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The Benefits of Bundling Strategies

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Abstract

This paper analyzes the effects of three bundling strategies – unbundling, mixed bundling, and pure bundling – on profit and sales, using a simulation study based on a model from *Schmalensee* (1984). The analysis shows under what conditions which strategy is the most profitable, how large the profit and sales differentials are for each strategy, and what characteristics the corresponding price structures have. Based on our results, we explain the differences observed in the study and derive a set of implications for practical price structuring.

1 Introduction*

Recently, fast-food restaurants seem to have been successful in grouping a number of products together. McDonald's, for instance, offers set menus in which various burgers are sold along with a portion of French fries and a soft drink. Pizza Hut operates likewise. This grouping of products and the corresponding price-setting strategy goes under the name "price bundling."[1] Offering the products for sale separately is known as "unbundling," offering them for sale exclusively in bundle form is pure "bundling;" and selling them in both bundled and unbundled form goes under the heading "mixed bundling."[2] Since all components of the menus described above are also sold separately, McDonald's and Pizza Hut are following a mixed-bundling strategy.

Firms like McDonald's and Pizza Hut are interested in increasing their shareholder value and thus maximizing profits. Therefore, we must ask which bundling strategy is most likely to attain the goal of profit maximization, and which pricing strategy should be pursued to achieve this goal.

Alas, the literature has yet to treat such questions systematically. Although *Adams/Yellen* (1976), *Simon* (1992) and *Fürderer* (1996, pp. 78) cite numerous examples of the benefits of particular strategies, such examples do not allow us to ascertain which factors influence the ability of the strategies to confer benefits. Much the same can be said of empirical investigations, such as those of *Bauer/Herrmann/Jung* (1996), *Wübker* (1998, pp. 131) and *Fürderer* (1996, pp. 90). Here, too (and of necessity), no systematic variation of the underlying conditions is undertaken.

The sole systematic investigation into the influence of the various factors that affect the ability of bundling strategies to provide benefits to firms is that of *Schmalensee* (1984). This study analyzed which of the three strategies is best and under what circumstances. Schmalensee found that, apart from the degree of correlation between consumers' reservation price (RP) for the products, the difference between the RP and the variable costs had a considerable effect on the benefits conferred by bundling strategies. .

However, as a result of the analytical framework which *Schmalensee* (1984) uses, he only considers the case of two "symmetrical" products (i.e., two products with similar demand and cost structures). Furthermore, he fails to analyze whether significant profit differentials derived from the various strategies are to be observed. What is more, his *modus operandi* does not allow us to gain insights into the structure of optimal pricing. For instance, he cannot provide any information as to whether the

* The authors wish to thank Prof. Dr. Sönke Albers, Dr. Georg Wübker and Dipl.-Kfm. Carsten Hahn for helpful comments and Marc Paolella for his support in the numerical estimation of the values of the bivariant normal distribution.

1 See *Simon* (1992), *Adams/Yellen* (1976), *Herrmann/Bauer* (1996).

2 See *Adams/Yellen* (1976), *Paun* (1993), *Wübker* (1998).

pure bundling price lies above or below the sum of the prices of the unbundled products, or whether the prices of the separate goods in the mixed bundling cases are below or above those of the unbundling cases.

This paper fills *Schmalensee's* (1984) gaps. We ask: under what conditions which bundling strategies lead to the highest profit; how large the profit differentials of the three strategies are; and what implications we can draw from the results.

In Section 2, we examine each bundling strategy and how each strategy produces benefits. Section 3 discusses the factors that influence these benefits. Section 4 presents a simulation study in which we compare the three strategies. The results of the study are presented in the Section 5. A summary of the practical implications of the study brings the paper to a close.

2 Description of the bundling strategies

In this section, we discuss the underlying assumptions of the paper and the benefits of each bundling strategy. This prepares the ground for the description of the price-bundling strategies.

2.1 Assumptions

Taking three products into account exacerbates the difficulty in solving the problem addressed in this paper.[3] Therefore, we concentrate on a two-product world and consider the influence of the products' demand structures on the benefits that the bundling strategies confer.[4] Following *Adams/Yellen* (1976), *Lewbel* (1985), and *McAfee/McMillan/Whinston* (1989), we make the following assumptions:

1. The variable costs for both products are constant.
2. The variable costs of the bundle are determined by the sum of the costs for the products of which the bundle consists.
3. Consumers require only one unit of a product, i.e., the reservation price (RP) for the second and all other units of the product is zero.
4. The RP for the bundle is determined by the sum of the RPs for the products of which the bundle consists.

These assumptions are not particularly restrictive. For example, in the case of McDonald's or Pizza Hut, we can assume, from the well-organized working methods, that variable costs are constant

3 See *Hanson/Martin* (1990), *Fürderer* (1996), pp. 102.

4 Effects of cost degression are considered by *Salinger* (1995), *Dansby/Conrad* (1984) and *Fürderer* (1996), pp. 70.

(even when sales increase) and that no significant cost changes occur as a result of bundling. Even the fourth assumption is not restrictive as long as we do not consider substitutes (e.g., two soft drinks) or complements (e.g., french fries with ketchup).[5] Only the third assumption appears to be critical, since the set menus often combine, say, two slices of pizza and a soft drink. However, in such cases, the two slices of pizza must be thought of as one unit of a product, thus fulfilling Assumption 3.

2.2 Causes of the benefits of the bundling strategies

To portray the causes of the benefits associated with each bundling strategy, we choose a comparison with *Pigou's* (1929) "first-order price discrimination." With this type of price discrimination, each consumer is charged an individual price such that no consumer surplus exists and the firm suffers no diminishing of its profits. Consumer surplus is defined as the difference between the consumer's RP and the actual price which s/he pays. In first-order price discrimination, the price corresponds to the consumer's RP, provided that all variable costs are covered. This form of price discrimination fulfils three conditions:[6]

1. Consumers whose RP is less than the costs are excluded from purchasing the good ("exclusion").
2. Consumers whose RP is above costs buy the product ("inclusion").
3. For each consumer, consumer surplus is zero ("extraction").

The extent to which these conditions are fulfilled influences the degree to which the bundling strategies confer benefits.

The following example shows which bundling strategies fulfil which of the above conditions. For the example, we use seven consumers and their RP for the two products each with a variable cost of 6 €.[7]

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5 See *Lewbel* (1985).

6 See *Adams/Yellen* (1976).

7 Methods for measuring reservation prices are described in *Wübker* (1998), *Skiera/Revenstorff* (1999) and *Skiera* (1999).

Table 1: Reservation prices

Consumer	RP_1	RP_2	$RP_1+RP_2=RP_B$
1	2	14	16
2	5	11	16
3	7	7	14
4	9	9	18
5	6	12	18
6	11	5	16
7	14	2	16

In the case of first-order price discrimination, Consumers 3 to 7 buy the first product and Consumers 1 to 5 the second. Each consumer buys at a price equivalent to their respective RP. A profit of 40€ (17€ + 23€) results.

2.3 Unbundling

Unbundling entails the sale of all products separately. In the example given, this leads to optimal prices of 11€ per product. As *Table 2* shows, unbundling results in a profit of 25€. The reduction in profit of 15€ compared with the case of first-order price discrimination results from the fact that the extraction and inclusion conditions are no longer fulfilled. The consumer surplus of Consumers 1, 5, and 7 is not fully extracted, and the purchases of Consumers 3 and 4 are excluded, even though their RP exceeds variable costs. Unbundling does not detract from the exclusion condition, because the optimal single prices of the goods cannot be less than the variable costs.

