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A Theory of Partitioned Pricing

Zhiqi Chen†

Carleton University

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Department of Economics

1125 Colonel By Drive
Ottawa, Ontario, Canada
K1S 5B6

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Abstract

Partitioned pricing is a common pricing practice that divides the price of a product into a base price and one or more mandatory surcharges. From the perspective of standard economic theory, this practice is puzzling because rational buyers care about the full price they pay for a product rather than whether and how the price is partitioned into various components. This paper develops a theory of partitioned pricing using a duopoly model where the owner of each firm determines the level of surcharge but delegates the setting of base price to a manager. It shows that in equilibrium both firms choose partitioned pricing over conventional all-inclusive pricing. Moreover, partitioned pricing leads to higher full prices and larger profits than all-inclusive pricing. Most surprisingly, collusion on surcharge without any coordination on base price is as profitable as collusion on all-inclusive price.

Key Words: partitioned pricing, surcharges, duopoly, strategic delegation, collusion

JEL Classification: L11, L22, L41

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I. Introduction

Partitioned pricing is a pricing strategy that divides the price of a product into a base price and one or more mandatory surcharges (Greenleaf, *et al*. 2016). For example, dealers of new automobiles typically negotiate prices with buyers, but the full price an automobile dealer charges a buyer consists of more than the negotiated price; it also includes surcharges such as documentation fee and destination charge (Linkov 2019). Other examples of partitioned pricing can be found in

- Air transportation, where many airlines impose fuel surcharges on passenger and air cargo services (Appel 2008 and Tuzovic, *et al*. 2014),
- Lodging industry, where some hotels charge a mandatory resort fee in addition to the nightly rate of a room (Wang 2019),
- Auction houses, where each bid winner is required to pay a "buyer's premium" in addition to the "hammer price" at which an item is sold (Ashenfelter & Graddy 2005),
- Online retailing, where many online retailers list separate fees for shipping and handling rather than including these fees in the price of the goods on order (Xia and Monroe 2004),
- Sports and entertainment ticketing, where ticket buyers must pay numerous fees (such as service charge, order processing fee, and facility fee) in addition to the base ticket price of an event (Consumer Reports 2016).

While the surcharges in these examples have different names, they share a common feature: a buyer cannot acquire the product in question without paying the associated surcharges. In other words, surcharges are mandatory.[1]

[1] This feature of partitioned pricing distinguishes it from add-on pricing (Ellison 2005, Gabaix & Laibson 2006), under which a buyer is offered the option of paying an additional charge for higher quality or for an ancillary product or service.

The proliferation of partitioned pricing in a wide range of markets means surcharges have become an increasingly important source of revenue for some firms. For example, in 2012, airlines worldwide charged approximately $36 billion in surcharges on top of base flight costs, which represents an increase of 11 percent compared to 2011 (Voester, *et al*. 2017). In 2015, hotels in the U.S. collected an estimated $2 billion in mandatory resort fees, 35 percent higher than the previous year (Young 2016). At major auction houses, buyers' premiums increased from 10 percent in the 1980s to as high as 26 percent today.[2] In the automobile industry, major automakers in the U.S. have increased destination charges from an average of $839 in 2011 to $1,244 in 2020, which is more than 2.5 times the rate of inflation (Monticello 2021).

Also reflecting the importance of surcharge to their businesses, the executives of some firms went as far as committing criminal offenses by colluding on surcharges. One of these cases involved international air cargo, in which over 20 airlines around the world colluded in the setting and implementation of fuel and other surcharges for international air cargo from 1999 to 2006 (US Department of Justice 2008a, European Commission 2010).[3] For their roles in the conspiracy, the airlines were forced to pay criminal fines in the amount of $1.8 billion in the United States (US Department of Justice 2020) and €776 million in Europe (European Commission 2017). Eight executives were sentenced to serve prison time in the United States (US Department of Justice 2020).

[2] The latest buyer's premium rates at Christie's and Sotheby's, two of the world's largest auction houses, can be found at their corporate websites: https://www.christies.com/buying-services/buying-guide/financial-information/ and https://www.sothebys.com/1-february-2021-buyers-premium.pdf. See Greenleaf, *et al*. (2016) and the references cited therein for more details about buyer's premium rates at auction houses.

[3] As disclosed in the lead footnote, I worked as an economics expert for a Canadian government agency on the air cargo conspiracy case from 2012 to 2015.

From the perspective of standard economic theory, the use of partitioned pricing by firms is puzzling. Since buyers are rational, their decision to purchase should depend on the full price they pay for a product rather than on whether and how the price is partitioned into various components. This suggests that firms will not be able to use partitioned pricing to manipulate consumers' demand for their products and hence there will be no benefit for them to adopt this pricing strategy. Furthermore, collusion on surcharge without fixing the base price should have no effect because a higher surcharge would simply be offset by a lower base price as firms compete for customers. If firms are to collude, it should be more effective, and more straightforward, to collude simply on conventional all-inclusive price.

The objective of this paper is to construct and analyze a theoretical model that will shed light on these puzzling conducts by firms. In this model, buyers are rational. Accordingly, their demand function for a product depends only on the full prices of this and other competing products; it does not depend on whether and how a full price is partitioned into different components. On the supply side, two firms sell differentiated products. Each firm chooses one of two pricing strategies: either conventional all-inclusive pricing or partitioned pricing under which the full price is comprised of a base price and a surcharge.

An important element in this model is strategic delegation, that is, the owner of each firm delegates some decisions to a manager. Specifically, the decision power within each firm is divided between the owner and the manager in the following way. The owner determines the pricing strategy and the incentive contract for the manager. In the case where the owner chooses partitioned pricing, she also sets the level for one component of the price (the "surcharge"). The manager, on the other hand, sets the level of the other component (the "base price").[4] Consistent

[4] To be clear, this theory does not depend on the names given to the two components of a partitioned price. What matters is that the owner determines one component and the manager sets the other

with the literature on strategic delegation (*e.g.*, Vickers 1985, Fershtman & Judd 1987, Sklivas 1987), the owner's objective is to maximize the firm's profit while the manager maximizes his own utility.

