Essays on the Theory of Industrial Organization: Credence Goods, Vertical Relations, and Product Bundling

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Chapter 5

The Impact of Product Qualities on Downstream Bundling in a Distribution Channel

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Abstract

We analyze the impact of exogenous and heterogeneous product qualities on a downstream firm's decision to bundle and the welfare effects of downstream bundling. We consider a distribution channel with two downstream firms and two monopolistic upstream producers. One upstream firm sells its *good 1* exclusively to one downstream firm and the other upstream firm sells its *good 2* to both downstream firms. The downstream firms compete in prices in the duopoly and the two-product downstream firm has the option to bundle its goods. We find that downstream bundling aggravates the double marginalization problem in the whole channel, but reduces the intensity of downstream competition. Finally, bundling is profitable for the two-product downstream firm only when the quality of good 2 exceeds the quality of good 1. However, bundling is *always* profitable when the production process is controlled by the downstream industry. Its impact on total welfare is ambiguous and depends on the distribution of market power in the channel and the qualities of the two traded goods.

JEL classification: D21; D61; L11; L15

Keywords: Double marginalization; Downstream bundling; Leverage theory; Quality differentiation

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5.1 Introduction

By now, the market for Subscription-Video-on-Demand streaming services[1] has developed into an important part of the digital entertainment. As such, in 2019 it will generate estimated 24.8 billion US$ in sales worldwide (Statista, 2019b). A common sales strategy in streaming service markets is to offer the products in a bundle. Consider for example Netflix, one of the biggest players within the streaming service industry (with 157.62 million subscribers worldwide in Q2 2019 (Statista, 2019a)). Netflix offers its whole library (movies, television shows, etc.) exclusively at a monthly price and hence plays a pure bundling strategy. The rising importance and impact of streaming services makes it highly relevant to evaluate their bundling strategy. Accordingly, we develop a model that covers several aspects the streaming service industry is characterized by. By means of that, we derive managerial as well as competition policy implications.

The market for streaming services combines several elements that may influence a firm's bundling strategy. Downstream firms like streaming services often procure their content from powerful producers such as movie studios and television production companies.[2] However, as the literature shows (see e.g. Bhargava, 2012), downstream bundling in a decentralized distribution channel may aggravate the problem of double marginalization (DM).[3] Moreover, streaming services can supply exclusive content but also content that is supplied by other streaming services as well. That is, the bundles of streaming services might be composed of monopolistic and oligopolistic products (Heinzel, 2019). A firm's bundling strategy may affect the intensity of oligopolistic competition and this, in turn, may have an impact on the bundling decision itself (Carbajo et al., 1990).

Another distinction of streaming services is that the goods included in their bundles might differ in quality. In Germany, Netflix supplies the TV series *Breaking Bad*, which has a rating of 9.5 (out of 10) stars on the rating website IMDb (IMDb, 2019b) but also the movie *Alien Warfare*, which is rated with 2.5 (out of 10) stars (IMDb, 2019a). Following Häckner (2000), the customers' valuation for a good can be interpreted as product quality. Banciu et al. (2010), Honhon and Pan (2017) as well as Ma and Mallik (2017) investigate optimal bundling strategies while considering quality differences between the component goods and show that the quality relationship between the goods affects the optimality of the bundling strategies. They demonstrate that the introduction of vertical production differentiation results in situations, where pure bundling dominates mixed bundling and pure components selling. This finding is in contrast to previous literature on bundling (namely Schmalensee, 1984; McAfee et al., 1989), that shows that

[1] We refer to Subscription-Video-on-Demand for the services offered by providers such as Netflix or Amazon Prime Video. From here on we abbreviate 'Subscription-Video-on-Demand streaming services' to 'streaming services'.

[2] Since some streaming services may also control the production process of the movie studios, later on we additionally analyze the case where the market power fully lies with the downstream firms.

[3] Regarding 'double marginalization' see Spengler (1950); Tirole (1988).

mixed bundling (weakly) dominates the other two strategies. Even though our paper has a different focus than the mentioned papers on vertical differentiation, their results demonstrate that product qualities should be considered when studying bundling.

In order to analyze bundling in a market that represents the characteristics of streaming service markets, we use the market structure of Heinzel (2019) and incorporate quality differences between the traded goods. The market consists of two goods, two upstream firms and two downstream firms. Both goods can be of distinctive quality levels which are exogenously given. Each upstream firm is a monopolistic producer of one good. One of the upstream firms sells its *good 1* exclusively to one downstream firm, whereas the other upstream firm sells its *good 2* to both downstream firms. Thus, one downstream firm supplies one product as a monopolist and competes with the other downstream firm in the second product market. This two-product downstream firm has the option to purely bundle the goods or to sell them separately to the final customers. We assume the downstream firms to compete in prices. We argue that this is applicable for the streaming industry because a movie or TV show is only provided at a constant quantity of one by a streaming service provider, which practically rules out quantity competition. Note that differences in the content size of streaming services could be rather interpreted as quality differentiation.

The focus of our framework lies on the analysis of the interplay between product qualities and downstream bundling. Therefore, we investigate the following research questions: *i) How do different degrees of product qualities impact the selling decision of the two-product downstream firm? ii) How do profitable downstream bundling and product qualities affect market results, especially welfare outcomes? iii) How does the distribution of market power in the channel affect our findings?*

The downstream market structure of our model relates to the leverage theory of bundling since the two-product downstream firm might leverage its market power from the monopoly into the duopoly by bundling. Other studies dealing with the leverage theory are, for instance, Carbajo et al. (1990); Whinston (1990); Martin (1999); Carlton and Waldman (2002); Spector (2007); Peitz (2008) or Chung et al. (2013). Close to our paper are the articles by Carbajo et al. (1990) and Martin (1999). Carbajo et al. (1990) consider a set-up with a two-product firm that competes with a one-product firm in one product market but is a monopolist in the other product market. They observe that bundling lowers the degree of competition between the firms given that they engage in price competition. This effect leads to bundling always being more profitable than separate selling. Given quantity competition, separate selling may be more profitable than bundling in their set-up. They additionally find that bundling always reduces consumer surplus but that it has ambiguous effects on social welfare. Martin (1999) considers the same market structure as Carbajo et al. (1990) but concentrates on quantity competition and considers complementarity as well as substitutability between the goods. He finds that bundling may change or create substitutability relationships between the traded goods. Furthermore, bundling always reduces consumer surplus and social welfare in the equilibrium in Martin's model.

Our paper also contributes to the literature strand that evaluates downstream bundling in a decentralized channel. Other articles within this research field are, for example, Bhargava (2012), Chakravarty et al. (2013), Cao et al. (2015), Giri et al. (2017), Ma and Mallik (2017), Cao et al. (2019) and Heinzel (2019). The article by Bhargava (2012) is especially connected to our paper. He illustrates that in a channel with a monopolistic retailer and two monopolistic manufacturers, retail bundling induces both manufacturers to overprice their goods. Thus, bundling aggravates the double marginalization problem and this makes bundling the inferior strategy compared to separate selling for the retailer. Also related to our work is the paper by Ma and Mallik (2017). They evaluate bundling in a channel that consists of one retailer, one manufacturer and two vertically differentiated goods (a premium and a basic good). They show that the results of Banciu et al. (2010) and Honhon and Pan (2017) regarding the (possible) dominance of pure bundling under vertical differentiation hold under vertical differentiation and double marginalization.

Recapitulating, the existing leverage theory research has mainly focused on non-vertical markets. The existing literature on downstream bundling has mainly studied distribution channels without downstream competition and widely neglected the impact of qualities. We add to the literature by being best to our knowledge the first paper to evaluate downstream bundling in a distribution channel, where the goods differ in qualities and the downstream market is of a leverage theory set-up. The key contribution of our paper is to analyze such market set-ups and to provide managerial and welfare implications for markets related to our framework. Hitherto only Heinzel (2019) evaluates downstream bundling in a distribution channel with such a leverage structure in the downstream market. He finds that under price competition, the positive influence of bundling in the form of a reduction in the intensity of downstream competition and an extension of monopoly power for the bundling firm can outweigh the negative influence of bundling in the form of an aggravated double marginalization problem. The final outcome regarding the profitability of bundling depends on the marginal costs of the upstream manufacturers. Contrary to this, downstream bundling is never profitable under quantity competition in his set-up. In Heinzel's model, both traded goods have symmetric quality levels and the qualities do not play a role in the analysis, which is in contrast to our model.

Our major findings can be summarized as follows. We find that the quality of good 2 needs to exceed the quality of good 1 for downstream bundling to be profitable for the two-product firm. However, bundling also aggravates the double marginalization problem for the bundling firm and therefore may not be a profitable strategy. Put differently, for a sufficiently low quality of good 2, the two-product downstream firm prefers to price its products independently. This is the case even though bundling reduces the intensity of

competition in the downstream duopoly and leads to an extension of the two-product firm's monopoly power with respect to good 1 into the downstream market for good 2.
To illustrate the impact of double marginalization, we analyze a centralized channel, where the full market power lies with the downstream firms and therefore the double marginalization is eliminated. We observe that bundling is always the two-product firm's best strategy in the centralized channel. Hence, we identify the double marginalization problem and its aggravation by bundling as a factor to lower the bundling incentives in the channel. Yet, when we consider that both goods are produced by a single upstream firm with upstream market power - and therefore also have double marginalization - bundling is again always the two-product firm's best strategy. This means that it is a combination of vertical externalities and horizontal externalities upstream that weakens the downstream firm's bundling incentives in the decentralized channel, which is in line with Bhargava (2012) and Heinzel (2019).
Our observation that bundling is not always the two-product firm's optimal strategy is especially interesting considering that parts of the previous leverage theory literature find bundling under price competition to be always profitable (compare Carbajo et al., 1990; Peitz, 2008). Chung et al. (2013) already identify the degree of inter-brand differentiation between the products in the oligopoly as a pivotal factor to drive the bundling decision. Our paper additionally identifies on the one hand the product qualities and differences in these levels and on the other hand the channel effects as decisive factors that drive the profitability of bundling.
Furthermore, we find that downstream bundling is a welfare deteriorating strategy in the decentralized channel since it lowers both consumer surplus and producer surplus in the equilibrium. In the centralized channel, profitable bundling decreases consumer surplus but increases producer surplus, which can lead to an increase in overall welfare. The ultimate welfare effects in the centralized channel are determined by the quality levels: total welfare is increased by profitable bundling for a sufficiently *low* quality level of good 2, and decreased for a sufficiently *high* quality level of good 2.
The rest of the paper is structured as follows. We analyze the decentralized channel in Section 5.2 and investigate the centralized channel in Section 5.3. Section 5.4 concludes.

5.2 Decentralized Channel: Framework and Analysis

5.2.1 Basics of the Model

The distribution channel consists of two downstream firms (D_A and D_B), two upstream firms (U_1 and U_2) and two products (*good 1* and *good 2*). In addition, there is a continuum of final customers in the market. Good 1 is manufactured by upstream firm U_1 and good 2 by upstream firm U_2. Both upstream firms are monopolists in their respective markets and both goods are produced at symmetric constant marginal cost $k \geq 0$.[4] We assume that upstream firm U_1 and downstream firm D_A have an exclusive relationship. In particular, we assume for both firms to behave according to an exclusivity contract, which allows U_1 to sell its good 1 only to D_A, making D_A the downstream monopolist for good 1. In the streaming service industry, this exclusive relationship might reflect a producing company, that sells certain productions exclusively to one streaming service. Another example for such exclusive agreements is the *Amazon Exclusives* program. Manufacturers involved in this program must sell their goods only via Amazon.com and not via any other online marketplace.[5] By contrast, good 2 is sold to both downstream firms by U_2, resulting in a downstream duopoly. It might be media content of one media producer which is offered to several streaming services. We assume the downstream firms to engage in price competition in the downstream duopoly.

The goods manufactured by the upstream firms are the input goods of the downstream firms and are resold without any changes in their characteristics as final goods by the downstream firms. This implies that i) the downstream firms transform the inputs into output on a one-to-one basis at zero cost and that ii) the downstream firms supply the products to the final consumers with the quality provided by the upstream firms. Moreover, neither D_A nor D_B have any production costs (e.g. for repackaging or bundling) when selling the goods to the final customers. This fits the motivating example of the streaming service industry insofar as that the streaming services usually sell the procured input practically unchanged as output to the final customers without facing any considerable production costs.

