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One-Stop-Shopping hinders Specialization

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One-Stop-Shopping hinders Specialization*

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Abstract

I study how consumer preferences for one-stop-shopping affect the resource allocation of multiproduct firms. In many markets, consumers prefer to buy multiple products at a single seller. At the same time, multiproduct firms have to split their resources between their products, for instance by allocating R&D budgets or shelf space. One-stop-shoppers treat firms' products as if offered as bundles. If there are only one-stop-shoppers, firms therefore cannot gain from a comparative advantage over a particular product. I show that firms become more inclined to specialize in different products and gain market power, as the share of one-stop-shoppers decreases. Thereby, industry profits rise, potentially to the detriment of consumers.

JEL Classification: D43, L13, L81

Keywords: one-stop-shopping, specialization, multiproduct competition.

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1 Introduction

One-stop-shopping is prevalent among consumers in both offline and online markets. In traditional shopping settings, many consumers prefer to purchase all of their groceries or other goods at a single retailer in order to save transportation costs and time. In digital markets, ecosystems generate consumption synergies for consumers that use multiple of their products and services, e.g. through product integration, centralized access and recommendation systems. Multiproduct firms operating in these environments face the important trade-off of allocating their resources among their products. This decision determines the firm's level of specialization across its product categories.

Retailers' product assortment decisions constitute a natural example of this trade-off. Given their limited shelf and storage space, retailers must allocate this capacity across different product categories. If they offer more variants of some product category, they can offer fewer variants of another category. Depending on whether consumers engage in one-stop-shopping or visit multiple retailers, they may care about the variety offered in only one category or multiple categories.[1]

In digital markets, many firms offer multiple devices that can be connected within their digital ecosystems. For instance, Apple and Samsung both offer notebooks, tablets, smartphones, and wearables.[2] Given fixed capacities of their R&D departments due to budgets and staffing, they need to prioritize R&D projects contributing to the development of different devices, thereby influencing the quality of these devices. If consumers purchase multiple devices from one firm, they benefit through simplified account and subscription management, joint apps and interfaces, as well as effortless data sharing across devices. Consumers who highly value these benefits therefore will choose to engage in one-stop-shopping.

The shopping behavior of consumers substantially affects how firms allocate their resources. If consumers do not face shopping frictions, they compare individual products among firms. Firms therefore can gain from specialization, obtaining a comparative advantage for a particular product. If consumers engage in one-stop-shopping, they care about the aggregate value provided by firms' product portfolios, which is maximized by a balanced allocation of resources among products under diminishing returns of investments.

The effect described above is demonstrated in my analysis. I study a duopoly model

[1] Another example is discussed by Bar-Isaac (2009). He argues that experts such as lawyers, consultants and academics face the trade-off of acquiring a broad education, or concentrating in a particular field.

[2] Smart home systems represent a similar example, where multiple interconnected devices from the same provider enable smooth integration.

involving differentiation between stores à la Hotelling (1929), where both firms offer two products. First, they decide how to allocate their resources among these products, thereby determining their qualities. Second, they compete in prices. There are two groups of consumers. One-stop-shoppers are forced to purchase both products at a single firm. Flexible shoppers face no shopping frictions. I show that (weakly) more firms are specializing in equilibrium, as the share of one-stop-shoppers decreases. As firms gain market power through specialization, industry profits are strictly increasing in the share of flexible shoppers. This can come to the detriment of consumers.