Table 2: Results of unbundling

					Profit lost in comparison to first degree price discrimination because of infraction of					
	Sales		Profit		Extraction		Inclusion		Exclusion	
Consumer	Prod. 1	Prod. 2	Prod. 1	Prod. 2	Prod. 1	Prod. 2	Prod. 1	Prod. 2	Prod. 1	Prod. 2
1	0	1	0	5	0	3	0	0	0	0
2	0	1	0	5	0	0	0	0	0	0
3	0	0	0	0	0	0	1	1	0	0
4	0	0	0	0	0	0	3	3	0	0
5	0	1	0	5	0	1	0	0	0	0
6	1	0	5	0	0	0	0	0	0	0
7	1	0	5	0	3	0	0	0	0	0
Each	2	3	10	15	3	4	4	4	0	0
Total	5		25		7		8		0	

2.4 Pure Bundling

We define "pure bundling" as the sale of products only as a bundle. The optimal price of the bundle in our example is 16€ (*Table 3*). This leads to a profit of 24€, which is 16€ below the profit level under the first-order price discrimination regime. This deficit is attributable to the fact that all three conditions are weakened. The extraction condition no longer applies to Consumers 4 and 5, since their RP for the bundle is 2€ above its price. Consumer 3 fails to purchase the bundle, even though her/his RP for the bundle's elements exceeds variable costs. Consequently, the inclusion condition is not fulfilled for this consumer.

In pure bundling, it is possible to transfer the consumer surplus for one product to the other product, in which case the high RP for the one can compensate for the low RP for the other. Consumers would thereby purchase the bundle, although their RP for the single products is lower than variable costs. In our example, pure bundling detracts from the exclusion condition for Consumers 1, 2, 6 and 7.

Table 3: Results of pure bundling

			Profit lost in comparison to first-degree price discrimination because of infraction of		
	Sales	Profit	Extraction	Inclusion	Exclusion
Consumer	Bundle	Bundle	Bundle	Bundle	Bundle
1	1	4	0	0	4
2	1	4	0	0	1
3	0	0	0	2	0
4	1	4	2	0	0
5	1	4	2	0	0
6	1	4	0	0	1
7	1	4	0	0	4
Total	6	24	4	2	10

2.5 Mixed Bundling

In mixed bundling, products can be sold either singly or in a bundle. The two foregoing bundling strategies can be thought of as special cases of mixed bundling. This is because, if the price of the bundle is exorbitantly high, all consumers buy the products as separate items. This strategy then becomes a case of unbundling. On the other hand, if the single prices of each product are set very high, a case of pure bundling will result.[8]

Since unbundling and pure bundling are special cases of mixed bundling, in our example the profit level for the latter is 32€ (*Table 4*). This is above the profit level of the two other strategies (by 25€ and 24€, respectively), but nevertheless 8€ below the first-order price discrimination profit level. All three conditions are weakened. The extraction condition is transgressed by Consumers 4 and 5 because there is a consumer surplus of 2€ when each bundle is purchased. Consumer 3 does not meet the inclusion condition, because s/he buys neither the single products nor the bundle, even though her/his RP exceeds variable costs. The exclusion condition is not fulfilled by Consumers 2 and 6,

[8] See also *Schmalensee* (1984), p. 194, and *Fürderer* (1996), p. 78. Fürderer remarkes that this holds only for non-negative reservation-prices as considered in this paper.

who both buy the bundle even though their RP for one of the two products lies below its respective variable cost.

Table 4: Results from mixed bundling

							Profit lost in comparison to first-degree price discrimination because of infraction of								
	Sales			Profit			Extraction			Inclusion			Exclusion		
Consumer	Prod. 1	Prod. 2	Bundle	Prod. 1	Prod. 2	Bundle	Prod. 1	Prod. 2	Bundle	Prod. 1	Prod. 2	Bundle	Prod. 1	Prod. 2	Bundle
1	0	1	0	0	8	0	0	0	0	0	0	0	0	0	0
2	0	0	1	0	0	4	0	0	0	0	0	0	0	0	1
3	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
4	0	0	1	0	0	4	0	0	2	0	0	0	0	0	0
5	0	0	1	0	0	4	0	0	2	0	0	0	0	0	0
6	0	0	1	0	0	4	0	0	0	0	0	0	0	0	1
7	1	0	0	8	0	0	0	0	0	0	0	0	0	0	0
Each	1	1	4	8	8	16	0	0	4	1	1	0	0	0	2
Total	6			32			4			2			2		

3 Factors that influence the benefits conferred by bundling

The prime benefit reaped through price bundling is in the transfer of the consumer surplus of one product to the other, which implies that a negative correlation between the RP for the two products is an essential prerequisite.[9]

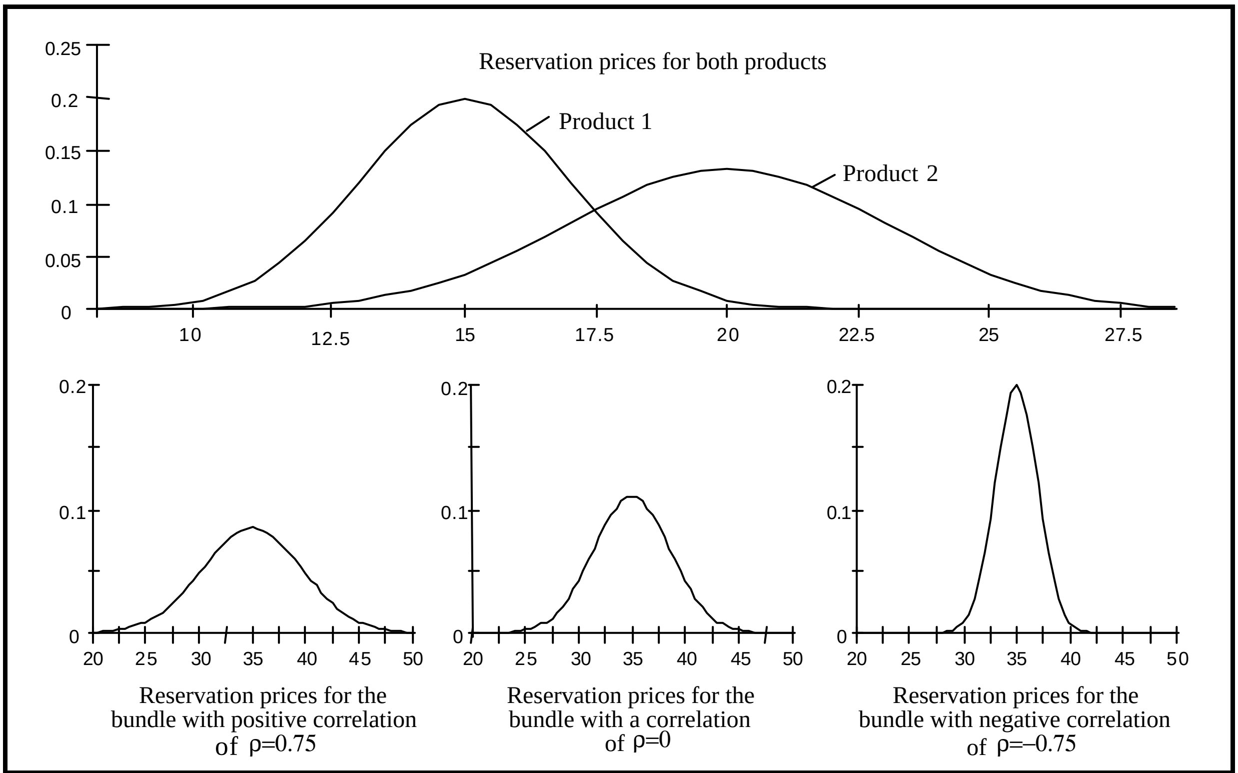
An implicit assumption here is that the variable costs will be lower than the corresponding RP. Behind this assumption is the idea that the low RP for one product balances the high RP of the other. This balance between the RP for the two products creates a more homogeneous RP for the bundle compared to that of the two products taken separately.

