Would the Social Planner Let Bags Fly Free?

Gad Allon
Kellogg School of Management, 2001 Sheridan Road Evanston , IL 60208 , g-allon@kellogg.northwestern.edu

Achal Bassamboo
Kellogg School of Management, 2001 Sheridan Road Evanston , IL 60208 , a-bassamboo@kellogg.northwestern.edu

Martin A. Lariviere
Kellogg School of Management, 2001 Sheridan Road Evanston , IL 60208 , m-lariviere@kellogg.northwestern.edu

August 29, 2011

Motivated by airline baggage fees, we consider a service provider offering a main service (e.g., transporting a person) and an ancillary service (e.g., transporting a checked bag) that an individual customer may or may not need. We ask whether the firm should bundle the two services and post a single price or unbundle them and price the ancillary service separately. We consider two motivations for unbundling the services. The first focuses on altering consumer behavior to lower the firm's costs. We assume that providing the ancillary service is costly but consumers can exert effort in order to reduce the rate at which the ancillary service is needed. We show that the firm unbundles and sets the fee for the ancillary service at the same level the social planner would. Profit maximization thus results in social efficiency. The second rationale for unbundling is segmentation. We assume that there are two segments that differ in the rate at which they use the ancillary service. The optimal contracts impose higher ancillary service fees on those less likely to use the service. In the airline setting, this would imply that business travelers would face higher baggage fees than leisure travelers. We conclude that the way in which airlines have implemented baggage fees is more consistent with attempts to control consumer behavior than segment customers.

1. Introduction

Describing what a service business does should be simple. Restaurants provide food while airlines transport passengers. Reality, however, is a little more complex. Restaurant serve multiple courses and a variety of beverages in addition to providing a place for conversation. There are also supporting activities such as bringing out food or bussing tables. Airlines move passengers' belongings as well as their bodies while issuing documents to clear airport security. Airlines may also offer a variety of in-flight amenities ranging from internet access to restrooms. The multidimensional nature of services raises the question of how they should be priced and sold. Specifically, should a service be sold as an inclusive bundle or should it be unbundled with each component priced separately?

The airline industry exemplifies the possibilities of unbundling. Traditionally, the basic ticket price incorporated many "ancillary" services such as checking a bag, an in-flight meal, and printing a boarding pass.

Today, most airlines charge fees for checking a bag or dining on board the plane. Some even charge to print a boarding pass at the airport (Carey, 2011). These changes have remade the industry. A recent survey reported that in 2007, 23 airlines worldwide reported ancillary fee income of $2.45 billion. In 2010, 47 airlines reported ancillary fee revenue of $21.46 billion (Amadeus, 2011). Some smaller discount airlines such as Spirit in the United States and Ryanair in Europe earn over 20% of their revenue from ancillary service fees. Even United Airlines, the second largest US-based carrier, gets over 14% of its revenue from fees (Amadeus, 2011).

In the US market, few fees have been as controversial as those for checked bags. In June 2008, American Airlines became the first major US airline to institute a fee on the first checked bag (Sharkey, 2008). By the end of 2009, all major US carriers except Southwest imposed baggage fees ranging from $15 to $25. In total, US carriers collected $3.4 billion in baggage fees in 2010 (Bureau of Transportation Statistics, 2011).

While the fees have been a boon to airlines, they have aggravated many travelers. Baggage fees appear atop a list of traveler's pet peeves (Consumer Reports, 2010). Airlines defend the practice of unbundling as providing customers flexibility and allowing them to pay for just what they use. As Ben Baldanza, Spirit Airlines's chief executive, put it, "We believe it is important to let customers decide what is of value to them. Imagine if you went to a restaurant and all the meals came with dessert. That's great if you like dessert but, if you don't, you would prefer the option to pay less for the meal and not take the dessert." (See Carey, 2011.)

Thus, the industry's standard defense depends on segmentation. Baldanza's argument assumes that there are groups of customers for whom traveling without a checked bag is easy while others find taking only a carry on onerous. Baggage fees then allow airlines to extract extra revenue from the latter group just as restaurants earn more from diners with a big appetite and a sweet tooth. If the need to check bags did not vary across segments, rational consumers would all respond to the imposition of baggage fees by demanding the same cut in ticket prices. The firm would consequently not be better off.

There is, however, another explanation for the use of baggage fees: To shape customer behavior. This is the argument put forth by Michael O'Leary, the CEO of Ryanair. "[P]aying for checked-in bags ... wasn't about getting revenue. It was about persuading people to change their travel behavior—to travel with carry-on luggage only. But that's enabled us to move to 100% Web check-in. So we now don't need check-in desks. We don't need check-in staff. Passengers love it because they'll never again get stuck in a Ryanair check-in queue. That helps us significantly lower airport and handling costs." (Michaels, 2009) Ryanair has also explored charging for using on-board lavatories for similar reasons. If customers used the on-board restrooms only as a last resort, Ryanair could fly planes with fewer lavatories but more seats.

In this paper we seek to evaluate the relative merits of these alternative justifications for baggage fees and other ancillary charges. We first consider a firm selling a service to a single customer segment. It offers a main service (e.g., transporting a person from point A to B) and an ancillary service (e.g., checking a bag) that customers may or may not need. The ancillary service can only be consumed if customers contract for the main service. Both services are costly to provide. Customers value the main service but do not value the ancillary service separately. However, they will consume the ancillary service if they need it. Customers can expend costly effort that lowers the chance that they will need the ancillary service.