Using this model, I show that when the firms act noncooperatively, they choose partitioned pricing over all-inclusive pricing in equilibrium. This, in turn, leads to higher full prices and larger profits than the case where firms adopt all-inclusive pricing. Furthermore, if firms collude on surcharge but set base price independently, they achieve the same levels of full price and profit as in the case where they collude on all-inclusive price. This last result is most surprising considering that on the surface, it is not obvious that collusion on surcharge alone can have any effect at all because the absence of coordination on base price means that firms can still undercut each other by lowering their base prices. Yet this analysis shows that collusion on a component of full price can be just as profitable as collusion on all-inclusive price.

Intuitively, strategic delegation plays a significant role in the above results. By delegating the decision on base price to the manager and making his wage dependent on the profit generated by the base price (the "base-price profit"), the owner avoids the situation where the imposition of a surcharge is completely neutralized by a corresponding fall in the base price. This enables the owner to raise the full price *via* the surcharge she sets. When the firms act noncooperatively, however, each owner faces the usual incentive to undercut its rival; the difference here is that they undercut each other in surcharge, a component of full price. Collusion on surcharge, on the other hand, enables the owners to maintain a high level of surcharge. Moreover, such collusion leads to the same full price and profit as collusion on all-inclusive price because it allows the owners to sustain the surcharge at a level that induces the managers to choose the "right" base

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component. In the analysis, I name the component controlled by the owner as "surcharge" because it is consistent with the stylized facts in the air cargo conspiracy case.

price. Therefore, by colluding on surcharge firms achieve the same outcome as collusion on all-inclusive price while maintaining an illusion of competition (in base price).

This paper contributes to the literature on partitioned pricing by presenting a novel theory that does not rely on irrational consumer behavior. The existing literature on partitioned pricing, mostly in the fields of marketing and consumer psychology, has focused on how and why partitioned pricing influences consumer behavior.[5] A common premise in this literature is that consumers are subject to bounded rationality and/or behavioral biases that distort their estimates of the total cost associated with the various components of a partitioned price. This allows firms to use partitioned pricing to enhance consumers' perception and evaluation of prices and offerings and stimulate purchasing behavior (Voester, *et al*. 2017). From a theoretical perspective, however, such behavioral explanations for partitioned pricing are not very insightful because one can explain virtually any apparent inconsistency with rational behavior by assuming that agents are not rational.

In contrast, this paper examines partitioned pricing from a very different perspective. Instead of influencing consumer behavior, partitioned pricing in this model changes firms' strategic behavior. The analysis shows that the adoption of partitioned pricing can generate larger profits for firms even in the presence of fully rational consumers. Therefore, this paper offers a theoretical explanation for partitioned pricing that does not sacrifice the fundamental assumption of rational economic agents.[6]

[5] See Greenleaf, *et al*. (2016) and Voester, *et al*. (2017) for comprehensive surveys of this literature.
[6] Also of some relevance to this paper is the literature on obfuscation, which refers to the practices by firms that intentionally make shopping complicated, difficult, or confusing (Ellison and Ellison 2009). By raising consumers' costs of searching for a lower price, obfuscation discourages consumers' search efforts and thus weakens the price competition among retailers (Carlin 2009, Wilson 2010, Ellison and Wolitzky 2012). To the extent that partitioned pricing increases consumers' search costs, obfuscation can be a reason for the adoption of this pricing strategy by firms.

Moreover, this paper contributes to the literature on cartels by studying the effects of a particular type of collusion, *i.e.*, collusion on surcharge. While cartels have been studied extensively in the literature, work on this specific type of collusion is scarce.[7] To my knowledge, there are only two (unpublished) papers that have formally analyzed collusion on surcharge: Garrod (2006) and Ross & Shadarevian (2021). In Garrod (2006), surcharge is used by firms to facilitate collusion on base price when their costs are subject to random shocks. In Ross & Shadarevian (2021), on the other hand, collusion on surcharge serves to discourage consumer search because they would receive no benefit from searching for a lower price when all firms increase their prices *via* surcharge at the same time. This, in turn, reduces a firm's incentive to cheat and enhances the stability of a cartel. Neither paper, however, offers a complete theory for why firms would collude on surcharge but not on base price. Garrod's analysis is predicated on collusion on base price. Ross & Shadarevian's theory implicitly assumes collusion on base price as well: without an agreement to maintain base price, firms would have an incentive to circumvent the agreement on surcharge by lowering their base prices, which would trigger consumer search and lead to cartel breakdown. The present paper, on the other hand, shows that collusion on surcharge without any coordination on base price is not just profitable, it is as profitable as collusion on all-inclusive price.

It is worth noting that the behavioral explanations for partitioned pricing in the marketing and consumer psychology literature are not amenable to offering any insight into firms' motivations for colluding on surcharges. When firms collude on only one component of the price, they have an incentive to undercut each other by lowering the other component. This incentive exists, and may even be stronger, in situations where consumers' perceptions about the full price of a

[7] For an insightful review of the literature on collusion, see Harrington (2017).

product are influenced by partitioned pricing. If, for example, consumers underestimate the full price because of their exclusive attention to base price, firms will have a strong incentive to undercut each other *via* base price. This will then neutralize any effect collusion on surcharge may have on full price and profit.

This paper is organized as follows. Section II presents the model and section III characterizes the equilibrium. Section IV investigates the effects of partitioned pricing while section V examines collusion on surcharge. Section VI concludes.