I contribute to a rich literature on markets characterized by one-stop-shopping behavior. Previous work analyzes the effects of consumers' shopping frictions on product lines (Klemperer, 1992; Klemperer and Padilla, 1997), the formation of malls (Beggs, 1994) and superstores (Johansen and Nilssen, 2016), slotting fees (Caprice and von Schlippenbach, 2013) as well as upstream merger incentives (Baye et al., 2018). Chen and Rey (2012, 2019) argue that loss leading can serve as both an exploitative practice and a form of competitive cross-subsidization in the presence of heterogeneous shopping patterns.[3] To the best of my knowledge, I am the first to study the comparative statics of multiproduct firms' specialization decisions with respect to shopping frictions.[4]

It is known from the literature on bundling and compatibility (Matutes and Regibeau, 1988; Economides, 1989; Nalebuff, 2000; Zhou, 2017) that price competition in duopoly is more intense when firms compete in bundles rather than individual components.[5] Intuitively, bundling reduces differentiation as the average valuation per product in a bundle is less dispersed than the valuation of individual products. Thomassen et al. (2017) argue that this effect also applies to one-stop-shopping. Using UK consumer data on grocery shopping, they show that consumers who are more inclined to one-stop-shop have a larger pro-competitive impact. I abstract from this effect by assuming horizontal differentiation between stores rather than products and demonstrate an alternative pro-competitive effect of one-stop-shopping. As more consumers engage in one-stop-shopping, firms become less inclined to specialize, which mitigates market power.

The remainder of the chapter is organized as follows. In Section 2, I present the model, which is solved backwards in the subsequent sections. Section 3 characterizes pricing and

[3] Heterogeneous shopping patterns are also part of their theory on conglomerate mergers (Chen and Rey, 2023).

[4] Chen and Rey (2019) analyze the resource allocation decision of firms as an extension to demonstrate that asymmetric comparative advantages would arise endogenously. There is however no trade-off involved, as there are constant returns of investment into single products.

[5] Zhou (2017) shows that this result does not necessarily hold for a larger number of firms.

Section 4 resource allocation. I analyze welfare implications in Section 5 and conclude in Section 6.

2 Setting

There are two retailers and a continuum of risk-neutral consumers of mass 1. Retailers are indexed by $k \in \{A,B\}$ and both offer two independent products which are indexed by $i \in \{1,2\}$. Consumers have unit demand for both products and no outside option. Firms set prices p_{ki} and face a discrete choice of how to allocate resources among the two products. Formally, their choice determines the qualities of their products (q_{k1}, q_{k2}). Firms could either choose to split resources equally and set $(q_{k1}, q_{k2}) = (q_m, q_m)$ or specialize in product 1 or 2 and set $(q_{k1}, q_{k2}) = (q_h, q_l)$ or $(q_{k1}, q_{k2}) = (q_l, q_h)$, where $q_h > q_m > q_l$. I assume that $q_m - q_l > q_h - q_m$, which captures decreasing returns of investment into a single product.

Consumers are heterogeneous in terms of their shopping cost. A share $\alpha \in [0,1]$ of consumers consists of one-stop-shoppers. Their shopping costs are prohibitively high such that they always purchase both products at the same retailer. A share $1-\alpha$ of consumers consists of flexible shoppers. They face no shopping frictions.

There is store differentiation among the two retailers. Firms are located at the extremes of a Hotelling line: While firm A is located at $l_A = 0$, firm B is located at $l_B = 1$. Consumers are uniformly distributed on the unit interval and accordingly incur linear transport costs τ when buying a product from one of the firms. Thus, the net utility of consumer j located at $x_j \in [0,1]$ when buying product i from firm k at price p_{ki} equals:

$$u_{jki}(p_{ki}, x_j) = q_{ki} - \tau(|x_j - l_k|) - p_{ki}$$

The total utility of a consumer amounts to the sum of the net utilities of the two products chosen by that consumer. The magnitude of transport costs is thus proportional to the number of products bought at a firm. In practice, this could resemble a preference for the different brands offered by retailers or the shopping experience, whose impact depends on the time spent at a store.

The timing of the game is as follows:

1. Firms simultaneously and publicly choose their resource allocation $(q_{k1}, q_{k2}) \in \{(q_m, q_m), (q_h, q_l), (q_l, q_h)\}$.
2. Firms simultaneously set prices p_{ki} for their products.

The equilibrium concept is subgame perfect equilibrium. I will proceed by backwards induction and first solve for the equilibrium of the pricing subgame. I assume that $\frac{q_h - q_l}{\tau} \leq 3$ to ensure an interior pricing equilibrium.

