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BUNDLING AND MENUS OF TWO-PART TARIFFS*

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Inducing self-selection among different segments of consumers is an important issue in pricing. Some firms induce self-selection by offering a menu of two-part tariffs (e.g., different rate plans) and letting consumers select the tariff and quantity they prefer. Other firms induce self-selection by offering a menu of price-quantity bundles (e.g., different package sizes) and letting consumers select only from among these bundles. We show that bundling is more profitable absent cost considerations. Social welfare may be higher or lower with bundling.

I. INTRODUCTION

AIRLINE COMPANIES DISCRIMINATE between business and leisure travelers by offering different classes of service, e.g., first class and coach class, and by requiring Saturday-night stays and advance purchases. Credit card companies discriminate among customers by offering gold, silver, and platinum cards that differ in annual fees, interest rates, and credit limits.[1] Phone companies offer different rate plans to discriminate between heavy and light users of long-distance service.[2] Consumer-goods products often come in different package sizes. Restaurants offer large and small size drinks.

In each of these examples, the firms know something about the aggregate distribution of their consumers' demand preferences, and they can identify distinct market segments, but they cannot distinguish ex-ante to which segment a given consumer belongs. Thus, if a firm wants to engage in price discrimination, it has no choice but to offer the same menu of options to all

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[1] For example, US Airways offers a gold, silver, and platinum card for their Dividend Miles program.
[2] For example, AT&T offers a long-distance calling plan with no monthly fee and a per-unit price of 10 cents a minute, and a long-distance calling plan with a monthly fee of $3.95 and a per-unit price of 7 cents a minute.

consumers and to price the menu so as to induce consumers to reveal their identity by the option they select.

Inducing self-selection among consumer segments is an important issue in pricing, and the technique for implementing it is well known: the firm must ensure that each consumer selects the option designed for her and not the option designed for another consumer. For example, the consumer to whom the gold card is targeted must find that the savings from paying a lower annual fee on the other cards is more than offset by the reduction in their amenities. The consumer to whom the large-size drink option is targeted must find that the savings from the lower price on the small-size drink option is more than offset by the reduction in quantity. And the consumer to whom the high monthly fee is targeted must find that the savings from the lower per-unit price more than offsets the gain from the option with the lower monthly fee and higher per-unit price.

Yet less is known about the optimal method of inducing self-selection, both from a profitability standpoint and from a social welfare perspective. In this paper, we derive conditions under which it is more profitable for a firm to offer a menu of price-quantity bundles (e.g., different package sizes) than a menu of two-part tariffs (e.g., different rate plans). We also consider which is better for social welfare. Although we focus on the case of two consumer types that differ in their quantity demanded of a product of fixed quality, our model also applies to the case where consumers differ in their willingness to pay for quality of a product of fixed quantity.

We find that, absent cost considerations, profits are higher with bundling than with two-part tariffs as long as standard single-crossing conditions apply and as long as it is optimal to serve all consumers at least some output. Thus, for example, with two consumer types, a firm can earn higher profit when consumers choose between two package sizes than when they choose between two payment schedules, one with a high fixed fee and low per-unit price and the other with a low fixed fee and high per-unit price. Analogously, if the two consumer types differ in their willingness to pay for quality, a firm can earn higher profit by offering a fixed product line of two qualities than by offering a menu of two pricing schedules that allow consumers to customize their quality needs.

Because bundling is more efficient than two-part tariffs at inducing self-selection, one might think that bundling would also be better for social welfare, causing the least distortion in the low-demand consumer's quantity.[3] However, we show that, depending on the shape of the demand curves, either pricing mechanism may be socially preferred. In the special case where the high-demand consumers' demand is a parallel shift out of the

[3] Neither pricing mechanism induces a distortion in the high-demand consumer's quantity.

low-demand consumers' demand, the two methods of inducing self-selection yield the same social welfare. Surprisingly, the social-welfare ranking of the two mechanisms is independent of the number or proportion of each type of consumer.

Faulhaber and Panzar (1977) were the first to rank methods of inducing self-selection in terms of profitability. They showed that, absent cost considerations, inducing self-selection from a menu of two-part tariffs is equivalent to inducing self-selection from a declining block rate tariff structure. However, they did not compare these methods to optimal menus of bundles. Murphy (1977) discussed two-part tariffs along with bundling, and conjectured that bundling would be more profitable than two-part tariffs with equal numbers of high and low-demand consumers. Spence (1980) made a similar conjecture about bundling in section 4 of his seminal work but then incorrectly concluded that the quantity consumed by the low-demand consumers would on average be higher with the optimal menu of bundles than with the optimal menu of two-part tariffs.

The rest of the paper proceeds as follows. In Section 2, we describe the firm's problem and solve first for the profit-maximizing menu of two-part tariffs and second for the profit-maximizing menu of price-quantity bundles. We then compare the firm's profit in the two cases. In Section 3, we consider whether social welfare is higher or lower with bundling than with two-part tariffs. In Section 4, we discuss the analogy to products of different qualities and offer concluding remarks.

II. THE MONOPOLIST'S PROBLEM

Let us consider the case where a monopolist produces a single good at constant marginal cost c and faces a demand composed of heterogenous consumers. For now, we assume consumers differ in their consumption preferences according to a taste parameter θ (the model easily extends to consumers with differing tastes for quality.) A consumer of type θ derives utility $V(q, \theta)$ from consumption of $q > 0$ units of the good and 0 otherwise. The following restrictions are imposed on $V(q, \theta)$:

$$(1) \qquad \frac{\partial V(q,\theta)}{\partial q} > 0, \quad \frac{\partial^2 V(q,\theta)}{\partial q^2} < 0,$$

$$(2) \qquad \frac{\partial V(q,\theta)}{\partial \theta} > 0, \quad \frac{\partial^2 V(q,\theta)}{\partial q \partial \theta} > 0.$$

For simplicity, we assume there are two groups (types) of consumers. The low-demand group has taste parameter θ_1 and occurs in proportion $\lambda \in [0, 1]$, and the high-demand group has taste parameter θ_2 and occurs in proportion $(1 - \lambda)$.

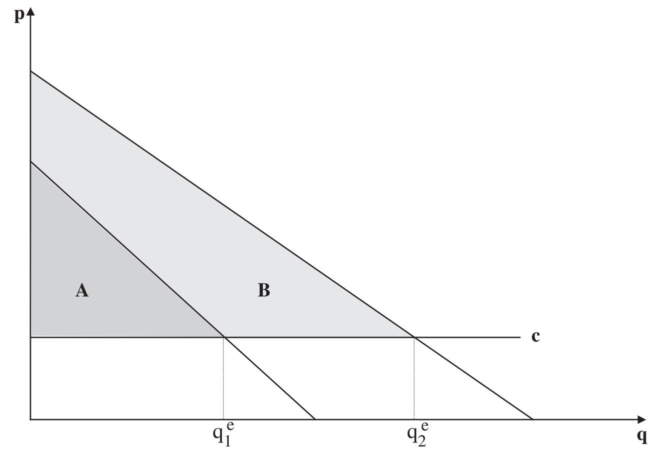

Figure 1
Consumer Demands

We assume $\theta_2 > \theta_1$. Given constant marginal costs of production, the number of consumers can be normalized to one without loss of generality.