In the subsequent sections, we solve the here considered game for the subgame perfect Nash equilibrium in pure strategies applying backward induction. Thereby, we consider the following timing (Figure 5.1): at first, the two-product downstream firm D_A decides whether to bundle the products or not, whereas it only bundles if bundling leads to a higher profit than selling the products separately. Afterwards, both upstream firms set their optimal prices. In particular, upstream firm U_1 (U_2) sets the input price c_1 (c_2), which depends on the two-product downstream firm's selling strategy. In the last step, both downstream firms choose their profit-maximizing prices.

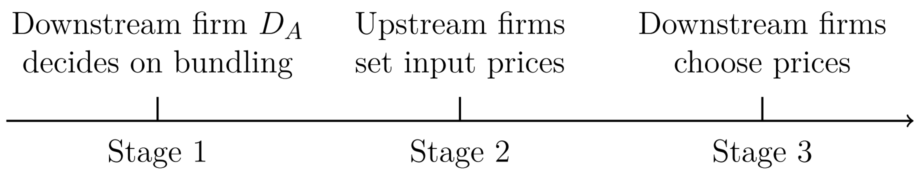

Figure 5.1: Timing of the game

[4]The following analysis reveals that our qualitative results hold for $k = 0$ without loss of generality.
[5]Regarding the reasoning for such exclusive relationships see Heinzel (2019).

We first solve the model for the case in which D_A sells its products separately, and then for the case in which D_A is assumed to bundle its products. We only consider pure bundling as a bundling strategy for D_A. In a last step, we compare the market results under separate selling and bundling to determine D_A's incentives to bundle. All proofs, first- and second-order conditions and comparisons can be found in Appendix 5.5.

5.2.2 Separate Selling: Nash Equilibrium Outcomes

Assume that downstream firm D_A plays a separate selling strategy (the superscript S denotes (mostly) the optimal solutions for this case) such that D_A supplies good 1 and good 2 separately and downstream firm D_B offers good 2 to the final customers. Good 2 is perfectly substitutable between the downstream firms, hence the final customers are indifferent between buying good 2 from either one of the two downstream firms. Figure 5.2 provides the market structure in the separate selling case.

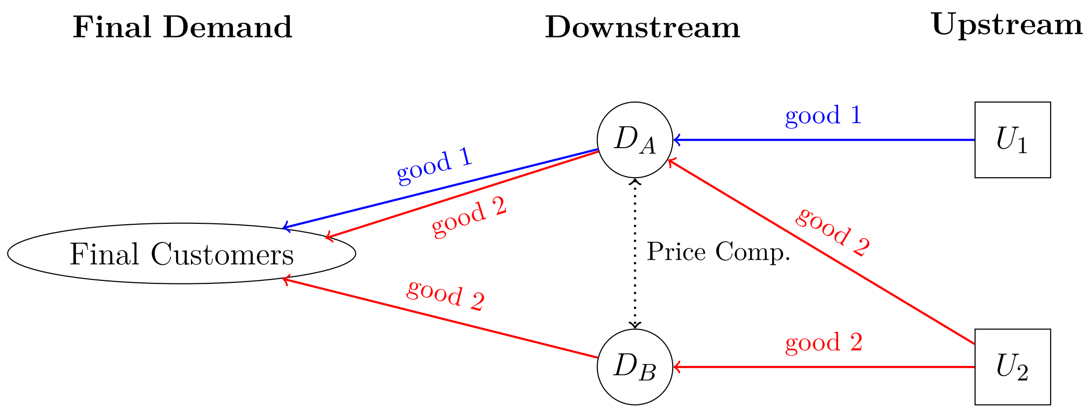

Figure 5.2: Market structure under *Separate Selling*

The aggregate final customers' preferences regarding good 1 and good 2 are given by a representative customer's utility, which is portrayed by the following Dixit (1979)-type utility function:

$$V(m, Q_1, Q_2) = m + a_1 Q_1 + a_2 Q_2 - \frac{1}{2}\left(Q_1^2 + Q_2^2\right), \tag{5.1}$$

where Q_1 (Q_2) is the quantity of good 1 (good 2) purchased by the representative customer and m is the quantity of other goods he consumes. The parameter $a_1 > 0$ ($a_2 > 0$) denotes the customer's valuation for good 1 (good 2). We assume $a_1, a_2 > k$ to ensure market transactions. As already pointed out, the customer valuation for a good can be interpreted as the product quality of a good as, for instance, in Häckner (2000).[6] We adopt this interpretation in our model and thus denote a_1 (a_2) as the quality of good 1

[6] This fits our motivating example of rating websites such as IMDb signaling quality. However, ratings may also present the customer taste.

(good 2). We allow for $a_1 = a_2$ but focus on the cases where we have $a_1 \neq a_2$. We assume the quality of each good to be *exogenously* given and the two standalone goods to be *independent* in demand, where the latter is incorporated in the customers' preferences. The price of the composite good m is normalized to one. The price of good 1 (good 2) is given by p_1 (p_2).

Solving the representative customer's optimization problem gives us the following inverse demand functions for the two standalone goods:

$$p_1 (Q_1) = a_1 - Q_1, \tag{5.2}$$

$$p_2 (Q_2) = a_2 - Q_2. \tag{5.3}$$

It holds that $Q_2 = q_{A2} + q_{B2}$, where q_{A2} is firm D_A's supplied quantity of good 2 and q_{B2} is firm D_B's supplied quantity of good 2. The downstream quantity of good 1 supplied by D_A is $q_{A1} = Q_1$. We derive the demand functions of the two goods as

$$Q_1(p_1) = a_1 - p_1, \tag{5.4}$$

$$Q_2(p_2) = a_2 - p_2. \tag{5.5}$$

The profit that downstream firm D_A maximizes is compounded by the profit it gains in the monopoly regarding good 1 and the profit it gains in the duopoly regarding good 2. Firm D_B's profit function consists solely of the profit it gains in the market for good 2. Finally, the equilibrium downstream profits are $\pi^S_{D_A} = (p^S_1 - c^S_1)q^S_{A1} + (p^S_2 - c^S_2)q^S_{A2}$ and $\pi^S_{D_B} = (p^S_2 - c^S_2)q^S_{B2}$ with the profit-maximizing downstream prices

$$p^S_1 = \frac{a_1 + c_1}{2}, \tag{5.6}$$

$$p^S_2 = c_2. \tag{5.7}$$

The downstream price for good 2 is in equilibrium driven down to marginal cost due to the price competition for a homogeneous good between the downstream firms. The marginal costs of the downstream firms are represented by the respective input prices.

We now turn to the upstream side of the supply chain. In order to receive firm D_A's input demand regarding good 1, we substitute Equation (5.6) into Equation (5.4). The input demand regarding good 2 is obtained by inserting Equation (5.7) into Equation (5.5). The resulting input demand functions are

$$Q_1 (c_1) = \frac{a_1 - c_1}{2}, \tag{5.8}$$

$$Q_2 (c_2) = a_2 - c_2. \tag{5.9}$$

Ultimately, the profit functions of the upstream firms are given as

$$\pi_{U_1}(c_1) = (c_1 - k) Q_1 (c_1), \tag{5.10}$$

$$\pi_{U_2}(c_2) = (c_2 - k) Q_2 (c_2). \tag{5.11}$$

Maximizing the profit functions with respect to the input prices leads to the equilibrium input prices

$$c_1^S = \frac{a_1 + k}{2}, \tag{5.12}$$

$$c_2^S = \frac{a_2 + k}{2}. \tag{5.13}$$

We receive the final market results by inserting the optimal input prices into the other market entities. Further below, Lemma 5.1 lists the optimal input prices and the residual equilibrium values under separate selling.

5.2.3 Bundling: Nash Equilibrium Outcomes

Now suppose that downstream firm D_A purely bundles its products (the superscript BL denotes (mostly) the equilibrium solutions for this case). Bundling in our set-up means that firm D_A ties good 1 with good 2 and sells solely the resulting product combination (called *bundle A*) at a single price. We assume that bundle A contains one unit of good 1 and one unit of good 2, which can be denoted as bundle $A : (1,1)$. For notational purposes, we denote firm D_B's product as *bundle* $B : (0,1)$, which consists only of one unit of good 2. Figure 5.3 depicts the market structure in the bundling case.

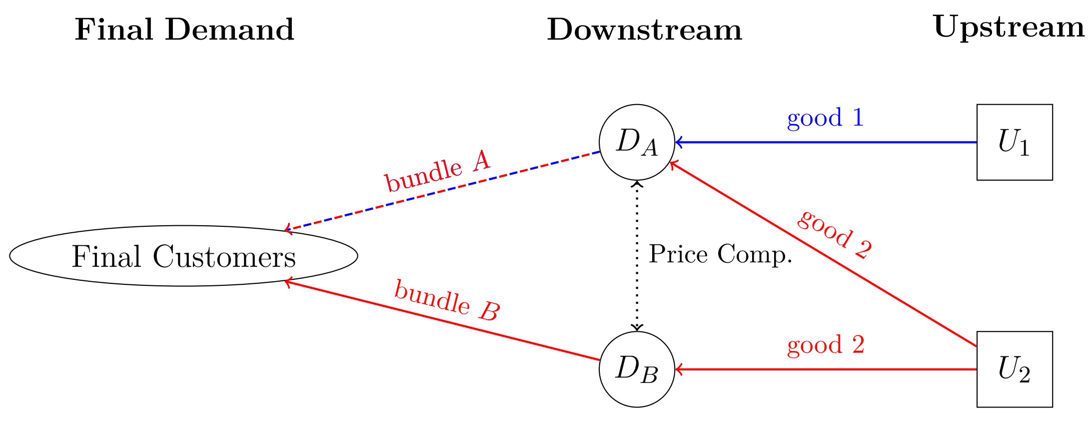

Figure 5.3: Market structure under *Bundling*

The relationships between the quantities of the two component goods and the bundles are

$$Q_1 = b_A, \tag{5.14}$$

$$Q_2 = b_A + b_B, \tag{5.15}$$

where b_A is the quantity of the bundles sold by firm D_A and b_B the quantity of bundles sold by firm D_B. Following a method used by Martin (1999), we substitute (5.14) and (5.15) into the representative customer's utility function V of the separate selling case. This method yields a utility function W that describes the utility the customer derives from consuming the bundles and other goods m:

$$W(m, b_A, b_B) = m + (a_1 + a_2)b_A + a_2 b_B - \frac{1}{2}\left(2b_A^2 + 2b_A b_B + b_B^2\right). \tag{5.16}$$

The same assumptions regarding the quality parameters a_1 and a_2 are valid here as in the separate selling case. We suppose *strict additivity* concerning the qualities of the two standalone goods.[7] This means that a bundle provides the same total quality as the sum of the qualities of its component goods. Consequently, bundling does not add (*superadditivity*) or reduce (*subadditivity*) any value in product quality.

The price of bundle A is denoted by p_A and the price of bundle B by p_B. Solving the customer's optimization problem regarding the bundles provides the inverse demand functions

$$p_A(b_A, b_B) = a_1 + a_2 - 2b_A - b_B, \tag{5.17}$$

$$p_B(b_A, b_B) = a_2 - b_A - b_B. \tag{5.18}$$

Thus, the demand functions for the bundles are

$$b_A(p_A, p_B) = a_1 - p_A + p_B, \tag{5.19}$$

$$b_B(p_A, p_B) = a_2 - a_1 + p_A - 2p_B. \tag{5.20}$$

We observe that $\frac{\partial b_A}{\partial p_B} > 0$ and $\frac{\partial b_B}{\partial p_A} > 0$. This means that the bundles are (imperfect) substitutes, whereas the standalone goods under separate selling are independent in demand. Hence, bundling creates substitutability between the goods, which is in line with the results of Martin (1999). Additionally, the two bundles pose *imperfect* substitutes, whereas under separate selling the products of both downstream firms in the market for good 2 are *perfect* substitutes. Consequently, bundling differentiates the goods sold by both downstream firms in the duopoly. This product differentiation enables both downstream firms to charge downstream prices above input prices under bundling.

In the bundling market, the downstream firms maximize the profits:

$$\pi_{D_A}(p_A, p_B) = (p_A - c_1 - c_2)\, b_A(p_A, p_B), \tag{5.21}$$

$$\pi_{D_B}(p_A, p_B) = (p_B - c_2)\, b_B(p_A, p_B). \tag{5.22}$$

[7] Venkatesh and Kamakura (2003) and Honhon and Pan (2017) refer to products with a strict additivity relationship as independently valued, which is consistent with our assumptions.