3 Pricing

I first solve for the pricing equilibrium in two benchmark cases, where there are only one-stop-shoppers ($\alpha = 1$) or only flexible shoppers ($\alpha = 0$).

3.1 Benchmark 1: Only one-stop-shoppers ($\alpha = 1$)

If there are only one-stop-shoppers, firms act as if competing in bundles on a single market, where consumers incur a linear transport cost of 2τ. Consumers only care about the bundle prices $P_k = p_{k1} + p_{k2}$. I define $\Delta = q_{A1} + q_{A2} - q_{B1} - q_{B2}$ ($\Lambda = \frac{\Delta}{4\tau}$) to capture the (adjusted) quality difference between the bundles offered by the firms. The indifferent consumer is located at $\hat{x}(P_A, P_B) = \frac{1}{2} + \frac{P_B - P_A}{4\tau} + \frac{\Delta}{4\tau}$. Firms solve the following profit maximization problem:

$$\text{Firm A: } \max_{P_A} P_A \left(\frac{1}{2} + \frac{P_B - P_A}{4\tau} + \Lambda \right)$$

$$\text{Firm B: } \max_{P_B} P_B \left(\frac{1}{2} + \frac{P_A - P_B}{4\tau} - \Lambda \right)$$

Standard Hotelling arguments yield equilibrium prices of $P_A^* = 2\tau + \frac{4}{3}\Lambda\tau$ and $P_B^* = 2\tau - \frac{4}{3}\Lambda\tau$ as well as equilibrium profits of $\pi_A^* = \left(\frac{1}{2} + \frac{1}{3}\Lambda\right)\left(2\tau + \frac{4}{3}\Lambda\tau\right)$ and $\pi_B^* = \left(\frac{1}{2} - \frac{1}{3}\Lambda\right)\left(2\tau - \frac{4}{3}\Lambda\tau\right)$. The equilibrium profits only depend on the quality difference between the bundles.

3.2 Benchmark 2: Only flexible consumers ($\alpha = 0$)

If there are only flexible shoppers, firms essentially compete on two independent markets, where consumers incur a linear transport cost of τ on each market. I define $\Delta_i = q_{Ai} - q_{Bi}$ ($\Lambda_i = \frac{\Delta_i}{2\tau}$) to capture the (adjusted) quality difference for product i. The indifferent consumer is located at $\hat{x}_i(p_{Ai}, p_{Bi}) = \frac{1}{2} + \frac{p_{Bi} - p_{Ai}}{2\tau} + \frac{\Delta_i}{2\tau}$. Firms solve the following profit maximization problem on market i:

$$\text{Firm A: } \max_{p_{Ai}} p_{Ai} \left(\frac{1}{2} + \frac{p_{Bi} - p_{Ai}}{2\tau} + \Lambda_i \right)$$

$$\text{Firm B: } \max_{p_{Bi}} p_{Bi}\left(\frac{1}{2}+\frac{p_{Ai}-p_{Bi}}{2\tau}-\Lambda_i\right)$$

Equilibrium prices of $p^*_{Ai}=\tau+\frac{2}{3}\Lambda_i\tau$ and $p^*_{Bi}=\tau-\frac{2}{3}\Lambda_i\tau$ are obtained. Equilibrium profits equal $\pi^*_{Ai}=\left(\frac{1}{2}+\frac{1}{3}\Lambda_i\right)\left(\tau+\frac{2}{3}\Lambda_i\tau\right)$ and $\pi^*_{Bi}=\left(\frac{1}{2}-\frac{1}{3}\Lambda_i\right)\left(\tau-\frac{2}{3}\Lambda_i\tau\right)$.[6] Firm A's (B's) profits are strictly increasing and strictly convex in Λ_i ($-\Lambda_i$). Therefore, total industry profits are higher if one firm holds a comparative advantage by offering a higher quality. Firms would therefore benefit if they could coordinate to specialize in different products.