Figure 1 illustrates this situation. The distribution of the RP for the single products is *ex hypothesi* normal N($\mu_i;\sigma_i$). That of the RP for the bundle is thus likewise normal: N($m_B = m_1 + m_2$; $\sigma_B = \sqrt{\sigma_1^2 + \sigma_2^2 + 2 \cdot \rho \cdot \sigma_1 \cdot \sigma_2}$). Comparable results are to be found with other distributions.

The variance in the case of uncorrelated RPs ($\rho = 0$) corresponds exactly to the sum of the RP variances for each product. Positively correlated RPs, e.g., $\rho = 0{,}75$, increase the standard deviation and thus the spread (mean variation) of the distribution. Consequently, a more heterogeneous demand structure emerges. With a negative RP correlation, e.g. $\rho = -0{,}75$, the standard deviation falls and the spread becomes smaller, resulting in a demand structure of greater homogeneity.

9 See, e.g., *Adams/Yellen* (1976), p. 485, *McAfee/McMillan/Whinston* (1989), p. 380, *Tacke* (1989), pp. 43.

Figure 1: Distribution of reservation –prices

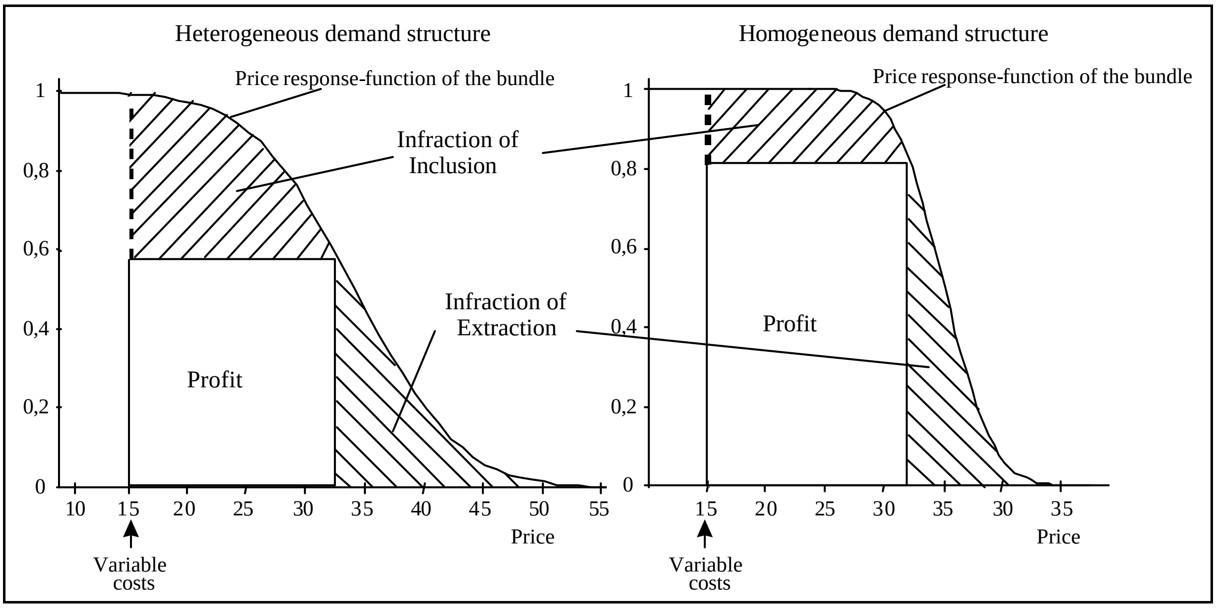


Distribution of reservation prices for product 1: N(15; 2)
Distribution of reservation prices for product 2: N(20; 3)
Distribution of reservation prices for the bundle (negative correlation): N(35; 2)
Distribution of reservation prices for the bundle (uncorrelated): N(35; 3.6)
Distribution of reservation prices for the bundle (positive correlation): N(35; 4.7)

The difference between one and the cumulative density function of the bundle can be interpreted as the price-response function for the bundle.

Figure 2 shows that the gradient of this function is clearly greater when consumers' RPs are negatively correlated. Hence, the demand structure becomes homogeneous. With low variable costs (here, 5€) the homogeneous demand structure (and the associated "compression" of the price-response-function) leads to higher profits than in the case of positively correlated RPs and the concomitant heterogeneous demand structure. The reason for this is that more consumers have a RP in excess of variable costs such that the extraction and inclusion conditions are fulfilled to a greater extent.

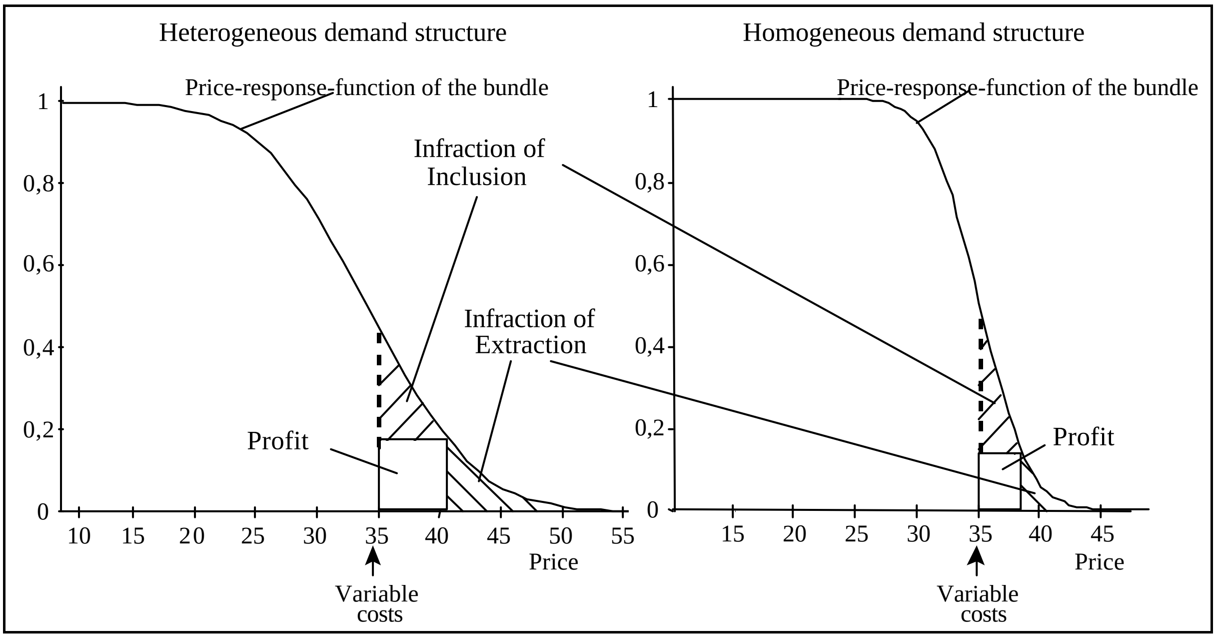
Figure 2: The effect of heterogeneous and homogeneous demand structures on profit when variable costs are low in the case of bundling



The positive effect of negatively correlated RPs and the homogeneous demand structure on profits is reversed when variable costs are high (here 35€).[10] In this case, we see a disproportionately large drop in the share of consumers with RPs above variable costs. As a result, profits are lower than they are with a heterogeneous demand structure given by positively correlated RPs (*Figure 3*).