Solving the optimization problems of the downstream firms leads to the equilibrium price for bundle A, respectively, bundle B:

$$p_A^{BL} = \frac{3a_1 + 4c_1 + a_2 + 6c_2}{7}, \tag{5.23}$$

$$p_B^{BL} = \frac{2a_2 - a_1 + c_1 + 5c_2}{7}. \tag{5.24}$$

We insert Equations (5.23) and (5.24) into Equations (5.19) and (5.20) to receive the input demand functions. We directly obtain the input demand for good 1 since $b_A = Q_1$. We get the input demand for good 2 by calculating $b_A + b_B = Q_2$. Note that we obtain $b_B(c_1, c_2) = \frac{2(2a_2 - a_1 - 2c_2 + c_1)}{7}$. We ultimately receive

$$Q_1(c_1, c_2) = \frac{3a_1 + a_2 - 3c_1 - c_2}{7}, \tag{5.25}$$

$$Q_2(c_1, c_2) = \frac{a_1 + 5a_2 - c_1 - 5c_2}{7}. \tag{5.26}$$

We observe $\frac{\partial Q_1}{\partial c_2} < 0$ and $\frac{\partial Q_2}{\partial c_1} < 0$. This means that the two standalone goods become *complementary* input goods because of being tied together in bundle A.
The profit functions of both upstream firms under bundling are analogous to the ones under separate selling. The profit-maximizing input prices of the upstream firms under bundling are

$$c_1^{BL} = \frac{29a_1 + 5a_2 + 25k}{59}, \tag{5.27}$$

$$c_2^{BL} = \frac{3a_1 + 29a_2 + 27k}{59}. \tag{5.28}$$

Since the two separate goods are complements under bundling, a raise in the quality of either good and therefore in the customer valuation induces higher input prices. This means that $\frac{\partial c_1^{BL}}{\partial a_{1,2}} > 0$ and $\frac{\partial c_2^{BL}}{\partial a_{1,2}} > 0$.
Inserting the equilibrium input prices under separate selling and bundling into the residual entities generates Lemma 5.1 below. Note that $b_B^{BL} > 0$ only holds for $a_2 > \frac{36a_1+29k}{65}$ and $p_B^{BL} > 0$ only for $a_2 > \frac{15a_1-160k}{268}$, where $\frac{36a_1+29k}{65} > \frac{15a_1-160k}{268}$. We therefore impose the restriction $a_2 > \frac{36a_1+29k}{65} =: \underline{a}_2^S$ in the following. The assumptions $a_1 > k$ and $a_2 > \underline{a}_2^S$, where $\underline{a}_2^S > k$, ensure non-negativity for all equilibrium market magnitudes.
The differentiation of the goods in the duopoly reduces the intensity of the hard price competition between the downstream firms and therefore allows D_B to charge a price for bundle B above the input price of good 2. This enables, in turn, firm D_A to set a very high price for bundle A, which is clearly larger than the sum of input prices of both component products. Hence, the reduction in the intensity of competition induced by bundling has a positive impact on the profits of both downstream firms.

Lemma 5.1. *The equilibrium values under separate selling and bundling are as follows:*

	Separate Selling	**Bundling**
Profits Downstream Firms	$\pi^S_{D_A} = \frac{(a_1-k)^2}{16}$	$\pi^{BL}_{D_A} = \frac{9(29a_1+5a_2-34k)^2}{170569}$
	$\pi^S_{D_B} = 0$	$\pi^{BL}_{D_B} = \frac{2(-36a_1+65a_2-29k)^2}{170569}$
Profits Upstream Firms	$\pi^S_{U_1} = \frac{(a_1-k)^2}{8}$	$\pi^{BL}_{U_1} = \frac{3(29a_1+5a_2-34k)^2}{24367}$
	$\pi^S_{U_2} = \frac{(a_2-k)^2}{4}$	$\pi^{BL}_{U_2} = \frac{5(3a_1+29a_2-32k)^2}{24367}$
Input Prices	$c^S_1 = \frac{a_1+k}{2}$	$c^{BL}_1 = \frac{29a_1+5a_2+25k}{59}$
	$c^S_2 = \frac{a_2+k}{2}$	$c^{BL}_2 = \frac{3a_1+29a_2+27k}{59}$
Downstream Prices	$p^S_1 = \frac{3a_1+k}{4}$	$p^{BL}_A = \frac{311a_1+253a_2+262k}{413}$
	$p^S_2 = \frac{a_2+k}{2}$	$p^{BL}_B = \frac{-15a_1+268a_2+160k}{413}$
Quantities	$Q^S_1 = \frac{a_1-k}{4}$	$Q^{BL}_1 = \frac{3(29a_1+5a_2-34k)}{413}$
	$Q^S_2 = \frac{a_2-k}{2}$	$Q^{BL}_2 = \frac{5(3a_1+29a_2-32k)}{413}$
Downstream Quantities	$q^S_{A1} = \frac{a_1-k}{4}$	$b^{BL}_A = \frac{3(29a_1+5a_2-34k)}{413}$
	$q^S_{A2} = \frac{a_2-k}{4}$	
	$q^S_{B2} = \frac{a_2-k}{4}$	$b^{BL}_B = \frac{2(-36a_1+65a_2-29k)}{413}$

Proof. See Appendix 5.5.1 and 5.5.2. □

The observed reduction in the intensity of competition under price competition is in line with previous papers on the leverage theory, such as Carbajo et al. (1990); Egli (2007); Chung et al. (2013); Heinzel (2019). It is the effect that may make bundling profitable for D_A as illustrated in the next section.

5.2.4 Bundling Decision and Consequences of Bundling

In this section, we first show under which conditions bundling represents the equilibrium strategy for downstream firm D_A. Firm D_A bundles only when its profit in bundling is greater than its profit in separate selling, which we refer to as *profitable bundling.* More specifically, we first derive the constellations and degrees of product quality levels that ensure the existence of a bundling equilibrium. In the next step, we investigate the role of input prices regarding firm D_A's motivation for bundling. Then, we analyze how profitable bundling affects the market magnitudes, such as the prices and profits of other firms, in comparison to separate selling. Finally, we examine the influence of profitable bundling on social welfare.

Bundling Incentives

We assume $p_1^S > p_2^S$ and hereby follow the reasoning of Carbajo et al. (1990).[8] They argue that it is the goal of the firm's bundling strategy to raise the downstream price of good 2 in order to extract more consumer surplus from consumers who buy good 1 under separate selling. Given that firm D_A bundles, all consumers that want to consume good 1 can only receive it by purchasing the bundle. Finally, in order to obtain good 1, they would also be willing to pay a higher price for good 2. Considering $p_1^S > p_2^S$, we compare D_A's separate selling profit with its bundling profit and identify the quality levels of good 1 and good 2 under which bundling is D_A's preferred strategy. Proposition 5.1 summarizes our findings.

Proposition 5.1. *In the decentralized channel, downstream firm D_A prefers bundling over separate selling if the quality of good 2 is sufficiently large, i.e. if $a_2 \in \left(\underline{a}_2^{BL}, \overline{a}_2\right)$, where $\underline{a}_2^{BL} := \frac{13a_1-k}{12}$ and $\overline{a}_2 := \frac{3a_1-k}{2}$.*

Proof. See Appendix 5.5.5. □

The condition $p_1^S > p_2^S$ gives us $\overline{a}_2$ as the upper quality bound of good 2 for general and profitable bundling (depicted by the blue dashed line in Figure 5.4). Taking into account our general boundaries $\underline{a}_2^S < a_2 < \overline{a}_2$, we find that bundling is more beneficial for firm D_A than separate selling when the quality of good 2 is sufficiently high, i.e. larger than $\underline{a}_2^{BL}$. This lower bound of the *profitable bundling interval* is displayed by the red dashed line in Figure 5.4 and the profitable bundling interval itself by the blue shaded area in Figure 5.4. In contrast, when $\underline{a}_2^S < a_2 < \underline{a}_2^{BL}$ (green shaded area in Figure 5.4), downstream firm D_A prefers to offer its products separately.
Moreover, Proposition 5.1 implies that within the profitable bundling interval it always holds that the quality of good 2 exceeds the quality of good 1 ($a_2 > a_1$).[9] This leads to the following insight:

Corollary 5.1. *The quality of good 2 must be larger than the quality of good 1 for downstream firm D_A to prefer bundling over separate selling.*

Notice that $a_2 > a_1$ is a necessary but not sufficient condition for D_A to prefer bundling, since D_A's separate selling profit exceeds its bundling profit in the region $\underline{a}_2^S < a_2 < \underline{a}_2^{BL}$, in which $a_2 > a_1$ can hold too (compare Figure 5.4). However, the reverse holds true as $a_2 < a_1$ implies $\pi_{D_A}^S > \pi_{D_A}^{BL}$.

[8]Note that this assumption is not crucial for the existence of a bundling equilibrium in our framework.

[9]In Figure 5.4, the area below the black solid line (that displays $a_1 = a_2$) marks the area in which good 1 is of higher quality compared to good 2 ($a_1 > a_2$). The area above the black solid line marks the area in which good 2 is of higher quality compared to good 1 ($a_1 < a_2$). The regions above $\overline{a}_2$ and below $\underline{a}_2^S$ are excluded due to our assumptions.

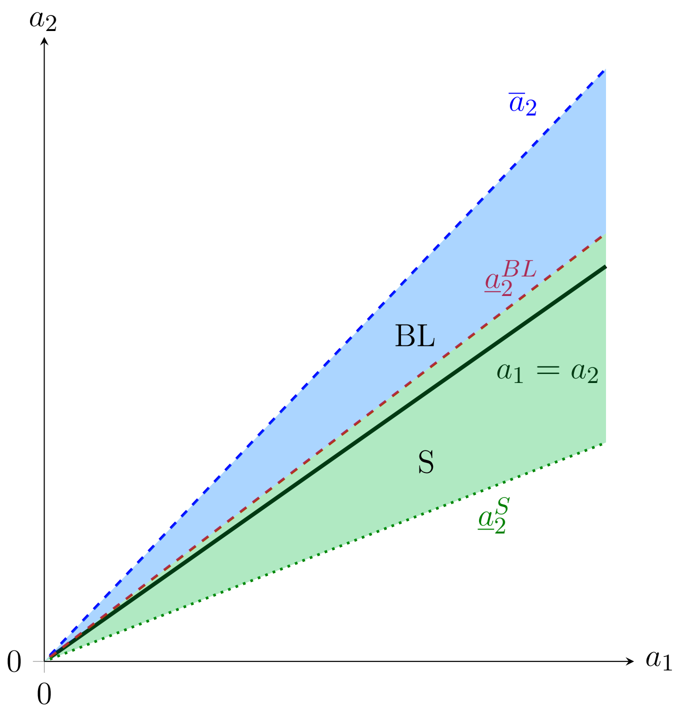

Figure 5.4: Separate Selling vs. Bundling (with $k = 0$)

The intuition behind Proposition 5.1 and Corollary 5.1 is as follows. In separate selling, changes in the quality of good 2 do not affect D_A's profit $\left(\frac{\partial \pi_{D_A}^S}{\partial a_2} = 0\right)$. This is because of two reasons: for one thing, the downstream price of good 2 is equal to its input price due to the intense price competition between the downstream firms in this market. For another thing, the standalone goods are independent in demand. Contrary to that, a higher quality of good 1 positively affects D_A's separate selling profit $\left(\frac{\partial \pi_{D_A}^S}{\partial a_1} > 0\right)$. This is because firm D_A charges the monopoly price of good 1 under separate selling and a higher customer's valuation for good 1 – thus a higher a_1 – allows firm D_A to set an even higher monopoly price $\left(\frac{\partial p_1^S}{\partial a_1} > 0\right)$.