3.3 The general case: $\alpha \in [0,1]$

Consider now the general case, where a share α of consumers consists of one-stop-shoppers, who decide which bundle to buy, while a share $1-\alpha$ consists of flexible consumers, who face no shopping frictions. Market-level prices of firms for product i influence $\hat{x}_i(p_{Ai},p_{Bi})$, which determines the demand of flexible shoppers. Bundle prices, which equal the sum of market-level prices, affect $\hat{x}(P_A,P_B)$ and thus the demand of one-stop-shoppers. Firms solve the following profit maximization problem:

$$\begin{aligned}\text{Firm A: } \max_{p_{A1},p_{A2}} \ & \alpha(p_{A1}+p_{A2})\left(\frac{1}{2}+\frac{p_{B1}+p_{B2}-p_{A1}-p_{A2}}{4\tau}+\Lambda\right)\\ &+(1-\alpha)p_{A1}\left(\frac{1}{2}+\frac{p_{B1}-p_{A1}}{2\tau}+\Lambda_1\right)\\ &+(1-\alpha)p_{A2}\left(\frac{1}{2}+\frac{p_{B2}-p_{A2}}{2\tau}+\Lambda_2\right)\end{aligned}$$

$$\begin{aligned}\text{Firm B: } \max_{p_{B1},p_{B2}} \ & \alpha(p_{B1}+p_{B2})\left(\frac{1}{2}+\frac{p_{A1}+p_{A2}-p_{B1}-p_{B2}}{4\tau}-\Lambda\right)\\ &+(1-\alpha)p_{B1}\left(\frac{1}{2}+\frac{p_{A1}-p_{B1}}{2\tau}-\Lambda_1\right)\\ &+(1-\alpha)p_{B2}\left(\frac{1}{2}+\frac{p_{A2}-p_{B2}}{2\tau}-\Lambda_2\right)\end{aligned}$$

Taking FOCs and solving for the fixed point of firms' best response correspondences, which is relegated to the Appendix, yields the following pricing equilibrium.[7]

[6] For the analysis in Section 4, I use normalized profits. Profits are divided by τ and 1 is subtracted to obtain normalized profits.

[7] For the analysis in Section 4, I use normalized profits. Profits are divided by τ, multiplied by 9, and 1 is

Proposition 1. *For any $\alpha \in [0,1]$, there exists a unique pure-strategy equilibrium at the pricing stage. Equilibrium prices are given by:*

$$p^*_{A1} = \frac{1}{3}\big(3 + (2-\alpha)\Lambda_1 - \alpha\Lambda_2 + \alpha 2\Lambda\big)\tau$$

$$p^*_{A2} = \frac{1}{3}\big(3 + (2-\alpha)\Lambda_2 - \alpha\Lambda_1 + \alpha 2\Lambda\big)\tau$$

$$p^*_{B1} = \frac{1}{3}\big(3 - (2-\alpha)\Lambda_1 + \alpha\Lambda_2 - \alpha 2\Lambda\big)\tau$$

$$p^*_{B2} = \frac{1}{3}\big(3 - (2-\alpha)\Lambda_2 + \alpha\Lambda_1 - \alpha 2\Lambda\big)\tau$$

Equilibrium profits equal:

$$\pi^*_A = \frac{1}{9}\tau\Big((2-\alpha)(1-\alpha)\Lambda_1^2 + (2-\alpha)(1-\alpha)\Lambda_2^2 + 2(1-\alpha)\Lambda_1(3+2\Lambda\alpha - \alpha\Lambda_2) + 2(1-\alpha)\Lambda_2(3+2\alpha\Lambda) + (3+2\alpha\Lambda)^2\Big)$$

$$\pi^*_B = \frac{1}{9}\tau\Big((2-\alpha)(1-\alpha)\Lambda_1^2 + (2-\alpha)(1-\alpha)\Lambda_2^2 + 2(1-\alpha)\Lambda_1(3-2\Lambda\alpha + \alpha\Lambda_2) - 2(1-\alpha)\Lambda_2(3-2\alpha\Lambda) + (3-2\alpha\Lambda)^2\Big)$$

Proof: See Appendix.