10 See *Bakos/Brynjolfsson* (1996).

Figure 3: The effect of heterogeneous and homogeneous demand structures on profits when variable costs are high in the case of bundling



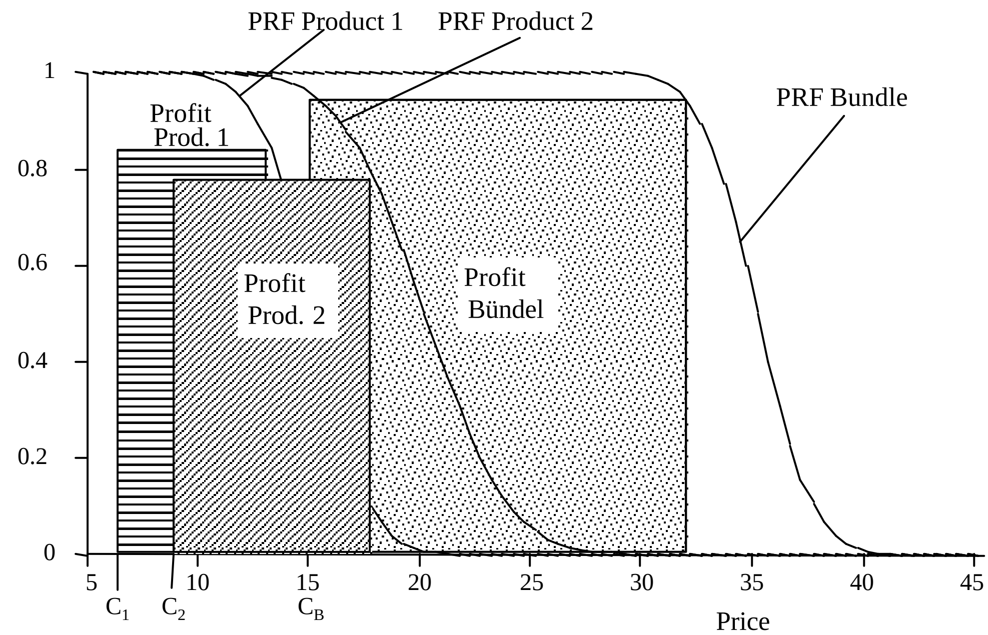
The level of variable costs thus has a great impact on the benefits of pure bundling vis-à-vis unbundling.[11]

Figure 4 shows that pure bundling profits with a homogeneous demand structure and low variable costs exceed profits when the products are unbundled. This is because the share of consumers with an RP for the bundle that is above variable costs is higher than the corresponding share for the separate products. Also, the greater homogeneity of consumers permits the firm to reap their RP more efficaciously.

[11] See *Schmalensee* (1984), p. S220.

Figure 4: The effect of low variable costs on profits in the case of pure bundling and unbundling

Reservation-prices with negative correlation



Optimal price for the bundle: 32 €
Optimal price for the single products: Product 1: 13 € Product 2: 17.50 €

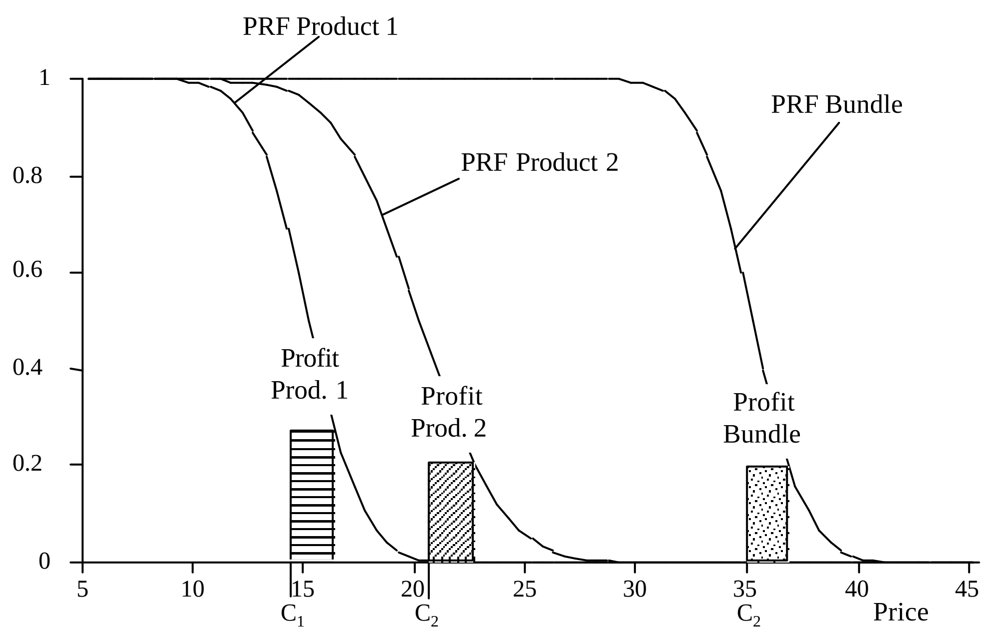
Profit with pure bundling: 15,864.30 € (+25.43%)
Profit with unbundling: 12,647.80 €

Variable costs: Product 1: C_1 = 6.50 €, Product 2: C_2 = 8.50 €
Number of consumers: 1,000; PRF: Price-Response-Function

A very different situation applies when variable costs are higher in relation to the RP. *Figure 5* reproduces the results derived by *Schmalensee* (1984), which show that when the variable costs are relatively high, the benefits of bundling with negatively correlated RPs are nonexistent. The homogeneity of the RPs in the bundling case leads to an increase in the proportion of consumers whose RP lies below variable costs.

Figure 5: The effects of high variable costs on profits in the case of pure bundling and unbundling

Reservation prices with negative correlation



Reservation prices with negative correlation
Optimal price for the bundle: 36.50 € Optimal price for the single products: Product 1: 16 € Product 2: 22.50 €
Profit with pure bundling: 339.90 € (-60.82%) Profit with unbundling: 867.50 €
Variable costs: Product 1: C_1 = 14.50 €, Product 2: C_2 = 20.50 € Number of consumers: 1,000; PRF: Price-Response-Function

The advantages of bundling thus depend on the relation between the RP and variable costs. *Schmalensee* (1984) suggests that in addition to the RP correlation, we think of the level of the standard mean gross profit (mark-up) as another important factor when we evaluate the advantages of bundling strategies.

We define the standard mean gross profit (SMGP) as follows:

(1) $$SMGP_i = \frac{\mu_i - c_i}{\sigma_i} \quad (i \in I),$$

where:

μ_i: Mean reservation price for the i[th] product,
σ_i: Standard deviation of the reservation-prices for the i[th] product,
c_i: Variable costs of the i[th] product,
I: Index of products,
$SMGP_i$: Standard mean gross profit of the i[th] product.