Now consider the bundling setting. The differentiation of goods in the duopoly and the subsequent reduction in the degree of downstream competition clearly raises firm D_A's incentives to bundle, as already indicated above. In addition, downstream firm D_A is able to extend the monopoly power it has in the market for good 1 to the second product market by bundling: it charges a higher price for bundle A than the sum of input prices and the sum of the prices it charges for the standalone goods under separate selling. Aside from those general implications of bundling for the pricing behavior, we find the following when focusing on the impact of the quality levels: an increase in the quality of good 2 makes firm D_A charge an even higher price for bundle A $\left(\frac{\partial p_A^{BL}}{\partial a_2} > 0\right)$. It follows from the softened competition that this quality increase of good 2 and the consequential

price (and quantity) increase raise D_A's bundling profit $\left(\frac{\partial \pi_{D_A}^{BL}}{\partial a_2} > 0\right)$.
To sum up, a lower quality of good 1 makes the separate selling strategy less attractive for downstream firm D_A while a higher quality of good 2 makes the bundling strategy more attractive for D_A. As a consequence, when the quality of good 2 is sufficiently large such that it also exceeds the quality of good 1, D_A's bundling profit exceeds its separate selling profit and therefore D_A prefers to bundle.
We study next how the input prices c_1 and c_2 are affected by downstream firm D_A's selling strategy to identify the influence of the price setting behavior of the upstream firms on D_A's bundling incentives. We find in general that the price setting reaction of the upstream firms to D_A's bundling strategy mitigates the attractiveness of bundling:

Proposition 5.2. *When firm D_A's bundles, then both upstream firms raise their input prices.*

Proof. See Appendix 5.5.6. □

The intuition behind the increase of input prices is as follows. Both upstream firms want to benefit from D_A's bundling strategy. The two standalone goods become complementary inputs due to bundling, which increases the need for both goods. Furthermore, since bundle A consists of the goods of both upstream firms, an increase in the input price of good 1 only partially impacts U_1's sales. By contrast, a raise in the input price of good 2 lowers the quantities of both bundles. However, in separate selling, a raise of the input price of good 2 has a rather strong negative effect on the downstream demand (and consequently the input demand) for good 2, due to good 2 being priced at its input price in the downstream market. Under bundling, this negative impact of a raised input price of good 2 on its sales is weakened since the bundle prices are set above input prices. Ultimately, the described effects induce both upstream firms to raise their prices.
We draw the conclusion that bundling aggravates the double marginalization problem between downstream firm D_A and the upstream firms. First, in the separate selling market, there is only double marginalization in the supply chain of the bilateral monopoly regarding good 1 (as $p_2^S = c_2^S$ in the second product market), whereas in the bundling market double marginalization emerges with respect to both bundles. In addition, the sum of the two input prices with bundling is greater than without bundling, which directly affects D_A as it sets a bundling price above the sum of the input prices. Finally, the double marginalization problem is worsened for D_A and for the whole channel. This effect might lead to a bundle price higher than optimal for D_A and consequently to too little bundle sales. Thus, the upstream firms' price setting reaction to bundling weakens the incentives for downstream bundling.
Nevertheless, we observe that despite an increase in both input prices and consequently a relatively heavy DM problem, it might be more profitable for firm D_A to bundle than

to sell the goods separately, depending on the product qualities. This means that the positive influences of bundling on D_A's profit, such as a lower degree of competition and the extension of market power, outweigh the negative influence in the form of an exacerbated double marginalization problem given the right constellation of qualities. We discuss the impact of double marginalization on bundling in more detail in Section 5.3 where we abstract from vertical externalities.

Consequences of Profitable Bundling

In this section, we investigate the consequences of bundling in the equilibrium, which implies that bundling is profitable for D_A. We refer to D_A's equilibrium bundling strategy in this section as 'profitable bundling' and 'bundling' synonymously.

Overall, the downstream industry benefits from the bundling strategy of the two-product downstream firm D_A. Not only the profit of D_A but also the profit of downstream firm D_B increases by bundling. Whereas D_B gains a profit of zero in separate selling, in the bundling equilibrium it gains a positive profit, due to the bundles being differentiated. The differentiation, the softened competition and the raised input price of good 2 result in higher downstream prices set by D_B and D_A, which yields a decrease in the downstream quantity of each downstream firm regarding good 2. Therefore, the total quantity of good 2 falls. In contrast to that, firm D_A's quantity and hence the total quantity of good 1 rises due to bundling. This can be explained by the fact that good 1 is in the bundle tied with a product of higher quality and more intense competition. Consequently, not only consumers with a high reservation price for the standalone good 1 but also consumers with a relatively high valuation for good 2 are willing to buy the bundle despite the increase in downstream prices.

As one unit of input represents one unit of output, we can directly derive the impact of bundling on the upstream quantities from the impact of bundling on the downstream quantities. The divergence in the influence of bundling on the upstream quantities leads to a consequential divergence in the influence of bundling on the profits of the upstream firms as depicted by

Proposition 5.3. *Profitable bundling leads to*

- *an increase in upstream firm U_1's profit,*
- *a decrease in upstream firm U_2's profit.*

Proof. See Appendix 5.5.7. □

Upstream firm U_1 sells a higher quantity at a higher price and hence its profit rises due to bundling. Contrary to that, U_2's profit is diminished by bundling even though U_2 raises its price as well. This illustrates that for U_2 raising its price is rather detrimental.

The softening in downstream competition and subsequent aggravation of the DM problem caused by the increase in input prices results in too low sales for U_2. Therefore, profitable bundling lowers U_2's profit.

We now turn to the welfare analysis of bundling. The producer surplus PS is defined as the sum of profits of the two upstream and two downstream firms. Total welfare W is given by the sum of the consumer surplus CS and the producer surplus PS. Lemma 5.2 summarizes the welfare results for the decentralized channel.

Lemma 5.2. *The welfare results for bundling and separate selling are as follows:*

Producer Surplus	$PS^S = \frac{7k^2-8a_2k-6a_1k+4a_2^2+3a_1^2}{16}$ $PS^{BL} = \frac{72202k^2-82700a_2k-61704a_1k+38635a_2^2+5430a_1a_2+28137a_1^2}{170569}$
Consumer Surplus	$CS^S = \frac{5k^2-8a_2k-2a_1k+4a_2^2+a_1^2}{32}$ $CS^{BL} = \frac{18002k^2-24730a_2k-11274a_1k+10625a_2^2+3480a_1a_2+3897a_1^2}{170569}$
Welfare	$W^S = \frac{19k^2-24a_2k-14a_1k+12a_2^2+7a_1^2}{32}$ $W^{BL} = \frac{3\left(30068k^2-35810a_2k-24326a_1k+16420a_2^2+2970a_1a_2+10678a_1^2\right)}{170569}$

Proof. See Appendix 5.5.1 and 5.5.2. □

By comparing the welfare results in Lemma 5.2, we find downstream bundling to be welfare harming in the decentralized channel as stated by

Proposition 5.4. *Profitable bundling results in*

- *a decrease in consumer surplus,*
- *a decrease in producer surplus,*
- *a decrease in total welfare.*

Proof. See Appendix 5.5.8. □

This reduction of consumer and total welfare induced by bundling has been observed in other parts of the existing bundling literature as well (see e.g. Martin, 1999). The intuition for the decrease in consumer surplus is straightforward. Both downstream firms raise their prices and this causes the consumer surplus to fall. The reduction in producer surplus is, however, somewhat surprising. The profits of both downstream firms as well as the profit of upstream firm U_1 are raised by bundling. Yet, the overall industry profit falls. This means that the decrease in upstream firm U_2's profit outweighs the total

increase in profits of the three residual firms. As a consequence, total welfare always diminishes when the two-product downstream firm D_A bundles in equilibrium.
In the next section, we study a centralized channel which we compare with the decentralized channel. The comparison between the two channels provides additional insights about the interplay of downstream bundling and the distribution of market power in a vertical channel.

5.3 Centralized Channel

5.3.1 Basics of the Model

In the centralized channel (this case is denoted by a *Tilde*), the regarded market has the same structure as the decentralized market, but the full market power lies with the downstream industry, resulting in the upstream firms being *price-takers*. This scenario also applies partly to the streaming service market. There are some productions as, for instance, *13 Reasons Why* (Netflix, 2018), which are produced by Netflix itself or whose production process Netflix controls. The centralized channel allows us to investigate the bundling incentives, the impact of the products' quality levels on market outcomes, and the welfare effects of bundling without double marginalization. Thus, it allows us to exclude double marginalization as a factor influencing the bundling decision.
Note that except for the distribution of market power in the channel and some specific assumptions about the qualities (see below), all assumptions remain the same as in the decentralized case. The optimization problems of the downstream firms are analogous to the respective ones in the decentralized channel. The timing is now as follows: at first, firm D_A decides on bundling, then both downstream firms decide on the input prices and finally set the downstream prices. Our approach for studying the centralized channel is the same as for the decentralized channel.
Since the two downstream firms have full the market power, they set the input prices equal to the upstream firms' marginal costs of production for both goods to keep their input costs as low as possible. Hence, we have in equilibrium $\tilde{c}_1^i = \tilde{c}_2^i = k$, where $i \in \{S, BL\}$. Consequently, the equilibrium price of good 1 under separate selling is given by $\tilde{p}_1^S = \frac{\tilde{a}_1+k}{2}$ and the equilibrium price of good 2 by $\tilde{p}_2^S = k$. Notice that we have $\tilde{b}_B^{BL} > 0$ for $\tilde{a}_2 > \frac{\tilde{a}_1+k}{2} =: \underline{\tilde{a}}_2$ and $\tilde{p}_B^{BL} > 0$ for $\tilde{a}_2 > \frac{\tilde{a}_1-6k}{2}$, where $\underline{\tilde{a}}_2 > \frac{\tilde{a}_1-6k}{2}$. Therefore, we assume $\tilde{a}_1 > k$ and $\tilde{a}_2 > \underline{\tilde{a}}_2$, where $\underline{\tilde{a}}_2 > k$, for the centralized channel which ensures non-negativity for all market entities. Again, $\tilde{p}_1^S > \tilde{p}_2^S$ must hold as a precondition for a bundling equilibrium, which is here always satisfied due to the assumption $\tilde{a}_1 > k$. An overview of all market results for the centralized case can be found in Appendix 5.5.3.

5.3.2 Analysis

Bundling Incentives

Comparing firm D_A's profit under bundling and separate selling generates Proposition 5.5, which is graphically displayed by Figure 5.5.[10]

Proposition 5.5. *In the centralized channel, downstream firm D_A always prefers bundling over separate selling.*

Proof. See Appendix 5.5.9. □

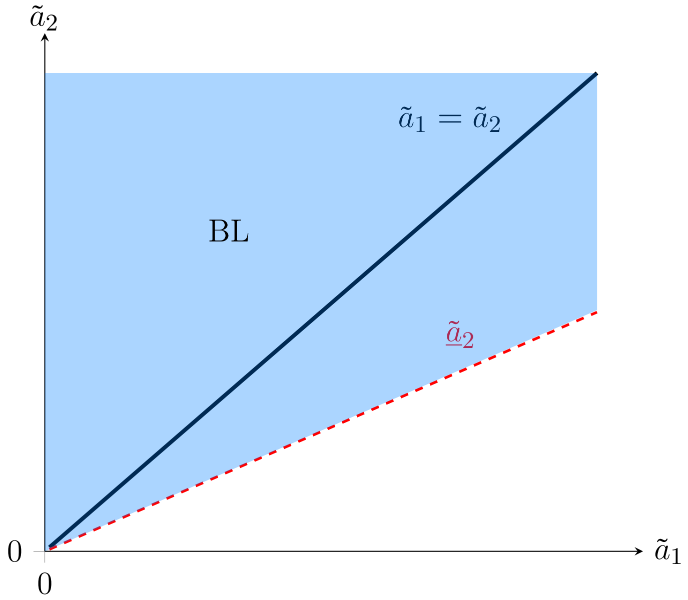

Figure 5.5: Centralized channel: Separate Selling vs. Bundling (with $k = 0$)

Consequently, if the downstream firms have the full market power in the channel, bundling always generates a greater profit for D_A than selling its goods separately opposed to the decentralized case. Proposition 5.5 implies that in the centralized channel it is not a necessary condition that good 2 is of higher quality than good 1 for bundling to be profitable (compare Figure 5.5), which is in contrast to the decentralized channel. In addition, bundling is profitable at a lower quality level of good 2 than in the decentralized channel because of $\underline{\tilde{a}}_2 < \underline{a}_2^{BL}$, where $\underline{a}_2^{BL}$ is the lower bound of the profitable bundling interval in the decentralized channel. This lower bound is greater than the lower bound in the centralized channel for profitable bundling. Analogous to the decentralized channel, a higher quality of good 2 means a higher bundling profit for D_A since it allows for a higher bundle price but has no impact on D_A's separate selling profit, whereas a higher

[10] There is only a blue shaded area in Figure 5.5 as bundling is always profitable. The area below the red dashed line ($\underline{\tilde{a}}_2$) in the figure is excluded by our assumptions.

quality of good 1 raises D_A's separate selling profit. Nevertheless, even when $\tilde{a}_1 > \tilde{a}_2$, bundling is more profitable for D_A than pricing the goods independently. We conclude from our findings that D_A's bundling incentives are stronger in the centralized channel than in the decentralized channel.