II. The Model

Consider an industry comprised of two firms, named A and B, that produce and sell differentiated products. The unit cost of production is constant and is normalized to 0. The demand for the product of firm i $(= A, B)$ is represented by a twice continuously differentiable function $x_i = x(p_i, p_j)$, where x_i denotes the quantity and p_i the price of product i, while p_j $(j \neq i)$ is the price of the rival's product. Let $x_{i1} \equiv \partial x_i/\partial p_i$, $x_{i2} \equiv \partial x_i/\partial p_j$, $x_{i11} \equiv \partial^2 x_i/\partial p_i^2$, $x_{i12} \equiv \partial^2 x_i/\partial p_i \partial p_j$. I assume that the demand functions are symmetric and satisfy the standard assumptions of Bertrand competition model. Specifically, for prices in the relevant range,

i. Demand for the product of firm i decreases in its own price and increases in the price of its rival, *i.e.*, $x_{i1} < 0$ and $x_{i2} > 0$.

ii. The incremental revenue from an infinitesimal price increase falls with its own price and rises with its rival's price, *i.e.*, $2x_{i1} + p_i x_{i11} < 0$ and $x_{i2} + p_i x_{i12} > 0$. The latter inequality implies that prices are strategic complements.

iii. The demand function satisfies the condition that ensures a unique Bertrand equilibrium, $|2x_{i1} + p_i x_{i11}| > x_{i2} + p_i x_{i12}$. Under this condition, the Bertrand bestreply functions of the two firms form a contraction mapping, which ensures that there is a unique Bertrand equilibrium (Vives 1999 p.47).

iv. The own-price effect on the demand is larger than the cross-price effect, *i.e.*, $|x_{i1}| > x_{i2}$ and $|x_{i11}| \geq |x_{i12}|$.

In addition, I assume that the demand functions satisfy the second-order conditions of the firms' optimization problems analyzed below. Note, as an example, that these assumptions are satisfied by a linear demand function of the form $x_i = a - p_i + \gamma(p_j - p_i)$ with $\gamma > 0$.

To incorporate the possibility of partitioned pricing (PP) into the firms' decision-making process, suppose that the price of firm i $(= A, B)$ has two components, a base price, denoted by b_i (≥ 0), and a surcharge denoted by s_i (≥ 0). In other words, the full price paid by a consumer is the sum of the base price and the surcharge, *i.e.*, $p_i = b_i + s_i$.

Note that the conventional all-inclusive pricing (AIP) can be viewed as a special case of PP. When $s_i = 0$, consumers pay a price with a single component, $p_i = b_i$.

Given that the unit cost of production is normalized to 0, a firm's profit can be written as $p_i x_i = p_i x(p_i, p_j)$. For ease of discussion, I define $b_i x_i$ as firm i's "base-price profit". In other words, base-price profit is the part of the profit associated with the base price.

Each firm has two decision-makers, an owner and a manager. The owner's objective is to maximize the profit of the firm.[8] She makes two decisions. First, she hires a manager and determines his wage contract. Second, she sets the level of surcharge s_i. In doing so, she also determines the pricing strategy: it adopts AIP if she sets $s_i = 0$. The manager, on the other hand,

[8] Alternatively, the owner in this model could also be interpreted as the top manager of the firm who is incentivized to maximize the firm's profit.

sets the price which, depending on the pricing strategy chosen by the owner, is either an all-inclusive price or a base price.[9]

Let w_i $(i = A, B)$ denote the wage of firm i's manager. It is comprised of two components: a base wage, denoted by w_{0i}, and a performance pay that depends on the base-price profit $(b_i x_i)$ as well as the total profit of the firm $(p_i x_i)$. Specifically, suppose that the manager's performance is measured by a weighted average of the two, $M_i = \alpha_i b_i x_i + (1 - \alpha_i) p_i x_i$ where $\alpha_i \in [0, 1]$, and his performance pay is an increasing function of M_i: $F_i(M_i)$ with $F_i' > 0$. Taken together, the manager's wage contract is represented by $w_i = w_{i0} + F_i(\alpha_i b_i x_i + (1 - \alpha_i) p_i x_i)$. Note that in the case where $\alpha_i = 0$, this becomes a standard incentive contract where the manager's performance pay is tied to the firm's total profit only.

As alluded to earlier, the owner of firm i chooses the performance pay function F and the values of w_{0i} and α_i. Suppose there is a competitive market for managers so that the owner has to offer a wage contract that provides the manager at least his reservation wage, denoted by $\overline{w}$. In other words, the owner faces the constraint $w_i \geq \overline{w}$ when hiring a manager.

Following the literature on strategic delegation (*e.g.*, Fershtman and Judd 1987 and Sklivas 1987), I suppose that the owners and managers of the two firms play a two-stage game. At stage 1, the owners simultaneously announce their respective surcharge (s_i) and their offer of a wage contract, $w_i = w_{i0} + F_i(\alpha_i b_i x_i + (1 - \alpha_i) p_i x_i)$, to their respective manager, who either accepts or rejects the offer. At stage 2, the managers simultaneously set the base prices b_i, after which consumers make their purchases.

[9] Hence, firms compete in prices (or components of prices) in this model. Given that the purpose of this paper is to study partitioned pricing, a quantity-competition model would not be suitable for this analysis.

Before I move on to analyze the equilibrium, let me pause to discuss a notable assumption in the preceding description of the model, namely, the assumption that an owner determines the surcharge while a manager sets the base price. This division of power is consistent with the practices in some industries. In international air cargo industry, for example, the base prices (*i.e.*, freight rates) for individual shipments are set by local cargo offices, but the surcharges are determined at higher cooperate levels with involvement by senior management in the head offices (European Commission 2010).[10] Similarly, in automobile retail industry the (base) price of a new car is typically negotiated between a buyer and a salesperson at a dealership, but the destination charge is predetermined and non-negotiable (Linkov 2019, Monticello 2021). This suggests that the surcharge is set by a higher authority than the salesperson.

It should be noted that in this model, surcharge and base price are merely names for the two price components under PP. While they are useful for the interpretation of my results in the context of industry practices, these names have no real impact on the substance of these results. In other words, the ensuing analysis would not be affected if I give the two price components nondescriptive generic names (such as X and Y) instead. Analytically, what really matter in this model are (a) the two price components are set by separate decision-makers in a firm, and (b) a manager's wage may depend, at least partially, on the price component he controls. In this broader context, collusion on "surcharge" means coordination among the owners (while the managers continue to act independently).