The greater the SMGP, the greater are the advantages of bundling. However, given that a bundle comprises two products, the exclusion condition may be compromised. Therefore, observing the SMGP of a product alone is not sufficient. The relation between the SMGPs of the two products must be taken into account. A bundle composed of two products – the one with a strongly positive, the other a strongly negative, SMGP – leads to a high probability that the exclusion condition will be compromised.

In summary, three factors influence the benefits of price-bundling:

- The correlation between the products' RPs
- The level of the SMGP of the products
- The composition of the SMGPs of the products

4 Construction of the simulation study

In this section, we detail the construction of our simulation study. We describe the underlying model, and then discuss the variation in the magnitude of the influencing variables.

4.1 Description of the model

For the purpose of this simulation, we draw upon *Schmalensee's* (1984) model, in which the following mutually independent demand functions for the single products are assumed:

(2) $$Q_i(p_i) = \int_{p_i}^{\infty} g(RP_i)\,d\,RP_i \qquad (i \in I),$$

The demand function for the bundle is given by:

(3) $$Q_B(p_B) = \int_{p_B}^{\infty} g(RP_B)\,d\,RP_B\,,$$

where:

$g(RP_B)$:	Distribution of the reservation-prices for the bundle,
$g(RP_i)$:	Distribution of the reservation-prices for the i^{th} product,
p_B:	Price for the bundle,
p_i:	Price for the i^{th} product,
Q_B:	Sales of the bundle,
Q_i:	Sales of the i^{th} product,
RP_B:	Reservation price for the bundle,
RP_i:	Reservation price for the i^{th} product.

The RP for the bundle is given by the sum of RPs for the bundle's components:

(4) $$RP_B = RP_1 + RP_2$$

The distribution of the RPs for the i^{th} product is assumed to be normal, with mean μ_i and standard deviation σ_i. Given that the addition of two normal distributions yields another normal distribution, the RPs for the bundle are likewise normally distributed, with mean $\mu_B=\mu_1+\mu_2$ and standard deviation $\sigma_B = \sqrt{\sigma_1^2 + \sigma_2^2 + 2\rho_{RP_1,RP_2}\sigma_1\sigma_2}$.

The unbundling profit function is:

(5) $$\pi_{UB} = Q_{1,UB} \cdot (p_{1,UB} - c_1) + Q_{2,UB} \cdot (p_{2,UB} - c_2)$$

with $$Q_{i,UB}(p_i) = \int_{p_i}^{\infty} \frac{1}{\sqrt{2\pi\sigma_i^2}} \cdot \exp\left(-\frac{(RP_i - \mu_i)^2}{2\sigma_i^2} \right) dRP_i \qquad (i \in I),$$

where:

π_{UB}:	Profit under an unbundling regime,
$Q_{i,UB}$:	Sales of the i^{th} product under an unbundling regime,
$p_{i,UB}$:	Price of the i^{th} product under an unbundling regime,
c_i:	Variable Costs of the i^{th} product,

and in the case of pure bundling:

(6) $$\pi_{PB} = Q_{B,PB} \cdot (p_{B,PB} - c_B)$$

with $$Q_{B,PB}(p_B) = \int_{p_B}^{\infty} \frac{1}{\sqrt{2\pi\sigma_B^2}} \cdot \exp\left(-\frac{(RP_B - \mu_B)^2}{2\sigma_B^2} \right) dRP_B$$

where:

π_{PB}:	Profit under a pure bundling regime,
$Q_{B,PB}$:	Sales of the bundle under a pure bundling regime,
$p_{B,PB}$:	Price of the bundle under a pure bundling regime,
c_B:	Variable Costs of the bundle.

In the case of mixed bundling:

(7) $$\pi_{MB} = Q_{1,MB} \cdot (p_{1,MB} - c_1) + Q_{2,MB} \cdot (p_{2,MB} - c_2) + Q_{B,MB} \cdot (p_{B,MB} - c_B)$$

with: $$Q_{1(2),MB}(p_{1,MB}, p_{2,MB}, p_{B,MB}) = \int_{0}^{P_{2(1),MB}-BD_{abs.}} \int_{P_{1(2),MB}}^{\infty} \frac{1}{2\pi\sigma_1\sigma_2\sqrt{1-\rho^2}} \cdot$$

$$\exp\left\{-\frac{1}{2(1-\rho^2)}\left[\left(\frac{RP_{1(2)}-\mu_{1(2)}}{\sigma_{1(2)}}\right)^2 - 2\rho\frac{RP_{1(2)}-\mu_{1(2)}}{\sigma_{1(2)}}\frac{RP_{2(1)}-\mu_{2(1)}}{\sigma_{2(1)}} + \left(\frac{RP_{2(1)}-\mu_{2(1)}}{\sigma_{2(1)}}\right)^2\right]\right\} d\,RP_{1(2)}dRP_{2(1)}$$

and $$Q_{B,MB} = \int_{P_{1,MB}}^{\infty} \int_{P_{2,MB}}^{\infty} g(RP_1, RP_2)\, dRP_2\, dRP_1 + \int_{P_{1,MB}}^{\infty} \int_{P_{2,MB}-BD_{abs.}}^{P_{2,MB}} g(RP_1, RP_2)\, dRP_2\, dRP_1$$

$$+ \int_{P_{1,MB}-BD_{abs.}}^{P_{1,MB}} \int_{P_{2,MB}}^{\infty} g(RP_1, RP_2) dRP_2\, dRP_1 + \int_{P_{1,MB}-BD_{abs.}}^{P_{1,MB}} \int_{P_{B,MB}-P_1}^{P_{2,MB}} g(RP_1, RP_2) dRP_2\, dRP_1$$

whereby:

$$g(RP_1, RP_2) = \frac{1}{2\pi\sigma_1\sigma_2\sqrt{1-\rho^2}} \cdot \exp\left\{-\frac{1}{2(1-\rho^2)}\left[\left(\frac{RP_1-\mu_1}{\sigma_1}\right)^2 - 2\rho\frac{RP_1-\mu_1}{\sigma_1}\frac{RP_2-\mu_2}{\sigma_2} + \left(\frac{RP_2-\mu_2}{\sigma_2}\right)^2\right]\right\}$$

where:

π_{MB}:	Profit under a mixed bundling regime,
$Q_{i,MB}$:	Sales of the i^{th} product under a mixed bundling regime,
$Q_{B,MB}$:	Sales of the bundle under a mixed bundling regime,
$p_{i,MB}$:	Price of the i^{th} product under a mixed bundling regime,
$p_{B,MB}$:	Price of the bundle under a mixed bundling regime,
$BD_{abs.}$:	Absolute bundle deduction = $P_{B,MB} - P_{1,MB} - P_{2,MB}$
c_i:	Variable cost of the i^{th} product,
c_B:	Variable cost of the bundle.

Depicting the optimal prices in closed form is not possible in any of the three cases.[12] The optima must therefore be determined numerically. In the case of pure bundling and unbundling, we use Microsoft™ Excel's Add-In – the Solver –and derive the profits with the help of the quasi-Newton process.[13] Although using Microsoft™ Excel to calculate integrals of univariant normal distributions is a routine procedure, the calculation of integrals for the bivariant normal distributions in the profit function (7) is more problematic. For this reason, we use an approximation suggested by *Hull* (1993), with which mixed-bundling profits for any combination of prices and variable costs can be established. Using this approximation, we use an optimization process for determining optimal prices and maximum profit.[14]

12 See *Schmalensee* (1984), *Fürderer* (1996), p. 84.

13 See *Nazareth* (1994) on the quasi-Newton process. The Solver is described in *Lilien/Rangaswamy* (1998), pp. 50.

14 See *Hull* (1993), p. 245.

4.2 Variations in the size of influence

In our simulation study we consider three scenarios:

1) $SMGP_1 = SMGP_2$

2) $SMGP_1 = 0{,}5 \cdot SMGP_2$

3) $SMGP_1 = -1 \cdot SMGP_2$

The first scenario considers the case of two products with the same SMGP (*Schmalensee's* (1984) “symmetrical” case); in the second, both SMGPs have the same sign, but different magnitudes; in the third, the same magnitude, but different signs.