The intuition behind this result is as follows. In the centralized channel, there is no double marginalization for either one of the downstream firms and thus no aggravation of a DM problem by bundling. Therefore, the effects of a softened competition and the extension of D_A's monopoly power, which we observe in either type of channel, have such a strong positive impact on D_A's bundling profit in the centralized channel that bundling is always profitable. However, it is not only the perspective of gaining a share of D_A's additional bundling profit that drives the upstream firms to raise their prices in the decentralized channel, which exarcebates the double marginalization problem for D_A and the whole channel. The horizontal externalities between the upstream firms play a pivotal role as well, which is in line with Bhargava (2012) and Heinzel (2019).

To illustrate this insight, consider the following change in the decentralized model: in order to exclude the horizontal externalities upstream, we analyze the case where the powerful upstream firms merge to a *multi-product upstream monopoly*, where we assume again $p_1^S > p_2^S$.[11] As a consequence, we have one powerful upstream firm U producing both goods and selling good 1 only to firm D_A and good 2 to both downstream firms. Upstream firm U sets its input prices in the bundling case exactly as in the separate selling case, i.e. $c_1^i = \frac{a_1+k}{2}$ and $c_2^i = \frac{a_2+k}{2}$. Hence, the input prices in the multi-product upstream monopoly are independent of the two-product downstream firm's selling strategy choice. This is because the multi-product upstream monopolist internalizes the demand externalities between the two goods, which represent complementary inputs under bundling. Regarding the bundling incentives in the multi-product upstream monopoly, we find that downstream firm D_A always prefers bundling over separate selling regardless of the quality relations of the goods, like in the centralized channel. Even though there is a DM problem concerning good 1 for D_A, it is not aggravated by bundling. Double marginalization in the market for good 2 is again created by bundling, but only to D_A's benefit since it can set higher prices under bundling and has to bear the same costs as with separate selling. In conclusion, aside from the structure of the decentralized channel with powerful upstream firms, we identify also the horizontal externalities between the independently operating upstream firms as a pivotal factor for the worsened DM problem.

Consequences of Profitable Bundling

We now analyze the equilibrium effects of profitable bundling. As it turns out, bundling is always profitable so that we use the terms 'bundling' and 'profitable bundling' again

[11] This assumption does not affect our insights about the bundling incentives for this case. Exact values for the multi-product upstream monopoly case can be found in Appendix 5.5.4.

as synonyms in this section. As in the decentralized channel, the softened competition in the downstream duopoly due to bundling leads to an increase in downstream prices. In particular, the price of bundle A is higher than the added prices of the standalone goods and the price of bundle B is higher than the input/standalone price of good 2. Therefore, even without double marginalization and thus without aggravating a DM problem, bundling raises the final market prices. Additionally, bundling induces again a positive profit for firm D_B, in comparison to a zero profit under separate selling.
Moreover, bundling may either reduce the output levels of both downstream firms in the market for good 2 or raise the output of one firm but lower the competitor's output. This means that D_A might help its competitor to strengthen its relative market position by bundling. Nevertheless, firm D_A would prefer to bundle because of the consequential raise in its own profit. Furthermore, the total quantity of good 2 is always lowered due to profitable bundling, whereas the total quantity of good 1 is always raised. The former clearly follows from the softening in competition in the duopoly and the latter from good 1 being sold together in a bundle with good 2, as in the decentralized channel. Notably, the quantity of good 1 rises even when good 2 has a lower quality level than good 1.
Turning to the welfare analysis of bundling, we find the following:

Proposition 5.6. *In the centralized channel, profitable bundling results in*

- *a decrease in consumer surplus,*
- *an increase in producer surplus,*
- *an increase in total welfare if* $\tilde{a}_2 \in \left(\underline{\tilde{a}}_2, \frac{19\tilde{a}_1 - 9k}{10}\right)$ *and a decrease in total welfare if* $\tilde{a}_2 > \frac{19\tilde{a}_1 - 9k}{10}$.

Proof. See Appendix 5.5.10. □

As in the decentralized channel, bundling diminishes the consumer surplus because it increases the prices of the final goods. Yet, the consumers partly benefit from the centralized market structure since they pay lower prices for the bundles than in the decentralized channel, due to the lack of double marginalization.[12] In contrast to the decentralized channel, the producer surplus increases since the profits of both downstream firms rise because of bundling, while both upstream firms earn zero profits independent of D_A's selling strategy. This rise in producer surplus is larger than the loss in consumer surplus if $\tilde{a}_2 \in \left(\underline{\tilde{a}}_2, \frac{19\tilde{a}_1 - 9k}{10}\right)$. Thereby, bundling raises social welfare for a sufficiently low quality of good 2. By contrast, when the quality of good 2 is sufficiently large, i.e. $\tilde{a}_2 > \frac{19\tilde{a}_1 - 9k}{10}$,

[12]The price of bundle A (bundle B) is smaller in the centralized channel than its counterpart in the decentralized channel for $a_2 > \frac{-67a_1 + 164k}{97}$ ($a_2 > \frac{-22a_1 + 97k}{75}$) which is always satisfied because of $k > \frac{-67a_1 + 164k}{97}, \frac{-22a_1 + 97k}{75}$.

then the loss in consumer surplus is greater than the rise in producer surplus and thus bundling diminishes social welfare like in the decentralized channel.
The intuition behind our observations is as follows. An increase in $\tilde{a}_2$ raises the consumer surplus under bundling and under separate selling $\left(\frac{\partial \tilde{CS}^S}{\partial \tilde{a}_2}, \frac{\partial \tilde{CS}^{BL}}{\partial \tilde{a}_2} > 0\right)$ due to the raise in the reservation prices of the customers and therefore higher equilibrium quantities. This increase is greater under separate selling than under bundling $\left(\frac{\partial \tilde{CS}^S}{\partial \tilde{a}_2} > \frac{\partial \tilde{CS}^{BL}}{\partial \tilde{a}_2}\right)$. Hence, a greater quality level of good 2 leads to even further diverging consumer surpluses under bundling and separate selling. The reason for this is that changes in the quality level of good 2 have no influence on the downstream prices under separate selling but a higher $\tilde{a}_2$ induces higher bundling prices $\left(\frac{\partial \tilde{p}_A^{BL}}{\partial \tilde{a}_2}, \frac{\partial \tilde{p}_B^{BL}}{\partial \tilde{a}_2} > 0\right)$. This has an additional negative impact on consumer surplus under bundling. As a consequence, for a sufficiently high quality level of good 2, the loss in consumer surplus is so great that it cannot be outweighed by the gain in producer surplus and, consequently, welfare falls. Note that the gain in producer surplus is even larger with a high $\tilde{a}_2$ as this means a larger producer surplus under bundling $\left(\frac{\partial \tilde{PS}^{BL}}{\partial \tilde{a}_2} > 0\right)$ due to higher downstream prices as well as downstream quantities and because $\tilde{a}_2$ does not affect the producer surplus under separate selling $\left(\frac{\partial \tilde{PS}^S}{\partial \tilde{a}_2} = 0\right)$. Yet, the gain cannot offset the great loss in consumer surplus.

5.4 Conclusion

In this paper, we study the impact of heterogeneous product qualities on a downstream firm's bundling decision in a distribution channel. We consider the downstream market to be of a common leverage theory market structure and the upstream producers to be powerful monopolists. In the downstream market, there is a two-product firm that is a monopolist in one product market but competes in prices with another downstream firm in the second market. We analyze the incentives of the two-product downstream firm to chose pure bundling as a selling strategy. Additionally, we investigate the impact of profitable bundling on the market outcomes, especially on welfare outcomes. Furthermore, we examine the role of product qualities as well as the distribution of market power in the channel regarding the consequences of bundling. We consider a centralized channel where the downstream firms have the full market power as a reference case.
We find that bundling is profitable for the two-product downstream firm only when the quality of the product sold in the downstream duopoly (*good 2*) is sufficiently high such that it also exceeds the quality of the product sold in the downstream market exclusively by the two-product firm (*good 1*). This is because the two-product firm especially benefits from the positive effects of bundling on its profit in the form of a reduction in the intensity of downstream competition and an extension of its monopoly power if good 2 is of great quality. The reason for this is that a high quality implies that customers have a high valuation and thus a high willingness to pay for good 2, which allows for a high bundle

price. Therefore, bundling is profitable for the two-product downstream firm when the quality of good 2 is great despite an aggravation of the double marginalization problem for the downstream firm as a consequence of bundling.

In the centralized channel, bundling is always profitable for the two-product downstream firm independent of the quality levels of the goods. The stronger bundling incentives in the centralized compared to the decentralized case result from the lack of double marginalization in the centralized channel. However, when we assume that the upstream firms in the decentralized channel merge, bundling is again always profitable. This result illustrates that it is the combination of vertical externalities and horizontal externalities upstream that weakens the incentives for downstream bundling in a distribution channel, which is in line with Bhargava (2012) and Heinzel (2019).

Regarding social welfare, we find that in the decentralized channel bundling reduces consumer and producer surplus in the equilibrium. The consumer surplus is decreased because bundling induces both downstream firms to raise their prices. Interestingly, only the upstream firm selling to both downstream firms suffers from bundling because of the softening in downstream competition. This loss, however, is greater than the total gain of the other firms, which results in an overall decrease in producer surplus due to bundling. By contrast, bundling raises the producer surplus in the centralized channel since the profits of both downstream firms increase, while the upstream firms as price-takers gain zero profits in any case. The consumer surplus diminishes in the centralized channel because of higher downstream prices under bundling, where a high quality of good 2 exacerbates this negative impact due to even higher downstream prices. As consequence, bundling raises (reduces) social welfare in the centralized channel in case the quality of good 2 is sufficiently low (high).

Summing up, we show that separate selling may be the superior selling strategy in comparison to bundling for a downstream firm. More specifically, in our model a two-product downstream firm in a leverage theory set-up may prefer separate selling over bundling. This result is in contrast to some parts of the previous literature on the leverage theory and can be explained by the channel structure and the consideration of powerful upstream firms. In addition, we identify the quality levels of the traded goods as a deciding factor regarding the profitability of bundling in a decentralized channel with downstream competition. The welfare effects of downstream bundling are ambiguous and are affected by the product qualities and the distribution of market power in the channel.

We derive the following managerial and economic implications from our model. Our findings suggest that downstream firms like streaming services should always take the qualities of the traded products into account when deciding on bundling. Also, they indicate that the component goods in a bundle that are provided by other downstream firms as well should be of higher quality than the exclusively provided products. Otherwise, bundling might not be an effective strategy. Consequently, we demonstrate that

in some cases, unbundling could raise the profits of the streaming services when they procure content from powerful producers, even though bundling is a common strategy in the streaming service industry. Moreover, we highlight that downstream bundling should not be free of antitrust concerns as it may have a negative impact on the market efficiency with respect to social welfare. Still, depending on the qualities of the goods, downstream bundling can also raise social welfare when the full market power in a distribution channel is with the downstream industry.
Our work provides a solid basis to connect future research to. One possibility would be to allow for mixed bundling, meaning the two-product downstream firm sells its goods bundled as well as separately. While the focus of the work would shift rather to finding the optimal selling strategy, shedding light on this issue within the scope of our market set-up surely could provide further important implications. Other research might be done regarding competition policy related issues, such as potential regulation methods for downstream bundling. The described extensions would allow for additional interesting research at the interface of management and economics.

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5.5 Appendix

5.5.1 Separate Selling

Equilibrium Conditions

As we have standard Bertrand competition assumptions in the market for good 2, the equilibrium downstream price of good 2 simply equals the input price of good 2. Moreover, D_A's profit is strictly concave in p_1 since $\frac{\partial^2 \pi_{D_A}}{\partial p_1^2} = -2 < 0$ and therefore the second-order condition (SOC) for a (global) maximum is always satisfied. The profit-maximizing monopoly downstream price of good 1 that D_A charges is determined by the first-order condition (FOC)

$$\frac{\partial \pi_{D_A}}{\partial p_1} = a_1 - 2p_1 + c_1 \stackrel{!}{=} 0. \tag{5.29}$$

Solving the FOC for p_1 generates the monopoly price.

In the upstream market, the profits of U_1 and U_2 are strictly concave in c_1 and c_2, respectively, since $\frac{d^2\pi_{U_1}}{dc_1^2} = -1 < 0$ and $\frac{d^2\pi_{U_2}}{dc_2^2} = -2 < 0$. The FOCs regarding the optimal input prices for both upstream firms are given as

$$\frac{d\pi_{U_1}}{dc_1} = \frac{a_1 - 2c_1 + k}{2} \stackrel{!}{=} 0, \tag{5.30}$$

$$\frac{d\pi_{U_2}}{dc_2} = a_2 - 2c_2 + k \stackrel{!}{=} 0. \tag{5.31}$$

Solving the FOCs for c_1 and c_2, respectively, gives us the equilibrium input prices c_1^S and c_2^S under separate selling.