At $\alpha = 1$ and $\alpha = 0$, Proposition 1 nests the outcomes of the benchmark cases discussed before. As α is increasing, the effect of product-specific quality differences on equilibrium profits shrinks, while the importance of quality differences in bundles grows.

4 Specialization

Given the pricing equilibrium, I can now proceed with the resource allocation decision of firms. It is straightforward to argue that a firm would never choose to specialize in the same product as its competitor.[8] It could specialize in the other product and earn higher profits from flexible shoppers. Furthermore, firms are indifferent between specializing in product 1 and product 2 when the other firm chooses to split resources equally. The game analyzed in this section can therefore be simplified: Each firm chooses between two actions that are not strictly dominated in any case. It could specialize in a product that its competitor does not specialize in (S), or split resources equally (E). Payoffs are determined by the equilibrium

subtracted to obtain normalized profits.

[8] I restrict attention to pure-strategy equilibria.

profits of the pricing stage. For the analysis, I use normalized profits as defined in footnotes 6 and 7.

4.1 Benchmark 1: Only one-stop-shoppers ($\alpha = 1$)

When facing only one-stop-shoppers, pricing equilibrium profits of firms solely depend on Λ. Therefore, they choose to maximize the quality differences between bundles and split resources equally. (E,E) is the unique equilibrium.

4.2 Benchmark 2: Only flexible shoppers ($\alpha = 0$)

If there are only flexible consumers, the equilibrium at the resource allocation stage depends on the magnitude of the effect of diminishing returns of investment. To simplify notation, I define $\sigma_h = \frac{q_h - q_m}{2\tau}$ and $\sigma_m = \frac{q_m - q_l}{2\tau}$. (E,E) constitutes an equilibrium under the following condition:

$$\underbrace{0}_{\text{Profits (E,E)}} \geq \underbrace{\frac{2}{9}(\sigma_h)^2 + \frac{2}{9} - \frac{2}{3}(\sigma_m - \sigma_h)}_{\text{Profits (S,E)}}$$

This results in the following inequality:

$$\frac{2}{3}(\sigma_m - \sigma_h) \geq \frac{2}{9}(\sigma_h)^2 + \frac{2}{9}(\sigma_m)^2 \tag{1}$$

An equilibrium, in which both firms split resources equally, arises if $\sigma_m - \sigma_h$ is sufficiently large. The opposite holds true for an equilibrium (S,S). Both firms are better off to specialize if the following condition is satisfied:

$$\underbrace{\frac{4}{9}(\sigma_h + \sigma_m)^2}_{\text{Profits (S,S)}} \geq \underbrace{\frac{2}{3}(\sigma_m - \sigma_h) + \frac{2}{9}(\sigma_h)^2 + \frac{2}{9}(\sigma_m)^2}_{\text{Profits (E,S)}}$$

This can be rewritten as follows:

$$\frac{2}{9}(\sigma_h)^2 + \frac{2}{9}(\sigma_m)^2 + \frac{8}{9}\sigma_h\sigma_m \geq \frac{2}{3}(\sigma_m - \sigma_h) \tag{2}$$

It is straightforward to see that inequalities (1) and (2) cannot be violated at the same time. Therefore, (E,S) or (S,E) cannot constitute an equilibrium. Depending on the parameters, the set of equilibria consists of either only (S,S), only (E,E) or (S,S) and (E,E). Intuitively, firms face a trade-off between a specialization effect and an efficiency effect. Under constant returns of investment, specialization would be optimal due to the convexity of the pricing equilibrium profits in Λ_i. However, splitting returns equally is more efficient due to diminishing returns of investment. The relative size of the efficiency effect and the specialization effect determine the equilibrium outcome.