In the three scenarios, we vary the correlation between the RPs for both products within the interval [-0.9;+0.9] in gradations of 0.3. However, we vary the SMGP of the first product within the interval [-2;+4] in steps of 2. We derive the following variations in the factors of influence (*Table 5*).

Table 5: Variation of key factors

Factors	Number of variations	Values
Variable costs	1	• 10
Standard deviation: σ_i	1	• 1
Correlation	7	• very strong negative: -0.9 • strong negative: -0.6 • negative: -0.3 • uncorrelated: 0 • positive: 0.3 • strong positive: 0.6 • very strong positive: 0.9
Mean RP of product 1: μ_1	4	• (10 - 2) • 10 • (10 + 2) • (10 + 4)
Mean RP of product 2: μ_2	3	• $\mu_2 = \mu_1$ • $\mu_2 = 2 \cdot \mu_1 - 10$ • $\mu_2 = 2 \cdot 10 - \mu_1$
Total number of datasets per strategy	$1 \cdot 1 \cdot 7 \cdot 4 \cdot 3 = 84$	

Since the effect of the SMGP is influenced by the mean of the RP, μ_i, as well as the concomitant standard deviation, σ_i, and the variable costs, c, it is sufficient if one of the three magnitudes is varied. And since we will also analyze the relation between the SMGPs, varying either c or μ_i is appropriate for the purpose of analysis. In our study, we choose – quite arbitrarily – the latter.

4.3 Description of the experimental design

By varying the influencing factors, the following 84 cases arise (*Table 6*):

Table 6: Experimental design

	μ_1	μ_2	$SMGP_1$	$SMGP_2$
Scenario 1: $SMGP_1 = SMGP_2$	8	8	-2	-2
	10	10	0	0
	12	12	2	2
	14	14	4	4
Scenario 2: $2 \cdot SMGP_1 = SMGP_2$	8	6	-2	-4
	10	10	0	0
	12	14	2	4
	14	18	4	8
Scenario 3: $SMGP_1 = -SMGP_2$	8	12	-2	2
	10	10	0	0
	12	8	2	-2
	14	6	4	-4
Each case counts for a correlation of: -0.9; -0.6; -0.3; 0; 0.3; 0.6; 0.9, a standard deviation σ_i=1 and variable costs c_i=10 ($i \in I$)				

5 Results of the simulation study

In this section, we discuss the results of the simulation study by comparing the profits and sales totals of the strategies. We also analyze the different price structures associated with each strategy.

5.1 Comparison of profits

Because there are many different starting points, we do not consider the absolute profit associated with the bundling strategies. Rather, we consider only the relative differences. To compare the bundling strategies with the unbundling strategy, we use the unbundling profit as a reference point. For the comparison of the two bundling strategies with each other, the corresponding reference point is the pure-bundling profit level.

(8) $$\Delta\pi_{PB/UB} = \frac{\pi_{PB} - \pi_{UB}}{\pi_{UB}}$$

(9) $$\Delta\pi_{MB/UB} = \frac{\pi_{MB} - \pi_{UB}}{\pi_{UB}}$$

(10) $$\Delta\pi_{PB/MB} = \frac{\pi_{PB} - \pi_{MB}}{\pi_{MB}}$$

where:

$\Delta\pi_{PB/UB}$: Profit differentials between pure bundling and unbundling,

$\Delta\pi_{MB/UB}$: Profit differentials between mixed bundling and unbundling,

$\Delta\pi_{PB/MB}$: Profit differentials between pure bundling and mixed bundling.

Table 7 depicts the profit differentials. The analysis of variance in *Table 8* shows the strength of the influencing factors on these differentials.

Table 7: Relative profit differentials

Profit differential	Mean	Median	Standard deviation	Minimum	Maximum	Number of cases
$\Delta\pi_{PB/UB}$	-0.397	-0.410	0.459	-1.000	0.480	84
$\Delta\pi_{MB/UB}$	0.052	0.015	0.095	0.000	0.490	84
$\Delta\pi_{PB/MB}$	-0.445	-0.440	0.403	-1.000	0.000	84

Predictably, mixed bundling yields the highest profit, averaging 5% over the unbundling and nearly 45% over the pure bundling levels. Pure bundling comes off badly because, in the many of the situations considered, at least one of the products has a negative SMGP.

Table 8 illuminates the fact that the profit differentials can be explained primarily by the size of the SMGPs and their relation to one another. The correlation between RPs is not significant as an explanatory factor.

Table 8: Explanation of the relative profit differentials

Dependent variable:	$D\pi_{PB/UB}$		
Scenario:	1	2	3
Mean:	-21%	-28%	-71%
Share of variance			
Correlation:	3.24%	0.00%	17.64%
SMGP:	75.69%	90.25%	72.25%
R^2:	78.93%	90.25%	89.89%
Dependent variable:	$D\pi_{MB/UB}$		
Scenario:	1	2	3
Mean:	8%	7%	1%
Share of variance:			
Correlation:	31.36%	38.44%	6.76%
SMGP:	37.31%	30.25%	72.25%
R^2:	68.67%	68.69%	79.01%
Dependent variable:	$D\pi_{PB/MB}$		
Scenario:	1	2	3
Mean:	-29%	-34%	-71%
Share of variance:			
Correlation:	12.25%	2.56%	19.39%
SMGP:	72.25%	90.25%	70.56%
R^2:	84.50%	92.81%	89.95%

5.2 Comparison of sales

Equations 11 through 13 show the different sales totals yielded by each bundling strategy:

(11) $$\Delta Q_{PB/UB} = \frac{2 \cdot Q_{B,PB} - (Q_{1,UB} + Q_{2,UB})}{Q_{1,UB} + Q_{2,UB}}$$

(12) $$\Delta Q_{MB/UB} = \frac{(Q_{1,MB} + Q_{2,MB} + 2 \cdot Q_{B,MB}) - (Q_{1,UB} + Q_{2,UB})}{Q_{1,UB} + Q_{2,UB}}$$

(13) $$\Delta Q_{PB/MB} = \frac{2 \cdot Q_{B,PB} - (Q_{1,MB} + Q_{2,MB} + 2 \cdot Q_{B,MB})}{Q_{1,MB} + Q_{2,MB} + Q_{B,MB}}$$

where:

$\Delta Q_{PB/UB}$: Sales differentials between pure bundling and unbundling,

$\Delta Q_{PB/MB}$: Sales differentials between unbundling and mixed bundling,

$\Delta Q_{MB/UB}$: Sales differentials between mixed bundling and unbundling.

Bundle AB's share of sales as a proportion of total sales is:

$$AB = \frac{2 \cdot Q_{B,MB}}{Q_{1,MB} + Q_{2,MB} + 2 \cdot Q_{B,MB}} \quad (14)$$

Table 9 describes the sales totals differentials are described in greater detail. Compared to the unbundling strategy, mixed bundling results in sales that average 6% greater.