The restrictions in (1) imply that utility is increasing in q but at a diminishing rate (this ensures that demand is downward sloping). The restrictions in (2) imply that utility is increasing in θ (this is a normalization) and that the demand curve of a high-demand consumer is weakly above the demand curve of a low-demand consumer (this satisfies the well known single-crossing condition).

Figure 1 illustrates the demand curves facing the monopolist. Let q_1^e denote the quantity that satisfies $\frac{\partial V(q,\theta_1)}{\partial q} = c$, and let q_2^e denote the quantity that satisfies $\frac{\partial V(q,\theta_2)}{\partial q} = c$. Assume resale among consumers is prohibitively costly so that there is no resale market. Then, if the monopolist can distinguish among consumers, it can extract all surplus by charging a per-unit price of c to both types, a fixed fee of A to the low-demand type, and a fixed fee of $A + B$ to the high-demand type. Alternatively, the monopolist can extract all surplus by offering a bundle of q_1^e units at a price of $A + cq_1^e$ to the low-demand type, and a bundle of q_2^e units at a price of $A + B + cq_2^e$ to the high-demand type. In this case, absent cost considerations, the monopolist will be indifferent between the profit-maximizing menu of two-part tariffs and the profit-maximizing menu of bundles.

However, if the monopolist cannot distinguish among consumers, then it will in general not be able to extract all the potential surplus. The reason is that the monopolist must then offer the same deal or deals to all consumers, taking into account the possibility of personal arbitrage (a consumer of one type chooses an option meant for another type).[4] In particular, the monopolist must choose the terms of its offer to prevent a high-demand consumer from mimicking a low-demand consumer, and this limits the amount of surplus the monopolist can extract. As we shall see, this also breaks the monopolist's indifference between two-part tariffs and bundling.

Menus of Two-part Tariffs

Suppose the monopolist offers a menu of two-part-tariffs $((p_1, F_1), (p_2, F_2))$, where p_i denotes the per-unit price and F_i is the fixed fee, $i = 1, 2$, with (p_1, F_1) meant for the low-demand consumer and (p_2, F_2) meant for the high-demand consumer. Let $q_1^*(p)$ denote the low-demand consumer's quantity choice if she faces a per-unit price of p and purchases a positive quantity, i.e., $q_1^*(p)$ solves $\frac{\partial V(q,\theta_1)}{\partial q} = p$, and let $q_2^*(p)$ be defined analogously. Then the monopolist's problem is

$$(3) \qquad \max_{p_1, p_2, F_1, F} \lambda(p_1 - c)q_1^*(p_1) + (1-\lambda)(p_2 - c)q_2^*(p_2) + \lambda F_1 + (1-\lambda)F_2,$$

subject to the low-demand consumer purchasing a positive quantity,

$$(4) \qquad V(q_1^*(p_1), \theta_1) - p_1 q_1^*(p_1) - F_1 \geq 0,$$

and the high-demand consumer choosing to purchase under (p_2, F_2) rather than (p_1, F_1),

$$(5) \qquad V(q_2^*(p_2), \theta_2) - p_2 q_2^*(p_2) - F_2 \geq V(q_2^*(p_1), \theta_2) - p_1 q_2^*(p_1) - F_1.$$

Because the maximand in (3) is increasing in F_1 and F_2, it follows that F_1 will be chosen to satisfy (4) with equality and that, given F_1, F_2 will be chosen to satisfy (5) with equality.[5] Since $V(q_1^*(p_1), \theta_2) > V(q_1^*(p_1), \theta_1)$, this implies that a low-demand consumer will derive no net surplus from consumption of the product while a high-demand consumer will derive positive net surplus.

To determine the profit-maximizing per-unit prices, we can substitute the fixed fees obtained in this way into the maximand in (3) and differentiate to

[4] In what follows, we assume that the monopolist wants to serve both consumer types. That is, we assume that selling to the high-demand consumers only is less profitable than selling to both types. See Salant (1989) for a characterization of the necessary and sufficient conditions for discrimination to be optimal in the two-type case.

[5] For completeness, there are two other constraints that should be mentioned: the high-demand consumer must want to purchase a positive quantity, and the low-demand consumer must not want to choose the option intended for the high-demand consumer. The latter constraint clearly never binds, and the former constraint is also not a problem. Since a high-demand consumer can always mimic a low-demand consumer and earn at least as high a surplus, the high-demand consumer purchases a positive quantity.

obtain the first-order conditions:

(6) $$\left(\frac{\partial V(q_2^*(p_2),\theta_2)}{\partial q}-c\right)\frac{\partial q_2^*(p_2)}{\partial p_2}=0,$$

(7) $$\lambda\left(\frac{\partial V(q_1^*(p_1),\theta_1)}{\partial q}-c\right)\frac{\partial q_1^*(p_1)}{\partial p_1}+(1-\lambda)\big(q_2^*(p_1)-q_1^*(p_1)\big)=0.$$

The expression in (6) implies that the profit-maximizing price to the high-demand consumers must equal the firm's marginal cost. Thus, there is no distortion at the top. However, there is a distortion at the bottom. To see this, note that the left-hand side of the expression in (7) consists of two terms. It is the existence of the second term, $(1-\lambda)\big(q_2^*(p_1)-q_1^*(p_1)\big)$, that causes a distortion in the price to a low-demand consumer. Since a high-demand consumer consumes more at any given price than a low-demand consumer, we have that $q_2^*(p_1)-q_1^*(p_1)>0$, which implies that the profit-maximizing price to the low-demand consumers will exceed the firm's marginal cost.

It follows that high-demand consumers will consume the efficient quantity q_2^e, while low-demand consumers will consume less than q_1^e. This result is well known in the price discrimination literature and the intuition is straightforward. The firm is constrained by the possibility that a high-demand consumer will choose the option meant for the low-demand consumer. To relax this constraint, the firm must distort the low-demand type's consumption downward (a high-demand consumer suffers more from a quantity reduction than a low-demand consumer), making it less tempting for the high-demand consumer to choose. Conversely, the high-demand consumers' consumption is not distorted because the low-demand consumers' personal-arbitrage constraint is never binding.