Welfare

The producer surplus is the sum of profits of all firms such that

$$\begin{aligned} PS^S &= \pi_{D_A}^S + \pi_{D_B}^S + \pi_{U_1}^S + \pi_{U_2}^S \\ &= \frac{7k^2 - 8a_2k - 6a_1k + 4a_2^2 + 3a_1^2}{16}. \end{aligned} \tag{5.32}$$

The consumer surplus for good 1 and good 2, respectively, is given by

$$CS_1^S = \frac{a_1 - p_1^S}{2} Q_1^S = \frac{(a_1 - k)^2}{32}, \tag{5.33}$$

$$CS_2^S = \frac{a_2 - p_2^S}{2} Q_2^S = \frac{(a_2 - k)^2}{8}. \tag{5.34}$$

Thus, total consumer surplus is

$$\begin{aligned} CS^S &= CS_1^S + CS_2^S \\ &= \frac{5k^2 - 8a_2k - 2a_1k + 4a_2^2 + a_1^2}{32}. \end{aligned} \tag{5.35}$$

Finally, total welfare is

$$\begin{aligned} W^S &= PS^S + CS^S \\ &= \frac{19k^2 - 24a_2k - 14a_1k + 12a_2^2 + 7a_1^2}{32}. \end{aligned} \tag{5.36}$$

5.5.2 Bundling

Equilibrium Conditions

Under bundling, we have $\frac{\partial^2 \pi_{D_A}}{\partial p_A^2} = -2 < 0$ and $\frac{\partial^2 \pi_{D_B}}{\partial p_B^2} = -4 < 0$ in the downstream market. The FOCs of the downstream firms with respect to the optimal downstream price for bundle A, respectively, bundle B are

$$\frac{\partial \pi_{D_A}}{\partial p_A} = p_B - 2p_A + a_1 + c_1 + c_2 \stackrel{!}{=} 0, \tag{5.37}$$

$$\frac{\partial \pi_{D_B}}{\partial p_B} = -4p_B + p_A + a_2 - a_1 + 2c_2 \stackrel{!}{=} 0. \tag{5.38}$$

From the FOCs we can derive the reaction functions of the downstream firms concerning their equilibrium prices as

$$p_A(p_B) = \frac{a_1 + c_1 + c_2 + p_B}{2}, \tag{5.39}$$

$$p_B(p_A) = \frac{a_2 - a_1 + 2c_2 + p_A}{4}. \tag{5.40}$$

The intersection of the two reaction functions generates the equilibrium prices of the two bundles.

In the upstream market, we have $\frac{\partial^2 \pi_{U_1}}{\partial c_1^2} = -\frac{6}{7} < 0$ and $\frac{\partial^2 \pi_{U_2}}{\partial c_2^2} = -\frac{10}{7} < 0$. The FOCs that determine the profit-maximizing input prices for the upstream firms are

$$\frac{\partial \pi_{U_1}}{\partial c_1} = \frac{3a_1 + a_2 - 6c_1 - c_2 + 3k}{7} \stackrel{!}{=} 0, \tag{5.41}$$

$$\frac{\partial \pi_{U_2}}{\partial c_2} = \frac{a_1 + 5a_2 - c_1 - 10c_2 + 5k}{7} \stackrel{!}{=} 0. \tag{5.42}$$

Solving the FOCs for c_1 and c_2, respectively, provides the reaction functions of the upstream firms regarding their optimal prices. We get

$$c_1(c_2) = \frac{3a_1 + a_2 - c_2 + 3k}{6}, \tag{5.43}$$

$$c_2(c_1) = \frac{5a_2 + a_1 + 5k - c_1}{10}. \tag{5.44}$$

The intersection of the two reaction functions generates the equilibrium input prices c_1^{BL} and c_2^{BL}.

Welfare

The producer surplus under bundling is described by

$$\begin{aligned}PS^{BL} &= \pi_{D_A}^{BL} + \pi_{D_B}^{BL} + \pi_{U_1}^{BL} + \pi_{U_2}^{BL} \\ &= \frac{72202k^2 - 82700a_2k - 61704a_1k + 38635a_2^2 + 5430a_1\,a_2 + 28137a_1^2}{170569}.\end{aligned} \tag{5.45}$$

The consumer surplus for bundle A and bundle B, respectively, is given by

$$CS_A^{BL} = \frac{a_1 + a_2 - p_A^{BL}}{2} b_A^{BL} = \frac{3(-5a_2 - 29a_1 + 34k)(-51a_1 - 80a_2 + 131k)}{170569}, \tag{5.46}$$

$$CS_B^{BL} = \frac{a_2 - p_B^{BL}}{2} b_B^{BL} = \frac{5(36a_1 - 65a_2 + 29k)(-3a_1 - 29a_2 + 32k)}{170569}. \tag{5.47}$$

Hence, the total consumer surplus is

$$\begin{aligned}CS^{BL} &= CS_A^{BL} + CS_B^{BL} \\ &= \frac{18002k^2 - 24730a_2k - 11274a_1k + 10625a_2^2 + 3480a_1a_2 + 3897a_1^2}{170569}.\end{aligned} \tag{5.48}$$

Consequently, total welfare in the bundling market amounts to

$$\begin{aligned}W^{BL} &= PS^{BL} + CS^{BL} \\ &= \frac{3\left(30068k^2 - 35810a_2k - 24326a_1k + 16420a_2^2 + 2970a_1a_2 + 10678a_1^2\right)}{170569}.\end{aligned} \tag{5.49}$$

Comparisons for the Decentralized Channel

- We have $\Delta p_A = p_1^S + p_2^S - p_A^{BL} = \frac{191k-186a_2-5a_1}{1652} < 0$ for $a_2 > \frac{191k-5a_1}{186}$, which is clearly fulfilled because of $a_2 > k > \frac{191k-5a_1}{186}$. Hence, the price of bundle A is larger than the sum of the prices of the standalone goods in any case.

- We get $\Delta q_{A2} = q_{A2}^S - b_A^{BL} = \frac{353a_2-348a_1+5k}{1652} > 0$ if $a_2 > \frac{348a_1+5k}{353}$. This condition is always satisfied under profitable bundling since $\underline{a}_2^{BL} > \frac{348a_1+5k}{353}$. That is, D_A's quantity of good 2 always decreases due to bundling in the equilibrium.

- We obtain $\Delta q_{B2} = q_{B2}^S - b_B^{BL} = \frac{288a_1-107a_2-181k}{1652} > 0$ if $a_2 < \frac{288a_1-181k}{107}$, which is always met in the profitable bundling interval since $\overline{a}_2 < \frac{288a_1-181k}{107}$. Therefore, profitable bundling reduces firm D_B's supplied quantity. Together with the previous point, this shows that profitable bundling reduces the total quantity of good 2.

- We have $\Delta Q_1 = Q_1^S - b_A^{BL} = \frac{5(13a_1-12a_2-k)}{1652} < 0$ when $a_2 > \underline{a}_2^{BL}$, which is obviously satisfied under profitable bundling. In conclusion, downstream firm D_A's quantity of good 1 is raised by profitable bundling.

5.5.3 Centralized Channel

The full market power is with the downstream firms in the centralized case. The optimization problems of the downstream firms are analogous to the ones in the decentralized channel (Appendix 5.5.1). The same holds for the welfare calculations. Hence, we simply set $\tilde{c}_1^S = \tilde{c}_1^{BL} = k$ and $\tilde{c}_2^S = \tilde{c}_2^{BL} = k$ and substitute the input prices into the relevant market entities. Tables 5.1 and 5.2 provide the market results in the centralized case.

	Separate Selling	**Bundling**
Profits Downstream Firms	$\tilde{\pi}_{D_A}^S = \frac{(\tilde{a}_1-k)^2}{4}$	$\tilde{\pi}_{D_A}^{BL} = \frac{(3\tilde{a}_1+\tilde{a}_2-4k)^2}{49}$
	$\tilde{\pi}_{D_B}^S = 0$	$\tilde{\pi}_{D_B}^{BL} = \frac{2(2\tilde{a}_2-\tilde{a}_1-k)^2}{49}$
Profits Upstream Firms	$\tilde{\pi}_{U_1}^S = 0$	$\tilde{\pi}_{U_1}^{BL} = 0$
	$\tilde{\pi}_{U_2}^S = 0$	$\tilde{\pi}_{U_2}^{BL} = 0$
Input Prices	$\tilde{c}_1^S = k$	$\tilde{c}_1^{BL} = k$
	$\tilde{c}_2^S = k$	$\tilde{c}_2^{BL} = k$
Downstream Prices	$\tilde{p}_1^S = \frac{\tilde{a}_1+k}{2}$	$\tilde{p}_A^{BL} = \frac{3\tilde{a}_1+\tilde{a}_2+10k}{7}$
	$\tilde{p}_2^S = k$	$\tilde{p}_B^{BL} = \frac{-\tilde{a}_1+2\tilde{a}_2+6k}{7}$
Quantities	$\tilde{Q}_1^S = \frac{\tilde{a}_1-k}{2}$	$\tilde{Q}_1^{BL} = \frac{3\tilde{a}_1+\tilde{a}_2-4k}{7}$
	$\tilde{Q}_2^S = \tilde{a}_2 - k$	$\tilde{Q}_2^{BL} = \frac{\tilde{a}_1+5\tilde{a}_2-6k}{7}$
Downstream Quantities	$\tilde{q}_{A1}^S = \frac{\tilde{a}_1-k}{2}$	$\tilde{b}_A^{BL} = \frac{3\tilde{a}_1+\tilde{a}_2-4k}{7}$
	$\tilde{q}_{A2}^S = \frac{\tilde{a}_2-k}{2}$	
	$\tilde{q}_{B2}^S = \frac{\tilde{a}_2-k}{2}$	$\tilde{b}_B^{BL} = \frac{2(-\tilde{a}_1+2\tilde{a}_2-k)}{7}$

Table 5.1: Centralized channel: equilibrium values

Producer Surplus	$\tilde{PS}^S = \frac{(\tilde{a}_1-k)^2}{4}$
	$\tilde{PS}^{BL} = \frac{18k^2-16\tilde{a}_2k-20\tilde{a}_1k+9\tilde{a}_2^2-2\tilde{a}_1\tilde{a}_2+11\tilde{a}_1^2}{49}$
Consumer Surplus	$\tilde{CS}^S = \frac{5k^2-8\tilde{a}_2k-2\tilde{a}_1k+4\tilde{a}_2^2+\tilde{a}_1^2}{8}$
	$\tilde{CS}^{BL} = \frac{26k^2-34\tilde{a}_2k-18\tilde{a}_1k+13\tilde{a}_2^2+8\tilde{a}_1\tilde{a}_2+5\tilde{a}_1^2}{49}$
Welfare	$\tilde{W}^S = \frac{7k^2-8\tilde{a}_2k-6\tilde{a}_1k+4\tilde{a}_2^2+3\tilde{a}_1^2}{8}$
	$\tilde{W}^{BL} = \frac{44k^2-50\tilde{a}_2k-38\tilde{a}_1k+22\tilde{a}_2^2+6\tilde{a}_1\tilde{a}_2+16\tilde{a}_1^2}{49}$

Table 5.2: Centralized channel: welfare outcomes

Comparisons for the Centralized Channel

- We obtain $\Delta\tilde{q}_{A2} = \tilde{q}_{A2}^{S} - \tilde{b}_{A}^{BL} = \frac{6\tilde{a}_1+5\tilde{a}_2+k}{14} < 0$ for $\tilde{a}_2 < \frac{6\tilde{a}_1-k}{5}$. We observe that $\underline{\tilde{a}}_2 < \frac{6\tilde{a}_1-k}{5}$. Hence, firm D_A's quantity of good 2 may rise due to bundling. Moreover, $\Delta\tilde{q}_{B2} = \tilde{q}_{B2}^{S} - \tilde{b}_{B}^{BL} = \frac{4\tilde{a}_1-\tilde{a}_2-3k}{14} < 0$ holds when $\tilde{a}_2 > 4\tilde{a}_1 - 3k$. We have $\underline{\tilde{a}}_2 < 4\tilde{a}_1 - 3k$. Thus, firm D_B's quantity of good 2 may increase as well due to bundling. However, as $4\tilde{a}_1 - 3k > \frac{6\tilde{a}_1-k}{5}$, we can rule out a situation where the quantities of good 2 of both firms increase in the bundling equilibrium. In contrast, when $4\tilde{a}_1 - 3k > \tilde{a}_2 > \frac{6\tilde{a}_1-k}{5}$, the quantities of both firms regarding good 2 fall.