The pure bundling sales total is clearly lower than that of both other strategies. The reason for this lies in the weaknesses of bundling which were described earlier: Bundling reduces the heterogeneity of demand such that in cases of high variable costs, the products can be sold only to a few customers. In this respect, unbundling is more flexible, because only those consumers with an RP for both products below variable costs drop out of the picture. On average, just as many products are sold as bundles as are sold singly in the mixed-bundling world.

Table 9: Relative sales totals differentials

Sales differential	Mean	Median	Standard deviation	Minimum	Maximum	Number of cases
$\Delta Q_{PB/UB}$	-0.185	0.000	0.377	-1.000	0.490	84
$\Delta Q_{MB/UB}$	0.063	0.030	0.086	0.000	0.460	84
$\Delta Q_{PB/MB}$	-0.245	-0.090	0.331	-1.000	0.050	84
AB	0.471	0.406	0.417	0.000	1.000	84

5.3 Comparison of prices

In the case of price differentials, too, we compare the single prices in the mixed-bundling case to those in the unbundling case.

$$\Delta p^*_{MB/UB} = \frac{(p^*_{1,MB} + p^*_{2,MB}) - (p^*_{1,UB} + p^*_{2,UB})}{(p^*_{1,UB} + p^*_{2,UB})} \quad (15)$$

where:

$\Delta p^*_{MB/UB}$: Price differentials for the products under a mixed bundling and an unbundling regime,

$p^*_{1,MB}$: Optimal price of product 1 under a mixed bundling regime,

$p^*_{2,MB}$: Optimal price of product 2 under a mixed bundling regime.

We can also compare the optimal pure-bundling price, on the one hand, to the sum of the optimal single prices (unbundling), and, on the other, to the optimal bundle price (mixed bundling):

(16) $$\Delta p^*_{PB/UB} = \frac{p^*_{B,PB} - (p^*_{1,UB} + p^*_{2,UB})}{(p^*_{1,UB} + p^*_{2,UB})}$$

(17) $$\Delta p^*_{PB/MB} = \frac{p^*_{B,PB} - p^*_{B,MB}}{p^*_{B,MB}}$$

where:

$\Delta p^*_{PB/UB}$ Price differentials between pure bundling and unbundling for both products,

$p^*_{B,PB}$: Price for the bundle under a pure bundling regime,

$\Delta p^*_{PB/MB}$: Price differentials for the bundle under a pure and a mixed bundling regime.

In the case of mixed bundling, to ascertain how much lower the bundle price is compared to the sum of the single prices, we compare the price of the bundle with the sum of the single-price items.:

(18) $$BD^*_{MB} = \frac{p^*_{B,MB} - (p^*_{1,MB} + p^*_{2,MB})}{(p^*_{1,MB} + p^*_{2,MB})}$$

where:

BD^*_{MB}: Relative bundle deduction under a mixed bundling regime.

Table 10: Relative price differentials

Profit differential	Mean	Median	Standard deviation	Minimum	Maximum	Number of cases
$\Delta p^*_{PB/UB}$	-0.046	-0.030	0.065	-0.260	0.090	84
$\Delta p^*_{MB/UB}$	0.111	0.095	0.119	0.000	0.500	84
$\Delta p^*_{PB/MB}$	-0.013	-0.004	0.022	-0.079	0.000	84
BD^*_{MB}	-0.100	-0.120	0.085	-0.310	0.000	84

From *Table 10*, three things become particularly clear:

1) The discount on the bundle does not need to be positive, so that the mixed-bundle price need never to be greater than the sum of the two single prices.

2) The optimal mixed-bundling single prices are never lower than the unbundling prices.

3) The pure-bundling price is never greater than the mixed-bundling price.

We explain the points as follows:

(1) A danger of mixed bundling is that the purchase of the bundle entails the non-fulfillment of the exclusion condition. That is, consumers, whose RP for both products is less than the corresponding

variable costs, buy the bundle. To avoid this possible problem, it is sufficient if we ensure that the bundle price corresponds to the sum of the single prices. In those cases in which a consumer has an RP for one of the products that is below variable costs, the consumer surplus on the purchase of the other product is always higher than that of the bundle.[15]

(2) The mixed-bundling price is set at a level that ensures that the consumers' RP is absorbed with an equally high RP for both products. The single prices of the mixed bundle reap the RP of consumers who have a high RP for only one of the two products. By setting the price levels thus, fewer consumers with a low RP are taken into account and hence the bundles command higher single prices. *Figure 6* shows that this in the case of two products with a high SMGP and negatively correlated RPs.[16] With mixed bundling, it is not necessary to take the relatively low RP in regions A and B into account when determining the single prices. Consequently, the single prices are higher in this case than in that of unbundling.

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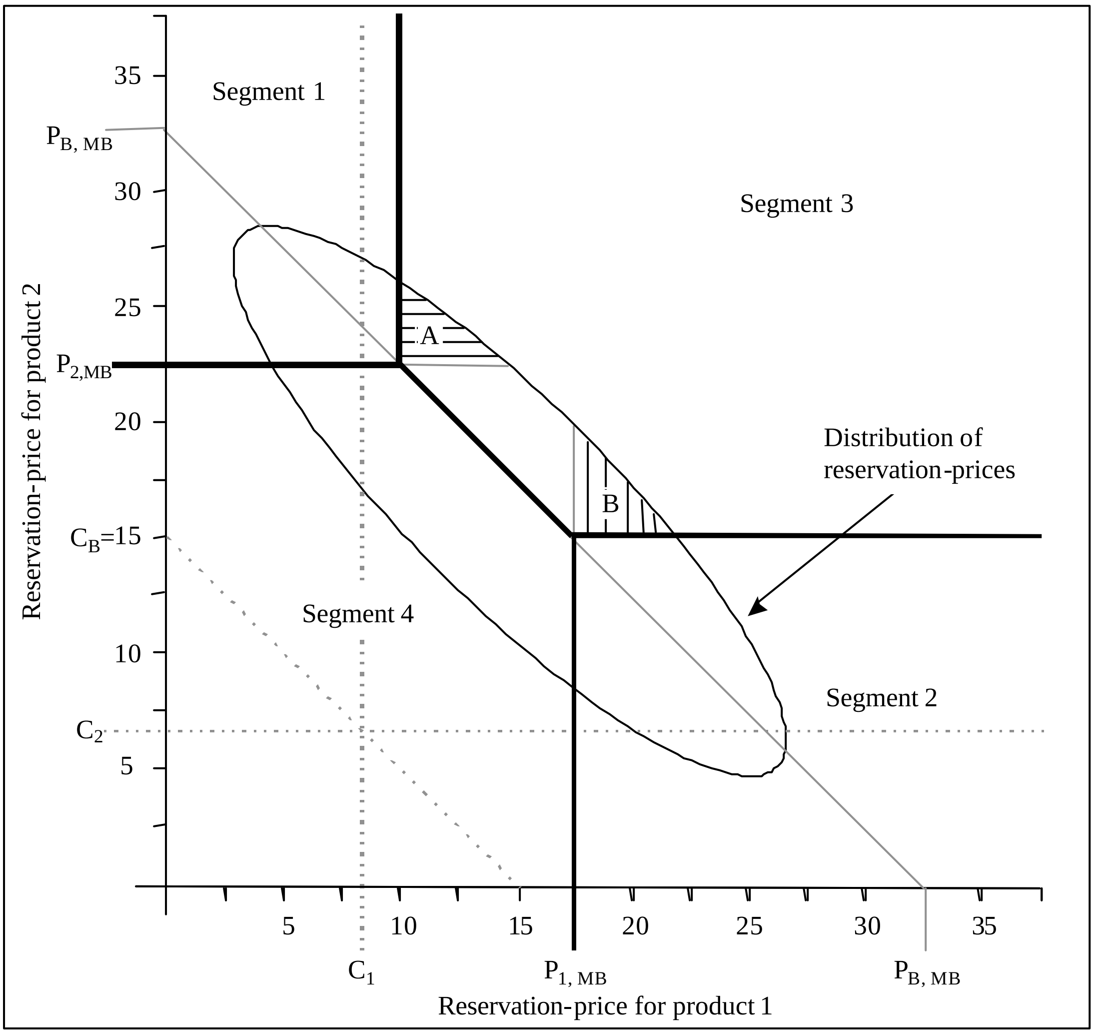
15 The difference between the consumer surplus associated with the bundle purchase and that of the purchase of the single product is identical to the difference between the RPs for the purchase of the other product and the concomitant variable costs.