[10] This can also be seen from the positions held by the eight airline executives who served jail time for their roles in the air cargo conspiracy case. For example, Keith Packer was the Commercial General Manager for British Airways World Cargo, and Maria Christina Ullings was the Senior Vice President of Cargo Sales and Marketing for Martinair Cargo (US Department of Justice 2008b and 2020).

III. Subgame Perfect Equilibrium

To determine the subgame perfect equilibrium in this game, I start with an analysis of stage 2. Recall that the full price of firm i is $p_i = b_i + s_i$, with $s_i = 0$ representing the case where the firm adopts AIP. Hence, I can unify the analysis of a manager's decision at stage 2 under PP and under AIP.

Since the wage of firm i's manager is an increasing function of the weighted average of the base profit and total profit, his optimization problem can be expressed as

$$max_{b_i}\ \alpha_i b_i x(b_i + s_i,\ b_j + s_j) + (1 - \alpha_i)(b_i + s_i)x(b_i + s_i, b_j + s_j). \qquad (1)$$

The first-order condition of this optimization problem,

$$x(b_i + s_i,\ b_j + s_j) + [b_i + (1 - \alpha_i)s_i]x_1(b_i + s_i,\ b_j + s_j) = 0, \qquad (2)$$

determines the manager's best response function. Solving the equation system formed by (2) for $i = A, B$, I obtain the base prices chosen by the managers as functions of $(s_A, s_B, \alpha_A, \alpha_B)$. From here I consider first how an exogenous increase in the level of a firm's surcharge under PP affects the base prices and full prices of the two firms.

PROPOSITION 1. Suppose $\alpha_i > 0$. A larger surcharge by firm i leads to higher full prices for both firms and higher base price for the rival firm. But it lowers firm i's own base price if the demand functions are linear or concave. In the case where $\alpha_i = 0$, on the other hand, a larger surcharge by firm i is offset by a reduction in its base price by the same amount, leaving the full prices of both firms unchanged.

Proof. The results are obtained by conducting comparative statics on the equation system formed by (2) with $i = A, B$. Let J denote the Jacobian associated with this equation system. It is straightforward to find that

$$J = \prod_{i=A}^{B} \{2x_{i1} + [b_i + (1 - \alpha_i)s_i]x_{i11}\} - \prod_{i=A}^{B} \{x_{i2} + [b_i + (1 - \alpha_i)s_i]x_{i12}\} > 0, (3)$$

and for $i, j = A, B$ $(i \neq j)$,

$$\frac{\partial b_i}{\partial s_i} = \frac{1}{J}\Bigg\{\prod_{i=A}^{B}\{x_{i2} + [b_i + (1-\alpha_i)s_i]x_{i12}\}$$

$$-\{(2-\alpha_i)x_{i1} + [b_i + (1-\alpha_i)s_i]x_{i11}\}\{2x_{j1} + [b_j + (1-\alpha_j)s_j]x_{j11}\}\Bigg\}, \quad (4)$$

$$\frac{\partial b_j}{\partial s_i} = -\frac{\alpha_i x_{i1}\{x_{j2} + [b_j + (1-\alpha_j)s_j]x_{j12}\}}{J} > 0 \text{ if } \alpha_i > 0. \qquad (5)$$

When determining the signs of (3) and (5), I note $b_i + (1-\alpha_i)s_i \leq p_i$ and make use of the assumptions on the demand functions. These assumptions also imply that the sign of (4) is negative if $\alpha_i = 0$. Moreover, (4) will have a negative sign for any $\alpha_i \in [0, 1]$ if I impose additional restrictions on the demand functions. For example, under the assumption $x_{i11} \leq 0$, I will have $|(2-\alpha_i)x_{i1} + [b_i + (1-\alpha_i)s_i]x_{i11}| > x_{i2} + [b_i + (1-\alpha_i)s_i]|x_{i12}| \geq x_{i2} + [b_i + (1-\alpha_i)s_i]x_{i12}$. The latter, along with the previous assumptions on the demand functions, ensures that (4) is negative for any $\alpha_i \in [0, 1]$. Note that both linear and concave demand functions satisfy $x_{i11} \leq 0$.

Noting that $p_i = b_i + s_i$, I use (4) and (5) to find

$$\frac{\partial p_i}{\partial s_i} = \frac{\alpha_i x_{i1}\{2x_{j1} + [b_j + (1-\alpha_j)s_j]x_{j11}\}}{J} > 0, \qquad (6)$$

and $\partial p_j/\partial s_i = \partial b_j/\partial s_i > 0$ if $\alpha_i > 0$. If $\alpha_i = 0$, on the other hand, (5) and (6) imply that $\partial p_i/\partial s_i = \partial p_j/\partial s_i = 0$, in which case $\partial b_i/\partial s_i = \partial(p_i - s_i)/\partial s_i = -1$. QED

Proposition 1 shows that the impact of an increase in surcharge s_i on prices depends on the value of α_i, the weight attached to base-price profit in the manager's performance measure. If $\alpha_i = 0$, the manager's performance is measured by the firm's profit alone. In this case, the adoption of PP has no impact on full prices of both firms because the manager will neutralize any increase in surcharge (s_i) with a reduction in the base price (b_i) of an equal amount. If $\alpha_i > 0$, on the other hand, the manager is given an incentive to increase base-price profit ($b_i x_i$), which mitigates his tendency to lower b_i. While the manager may still reduce b_i in response to a rise in s_i, the reduction will be smaller than the increase in s_i, thus driving up the firm's full price. This also leads to a higher full price at the rival firm because prices are strategic complements.