- We have $\Delta\tilde{Q}_2 = \tilde{Q}_2^{S} - \tilde{Q}_2^{BL} = \frac{-\tilde{a}_1+2\tilde{a}_2-k}{7} > 0$ for $\tilde{a}_2 > \underline{\tilde{a}}_2$. Clearly, the total quantity of good 2 diminishes as a consequence of bundling.

- It holds that $\Delta\tilde{Q}_1 = \tilde{Q}_1^{S} - \tilde{Q}_1^{BL} = \frac{\tilde{a}_1-2\tilde{a}_2+k}{14} < 0$ if $\tilde{a}_2 > \underline{\tilde{a}}_2$. Obviously, the supplied quantity of good 1 rises due to bundling.

- We have $\Delta\tilde{p}_A = \tilde{p}_1^{S} + \tilde{p}_2^{S} - \tilde{p}_A^{BL} = \frac{\tilde{a}_1-2\tilde{a}_2+k}{14} < 0$ for $\tilde{a}_2 > \underline{\tilde{a}}_2$. This means that the price of bundle A is clearly larger than the sum of the prices of the standalone goods.

- We obtain $\Delta\frac{\partial\tilde{CS}}{\partial\tilde{a}_2} = \frac{\partial\tilde{CS}^{S}}{\partial\tilde{a}_2} - \frac{\partial\tilde{CS}^{BL}}{\partial\tilde{a}_2} > 0$ when $\tilde{a}_2 > \frac{8\tilde{a}_1+15k}{23}$, which is always fulfilled because of $\tilde{a}_2 > \underline{\tilde{a}}_2 > \frac{8\tilde{a}_1+15k}{23}$.

Decentralized versus Centralized Channel

- We have $\Delta p_A^{VS} = \tilde{p}_A^{BL} - p_A^{BL} = \frac{2(-67a_1-97a_2+164k)}{413} < 0$ when $a_2 > \frac{-67a_1+164k}{97}$, which is always satisfied because $a_1 > k > \frac{-67a_1+164k}{97}$. We can conclude that the price of bundle A is always lower in the centralized channel than in the decentralized channel.

- We get $\Delta p_B^{VS} = \tilde{p}_B^{BL} - p_B^{BL} = \frac{2(-22a_1-75a_2+97k)}{413} < 0$ when $a_2 > \frac{-22a_1+97k}{75}$, which is satisfied because $a_1 > k > \frac{-22a_1+97k}{75}$. Thus, the price of bundle B is lower in the centralized channel than in the decentralized channel in any case.

5.5.4 Multi-Product Upstream Monopoly

Consider the case that both products, good 1 and good 2, are produced solely by one independent upstream firm, which is called firm U, in the decentralized channel.

Separate Selling

In separate selling, the multi-product upstream monopolist maximizes the following profit function:

$$\pi_U\left(c_1, c_2\right) = \left(c_1 - k\right) Q_1\left(c_1\right) + \left(c_2 - k\right) Q_2\left(c_2\right). \tag{5.50}$$

Both produced goods, good 1 and good 2, are independent in demand. Thereby, the profit is strictly concave in input prices and we derive the same FOCs as in the case with two independent upstream producers. Consequently, solving the optimization problem of the multi-product upstream firm leads to the same input prices as with two separate producers, i.e. $c_1^S = \frac{a_1+k}{2}$ and $c_2^S = \frac{a_2+k}{2}$.

Bundling

In case downstream firm D_A bundles its products, multi-product upstream monopoly firm U's profit function is analogous to under separate selling. We here have $\frac{\partial^2 \pi_U}{\partial c_1^2} = -\frac{6}{7}$ and $\frac{\partial^2 \pi_U}{\partial c_2^2} = -\frac{10}{7}$. The FOCs for U's equilibrium input prices read

$$\frac{\partial \pi_U}{\partial c_1} = \frac{3a_1 + a_2 + 4k - 6c_1 - 2c_2}{7} \stackrel{!}{=} 0, \tag{5.51}$$

$$\frac{\partial \pi_U}{\partial c_2} = \frac{a_1 + 5a_2 + 6k - 2c_1 - 10c_2}{7} \stackrel{!}{=} 0. \tag{5.52}$$

Solving the equation system of FOCs above for c_1 and c_2 leads to the optimal input prices, which are identical to the according input prices of the multi-product upstream monopolist in the separate selling case.

The Tables 5.3 and 5.4 provide an overview of the market results after inserting the optimal input prices for the separate selling case and the bundling case. We have $b_B > 0$ for $a_2 > \frac{a_1+k}{2}$ and $p_B > 0$ for $a_2 > \frac{a_1-6k}{9}$, where $\frac{a_1+k}{2} > \frac{a_1-6k}{9}$. We thus assume $a_1 > k$ and $a_2 > \frac{a_1+k}{2}$, where $\frac{a_1+k}{2} > k$, in the multi-product upstream monopoly case, which ensures non-negativity for all market parameters.

Bundling Decision

In the multi-product upstream monopoly setting, $p_1^S > p_2^S$ holds when $a_2 < \frac{3a_1-k}{2}$. Notice that $\frac{3a_1-k}{2} > \frac{a_1+k}{2}$. As a consequence, we restrict here the quality of good 2 from above by $\frac{3a_1-k}{2}$, which differs from the centralized case. In this setting, downstream firm D_A's profit under bundling exceeds its separate selling profit if and only if

$$\begin{aligned} \Delta\pi_{D_A} &= \pi_{D_A}^S - \pi_{D_A}^{BL} \\ &= -\frac{(-2a_2 + a_1 + k)\,(-2a_2 - 13a_1 + 15k)}{784} < 0. \end{aligned} \tag{5.53}$$

Note that $\Delta\pi_{D_A}$ is quadratic and strictly concave in a_2 $\left(\frac{\partial^2 \Delta\pi_{D_A}}{\partial a_2^2} = -\frac{1}{98} < 0\right)$. We get $\Delta\pi_{D_A} < 0$ for $a_2 < \frac{15k-13a_1}{2}$ and for $a_2 > \frac{a_1+k}{2}$. The latter is given by assumption and thus we always have $\Delta\pi_{D_A} < 0$. Therefore, bundling is profitable for D_A in any case when both goods are produced by one monopolistic producer.

	Separate Selling	**Bundling**
Profits Downstream Firms	$\pi_{D_A}^S = \frac{(a_1-k)^2}{16}$	$\pi_{D_A}^{BL} = \frac{(3a_1+a_2-4k)^2}{196}$
	$\pi_{D_B}^S = 0$	$\pi_{D_B}^{BL} = \frac{(-a_1+2a_2-k)^2}{98}$
Profits Upstream Firm U	$\pi_U^S = \frac{3k^2-4a_2k-2a_1k}{8}$	$\pi_U^{BL} = \frac{10k^2-12a_2k-8a_1k+5a_2^2}{28}$
	$+\frac{2a_2^2+a_1^2}{8}$	$+\frac{2a_1a_2+3a_1^2}{28}$
Input Prices	$c_1^S = \frac{a_1+k}{2}$	$c_1^{BL} = \frac{a_1+k}{2}$
	$c_2^S = \frac{a_2+k}{2}$	$c_2^{BL} = \frac{a_2+k}{2}$
Downstream Prices	$p_1^S = \frac{3a_1+k}{4}$	$p_A^{BL} = \frac{5a_1+4a_2+5k}{7}$
	$p_2^S = \frac{a_2+k}{2}$	$p_B^{BL} = \frac{-a_1+9a_2+6k}{14}$
Quantities	$Q_1^S = \frac{a_1-k}{4}$	$Q_1^{BL} = \frac{3a_1+a_2-4k}{14}$
	$Q_2^S = \frac{a_2-k}{2}$	$Q_2^{BL} = \frac{a_1+5a_2-6k}{14}$
Downstream Quantities	$q_{A1}^S = \frac{a_1-k}{4}$	$b_A^{BL} = \frac{3a_1+a_2-4k}{14}$
	$q_{A2}^S = \frac{a_2-k}{4}$	
	$q_{B2}^S = \frac{a_2-k}{4}$	$b_B^{BL} = \frac{-a_1+2a_2-k}{7}$

Table 5.3: Multi-product upstream monopoly: equilibrium values

Producer Surplus	$PS^S = \frac{7k^2-8a_2k-6a_1k+4a_2^2+3a_1^2}{16}$
	$PS^{BL} = \frac{22k^2-25a_2k-19a_1k+11a_2^2+3a_1\,a_2+8a_1^2}{49}$
Consumer Surplus	$CS^S = \frac{5k^2-8a_2k-2a_1k+4a_2^2+a_1^2}{32}$
	$CS^{BL} = \frac{26k^2-34a_2k-18a_1k+13a_2^2+8a_1a_2+5a_1^2}{196}$
Welfare	$W^S = \frac{19k^2-24a_2k-14a_1k+12a_2^2+7a_1^2}{32}$
	$W^{BL} = \frac{114k^2-134a_2k-94a_1k+57a_2^2+20a_1a_2+37a_1^2}{196}$

Table 5.4: Multi-product upstream monopoly: welfare outcomes

5.5.5 Proof of Proposition 5.1

Downstream firm D_A's bundling profit exceeds its separate selling profit if and only if

$$\begin{aligned}\Delta\pi_{D_A} &= \pi_{D_A}^S - \pi_{D_A}^{BL} \\ &= \frac{5(13a_1-12a_2-k)(761a_1+60a_2-821k)}{2729104} < 0. \end{aligned} \tag{5.54}$$

Notice that $\Delta\pi_{D_A}$ is quadratic and strictly concave in a_2 $\left(\frac{\partial^2 \Delta\pi_{D_A}}{\partial a_2^2} = -\frac{450}{170569} < 0\right)$. As a consequence, we obtain $\Delta\pi_{D_A} < 0$ for $a_2 < a_2^1 := \frac{-761a_1+821k}{60}$ or $a_2 > a_2^2 := \frac{13a_1-k}{12}$. As $a_1, a_2 > k$ by assumption, we clearly have $a_2^2 > k \geq 0$, $k > a_2^1$ and $\overline{a}_2 > a_2^2$. Consequently, firm D_A prefers bundling over separate selling when $a_2 \in \left(\underline{a}_2^{BL}, \overline{a}_2\right)$, where $\underline{a}_2^{BL} := a_2^2$ stands for the lower bound of the profitable bundling interval and $\overline{a}_2 := \frac{3a_1-k}{2}$ for the upper bound of the profitable and the general bundling interval. Notice that the upper bound is derived from the assumption $p_1^S > p_2^S$. In case $a_2 \in \left(\underline{a}_2^S, \underline{a}_2^{BL}\right)$, where $\underline{a}_2^S := \frac{36a_1+29k}{65}$, firm D_A prefers separate selling over bundling since then $\Delta\pi_{D_A} > 0$ such that bundling results in a lower profit than separate selling. Note that the lower bound $\underline{a}_2^S$ is derived from the non-negativity constraints.

5.5.6 Proof of Proposition 5.2

We get $c_1^S < c_1^{BL}$ when $a_2 > \frac{a_1+9k}{10}$, where $\underline{a}_2^S > \frac{a_1+9k}{10}$. Hence, for any $a_2 \in \left(\underline{a}_2^S, \overline{a}_2\right)$, bundling raises the input price of good 1.
We have $c_2^S < c_2^{BL}$ if $a_2 < 6a_1 - 5k$. Note that $\overline{a}_2 < 6a_1 - 5k$ since we assume $a_1 > k$. Consequently, for any $a_2 \in \left(\underline{a}_2^S, \overline{a}_2\right)$, bundling increases the input price of good 2.

5.5.7 Proof of Proposition 5.3

The proof of the proposition is as follows:

- Upstream firm U_1's profit increases due to bundling if and only if

$$\begin{aligned}\Delta\pi_{U_1} &= \pi_{U_1}^S - \pi_{U_1}^{BL} \\ &= \frac{4183a_1^2 - 600a_2^2 - 6960a_1a_2 + 8160a_2k - 1406a_1k - 3377k^2}{194936} < 0. \qquad (5.55)\end{aligned}$$

  Note that $\Delta\pi_{U_1}$ is quadratic and strictly concave in a_2 $\left(\frac{\partial^2 \Delta\pi_{U_1}}{\partial a_2^2} = -\frac{150}{24367} < 0\right)$ and that $\Delta\pi_{U_1} < 0$ for $a_2 < \frac{(59\sqrt{42}+408)k+(-59\sqrt{42}-348)a_1}{60}$ or $a_2 > -\frac{(59\sqrt{42}-408)k+(348-59\sqrt{42})a_1}{60}$. The lower bound of the profitable bundling interval is greater than the larger root of $\Delta\pi_{U_1}$, i.e. $\underline{a}_2^{BL} > -\frac{\left(59\sqrt{42}-408\right)k+\left(348-59\sqrt{42}\right)a_1}{60}$. Thereby, in the profitable bundling interval, $a_2 > -\frac{(59\sqrt{42}-408)k+(348-59\sqrt{42})a_1}{60}$ is satisfied in any case and thus we always have $\Delta\pi_{U_1} < 0$. Therefore, the profit of upstream firm U_1 increases with certainty due to profitable bundling.