Let $((p_1^*,F_1^*),(p_2^*,F_2^*))$ solve the monopolist's problem in (3)–(5), and let $T_1^*\equiv p_1^*q_1^*(p_1^*)+F_1^*$ denote the amount paid to the monopolist by a low-demand consumer. Define T_2^* analogously. Then the monopolist's maximized profit given the optimal menu of two-part tariffs is

$$\pi^{2PT}\equiv\lambda(T_1^*-cq_1^*(p_1^*))+(1-\lambda)(T_2^*-cq_2^*(p_2^*)).$$

Bundling

Now suppose the monopolist offers a menu of bundles $((q_1,T_1),(q_2,T_2))$, where q_i denotes the bundled quantity of the good and T_i is its price, with (q_1,T_1) meant for the low-demand consumer and (q_2,T_2) meant for the high-demand consumer.[6] Then the monopolist's

[6] As an example, one can think of different package sizes of consumer goods as a menu of price-quantity bundles where the units of the product are appropriately defined. In particular, cereal might be sold in an 18 oz. box and a 10 oz. box. The former can be thought of as a bundle of 18 ounces and the latter as a bundle of 10 ounces.

problem is

$$(8) \qquad \max_{q_1, q_2, T_1, T_2} \lambda(T_1 - cq_1) + (1-\lambda)(T_2 - cq_2),$$

subject to the low-demand consumer purchasing a positive quantity,

$$(9) \qquad V(q_1, \theta_1) - T_1 \geq 0,$$

and the high-demand consumer choosing the bundle q_2 at price T_2 rather than q_1 at price T_1,

$$(10) \qquad V(q_2, \theta_2) - T_2 \geq V(q_1, \theta_2) - T_1.$$

Because the maximand in (8) is increasing in T_1 and T_2, it follows that T_1 will be chosen to satisfy (9) with equality and that, given T_1, T_2 will be chosen to satisfy (10) with equality. As in the case with a menu of two-part tariffs, a low-demand consumer will derive no net surplus from consumption of the product while a high-demand consumer will derive positive net surplus.

To determine the profit-maximizing quantities, we can substitute the T_1 and T_2 obtained in this way into the maximand in (8) and differentiate to obtain the first-order conditions:

$$(11) \qquad \frac{\partial V(q_2, \theta_2)}{\partial q} - c = 0,$$

$$(12) \qquad \lambda\left(\frac{\partial V(q_1, \theta_1)}{\partial q} - c\right) + (1-\lambda)\left(\frac{\partial V(q_1, \theta_1)}{\partial q} - \frac{\partial V(q_1, \theta_2)}{\partial q}\right) = 0,$$

The expression in (11) implies that the profit-maximizing quantity to the high-demand consumers is the efficient quantity q_2^e (thus, there is no distortion at the top). The left-hand side of the expression in (12) consists of two terms. It is the existence of the second term, $(1-\lambda)\left(\frac{\partial V(q_1,\theta_1)}{\partial q} - \frac{\partial V(q_1,\theta_2)}{\partial q}\right)$, that causes a distortion in the quantity to a low-demand consumer. Since a high-demand consumer is assumed to have higher utility at any given quantity than a low-demand consumer, we have that $\frac{\partial V(q_1,\theta_1)}{\partial q} - \frac{\partial V(q_1,\theta_2)}{\partial q} < 0$, which implies that the profit-maximizing quantity to the low-demand consumers is less than the efficient quantity q_1^e (thus, there is a distortion at the bottom).

Let $((\hat{q}_1, \hat{T}_1), (\hat{q}_2, \hat{T}_2))$ solve the monopolist's problem in (8)–(10). Then the monopolist's maximized profit given the optimal menu of price-quantity bundles is

$$\pi^B \equiv \lambda(\hat{T}_1 - c\hat{q}_1) + (1-\lambda)(\hat{T}_2 - c\hat{q}_2).$$

Bundling versus menus of two-part tariffs

We have looked at two pricing mechanisms a monopolist might use to exploit consumer self-selection: bundling and two-part tariffs. The two mechanisms share some common features. In both cases, the quantity consumed by a high-demand consumer is efficient, and the quantity consumed by a low-demand consumer is distorted downward. However, there are also significant differences. As we will now show, absent cost considerations, neither the monopolist's maximized profit nor social welfare will in general be the same in the two cases. We begin by comparing profits.

We know from the revelation principle that there is no loss of generality in restricting the monopolist's attention to direct revelation mechanisms in which consumers are induced to reveal their type truthfully. Since direct revelation mechanisms are simply menus of price-quantity bundles that have at most as many options as the number of consumer types, any direct revelation mechanism can be implemented as a simple bundling mechanism and vice versa.[7] Hence, it follows from the revelation principle that the profit-maximizing bundling mechanism achieves the highest possible profit over all pricing mechanisms, and thus that bundling must be weakly superior to two-part tariffs: $\pi^B \geq \pi^{2PT}$. However, the revelation principle does not imply that bundling strictly outperforms two-part tariffs. Murphy (1977) conjectured that bundling would outperform two-part tariffs whenever there were equal numbers of high and low demand consumers. We now prove his conjecture and extend it to include any number of consumers and proportion of each type.[8]

Proposition 1. The profit-maximizing menu of price-quantity bundles yields strictly higher profit than the profit-maximizing menu of two-part tariffs. That is, $\pi^B > \pi^{2PT}$.

Proof. We show that there exists a menu of bundles that replicates the profit-maximizing two-part tariff quantities, gives strictly higher payoff, and satisfies the constraints in (9) and (10).

Let ε be an arbitrarily small positive number and consider the menu of bundles $((q_1^*(p_1^*), T_1^*), (q_2^*(p_2^*), T_2^* + \varepsilon))$. Assume, for now, that this menu is feasible, i.e., it satisfies the constraints in (9) and (10). Then, by choosing this

[7] The expression 'revelation principle' first appeared in Myerson (1981). For earlier discussions of the principle's implications, see Myerson (1979) and Dasgupta, Hammond, and Maskin (1979). For an up-to-date discussion of its applicability in principal-agent models with asymmetric information, see Laffont and Martimort (2002).

[8] Spence (1980) offered an incomplete proof of Murphy's conjecture. He showed that the quantities and prices in the profit-maximizing menu of bundles *could not* be induced by a *feasible* menu of two-part tariffs, but did not show that the induced quantities and payments in the profit-maximizing menu of two-part tariffs *could* be induced by a *feasible* menu of bundles. Spence also interpreted his findings incorrectly, as we shall see in Section 3.

menu, the monopolist could have had a profit of

$$\pi^{\varepsilon} \equiv \lambda(T_1^* - cq_1^*(p_1^*)) + (1-\lambda)(T_2^* - cq_2^*(p_2^*) + \varepsilon) > \pi^{2PT}.$$

Since the monopolist did not choose the menu $((q_1^*(p_1^*), T_1^*), (q_2^*(p_2^*), T_2^* + \varepsilon))$, but instead maximized its profit with the menu $((\hat{q}_1, \hat{T}_1), (\hat{q}_2, \hat{T}_2))$, it follows that $\pi^B \geq \pi^{\varepsilon}$. Thus, it follows that $\pi^B > \pi^{2PT}$.

To complete the proof, it remains to show that the menu $((q_1^*(p_1^*), T_1^*), (q_2^*(p_2^*), T_2^* + \varepsilon))$ satisfies the constraints in (9) and (10). We relegate this part of the proof to the appendix. QED

The proof of Proposition 1 suggests how a firm that is inducing self-selection with a menu of two-part tariffs can implement an increase in its profit. Regardless of the induced quantity choices of the low and high-demand consumers given the menu of two-part tariffs employed by the firm, the firm can do strictly better by offering these same quantities as bundles at prices such that the amount collected from the low-demand consumers is unchanged and the amount collected from the high-demand consumers is increased by a small amount. As shown in the proof, this menu of price-quantity bundles satisfies the self-selection constraints and leads to strictly higher profit.