The preceding discussion suggests that an increase in s_i may have an ambiguous effect on b_i. If α_i is sufficiently large, it is possible that the manager's incentive to increase base-price profit becomes so strong that he would raise b_i in response to a larger s_i. However, Proposition 1 shows that this possibility can be ruled out if the demand functions are linear or concave.

Having explored the role of s_i and α_i in the managers' decisions, I now consider stage 1 where the owners determine the values of these variables. To be more precise, at stage 1 each owner chooses $\{s_i, \alpha_i, w_{i0}\}$ and a performance pay function F_i subject to the manager's participation constraint $w_i \geq \overline{w}$. Each owner's objective is to maximize her profit:

$$\pi_i = p_i x_i - w_i = p_i x_i - w_{i0} - F_i(\alpha_i b_i x_i + (1 - \alpha_i) p_i x_i). \quad (7)$$

Since π_i is decreasing in w_{i0} and in the value of F_i, she will choose w_{i0} and F_i in such a way that the manager's participation constraint holds with equality, *i.e.*, $w_i = \overline{w}$. This implies that the owner's profit at stage 1 is equal to $p_i x_i - \overline{w}$.

Since any strictly increasing function F_i will induce a manager to maximize M_i, there is no unique solution to the owner's choice of F_i; any combination of an increasing function F_i and a positive constant w_{i0} that satisfies $w_i = \overline{w}$ will suffice. Therefore, the ensuing analysis will focus on the owners' choices of $\{s_i, \alpha_i\}$ only.

Analytically, it is convenient to define a new variable, $\hat{s}_i \equiv \alpha_i s_i$, and study the owners' optimization problems in terms of $(p_i, \hat{s}_i)$ $(i = A, B)$. Note in (2) that $[b_i + (1 - \alpha_i)s_i] = p_i + \alpha_i s_i$, and $b_i + s_i = p_i$. Accordingly, I can rewrite (2) as

$$x(p_i, p_j) + [p_i - \hat{s}_i]\frac{\partial x(p_i, p_j)}{\partial p_i} = 0. \qquad (8)$$

The equation system formed by (8) for $i = A$ and B determines the full prices as functions of $(\hat{s}_i, \hat{s}_j)$, denoted by $p_i = p(\hat{s}_i, \hat{s}_j)$ $(i, j = A, B$ and $i \neq j)$. Then I can use this solution to write the owner's profit at stage 1 as

$$\pi_i(\hat{s}_i, \hat{s}_j) = p(\hat{s}_i, \hat{s}_j)x\big(p(\hat{s}_i, \hat{s}_j), p(\hat{s}_j, \hat{s}_i)\big) - \bar{w}. \qquad (9)$$

Note that (9) depends on $\hat{s}_i$ $(\equiv \alpha_i s_i)$ rather than α_i and s_i individually. Hence, I can treat the owner's optimization problem as choosing $\hat{s}_i$ to maximize the value of (9).

Differentiating (9) with respect to $\hat{s}_i$ and using the envelope theorem, I obtain the first-order condition of the owner's optimization problem:

$$\frac{\partial \pi_i(\hat{s}_i, \hat{s}_j)}{\partial \hat{s}_i} = \hat{s}_i x_{i1}\frac{\partial p_i}{\partial \hat{s}_i} + p_i x_{i2}\frac{dp_j}{d\hat{s}_i} = 0. \qquad (10)$$

The system of equations formed by (10) for the two firms determine the equilibrium value of $(\hat{s}_A, \hat{s}_B)$. Since the two firms are symmetric in all aspects, I focus on a symmetric equilibrium where $\hat{s}_A = \hat{s}_B$. Let $\hat{s}^P$ denote the symmetric equilibrium value of $\hat{s}_i$.

PROPOSITION 2. In a symmetric equilibrium, the owners of the two firms choose s_i and α_i in such a way that $s_i\alpha_i = \hat{s}^P$, where $\hat{s}^P$ is determined by

$$\hat{s}^P\frac{\partial x(p_i, p_j)}{\partial p_i}\left[2\frac{\partial x(p_i, p_j)}{\partial p_i} + (p_i - \hat{s}^P)\frac{\partial^2 x(p_i, p_j)}{\partial p_i^2}\right]$$

$$= p_i\frac{\partial x(p_i, p_j)}{\partial p_j}\left[\frac{\partial x(p_i, p_j)}{\partial p_j} + (p_i - \hat{s}^P)\frac{\partial^2 x(p_i, p_j)}{\partial p_i p_j}\right], \qquad (11)$$

in which $p_i = p_j = p(\hat{s}^P, \hat{s}^P)$. Moreover, $0 < \hat{s}^P < p(\hat{s}^P, \hat{s}^P)$.

Proof. Let $\hat{J}$ denote the Jacobian associated with the equation system formed by (8) for $i = \{A, B\}$. It can be shown that $\hat{J} = J > 0$ with $b_i + (1 - \alpha_i)s_i$ being replaced by its equivalent $p_i - \hat{s}_i$. I conduct comparative statics to find

$$\frac{\partial p_i}{\partial \hat{s}_i} = \frac{x_{i1}\{2x_{j1} + [p_j - \hat{s}_j]x_{j11}\}}{\hat{J}} > 0, \qquad (12)$$

$$\frac{\partial p_j}{\partial \hat{s}_i} = -\frac{x_{i1}\{x_{j2} + [p_j - \hat{s}_j]x_{j12}\}}{\hat{J}} > 0. \qquad (13)$$

The signs of (12) and (13) are determined by using the properties of the demand functions and $p_j - \hat{s}_j \le p_j$. By symmetry of the demand functions, I have $x_{Ak} = x_{Bk}, x_{Akk} = x_{Bkk}$ and $x_{Akl} = x_{Bkl}$ $(k, l = 1{,}2; k \neq l)$ at $\hat{s}_A = \hat{s}_B$. Substituting (12)-(13) into (10) and evaluating it at $\hat{s}_i = \hat{s}^P$ and $p_i = p_j = p(\hat{s}^P, \hat{s}^P)$, I obtain (11). Hence, $\hat{s}_1 = \hat{s}_2 = \hat{s}^P$ satisfies the first-order conditions of the owners' optimization problems.