4.3 The general case: $\alpha \in [0,1]$

In the general case $\alpha \in [0,1]$, splitting resources equally constitutes a best response to itself if the following condition is met:

$$\underbrace{0}_{\text{Profits (E,E)}} \geq \underbrace{6(\sigma_h - \sigma_m) + (2-\alpha)\sigma_h^2 + (2-\alpha)\sigma_m^2 - 2\alpha\sigma_h\sigma_m}_{\text{Profits (S,E)}} \tag{3}$$

When the other firm specializes, specialization is a best response under the following condition:

$$\underbrace{4(1-\alpha)\sigma_m^2 + 4(1-\alpha)\sigma_h^2 + 8(1-\alpha)\sigma_m\sigma_h}_{\text{Profits (S,S)}} \geq \underbrace{6(\sigma_m - \sigma_h) + (2-\alpha)\sigma_h^2 + (2-\alpha)\sigma_m^2 - 2\alpha\sigma_h\sigma_m}_{\text{Profits (E,S)}} \tag{4}$$

The equilibrium can then be characterized as follows:

Proposition 2. *Consider any $\alpha \in [0,1]$. There exists at least one pure-strategy equilibrium at the resource allocation stage:*

- *(E,E) constitutes an equilibrium if condition (3) holds.*
- *(S,E) and (E,S) constitute equilibria if conditions (3) and (4) do both not hold.*
- *(S,S) constitutes an equilibrium if condition (4) holds.*

It is straightforward to see that the RHS of (3) and the difference of the LHS and the RHS of (4) are strictly decreasing in α. This results in the following comparative statics:

Corollary 1. *Define $\bar{\alpha} = \frac{6(\sigma_h-\sigma_m)+2\sigma_h^2+2\sigma_m^2}{\sigma_h^2+\sigma_m^2+2\sigma_m\sigma_h}$ and $\tilde{\alpha} = \frac{2\sigma_m^2+2\sigma_h^2+8\sigma_m\sigma_h+6(\sigma_h-\sigma_m)}{3\sigma_m^2+3\sigma_h^2+6\sigma_m\sigma_h}$.*[9]

- *(E,E) constitutes an equilibrium if $\alpha \geq \bar{\alpha}$.*
- *(S,E) and (E,S) constitute equilibria if $\alpha \leq \bar{\alpha}$ and $\alpha \geq \tilde{\alpha}$.*

[9] Both, $\bar{\alpha}$ and $\tilde{\alpha}$ might take negative values.

- *(S,S) constitutes an equilibrium if $\alpha \leq \tilde{\alpha}$.*

Under a given rule of equilibrium selection, the number of firms specializing in equilibrium is (weakly decreasing) in the share of one-stop-shoppers. Intuitively, the magnitude of the specialization effect is decreasing in the share of one-stop-shoppers. Therefore, firms only have a unilateral incentive to specialize if the share of flexible shoppers is sufficiently high.

5 Welfare

It is commonly expected that firms can abuse frictions on the consumer side to raise profits. My model however yields the opposite prediction: Firms benefit if less consumers face shopping frictions.

Proposition 3. *Fix any rule of equilibrium selection that is independent of α.*[10] *Then, firms' equilibrium profits are (weakly) decreasing in α.*

Proof: See Appendix.

The argument to establish this result is twofold. First, firms would like to coordinate on specialization regardless of α. While the sum of the equilibrium prices $p_{Ai} + p_{Bi}$ is independent of Λ_i, Λ_{-i} and Λ, a larger share of consumers purchases at the firm setting the higher price on market i in an equilibrium involving one firm specializing on market i. Industry profits are therefore increasing in the number of firms specializing. A decrease in α can lead to an equilibrium involving more firms specializing according to Corollary 1. Second, the magnitude of the specialization effect is decreasing in α. Therefore, firms' profits are decreasing in α even when the action profile at the resource allocation stage is fixed.

I illustrate the effects on consumer surplus and total welfare, by comparing the two benchmark cases of $\alpha = 1$ and $\alpha = 0$ under the assumption that condition (1) does not hold, which implies that (S,S) is the unique equilibrium at the resource allocation stage.