Bundling does better than a menu of two-part tariffs because it constrains the amount of surplus a high-demand consumer can obtain if she chooses the option meant for a low-demand consumer. To see this, suppose a high-demand consumer were to choose the option meant for a low-demand consumer. Then, with bundling, she would be forced to consume the same quantity that a low-demand consumer would consume, whereas with a menu of two-part tariffs, she could reoptimize to a higher quantity and increase the amount of surplus she could obtain (reduce the amount of surplus the monopolist can extract). We can illustrate this intuition in Figure 2. We have drawn the profit-maximizing per-unit prices and the corresponding quantity choices of a high and low-demand consumer when the monopolist offers a menu of two-part tariffs. As illustrated, $p_2^* = c$ and $p_1^* > c$, which follow from the first-order conditions in (6) and (7). From (4), we have that F_1^* equals the shaded area A, and from (5), we have that F_2^* equals the shaded area $A + B + C$. To induce self-selection, the monopolist must leave the high-demand consumer a surplus of $D + E$.

The monopolist can increase its profit by at least $(1-\lambda)E$ when it adopts a strategy of bundling because it can always induce self-selection by choosing a menu of bundles with the same quantities that would be chosen under the optimal menu of two-part tariffs, $q_1^*(p_1^*)$ and $q_2^*(p_2^*)$, a price for the first bundle that is the same as the total payment of the low-demand consumer under the optimal menu of two-part tariffs, $A + p_1^* q_1^*(p_1^*)$, and a price for the second bundle that exceeds by area E the total payment of the high-demand

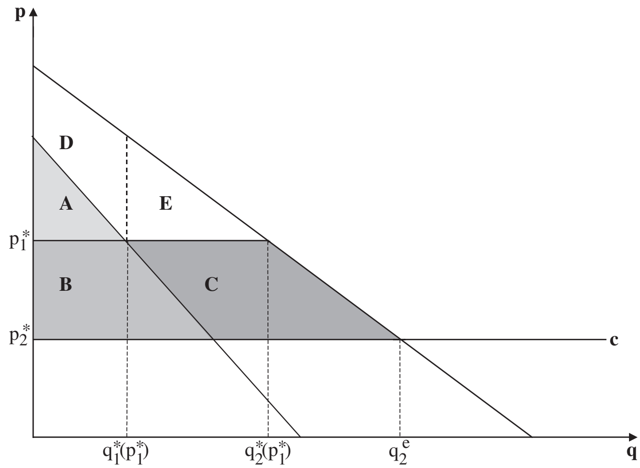

Figure 2
Optimal Menu of Two-Part Tariffs

consumer under the optimal menu of two-part tariffs, $A + B + C + E + p_2^* q_2^e$. Since the high-demand consumer pays more and the low-demand consumer pays the same, the monopolist's profit increases. Of course, the monopolist may be able to do even better by changing the bundled quantities from those that would be induced with two-part tariffs.

III. PROFIT-MAXIMIZING QUANTITIES WITH BUNDLING

Spence (1980, 829) conjectured that the quantity consumed by the low-demand consumers would be higher (less distorted) with the profit-maximizing menu of bundles than with the profit-maximizing menu of two-part tariffs (recall that the quantity meant for the high-demand consumers is q_2^e and is without change).[9] This conjecture has some intuitive appeal because menus of price-quantity bundles are more efficient at extracting surplus than menus of two-part-tariffs (and therefore closer to achieving perfect price discrimination), and therefore it would seem that the quantity sold to the low-demand type would be higher (closer to q_1^e) with the profit-maximizing menu of bundles than with the profit-maximizing menu of two-part tariffs.[10] However, this intuition is incorrect. In what follows, we will

[9] After showing that the quantities and prices in the profit-maximizing menu of price-quantity bundles *could not* be induced by a feasible menu of two-part tariffs, Spence wrote, 'Therefore, the ability to extract revenues from a given bundle of goods (one for each group) is lower under the two-part tariff approach. And this will force the required prices up, on average, and the quantities purchased down.' We will show that this conjecture is incorrect.

[10] Recall that with perfect price discrimination, a firm would sell the quantity q_1^e to the low-demand consumers.

derive conditions under which the optimal bundled quantity is higher, lower, and the same for the low-demand consumers compared to what it would be with two-part tariffs.

To see how the monopolist should adjust its quantities, recall that (7) implies that

$$\lambda\left(\frac{\partial V(q_1^*(p_1^*),\theta_1)}{\partial q}-c\right)\frac{\partial q_1^*(p_1^*)}{\partial p_1}+(1-\lambda)\big(q_2^*(p_1^*)-q_1^*(p_1^*)\big)=0, \tag{13}$$

and (12) implies that the low-demand quantity in the optimal menu of price-quantity bundles solves

$$\lambda\left(\frac{\partial V(q_1,\theta_1)}{\partial q}-c\right)+(1-\lambda)\left(\frac{\partial V(q_1,\theta_1)}{\partial q}-\frac{\partial V(q_1,\theta_2)}{\partial q}\right)=0. \tag{14}$$

If we evaluate the left-hand side of (14) at $q_1^*(p_1^*)$ and use (13) and the fact that

$$\frac{\partial^2 V(q_1^*(p_1^*),\theta_1)}{\partial q^2}\frac{\partial q_1^*(p_1^*)}{\partial p_1}=1,$$

then the left-hand side of (14) can be written as

$$\begin{aligned}&(1-\lambda)\big(q_1^*(p_1^*)-q_2^*(p_1^*)\big)\frac{\partial^2 V(q_1^*(p_1^*),\theta_1)}{\partial q^2}\\ &+(1-\lambda)\left(\frac{\partial V(q_1^*(p_1^*),\theta_1)}{\partial q}-\frac{\partial V(q_1^*(p_1^*),\theta_2)}{\partial q}\right).\end{aligned} \tag{15}$$

For all $\lambda \neq 1$, and using the fact that

$$\frac{\partial V(q_1^*(p_1^*),\theta_1)}{\partial q}=\frac{\partial V(q_2^*(p_1^*),\theta_2)}{\partial q},$$

we have that the sign of (15) is the same as the sign of

$$\int_{q_1^*(p_1^*)}^{q_2^*(p_1^*)}\left(\frac{\partial^2 V(q,\theta_2)}{\partial q^2}-\frac{\partial^2 V(q_1^*(p_1^*),\theta_1)}{\partial q^2}\right)dq, \tag{16}$$

which may be positive, negative, or zero depending on the slope of the high-demand consumer's demand *vis à vis* the slope of the low-demand consumer's demand at $q_1^*(p_1^*)$, over the range $q_2^*(p_1^*) - q_1^*(p_1^*)$. It follows that if (16) is positive, then $\hat{q}_1 > q_1^*(p_1^*)$, and if (16) is negative, then $\hat{q}_1 < q_1^*(p_1^*)$.