Note from (10) that

$$\left.\frac{\partial \pi_i(\hat{s}_i, \hat{s}_j)}{\partial \hat{s}_i}\right|_{\hat{s}_i = 0} = p_i x_{i2}\frac{dp_j}{d\hat{s}_i} > 0. \qquad (14)$$

Hence, the equilibrium value of $\hat{s}_i$ must be positive, *i.e.*, $\hat{s}^P > 0$. Comparing the terms on the two sides of (11), I use the properties of the demand functions to find that

$$\frac{\partial x(p_i, p_j)}{\partial p_i}\left[2\frac{\partial x(p_i, p_j)}{\partial p_i} + (p_i - \hat{s}_i)\frac{\partial^2 x(p_i, p_j)}{\partial p_i^2}\right] > \frac{\partial x(p_i, p_j)}{\partial p_j}\left[\frac{\partial x(p_i, p_j)}{\partial p_j} + (p_i - \hat{s}_i)\frac{\partial^2 x(p_i, p_j)}{\partial p_i p_j}\right]. \quad (15)$$

Then (15) and (11) imply $\hat{s}^P < p(\hat{s}^P, \hat{s}^P)$. QED

Proposition 2 has a couple of interesting implications. First, $\hat{s}^P > 0$ implies that $s_i > 0$ and $\alpha_i > 0$ in equilibrium; that is, each owner will set a positive surcharge and attach a positive weight to base-price profit in the manager's performance measure. This also means that both firms adopt PP in equilibrium. Second, the equilibrium values of s_i and α_i are not unique; any combination of $s_i > 0$ and $\alpha_i > 0$ can be an equilibrium as long as it satisfies $s_i\alpha_i = \hat{s}^P$. In particular, $\alpha_A = \alpha_B = 1$ and $s_A = s_B = \hat{s}^P$ is an equilibrium. Note that with $\alpha_i = 1$, a manager is incentivized to maximize base-price profit only.

This result is consistent with the practices in international air cargo and automobile retail industries. The records I reviewed as an economics expert on the air cargo conspiracy case show that performance of local cargo office is measured in terms of base price (the freight rate) rather than full price (freight rate plus surcharges). In automobile retailing, the commission of a car salesperson is based on the difference between the invoice price (the dealer's cost) of a car and the (base) price negotiated between the salesperson and the buyer (Santos 2020). The latter roughly corresponds to the (per unit) base-price profit in this model.

For ease of presentation, let $p^P \equiv p(\hat{s}^P, \hat{s}^P)$ and $\pi^P \equiv \pi_i(\hat{s}^P, \hat{s}^P)$. In other words, p^P is the equilibrium full price and π^P the equilibrium level of an owner's profit under PP.

IV. Effects of Partitioned Pricing

In this section, I analyze the effects of PP by comparing the equilibrium under PP with that under conventional AIP. Regarding the latter, I will consider two scenarios: one where the firms set their all-inclusive prices independently and the other where they choose these prices cooperatively.

I first compare the PP equilibrium with that in the scenario where the firms adopt AIP and choose their prices independently. To characterize the equilibrium in this scenario, recall that AIP can be viewed as a special case of PP with $s_i = 0$. Accordingly, the equilibrium in this scenario is equivalent to the stage-2 equilibrium under PP with $\hat{s}_A = \hat{s}_B = 0$. Formally, let p^I

denote the full price and π^I an owner's profit in a symmetric equilibrium under AIP. Then $p^I = p(\hat{s}_A, \hat{s}_B)$ and $\pi^I = \pi_i(\hat{s}_A, \hat{s}_B)$ with $\hat{s}_A = \hat{s}_B = 0$.

Since the firms choose a positive surcharge under PP, Proposition 1 implies that the full prices under PP are higher than those under AIP. Higher full prices, in turn, mean larger profits for both firms. Therefore, I obtain the following result.

PROPOSITION 3. $p^P > p^I$ and $\pi^P > \pi^I$.

Proof. Proposition 1 implies that $p(\hat{s}^P, \hat{s}^P) > p(0, \hat{s}^P) > p(0,0)$. Moreover, (14) implies $\pi_i(\hat{s}^P, \hat{s}^P) > \pi_i(0, \hat{s}^P)$. Differentiating (9), I obtain

$$\left.\frac{\partial \pi_i(\hat{s}_i, \hat{s}_j)}{\partial \hat{s}_j}\right|_{\hat{s}_i=0} = p_i x_{i2} \frac{dp_j}{d\hat{s}_j} > 0, \qquad (16)$$

from which I infer that $\pi_i(0, \hat{s}^P) > \pi_i(0,0)$. Therefore, $\pi_i(\hat{s}^P, \hat{s}^P) > \pi^I$. QED

Proposition 3 is interesting because it is not intuitively obvious that the owner of a firm would necessarily earn a larger profit under PP than under AIP. As shown in Proposition 1, under PP the manager has a tendency to reduce base price in response to the imposition of a surcharge. Consequently, the owner does not have direct control over the full price. Under AIP, on the other hand, the owner can ensure a profit-maximizing full (all-inclusive) price by either setting the price herself or by incentivizing the manager to do so. This suggests that the owner could end up earning a smaller profit under PP than under AIP.

What the above intuition misses is the strategic effect of PP. By attaching a positive weight to base-price profit in the manager's performance measure, the owner can mitigate the latter's tendency to reduce base price and thus induce a higher full price *via* surcharge. With prices being strategic complements, this leads to a higher full price at the rival firm as well. It is this strategic effect of PP that enables the owner to earn a larger profit than under AIP.