Proposition 4. *Suppose that condition (1) does not hold. Then, total welfare is higher under $\alpha = 0$ than under $\alpha = 1$. If $\tau \geq \sqrt{\frac{5}{4}}$, consumer surplus is lower under $\alpha = 0$ than under $\alpha = 1$.*

[10] A rule of equilibrium selection is defined to be independent of α if and only if it fulfills the following criterion: If the same set of equilibria arises for $\alpha_1, \alpha_2 \in [0,1]$, then the same equilibrium is selected for α_1 and α_2. One example is constituted by selecting the equilibrium maximizing firms' total profits.

Proof: See Appendix.

A removal of shopping frictions can lead to increased profits of firms to the detriment of consumers. This is particularly remarkable, as my framework does not quantify the increase in shopping costs for consumers who engage in multi-stop shopping under $\alpha = 0$. The difference in consumer surplus (and welfare) between $\alpha = 0$ and $\alpha = 1$ can therefore be seen as a conservative upper bound.

6 Conclusion

In this paper, I study the comparative statics of multiproduct firms' resource allocation with respect to consumers' shopping frictions. If less consumers are one-stop-shoppers, firms are more inclined to specialize and gain market power. Industry profits are therefore decreasing in the share of one-stop-shoppers. An important limitation of my analysis is the assumption that the share of one-stop-shoppers is exogenous and therefore not influenced by pricing.

The special case of $\alpha = 1$ ($\alpha = 0$) can alternatively be interpreted as a market where firms do (not) choose to bundle their products or make their products compatible. My analysis therefore demonstrates a procompetitive effect of both bundling and incompatibility. If firms had the choice, they would prefer not to bundle or make their products compatible before entering the stage game analyzed in this paper.

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Appendix

Proof of Proposition 1

Taking the FOCs yields the following best response functions:

$$p_{A1} = \frac{\tau}{2-\alpha} + \frac{\alpha\Lambda 2\tau}{2-\alpha} + \frac{(1-\alpha)\Lambda_1 2\tau}{2-\alpha} + \frac{1}{2}p_{B1} + \frac{\alpha/2}{2-\alpha}p_{B2} - \frac{\alpha}{2-\alpha}p_{A2}$$

$$p_{A2} = \frac{\tau}{2-\alpha} + \frac{\alpha\Lambda 2\tau}{2-\alpha} + \frac{(1-\alpha)\Lambda_2 2\tau}{2-\alpha} + \frac{1}{2}p_{B2} + \frac{\alpha/2}{2-\alpha}p_{B1} - \frac{\alpha}{2-\alpha}p_{A1}$$

$$p_{B1} = \frac{\tau}{2-\alpha} - \frac{\alpha\Lambda 2\tau}{2-\alpha} - \frac{(1-\alpha)\Lambda_1 2\tau}{2-\alpha} + \frac{1}{2}p_{A1} + \frac{\alpha/2}{2-\alpha}p_{A2} - \frac{\alpha}{2-\alpha}p_{B2}$$

$$p_{B2} = \frac{\tau}{2-\alpha} - \frac{\alpha\Lambda 2\tau}{2-\alpha} - \frac{(1-\alpha)\Lambda_2 2\tau}{2-\alpha} + \frac{1}{2}p_{A2} + \frac{\alpha/2}{2-\alpha}p_{A1} - \frac{\alpha}{2-\alpha}p_{B1}$$

The equilibrium prices are the unique solution to this system of equations. It remains to establish global concavity of the profit functions. The Hessian matrices of both firms are given as follows:

$$\begin{bmatrix} -\frac{2-\alpha}{2\tau} & -\frac{\alpha}{2\tau} \\ -\frac{\alpha}{2\tau} & -\frac{2-\alpha}{2\tau} \end{bmatrix}$$

As the first leading principal minor is negative and the second leading principal minor is positive, the Hessian matrix is negative definite. Therefore, the profit functions are strictly concave in price vectors for both firms.