Since we know from (7) and (12) that $q_1^*(p_1^*)$ and $\hat{q}_1$ are less than q_1^e, and since we know from (16) that the sign of $\hat{q}_1 - q_1^*(p_1^*)$ may be positive, negative, or zero, we have that the profit-maximizing menu of price-quantity bundles may yield higher, lower, or the same social welfare as the profit-maximizing menu of two-part tariffs. Since (16) is independent of λ, it also follows that the social ranking is independent of the number of consumers and relative proportion of each consumer type.

III(i). *Illustrative classes of utility functions*

We can illustrate the three possible social welfare rankings by considering the class of utility functions $V(q, \theta)$ that yield linear demand curves. The following proposition gives the results.

Proposition 2. For all utility functions $V(q, \theta)$ yielding linear demand curves, we have

$$\hat{q}_1 < q_1^*(p_1^*) \;\Leftrightarrow\; \frac{\partial^2 V(q, \theta_2)}{\partial q^2} < \frac{\partial^2 V(q, \theta_1)}{\partial q^2},$$

$$\hat{q}_1 > q_1^*(p_1^*) \;\Leftrightarrow\; \frac{\partial^2 V(q, \theta_2)}{\partial q^2} > \frac{\partial^2 V(q, \theta_1)}{\partial q^2},$$

and

$$\hat{q}_1 = q_1^*(p_1^*) \;\Leftrightarrow\; \frac{\partial^2 V(q, \theta_2)}{\partial q^2} = \frac{\partial^2 V(q, \theta_1)}{\partial q^2}.$$

Proof. For all utility functions $V(q, \theta)$ yielding linear demand curves, Proposition 2 follows immediately from (16) and the fact that $\frac{\partial^2 V(q,\theta)}{\partial q^2}$ is constant for all q. QED

Since the second partial derivative of $V(q, \theta)$ with respect to q is the slope of a type θ consumer's demand curve, it follows from Proposition 2 that the social welfare ranking of bundling *vis à vis*, two-part tariffs depends only on the slopes of the demand curves. For demand curves that are linear in output, welfare is lower with bundling if and only if the demand curve of the high-demand consumers is *steeper* than the demand curve of the low-demand consumers. For demand curves that are linear in output, welfare is higher with bundling if and only if the demand curve of the high-demand consumers is *flatter* than the demand curve of the low-demand consumers. For linear demand functions that are parallel shifts of one another, welfare is the same in the two cases.

Of particular interest are the conditions under which two-part tariffs yield higher welfare than bundling since these represent conditions under which a ban on bundling could increase welfare. We now consider a second class of utility functions for which the bundled output can be smaller. Indeed, as we will show, for this class of utility functions, output is always smaller with bundling.

Suppose consumers have identical preferences for the monopolist's product, but different incomes. Then, as shown in Tirole (1988, 143), a consumer's utility from consumption of $q > 0$ units of the good gross of any payment to the monopolist can be represented by the class of utility functions $V(q, \theta) = f(\theta)g(q)$. This is a nice class of functions to consider because the entire heterogeneity in consumers' tastes can be derived solely from differences in their income. Assuming as before that there are two types of consumers with parameters θ_1 and θ_2, where $\theta_2 > \theta_1$, we have:

Proposition 3. For weakly concave demand functions of the class $V(q, \theta) = f(\theta)g(q)$, the quantity of the good purchased by the low-demand consumers is strictly lower under the optimal menu of price-quantity bundles than under the optimal menu of two-part tariffs. That is, $\hat{q}_1 < q_1^*(p_1^*)$.

Proof. Given the hypothesized class of demand functions, $V(q, \theta) = f(\theta)g(q)$, we have $\frac{\partial V(q,\theta)}{\partial q} = f(\theta)g'(q)$, implying that (16) can be written as

$$f(\theta_2)\big(g'(q_2^*(p_1^*)) - g'(q_1^*(p_1^*))\big) - f(\theta_1)\big(q_2^*(p_1^*) - q_1^*(p_1^*)\big)g''(q_1^*(p_1^*)).$$

Since $f(\theta_2) > f(\theta_1)$, weak concavity of g' implies that the expression above is negative. QED

Proposition 3 shows that for all utility functions which are multiplicatively separable in output and consumer type (implying that the horizontal axis intercept is independent of θ), and have weakly negative third derivatives in output, bundling yields lower output than two-part tariffs.

Example with a lower bundled quantity

Propositions 2 and 3 describe different sufficient conditions for quantity to fall with bundling. However, it is important to note that these conditions do overlap. This is evident for the case in which $V(q, \theta) = \theta\left(aq - \frac{q^2}{2}\right)$, which satisfies both Proposition 2 (first condition) and Proposition 3.

For $V(q, \theta) = \theta\left(aq - \frac{q^2}{2}\right)$, demand is linear with a horizontal axis intercept that is independent of θ and a slope that is decreasing in θ. In particular, the low-demand consumer's inverse demand is $p = \theta_1(a - q)$ and the high-demand consumer's inverse demand is $p = \theta_2(a - q)$. Using these inverse demands, we can solve for q as a function of p, $q_i = q_i^*(p)$, where $q_i^*(p) = a - \frac{p}{\theta_i}$, $i = 1, 2$.

We begin with the case of two-part tariffs. Substitutions into (6) and (7) and solving gives

$$q_1^*(p_1^*) = a - \frac{c}{\theta_1\left(1 - \frac{(1-\lambda)(\theta_2-\theta_1)}{\lambda\theta_2}\right)}, \quad q_2^*(p_2^*) = a - \frac{c}{\theta_2}.$$

For the case of bundling, substitutions into (11) and (12) and solving gives

$$\hat{q}_1 = a - \frac{c}{\theta_1\left(1 - \frac{(1-\lambda)(\theta_2-\theta_1)}{\lambda\theta_1}\right)}, \quad \hat{q}_2 = a - \frac{c}{\theta_2}.$$

In comparing the solutions for $q_2^*(p_2^*)$ and $\hat{q}_2$, we see that the quantity meant for the high-demand consumers is the same, while the quantity meant for the low-demand consumers is strictly *lower* under the optimal menu of bundles than under the optimal menu of two-part tariffs.

Using the values $a = 10$, $c = 6$, $\lambda = 2/3$, $\theta_1 = 2$, and $\theta_2 = 4$, we show in the appendix that bundling increases the monopolist's profit by 8% over the optimal menu of two-part tariffs.

Example with a higher bundled quantity

To illustrate the second condition in Proposition 2, suppose $V(q,\theta) = aq - \frac{q^2}{2\theta}$, so that the high-demand consumer's demand curve is flatter than the low-demand consumer's demand curve. For $V(q,\theta) = aq - \frac{q^2}{2\theta}$, demand is linear with a vertical axis intercept that is independent of θ and a slope that is increasing in θ. In particular, the low-demand consumer's inverse demand is $p = a - \frac{q}{\theta_1}$ and the high-demand consumer's inverse demand is $p = a - \frac{q}{\theta_2}$. Using these inverse demands, we can then solve for q as a function of p, $q_i = q_i^*(p)$, where $q_i^*(p) = \theta_i(a-p)$, $i = 1, 2$.