Proposition 3 is reminiscent of an important finding in the strategic delegation literature, that is, by incentivizing her manager to maximize a weighted average of profit and revenue, the owner of a firm may be able to achieve a higher price and a larger profit in an oligopolistic market (Fershtman & Judd 1987 and Sklivas 1987). That type of incentive contracts, however, would be powerless in the model here because, with unit cost of production being set to 0, there is no difference between revenue and profit. One contribution of this analysis is that it identifies a new instrument, namely partitioned pricing, through which strategic delegation may lead to higher prices and larger profits.

In addition, one feature that differentiates this model from the existing models of strategic delegation is that the equilibrium values of each owner's choice variables, s_i and α_i, are not unique. This extra degree of freedom leaves space for the owner to use an incentive contract to achieve more than just the strategic objective studied here. For example, in a more elaborate model where a firm's profit is also affected by the manager's effort, the owner may be able to use a combination of s_i and α_i to induce both a higher full price and a higher effort level.[11]

However, I would hasten to emphasize that the main contribution of this paper is not about strategic delegation *per se*. Rather it is about a novel theory of partitioned pricing based on strategic delegation, a theory that is faithful to the fundamental assumption of rational economic agents and is consistent with the practices in industries such as air cargo and automobile retail services.

Given the finding in Proposition 3 that the full prices under PP are higher than those under AIP, it is natural to ask: can PP raise the full prices to the level that maximizes the firms' joint

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[11] In this analysis, I have chosen not to incorporate managerial efforts into the model because it would detract from the objective of this paper, which is to develop a (clear and simple) theory of partitioned pricing.

profit? To answer this question, I analyze the scenario where the two firms adopt AIP and set their prices cooperatively. In other words, they choose their all-inclusive prices to maximize their joint profit:

$$\max_{p_A, p_B} \Pi = p_A x(p_A, p_B) + p_B x(p_B, p_A) - 2\overline{w}. \quad (17)$$

The first-order condition associated with (17) is

$$\frac{\partial \Pi}{\partial p_i} = x(p_i, p_j) + p_i \frac{\partial x(p_i, p_j)}{\partial p_i} + p_j \frac{\partial x(p_j, p_i)}{\partial p_i} = 0 \;\; (i, j = A, B; i \neq j). \quad (18)$$

Let p^M denote the (symmetric) joint-profit maximizing full price. Then $p_i = p_j = p^M$ satisfies (18). By comparing this joint-profit maximization solution with the equilibrium under PP, I find

PROPOSITION 4. $p^P < p^M$ and $\pi^P < \pi^M$.

Proof. Consider the sign of $\partial \Pi / \partial p_i$ at $p_i = p_j = p^P$. Rewriting the first-order condition associated with the maximization of an owner's profit (9), I obtain

$$x(p_i, p_j) + p_i \frac{\partial x(p_i, p_j)}{\partial p_i} = -p_i \frac{\partial x(p_i, p_j)}{\partial p_j} \frac{\partial p_j / \partial \hat{s}_i}{\partial p_i / \partial \hat{s}_i}. \quad (19)$$

Substituting (19) into $\partial \Pi / \partial p_i$ in (18) and noting that $x_{i2} = x_{j2}$ at $p_i = p_j = p^P$, I find

$$\left.\frac{\partial \Pi}{\partial p_i}\right|_{p_i = p_j = p^P} = p_i \frac{\partial x(p_i, p_j)}{\partial p_j} \left[1 - \frac{\partial p_j / \partial \hat{s}_i}{\partial p_i / \partial \hat{s}_i}\right] > 0. \quad (20)$$

The sign of (20) is determined by using (12) and (13). From (20), I conclude that $p^P < p^M$. Since $p^P \neq p^M$, I have $\pi^M > \pi^P$ by the definition of π^M. QED

Proposition 4 states that the full price under PP is below that of joint-profit maximization. Intuitively, this result is not surprising. While the adoption of PP enables the owners to induce higher full prices *via* surcharges, each owner still faces the usual incentive to undercut its rival; the difference here is that they undercut each other with a component of full price. But the effect of undercutting is similar, that is, driving full price below the level that would maximize their joint profit.

All of the above results can be verified using the special case of linear demand functions. Specifically, suppose the demand function for product i is represented by $x_i = a - p_i + \gamma(p_j - p_i)$ with $\gamma > 0$. It is straightforward to derive the equilibrium full prices and profits in the three scenarios studied above:[12]

$$p^P = \frac{2(1+\gamma)a}{4+6\gamma+\gamma^2}, \qquad p^I = \frac{a}{2+\gamma}, \qquad p^M = \frac{a}{2}; \qquad (21)$$

$$\pi^P = \frac{2(1+\gamma)(2+4\gamma+\gamma^2)a^2}{(4+6\gamma+\gamma^2)^2}, \quad \pi^I = \frac{(1+\gamma)a^2}{(2+\gamma)^2}, \quad \pi^M = \frac{a^2}{4}. \qquad (22)$$

Using (21)-(22), one can confirm that $p^M > p^P > p^I$ and $\pi^M > \pi^P > \pi^I$. Moreover, it is easy to show that

$$\frac{\partial[(p^P - p^I)/p^I]}{\partial\gamma} = \frac{2\gamma(4+3\gamma)}{(4+6\gamma+\gamma^2)^2} > 0, \qquad (23)$$

$$\frac{\partial[(\pi^P - \pi^I)/\pi^I]}{\partial\gamma} = \frac{8\gamma^2(3+\gamma)(2+\gamma)}{(4+6\gamma+\gamma^2)^3} > 0. \quad (24)$$

Equations (23)-(24) imply that relative to AIP, the percentage increases in full price and profit caused by the adoption of PP is greater when γ is larger. Intuitively, a larger γ means a higher degree of substitutability between the products of the two firms. Accordingly, competition between the two firms is more intense when γ is larger. Therefore, (23) and (24) indicate that the adoption of PP brings a larger gain to firms when competition is more intense.

[12] With these linear demand functions, the second-order conditions of the firms' optimization problems in all three scenarios are satisfied without any additional assumptions.