16 With strong positive correlations, the differences are not so pronounced, because then, for example, the pure-bundling price corresponds to the sum of the unbundled single prices.

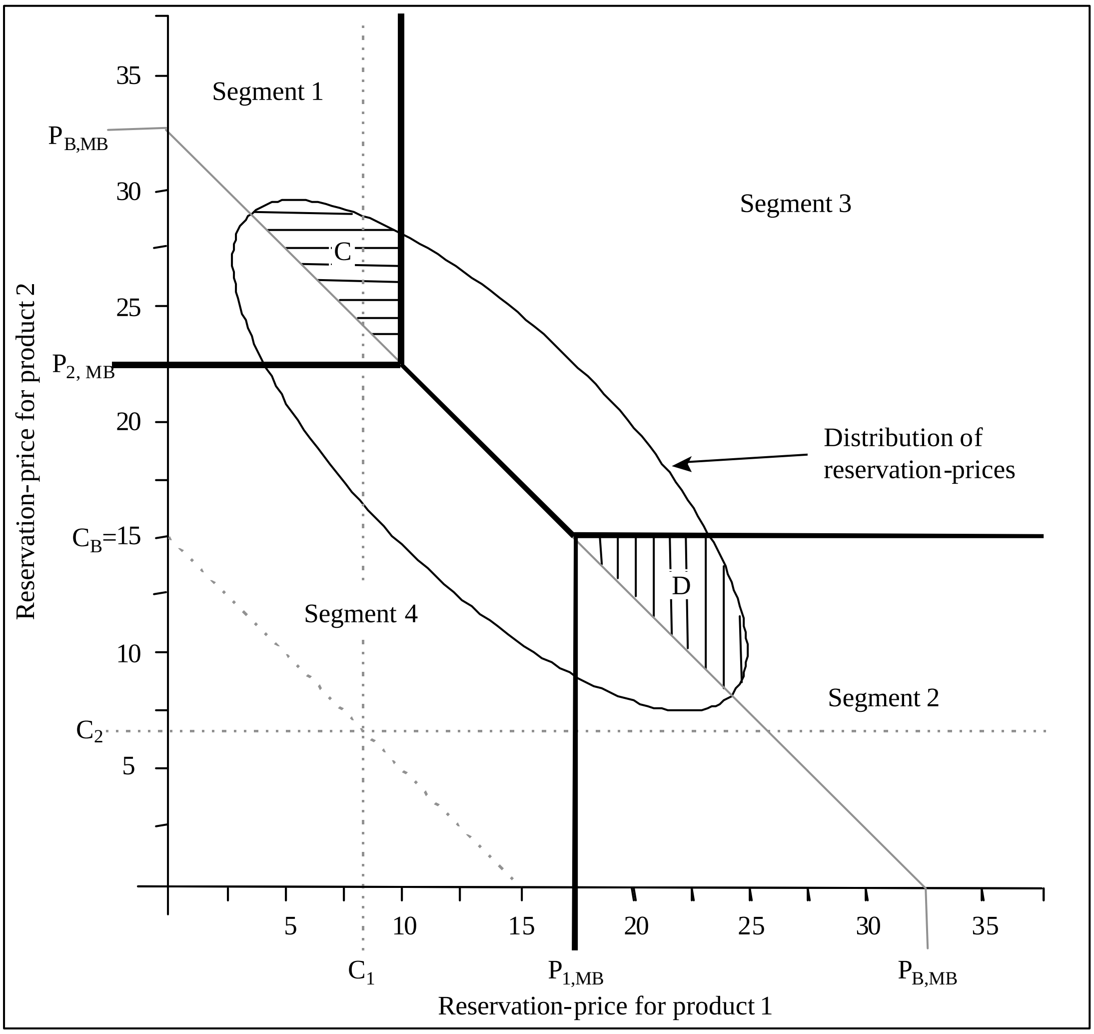
Figure 6: Comparison of the prices under a mixed bundling and an unbundling regime



(3) With mixed bundling, we divide consumers into four segments: those who buy only one of the products (Segments 1 and 2, *Figure 7*), those who buy the bundle (Segment 3) and those who buy nothing (Segment 4).

By contrast, with pure bundling, only two segments correspond to buyers and non-buyers. *Figure 7* shows that consumers with a low RP for the bundle but a high RP for one of the two products, can be found in Regions C and D in the mixed bundling case, i.e., buyers of one of the products. As a result, fewer consumers with a low RP are taken into account when the mixed-bundling price is set. This price is therefore higher than the pure-bundling price.

Figure 7: Comparison of the bundle price in mixed and pure bundling



6 Practical implications

The results show that the degree of benefit conferred by the bundling strategies depends essentially on the relation between the RP and variable costs (here, measured by the SMGP). Bundling is only worthwhile if the RP exceeds variable costs. In such a case, negatively correlated RPs for the single products increases the benefits conferred by bundling. However, this latter influence is of less importance than the relation between RP and variable costs.

The influence of the relation between the RP and the variable costs can explain why mixed bundling of food and drink is successful for fast food restaurants, but not so for ordinary restaurants: the SMGP on food in fast food outlets is higher, and that for drinks is lower, than it is in regular restaurants.

The prices of food and drink can be used as indicators of RP. Regular restaurants make more money on drink than on food. Consequently, the less profitable product (food) would have to be bundled with the more profitable (drink), if bundling were to be attempted at all. But due to the differential profitability, no positive effect of profit can be expected. In the case of fast food restaurants, the SMGPs are similar for food and drink, so that equally profitable products can be bundled, leading to a positive effect on profits.

As a rule, firms can orient their decision for or against bundling to the relation between the RP and variable costs. Under the conditions with which we have been working, the pure-bundling strategy is less efficacious than its unbundling counterpart because of the relatively small profit increases associated with the former. Hence, a unbundling strategy should be used. By switching from unbundling to mixed bundling, the optimal single prices of the products increase.

Summary

Using a simulation study which is based on a model by *Schmalensee* (1984), we analyze the impact on profit and sales of the three price bundling strategies of unbundling, mixed bundling, and pure bundling. Our analysis shows under what conditions which of the three price bundling strategies leads to the highest profit, how large the profit and sales differences of the three strategies are, and what characteristics the corresponding price structures have. On the basis of these results, we derive assertions for the differences and some implications for the price structuring in practice.

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