We begin with the case of two-part tariffs. Substitutions into (6) and (7) and solving gives

$$q_1^*(p_1^*) = \frac{\theta_1(a-c)}{1 + \left(\frac{1-\lambda}{\lambda}\right)\left(\frac{\theta_2-\theta_1}{\theta_1}\right)}, \quad q_2^*(p_2^*) = \theta_2(a-c).$$

For the case of bundling, substitutions into (11) and (12) and solving gives

$$\hat{q}_1 = \frac{\theta_1(a-c)}{1 + \left(\frac{1-\lambda}{\lambda}\right)\left(\frac{\theta_2-\theta_1}{\theta_2}\right)}, \quad \hat{q}_2 = \theta_2(a-c).$$

In comparing the solutions for $q_2^*(p_2^*)$ and $\hat{q}_2$, we see that the quantity meant for the high-demand consumers is the same, while the quantity meant for the low-demand consumers is strictly *higher* under the optimal menu of bundles than under the optimal menu of two-part tariffs.

Using the values $a = 10$, $c = 6$, $\lambda = 2/3$, $\theta_1 = 2$, and $\theta_2 = 4$, we show in the appendix that bundling increases the monopolist's profit by almost 8% over the optimal menu of two-part tariffs.

Example in which both quantities are the same

To illustrate the third condition in Proposition 2, we consider parallel shifts of demand curves. In particular, we let $V(q, \theta) = a\theta q - \frac{q^2}{2}$, so that demands are $q_i = q_i^*(p)$, where $q_i^*(p) = a\theta_i - p,\ i = 1, 2$. In this case, the solution is the same whether we substitute into (6) and (7) or (11) and (12):

$$q_1^*(p_1^*) = \hat{q}_1 = a\left(\frac{\theta_1 - (1-\lambda)\theta_2}{\lambda}\right) - c, \quad q_2^*(p_2^*) = \hat{q}_2 = a\theta_2 - c.$$

Using the values $a = 10$, $c = 6$, $\lambda = 2/3$, $\theta_1 = 2$, and $\theta_2 = 4$, we show in the appendix that bundling increases the monopolist's profit by almost 51% over the optimal menu of two-part tariffs.

IV. CONCLUSION

We have shown that a firm can earn higher profit with a menu of price-quantity bundles than with a menu of two-part tariffs when inducing self-selection. To illustrate, consider the case of an amusement park where the owner must decide whether to offer two-part tariffs or price-quantity bundles, and suppose that its customers can be segmented into two types. With a menu of two-part tariffs, the firm can segment the two types by letting them choose between a high admissions fee but a low per-unit cost of each ride and a low admissions fee but a high per-unit cost of each ride, where the number of rides is left up to each consumer. Alternatively, the firm can segment the two types by letting them choose between a standard package of a fixed number of rides at a given price (which includes admission) and a premium package which consists of a greater fixed number of rides at a higher price (which includes admission). Of these methods of inducing self-selection, our results imply that the latter offers the greater profit potential.

Our results also imply, however, that the profit-maximizing menu of bundles may be worse for social welfare than the profit-maximizing menu of two-part tariffs. For example, if consumers have identical preferences for the amusement park's offerings, but different incomes, then, our results imply that welfare will be lower when the owner of the amusement park offers a standard package and premium package than when the owner is constrained to offer a menu of two-part tariffs. This result is surprising because intuition might suggest that the more efficient means of surplus extraction (bundling) would result in a smaller distortion to the low-demand consumers.

We have abstracted from cost considerations in our analysis. It may be that when the cost of implementing a menu of price-quantity bundles is compared to the cost of implementing a menu of two-part tariffs, the latter becomes more profitable. For example, cell-phone companies offer a menu of different rates plans, which are essentially two-part tariffs. In this case, it may be very costly (*vis*. inefficient) to implement a menu of bundles. On the other hand, cost considerations may also work to favor menus of bundles. Consider the case of a potato chip manufacturer. It would be highly inefficient for the firm to offer a dispensing machine in the grocery store that allowed each consumer to choose her preferred quantity. In this case, we would expect the chip manufacturer to bundle its potato chips in packages of different sizes. Our analysis suggests that even in the absence of these cost considerations, the chip manufacturer might find it more profitable to bundle.

We have assumed the market consists of two consumer types. This assumption is inessential to our results as long as the number of consumer types is finite. To see this, suppose the firm identifies three consumer types (heavy users, medium users, and light users) and decides to offer an option to each. Then, as before, our results suggest that a menu of price-quantity bundles can do better than a menu of two-part tariffs (cost considerations aside) because regardless of the induced quantity choices of the low, medium, and high-demand consumers given the optimal menu of two-part tariffs, the firm can do strictly better by offering these same quantities as bundles at prices such that the amount collected from the low and medium demand consumers is unchanged and the amount collected from the high-demand consumers is increased by a small amount.

Our results would not apply, however, if there were a continuum of consumer types. Intuitively, in a model with a finite number of consumer groups, there is some separation in 'taste' space θ between consumer groups, which implies there is money on the table the monopolist can claim by restricting consumer choice using price-quantity bundles. With a continuum of consumers, there is no separation in taste space among consumer types, and a nonlinear price-schedule is optimal (Willig, 1978). In this case, there is no money left on the table for the monopolist to claim using bundles rather than two-part tariffs and the two pricing mechanisms yield the same outcome.

We have assumed that firms sell directly to consumers. This assumption is inessential. In business-to-business selling, where manufacturers sell to retailers, we can think of the retailers as consumers. In this case, the manufacturer may know that it faces retailers of different sizes but, given existing antitrust laws, e.g., the Robinson-Patman Act, it may not be possible directly to offer discriminatory terms to the large and small retailer. However, as many commentators have pointed out, it is often possible to satisfy antitrust laws against price-discrimination by offering a menu of options and letting each retailer self select.[11] As long as the various options are functionally available to all, our results suggest that a manufacturer can

[11] For a comprehensive legal treatment of this issue in the U.S., see *Antitrust Law Developments*, 4th edition, 1997, and *The Robinson-Patman Act: Policy and Law Volume 1*, 1980. See also Schwartz (1986) and Monroe (1990).

do better by forcing retailers to choose from a menu of price-quantity bundles than by allowing them to choose from among two-part tariffs.

Finally, we have assumed that the firm discriminates among consumers who differ in their quantity demanded of the good at equal prices. But our model also extends to the case in which all consumers demand one unit of the product but differ in their willingness to pay for quality.[12] In this case, our results suggest that the firm should offer a menu of price-quality bundles rather than a menu of two-part tariffs. Suppose, for instance, that a car manufacturer faces two types of consumers, those with a relatively high willingness to pay for quality and those with a relatively low willingness to pay for quality. Then, our results suggest that the car manufacturer should offer a basic car (with a certain set of amenities) and a more luxurious car (with an increased set of amenities), but should not allow consumers to purchase amenities separately. The intuition is that it is harder to induce self-selection if a high-quality consumer can purchase the basic car and upgrade it with additional amenities than if the same consumer is stuck with an either-or choice.