Proof of Proposition 3

It is straightforward to establish that equilibrium profits under a fixed action profile at the resource allocation stage are constant in α for (E,E) and strictly decreasing in α for (S,E), (S,S) and (E,S). It remains to be checked that profits decrease if there is a shift in the equilibrium at the resource allocation stage. Suppose that the equilibrium shifts from (E,E) to (S,E) or (E,S). Then, profits of the firm specializing are increased as condition (3) is violated and profits of the firm splitting resources equally are increased as profits under (E,S) are higher than under (S,E) and condition (3) is violated. Suppose that the equilibrium shifts from (E,E) to (S,S). Then, profits of both firms are increased as the (normalized) profits under (S,S) are strictly positive. Lastly, suppose that the equilibrium shifts from (S,E) or (E,S) to (S,S). Then, the profits of the firm previously splitting resources equally increase as condition (4) holds and the profits of the firm previously specializing increase as profits under (E,S) are higher than under (S,E) and condition (4) holds.

Proof of Proposition 4

If $\alpha = 1$, firms do not specialize in equilibrium. On each market i, consumers receive a utility of q_m, pay a price of τ and an average transport cost of $\frac{1}{4}\tau$. If $\alpha = 0$, the following expressions are obtained:

$$\text{Average utility: } \left(\frac{1}{2}+\frac{1}{3}\frac{(q_h-q_l)}{2\tau}\right)q_h+\left(\frac{1}{2}-\frac{1}{3}\frac{(q_h-q_l)}{2\tau}\right)q_l$$
$$\text{Average price: } \tau\left(1+\left(\frac{1}{2}+\frac{1}{3}\frac{(q_h-q_l)}{2\tau}\right)\frac{(q_h-q_l)}{2\tau}-\left(\frac{1}{2}-\frac{1}{3}\frac{(q_h-q_l)}{2\tau}\right)\frac{(q_h-q_l)}{2\tau}\right)$$
$$\text{Average transport cost: } \tau\left(\left(\frac{1}{2}+\frac{1}{3}\frac{(q_h-q_l)}{2\tau}\right)^2\frac{\tau}{2}+\left(\frac{1}{2}-\frac{1}{3}\frac{(q_h-q_l)}{2\tau}\right)^2\frac{\tau}{2}\right)$$

The difference in consumer surplus between $\alpha = 0$ and $\alpha = 1$ boils down to:

$$\frac{1}{2}(q_h+q_l-2q_m)+\frac{5(q_h-q_l)^2}{36\tau}-\frac{1}{9}(q_h-q_l)^2\tau$$

The first term is negative due to decreasing returns of investment. It is straightforward to show that the sum of the second and the third term is negative if $\tau \geq \sqrt{\frac{5}{4}}$. This inequality is therefore a sufficient condition for a lower consumer surplus under $\alpha = 0$.

The difference in welfare between $\alpha = 0$ and $\alpha = 1$ boils down to:

$$\frac{1}{2}(q_h+q_l-2q_m)+\frac{5(q_h-q_l)^2}{36\tau}$$

Thus, total welfare is higher under $\alpha = 0$ if the following inequality holds:

$$\frac{5(q_h-q_l)^2}{36\tau} \geq \frac{1}{2}(2q_m-q_h-q_l)$$

The negation of condition (1) can be rewritten as:

$$\frac{1}{12\tau}\left((q_h-q_m)^2+(q_m-q_l)^2\right) \geq \frac{1}{2}(2q_m-q_h-q_l)$$

It holds that:

$$\frac{1}{12\tau}\left((q_h-q_m)^2+(q_m-q_l)^2\right)\leq\frac{1}{12\tau}\left((q_h-q_m)^2+(q_m-q_l)^2+2(q_h-q_m)(q_m-q_l)\right)$$
$$=\frac{1}{12\tau}\left(q_h-q_l\right)^2\leq\frac{5}{36\tau}\left(q_h-q_l\right)^2$$

Therefore, the negation of condition (1) implies that total welfare is higher under $\alpha=0$.