- Upstream firm U_2's profit is raised by bundling if and only if

$$\Delta\pi_{U_2} = \pi_{U_2}^{S} - \pi_{U_2}^{BL}$$
$$= \frac{3887k^2 - 11614a_2k + 3840a_1k + 7547a_2^2 - 3480a_1a_2 - 180a_1^2}{97468} < 0. \qquad (5.56)$$

Note that $\Delta\pi_{U_2}$ is quadratic and strictly convex in a_2 $\left(\frac{\partial^2\Delta\pi_{U_2}}{\partial a_2^2} = \frac{7547}{48734} > 0\right)$. We get $\Delta\pi_{U_2} < 0$ if $a_2 \in \left(\frac{(354\sqrt{35}+5807)k+(1740-354\sqrt{35})a_1}{7547}, -\frac{(354\sqrt{35}-5807)k+(-354\sqrt{35}-1740)a_1}{7547}\right)$. However, it holds that $\underline{a}_2^{BL} > -\frac{\left(354\sqrt{35}-5807\right)k+\left(-354\sqrt{35}-1740\right)a_1}{7547}$. That is, the lower bound of the profitable bundling interval is greater than the upper bound of the interval of a_2, in which $\Delta\pi_{U_2} < 0$. Hence, for any a_2 in the profitable bundling interval, $\Delta\pi_{U_2} > 0$ is given. Therefore, profitable bundling always diminishes U_2's profit.

5.5.8 Proof of Proposition 5.4

We prove the cases according to the cases in the proposition:

- The consumer surplus increases as a consequence of bundling if and only if

$$\Delta CS = CS^S - CS^{BL} \qquad (5.57)$$
$$= \frac{276781k^2 - 573192a_2k + 19630a_1k + 342276a_2^2 - 111360a_1a_2 + 45865a_1^2}{5458208} < 0.$$

Notice that ΔCS is quadratic and strictly convex in a_2 $\left(\frac{\partial^2\Delta CS}{\partial a_2^2} = \frac{85569}{682276} > 0\right)$ with its vertex regarding a_2 at $V\left(\frac{4640a_1+23883k}{28523}\middle|\frac{6155(a_1-k)^2}{912736}\right)$. It holds that $\frac{6155(a_1-k)^2}{912736} > 0$ and therefore ΔCS is always greater zero. This means that bundling diminishes the consumer surplus in any case.

- The producer surplus rises due to bundling if and only if

$$\Delta PS = PS^S - PS^{BL} \qquad (5.58)$$
$$= \frac{3(12917k^2 - 13784a_2k - 12050a_1k + 21372a_2^2 - 28960a_1a_2 + 20505a_1^2)}{2729104} < 0.$$

The function ΔPS is quadratic and strictly convex in a_2 $\left(\frac{\partial^2\Delta PS}{\partial a_2^2} = \frac{16209}{341138} > 0\right)$. It has its vertex with respect to a_2 at $V\left(\frac{3620a_1+1723k}{5343}\middle|\frac{335(a_1-k)^2}{28496}\right)$. Note that $\frac{335(a_1-k)^2}{28496} > 0$ holds and thus $\Delta PS > 0$ holds with certainty. Consequently, the producer surplus decreases as a consequence of bundling.

- The previous two cases show that bundling reduces consumer as well as producer surplus and thereby they show that bundling lowers total welfare.

5.5.9 Proof of Proposition 5.5

In the centralized channel, firm D_A's bundling profit exceeds its separate selling profit if and only if

$$\begin{aligned}\Delta\tilde{\pi}_{D_A} &= \tilde{\pi}_{D_A}^{S} - \tilde{\pi}_{D_A}^{BL} \\ &= \frac{(\tilde{a}_1 - 2\tilde{a}_2 + k)(13\tilde{a}_1 + 2\tilde{a}_2 - 15k)}{196} < 0.\end{aligned} \tag{5.59}$$

Note that $\Delta\tilde{\pi}_{D_A}$ is quadratic and strictly concave in $\tilde{a}_2$ $\left(\frac{\partial^2 \Delta\tilde{\pi}_{D_A}}{\partial \tilde{a}_2^2} = -\frac{2}{49} < 0\right)$. Solving for $\tilde{a}_2$ yields that we have $\Delta\tilde{\pi}_{D_A} < 0$ for $\tilde{a}_2 < \frac{-13\tilde{a}_1+15k}{2}$ or for $\tilde{a}_2 > \frac{\tilde{a}_1+k}{2} =: \underline{\tilde{a}}_2$. Since $\tilde{a}_2 > \underline{\tilde{a}}_2$ by assumption, we always have $\Delta\tilde{\pi}_{D_A} < 0$. This means that firm D_A always prefers bundling over separate selling in the centralized channel.

5.5.10 Proof of Proposition 5.6

We prove the cases in the order proposed in the proposition:

- The consumer surplus is raised by bundling if and only if

$$\begin{aligned}\Delta\tilde{CS} &= \tilde{CS}^{S} - \tilde{CS}^{BL} \\ &= \frac{(\tilde{a}_1 - 2\tilde{a}_2 + k)(9\tilde{a}_1 - 46\tilde{a}_2 + 37k)}{392} < 0.\end{aligned} \tag{5.60}$$

  We observe that $\Delta\tilde{CS}$ is quadratic and strictly convex in $\tilde{a}_2$ $\left(\frac{\partial^2 \Delta\tilde{CS}}{\partial \tilde{a}_2^2} = \frac{23}{49} > 0\right)$. Furthermore, we observe that $\Delta\tilde{CS} < 0$ for $\tilde{a}_2 \in \left(\frac{9\tilde{a}_1+37k}{46}, \underline{\tilde{a}}_2\right)$. However, when $\tilde{a}_2 > \underline{\tilde{a}}_2$, we get $\Delta\tilde{CS} > 0$, where $\tilde{a}_2 > \underline{\tilde{a}}_2$ is given by assumption. Consequently, the consumer surplus is always reduced by bundling.

- Firm D_A earns a greater profit with bundling than with separate selling. Additionally, D_B gains a positive profit under bundling in contrast to a zero profit under separate selling. Clearly, the producer surplus consisting of the profits of the two downstream firms and the zero profits of the two upstream firms is raised by bundling.

- Total welfare rises as a consequence of bundling if and only if

$$\begin{aligned}\Delta\tilde{W} &= \tilde{W}^{S} - \tilde{W}^{BL} \\ &= \frac{19\tilde{a}_1^2 + 20\tilde{a}_2^2 - 48\tilde{a}_1\tilde{a}_2 - 9k^2 + k(8\tilde{a}_2 + 10\tilde{a}_1)}{392} < 0.\end{aligned} \tag{5.61}$$

Note that $\Delta\tilde{W}$ is quadratic and strictly convex in $\tilde{a}_2$ $\left(\frac{\partial^2\Delta\tilde{W}}{\partial\tilde{a}_2^2} = \frac{5}{49} > 0\right)$. Further note that when $\tilde{a}_2 \in \left(\underline{\tilde{a}}_2, \frac{19\tilde{a}_1-9k}{10}\right)$, we obtain $\Delta\tilde{W} < 0$. Hence, for $\tilde{a}_2 \in \left(\underline{\tilde{a}}_2, \frac{19\tilde{a}_1-9k}{10}\right)$, bundling increases the total welfare. If $\tilde{a}_2 > \frac{19\tilde{a}_1-9k}{10}$, however, we have $\Delta\tilde{W} > 0$ and then bundling decreases the total welfare in the centralized channel. Remember that $\tilde{a}_2 < \underline{\tilde{a}}_2$ is ruled out by assumption.

Bibliography

Banciu, M., E. Gal-Or, and P. Mirchandani (2010). Bundling strategies when products are vertically differentiated and capacities are limited. *Management Science 56*, 2207–2223.

Bhargava, H. K. (2012). Retailer-driven product bundling in a distribution channel. *Marketing Science 31*(6), 1014–1021.

Cao, Q., X. Geng, K. E. Stecke, and J. Zhang (2019). Operational role of retail bundling and its implications in a supply chain. *Production and Operations Management 28*(8), 1903–1920.

Cao, Q., X. Geng, and J. Zhang (2015). Strategic role of retailer bundling in a distribution channel. *Journal of Retailing 91*(1), 50–67.

Carbajo, J., D. de Meza, and D. Seidmann (1990). A strategic motivation for commodity bundling. *The Journal of Industrial Economics 38*(3), 283–298.

Carlton, D. W. and M. Waldman (2002). The strategic use of tying to preserve and create market power in evolving industries. *The RAND Journal of Economics 33*(2), 194–220.

Chakravarty, A., A. Mild, and A. Taudes (2013). Bundling decisions in supply chains. *European Journal of Operational Research 231*(3), 617–630.

Chung, H.-L., Y.-S. Lin, and J.-L. Hu (2013). Bundling strategy and product differentiation. *Journal of Economics 108*(3), 207–229.

Dixit, A. (1979). A model of duopoly suggesting a theory of entry barriers. *The Bell Journal of Economics 10*(1), 20–32.

Egli, A. (2007). On stability in competition: Tying and horizontal product differentiation. *Review of Industrial Organization 30*(1), 29–38.

Giri, R. N., S. K. Mondal, and M. Maiti (2017). Bundle pricing strategies for two complementary products with different channel powers. *Annals of Operations Research*, 1–25.

Häckner, J. (2000). A note on price and quantity competition in differentiated oligopolies. *Journal of Economic Theory 93*(2), 233–239.

Heinzel, J. (2019, June). Bundling in a distribution channel with retail competition. Working Papers CIE 120, Paderborn University, CIE Center for International Economics.

Honhon, D. and X. A. Pan (2017). Improving profits by bundling vertically differentiated products. *Production and Operations Management 26*(8), 1481–1497.

IMDb (2019a). Alien Warfare. https://www.imdb.com/title/tt9562694/. Accessed August 16, 2019.

IMDb (2019b). Die besten Serien auf Netflix (2019). https://www.imdb.com/list/ls020448959/?ref_=otl_1$. Accessed August 15 2019.

Ma, M. and S. Mallik (2017). Bundling of vertically differentiated products in a supply chain. *Decision Sciences 48*(4), 625–656.

Martin, S. (1999). Strategic and welfare implications of bundling. *Economics Letters 62*(3), 371–376.

McAfee, R. P., J. McMillan, and M. D. Whinston (1989). Multiproduct monopoly, commodity bundling, and correlation of values. *The Quarterly Journal of Economics 104*(2), 371–383.

Netflix (2018). 13 Reasons Why. https://media.netflix.com/en/only-on-netflix/122620. Accessed July 26, 2018.

Peitz, M. (2008). Bundling may blockade entry. *International Journal of Industrial Organization 26*(1), 41–58.

Schmalensee, R. (1984). Gaussian demand and commodity bundling. *The Journal of Business 57*(1(2)), 211–230.

Spector, D. (2007). Bundling, tying, and collusion. *International Journal of Industrial Organization 25*(3), 575–581.

Spengler, J. J. (1950). Vertical integration and antitrust policy. *The Journal of Political Economy 58*(4), 347–352.

Statista (2019a). Anzahl der Streaming-Abonnenten von Netflix weltweit vom 3. Quartal 2011 bis zum 2. Quartal 2018 (in Millionen). https://de.statista.com/statistik/daten/studie/196642/umfrage/abonnenten-von-netflix-quartalszahlen/accessedAugust,15201. Accessed August 15, 2019.

Statista (2019b). Video-on-Demand. https://de.statista.com/outlook/206/100/video-streaming--svod-/weltweit?currency=usd. Accessed August 15, 2019.

Tirole, J. (1988). *The theory of industrial organization*. MIT Press.

Venkatesh, R. and W. Kamakura (2003). Optimal bundling and pricing under a monopoly: Contrasting complements and substitutes from independently valued products. *The Journal of Business 76*(2), 211–231.

Whinston, M. D. (1990). Tying, foreclosure, and exclusion. *American Economic Review 80*(4), 837–859.