APPENDIX

Proof of Proposition 1. The first part of the proof is given in the text following Proposition 1. To complete the proof, we must show that the menu $((q_1^*(p_1^*), T_1^*),$ $(q_2^*(p_2^*), T_2^* + \varepsilon))$ satisfies the constraints in (9) and (10). To do this, it is useful to begin by solving explicitly for F_i^*.

Recall that $T_i^* \equiv p_i^* q_i^*(p_i^*) + F_i^*$ denotes the total payment received by the monopolist from a type i consumer. Since the maximand in (3) is increasing in F_1 and F_2, we know that F_1^* and F_2^* must satisfy the constraints in (4) and (5) with equality. Solving for F_1^* and F_1^* yields

$$F_1^* = V(q_1^*(p_1^*), \theta_1) - p_1^* q_1^*(p_1^*),$$

$$F_2^* = F_1^* + V(q_2^*(p_2^*), \theta_2) - V(q_2^*(p_1^*), \theta_2) + p_1 q_2^*(p_1^*) - p_2^* q_2^*(p_2^*).$$

Substituting F_1^* and F_2^* into T_1^* and T_2^* gives

$$T_1^* = V(q_1^*(p_1^*), \theta_1),$$

$$T_2^* = V(q_2^*(p_2^*), \theta_2) - V(q_2^*(p_1^*), \theta_2) + p_1^*(q_2^*(p_1^*) - q_1^*(p_1^*)) + V(q_1^*(p_1^*), \theta_1).$$

It follows immediately that the constraint in (9), $V(q_1^*(p_1^*), \theta_1) - T_1^* \geq 0$, is satisfied. To show that (10) is satisfied, we substitute the menu $((q_1^*(p_1^*), T_1^*),\ (q_2^*(p_2^*), T_2^* + \varepsilon))$ into (10) to obtain

$$V(q_2^*(p_1^*), \theta_2) - T_2^* - \varepsilon \geq V(q_1^*(p_1^*), \theta_2) - T_1^*.$$

[12] With a simple relabeling of variables, discrimination by quality can be shown to be formally identical to discrimination by quantity. See Maskin and Riley (1984), who were the first to draw the parallels in the two cases.

Substituting in for T_1^* and T_2^* gives

$$V(q_2^*(p_1^*), \theta_2) - p_1^*(q_2^*(p_1^*) - q_1^*(p_1^*)) \geq V(q_1^*(p_1^*), \theta_2) + \varepsilon,$$

which can be rewritten as

$$\text{(A1)} \qquad \left[V(q_2^*(p_1^*), \theta_2) - p_1^* q_2^*(p_1^*) - F_1^*\right] - \left[V(q_1^*(p_1^*), \theta_2) - p_1^* q_1^*(p_1^*) - F_1^*\right] \geq \varepsilon.$$

The first set of terms, $V(q_2^*(p_1^*), \theta_2) - p_1^* q_2^*(p_1^*) - F_1^*$, is a high-demand consumer's net surplus when it faces a two-part tariff (p_1^*, F_1^*) and chooses quantity $q_2^*(p_1^*)$, while the second set of terms, $V(q_1^*(p_1^*), \theta_2) - p_1^* q_1^*(p_1^*) - F_1^*$, is a high-demand consumer's net surplus when it faces the same two-part tariff (p_1^*, F_1^*) and chooses quantity $q_1^*(p_1^*)$. Since $q_2^*(p_1^*)$ is the high-demand consumer's optimum quantity choice when it faces a per-unit price of p_1^*, it must be that

$$\text{(A2)} \qquad V(q_2^*(p_1^*), \theta_2) - p_1^* q_2^*(p_1^*) - F_1^* > V(q_1^*(p_1^*), \theta_2) - p_1^* q_1^*(p_1^*) - F_1^*,$$

i.e., the left-hand side of (A2) is strictly positive. This implies that for ε sufficiently small, (A2) is satisfied, which implies that (10) is satisfied. Thus, we have shown that the menu of bundles $((q_1^*(p_1^*), T_1^*),\ (q_2^*(p_2^*), T_2^* + \varepsilon))$ satisfies the constraints in (9) and (10). QED

Example with a lower bundled quantity: $V(q, \theta) = \theta(aq - \frac{q^2}{2})$

Figure 3 illustrates the comparison and corresponding profits when $a = 10$, $c = 6$, $\lambda = 2/3$, $\theta_1 = 2$, and $\theta_2 = 4$. Using these values, we first solve for the quantities in each case, i.e., $q_1^*(p_1^*) = 6$, $\hat{q}_1 = 4$, and $q_2^*(p_2^*) = \hat{q}_2 = 8.5$. We next solve for the per-unit prices and

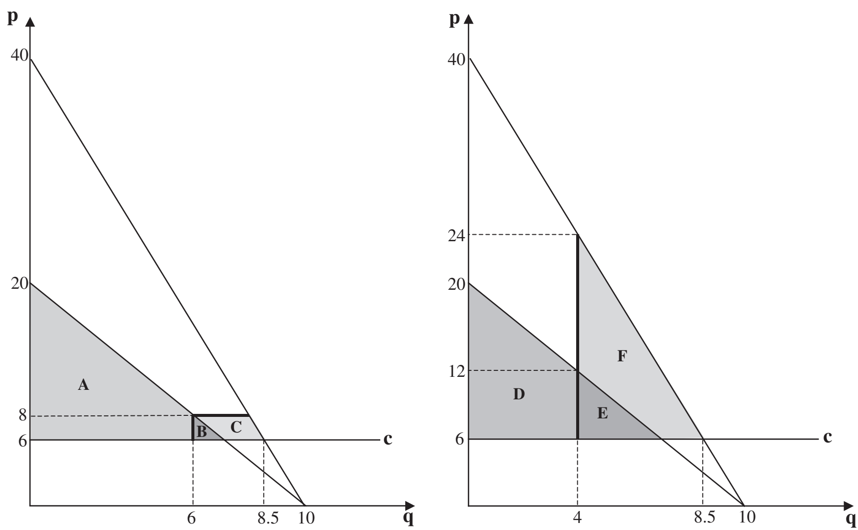

Figure 3
Example of Lower Bundled Quantity

payments with two-part tariffs, i.e. $p_1^* = 8$, $p_2^* = 6$, $T_1^* = 84$, and $T_2^* = 103.5$. Using these values, we then solve for the monopolist's maximized profit with two-part-tariffs, $\pi^{2PT} = 49.5$. Next, we solve for the prices under bundling, i.e. $\hat{T}_1 = 64$, and $\hat{T}_2 = 131.5$. Using these values, we then solve for the monopolist's maximized profit with bundling, $\pi^B = 53.5$. Therefore, we have a percentage increase in profit of 8% for the optimal menu of price-quantity bundles compared to the optimal menu of two-part-tariffs.

The diagram on the left shows the solution with the optimal menu of two-part tariffs. The profit on sales to the low-demand consumers is $\frac{2}{3}A$. The profit on sales to the high demand consumers is $\frac{1}{3}(A + B + C)$. The first-order conditions in (6) and (7) imply that an infinitesimally small increase in p_1 above p_1^* causes a decrease in profit from the low-demand consumers equal to $\frac{dq_1^*}{dp_1}$ times the thick vertical line at $q = 6$, and an increase in profit from the high-demand consumers equal to the thick horizontal line at $p = 8$. At the optimum the gains are exactly offset by the losses.

