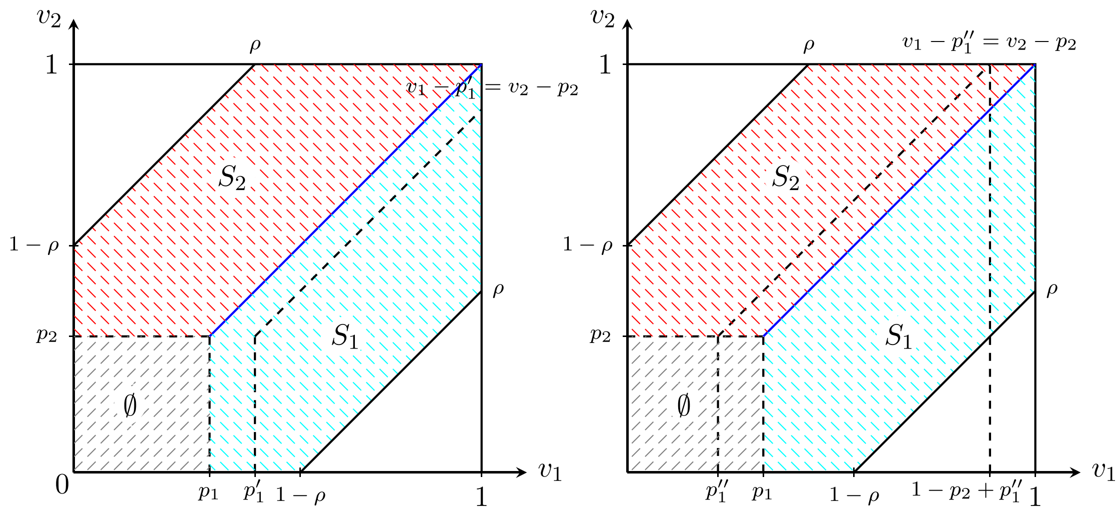

Fig. A.19. Change in the demand for Firm 1 following a price increase and a price reduction.

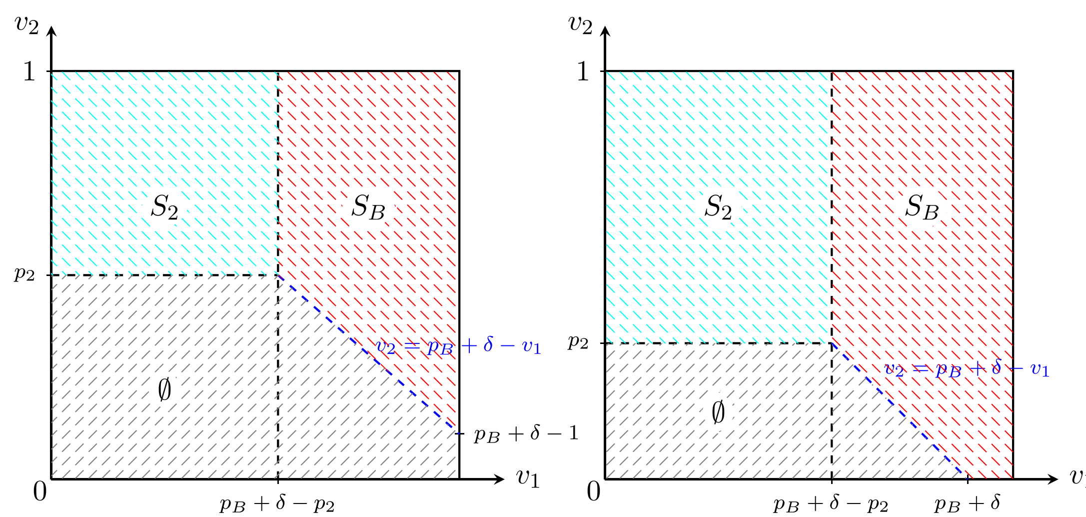

Fig. A.20. Consumer choices for $p_B + \delta \geq 1$ and $p_B + \delta < 1$ respectively.

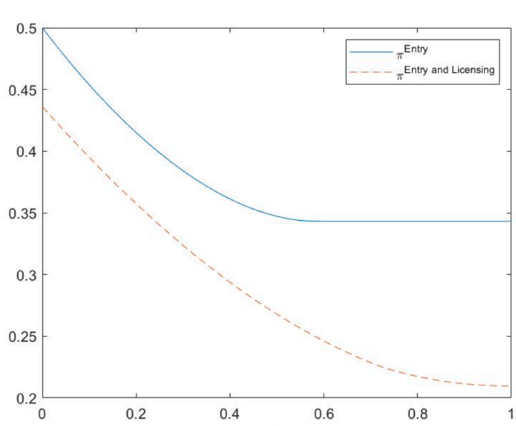

Fig. A.21. Industry profit: Entry vs entry and licensing.

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