V. Collusion on Surcharge

To analyze collusion on surcharge, I consider a situation where the owners of the two firms choose surcharges cooperatively to maximize their joint profit but the managers set base prices independently. In other words, the collusion here is only on one component of full price, namely the surcharge.[13]

To be more specific, I modify the two-stage game presented in section II as follows. At stage 1, the owners jointly determine their surcharges, and at stage 2, the managers simultaneously (and independently) set the base prices. To keep the analysis simple, I assume that at the time when the owners enter into a cartel agreement, parameter α_i $(i = A, B)$ in the managers' contracts has already been fixed at a positive level by past practices. Accordingly, $\alpha_i > 0$ is taken as exogenous in the ensuing analysis.[14]

Since the managers continue to set base prices independently, the equilibrium at stage 2 of this collusion game is determined by the same conditions as before, specifically equation (8) for $i = A, B$. Accordingly, the full prices can be represented by $p_i(\hat{s}_i, \hat{s}_j)$ $(i, j = A, B; i \neq j)$. At stage 1, the two owners collude by setting (s_A, s_B) to maximize their joint profit

$$\Pi = p(\hat{s}_A, \hat{s}_B)x\big(p(\hat{s}_A, \hat{s}_B), p(\hat{s}_B, \hat{s}_A)\big) + p(\hat{s}_B, \hat{s}_A)x\big(p(\hat{s}_B, \hat{s}_A), p(\hat{s}_A, \hat{s}_B)\big) - 2\overline{w}. \quad (25)$$

The first-order condition of this optimization problem is

$$\frac{\partial \Pi}{\partial s_i} = \frac{\partial \Pi}{\partial p_i}\frac{\partial p_i}{\partial \hat{s}_i}\alpha_i + \frac{\partial \Pi}{\partial p_j}\frac{\partial p_j}{\partial \hat{s}_i}\alpha_i = 0 \quad (i, j = A, B; i \neq j). \qquad (26)$$

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[13] This is what happened in the air cargo conspiracy case. As detailed in European Commission's decision on this case (European Commission 2010), the cooperation among the airlines was centered around the setting and implementation of surcharges. Indeed, the records I reviewed as an economics expert on this case show that the airlines' local cargo offices at Canadian airports continued to compete in freight rates during the period when the executives at higher levels of the companies coordinated on the surcharges.

[14] To be clear, the only restriction on α_i here is that it should not be equal to zero. Hence, the results from the ensuing analysis go through for any α_i in the interval $(0, 1]$.

The equation system formed by (26) for $i = A$ and B determines the cartel surcharge chosen by the owners. Let p^C denote the full price and π^C the profit in this cartel equilibrium. A comparison of (26) with (18) leads to the following finding.

PROPOSITION 5. $p^C = p^M$ and $\pi^C = \pi^M$.

Proof. Note from (12) and (13) that $\partial p_i/\partial \hat{s}_i \neq \partial p_j/\partial \hat{s}_i$. Then (26) entails $\partial \Pi/\partial p_i = 0$ for $i = A$ and B. Hence, $p^C = p^M$, which, in turn, implies $\pi^C = \pi^M$. QED

Proposition 5 states that collusion on surcharge (a component of full price) leads to the same full price and profit as collusion on all-inclusive price. This result is interesting considering that on the surface, firms still compete in base price; it is not obvious that collusion on surcharge alone can have any effect at all because the absence of coordination on base price means that firms could still undercut each other by lowering their base prices. Yet this analysis shows that collusion on a component of full price can be just as profitable as collusion on all-inclusive price.

Intuitively, strategic delegation plays a significant role in this result. As shown in section IV, by delegating the decision on base price to the manager and making his wage dependent on base-price profit, the owner is able to raise the full price *via* the surcharge she sets. When the firms act noncooperatively, however, each owner has an incentive to undercut its rival by lowing her surcharge. Collusion on surcharge, on the other hand, enables the owners to maintain surcharge at a level that induces the managers to choose the "right" base price. As a result, collusion on surcharge leads to the same price and profit as collusion on all-inclusive price.

The implication of Proposition 5 for consumer welfare is obvious. Since collusion on surcharge raises the full price to the same level as collusion on all-inclusive price, it is as harmful to consumers as conventional cartels that fix all-inclusive prices.

While Proposition 5 suggests that the firms should be indifferent between the two types of cartels, collusion on surcharge may have a few practical advantages over collusion on all-inclusive price. First, by colluding on only one component of the full price, the firms maintain an illusion of competition (in base price). This may help firms deflect customer outrage over high prices and evade scrutiny by antitrust authorities. Second, in firms where price decisions are delegated to many employees, collusion on surcharge may enable the firms to limit the involvement in the conspiracy to a small number of top executives. This, in turn, may reduce the probability of detection by antitrust authorities.

Furthermore, it is useful to recall that in this model, "surcharge" is merely a name for the price component set by the owner of a firm. What matters to the results here is coordination among the owners, not the name they attach to their price component. This flexibility in name brings an additional benefit to colluding firms as they can be creative in choosing a name that will ostensibly justify their price increase and avoid suspicion by competition authorities.[15]

VI. Conclusions

I have examined the strategic effects of partitioned pricing, a pricing strategy that has not received much attention in economics literature. My analysis shows that partitioned pricing leads to higher full prices and larger profits than all-inclusive pricing. This provides a theoretical explanation for the phenomenon of partitioned pricing, an explanation that is faithful to the fundamental assumption of rational economic agents and is consistent with the practices in industries such as air cargo and automobile retail services.

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[15] Indeed, in the air cargo conspiracy case, the airlines attributed the increases in fuel surcharges to higher fuel prices (European Commission 2010).

Furthermore, this analysis sheds light on the motivations behind and the effects of firms' conduct in antitrust cases involving surcharges, such as the air cargo conspiracy. It shows that collusion on surcharge without coordination on base price can be just as profitable for firms and as harmful to purchasers as collusion on all-inclusive price.

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