The diagram on the right shows the solution with the optimal menu of price-quantity bundles. The profit on sales to the low-demand consumers is $\frac{2}{3}D$. The profit on sales to the high-demand consumers is $\frac{1}{3}(D + E + F)$. The first-order conditions in (11) and (12) imply that an infinitesimally small decrease in q_1 below $\hat{q}_1$ causes a decrease in the profit from the low-demand consumers equal to the thick vertical line at $q = 4$ from $p = c$ to $p = 12$, and an increase in the profit from the high-demand consumers equal to the thick vertical line at $q = 4$ from $p = 12$ to $p = 24$. The latter interval is twice the length of the former because there are twice as many low-demand consumers.

Example with a higher bundled quantity: $V(q, \theta) = aq - \frac{q^2}{2\theta}$

Figure 4 illustrates the comparison and corresponding profits when $a = 10$, $c = 6$, $\lambda = 2/3$, $\theta_1 = 2$, and $\theta_2 = 4$. In this case, we get $q_1^*(p_1^*) = 5.33$, $\hat{q}_1 = 6.4$, and $q_2^*(p_2^*) = \hat{q}_2 = 16$. The per-unit prices and payments under the optimal menu of two-part-tariffs are $p_1^* = 7.33$, $p_2^* = 6$, $T_1^* = 46.2$, and $T_2^* = 120.9$. The monopolist's maximized profit is $\pi^{2PT} = 17.8$. By comparison, the prices under the optimal menu of price-quantity bundles are $\hat{T}_1 = 53.8$, and $\hat{T}_2 = 122.9$, and the monopolist's maximized profit is $\pi^B = 19.2$. This gives a percentage increase in profit of almost 8% for the optimal menu of price-quantity bundles compared to the optimal menu of two-part-tariffs.

The diagram on the left shows the solution with the optimal menu of two-part tariffs. The profit on sales to the low-demand consumers is $\frac{2}{3}A$. The profit on sales to the high demand consumers is $\frac{1}{3}(A + B + C)$. The first-order conditions in (6) and (7) imply that an infinitesimally small increase in p_1 above p_1^* causes a decrease in profit from the low-demand consumers equal to $\frac{dq_1^*}{dp_1}$ times the thick vertical line at $q = 5.3$, and an increase in profit from the high-demand consumers equal to the thick horizontal line at $p = 7.3$. At the optimum the gains are exactly offset by the losses.

The diagram on the right shows the solution with the optimal menu of price-quantity bundles. The profit on sales to the low-demand consumers is $\frac{2}{3}D$. The profit on sales to the high demand consumers is $\frac{1}{3}(D + E + F)$. The first-order conditions in (11) and (12) imply that an infinitesimally small decrease in q_1 below $\hat{q}_1$ causes a decrease in profit from the low-demand consumers equal to the thick vertical line at $q = 6.4$ from $p = c$ to $p = 6.8$, and an increase in profit from the high-demand consumers equal to the thick vertical line at $q = 6.4$ from $p = 6.8$ to $p = 8.4$. The latter interval is twice the length of the former because there are twice as many low-demand consumers.

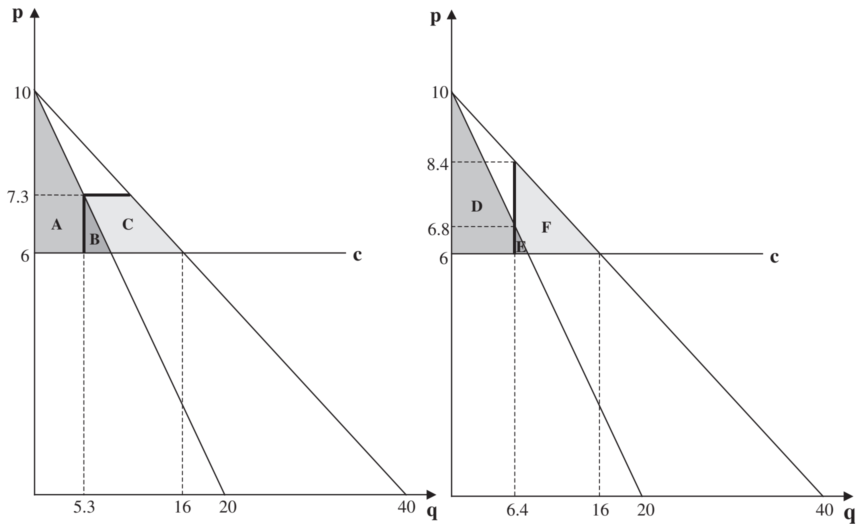

Figure 4
Example of Higher Bundled Quantity

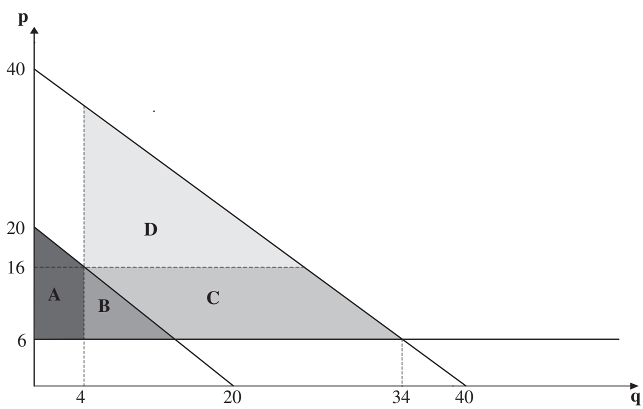

Figure 5
Example of no change

Example in which both quantities are the same: $V(q, \theta) = a\theta q - \frac{q^2}{2}$

Figure 5 illustrates the case where $a = 10$, $c = 6$, $\lambda = 2/3$, $\theta_1 = 2$, and $\theta_2 = 4$. In this case, we get $q_1^*(p_1^*) = \hat{q}_1 = 4$, and $q_2^*(p_2^*) = \hat{q}_2 = 34$. The per-unit prices and payments under the optimal menu of two-part-tariffs are $p_1^* = 16$, $p_2^* = 6$, $T_1^* = 72$, and $T_2^* = 502$. The monopolist's maximized profit is $\pi^{2PT} = 131.33$. By comparison, the prices under the optimal menu of price-quantity bundles are $\hat{T}_1 = 72$, and $\hat{T}_2 = 702$, and the monopolist's maximized profit is $\pi^B = 198$. This yields an increase in profit of almost 51% when the monopolist chooses bundling compared to two-part-tariffs.

Under the optimal menu of two-part tariffs, the profit on sales to low-demand consumers is $\frac{2}{3}A$ and the profit on sales to high-demand consumers is $\frac{1}{3}(A + B + C)$. By comparison, under the optimal menu of price-quantity bundles, the profit on sales to low-demand consumers is $\frac{2}{3}A$ and the profit on sales to high-demand consumers is $\frac{1}{3}(A + B + C + D)$. In this case, bundling yields strictly higher profit, but since the quantities are unchanged, social welfare is unchanged.

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