When service is bundled, customers exert no effort and drive up the firm's cost. When the firm is allowed to unbundle the services, pricing the ancillary service separately induces customers to exert effort and lower the firm's cost. Furthermore, the firm induces the socially efficient effort level. That is, the social planner would impose the same baggage fee as the profit maximizing firm. This result holds whether customers share a common reservation value for the main service or have generally distributed reservation values. The result also extends from a monopoly setting to a competitive market.

We then consider segmentation. The firm now sells to two sets of customers who differ either in their effort costs or in the effectiveness of their effort. To separate between the customers, the firm imposes a high ancillary service fee on those with a low cost for avoiding the ancillary service (or those with very effective effort) while having a low ancillary service fee (and possibly bundling) for those who find it hard to avoid the ancillary service. Thus, airlines should be imposing high baggage fees on road-warrior, business executives while offering a break on checked bags to leisure travelers. However, we observe that frequent fliers are often exempted from baggage fees while occasional travelers always pay. Stated another way, the industry explanation for baggage fees has implications that do not match what one sees in the marketplace.

We consequently conclude that to the extent that airlines segment customers, they are not doing it along the lines of the need to check luggage.

Finally, we also consider market features that impede the implementation of socially-efficient fees. First, we show that taxing revenue from the main service but not fees for the ancillary service (as is done in the United States) leads to inefficiently high baggage fees and excess consumer effort. Next we consider risk averse customers, a relevant consideration since ancillary service fees impose uncertainty on consumers. If customers are risk averse, the firm lowers its ancillary service fee and may in fact bundle. Consumer effort may be either too low or too high.

Below we first review the literature and then present the basic model. Section 4 analyzes the setting with one customer segment while section 5 considers selling to two segments. Section 6 investigates the impact of taxes and risk aversion. Section 7 concludes.

2. Literature Review

Our work relates to several strands of research in economics and operations management. Here we briefly survey several of these.

Two-part tariffs. The use of an ancillary fee moves a service provider from offering a simple price to posting a two-part tariff. The economics literature supports two-part tariffs as the preferred pricing scheme for a profit-maximizing firm with market power. We refer the reader to Armstrong (2006) for a detailed survey and references therein. The most relevant citation for us is the seminal work of Oi (1971). He shows that a two-part tariff scheme allows a monopolist selling to homogeneous customers to allocate efficiently by setting its usage price at the marginal cost of production while using a flat fee to extract consumer surplus. When faced with multiple types of customers, the monopolist generally prices above the cost of production. We similarly show that monopolist or competitive firms facing homogenous customers will favor pricing at marginal cost. When a monopolist in our model faces multiple customer segments, however, it will price below marginal cost.

Hayes (1987) provides an alternate view for two-part tariff as insurance to risk averse buyers under uncertainty. Buyers subscribe to the contract before resolution of the uncertainty. Sellers set two-part prices that trade off between insuring buyers against the uncertainty and the ex post deadweight loss from inefficient usage. Essegaier et al. (2002) studies the impact of two-part tariff as well as flat fees when the firm has a capacity constraint. Recently, Png and Wang (2010) consider two-part pricing of a service offered to risk-averse buyers subject to demand uncertainty with a focus on understanding the impact of correlation between the marginal and total benefits from the service on the optimal usage price. We consider a monopolist selling to risk averse customers and show that profit maximization no longer results in inducing efficient customer effort.

Advance selling. In our model, the firm sells to the consumers before they realize whether or not they need the ancillary service. In this aspect, our paper is also related to the literature on advance selling. DeGraba (1995) is among the first to explore how selling to customers who are uncertain of how they will value the good can raise the firm's profit. Intuitively, demand from uninformed customers is inelastic, and this allows selling a large quantity at a relatively high price. Xie and Shugan (2001) studies a model of advance selling accounting for other effects such as multiple periods, exogenous credibility and risk aversion. In a recent paper, Cachon and Feldman (2008) compares subscription versus pay-per-use in services. They show that even when there are congestion effects, subscription may have substantial benefits over pay-per-use.

Operations management with strategic customers. Our paper is also related to the growing literature in operations management in general and revenue management in particular that deals with the ability of the firm to shape consumer behavior. See Talluri and van Ryzin (2005) for a detailed discussion of revenue management and Netessine and Tang. (2009) for more on how consumer behavior interacts with operating decisions. Much of this work is built on detailed modeling of the consumer. The focus of our paper is on the role of ancillary service fees in shaping consumer behavior. van Ryzin and Liu (2008) studied settings in which firms can force customers to order early by rationing their capacity. Thus, similar to the ancillary service fee in our model, the rationing risk created by the retailer shapes the customer behavior.

Finally, we are aware of only one paper that deals directly with the role of ancillary fees in pricing services. Shulman and Geng (2011) build a model with three segments. The first never needs the ancillary service. The second may consume the service depending on how it is priced and rationally anticipates the pricing of the ancillary service when contracting for the main service. The third, like the second, may consume the ancillary service but irrationally does not anticipate having to pay for the ancillary service when contracting for the main service. The firm may gain from unbundling the services by exploiting the third segment if the first segment is not too large. In our model, all customers are rational and the persistence of ancillary service fees would not depend on the existence of uninformed customers.

3. Model basics

Consider a firm selling a service that consists of two components, a main service and an ancillary service. All customers obtain value μ from the main service. The ancillary service cannot be consumed independently of the main service. Customers do not have an explicit value for the ancillary service but if it is needed, they must consume it regardless of any charge. In the airline setting, the main service is transporting the customer while the ancillary service is handling checked bags or providing a lavatory.

The customer's need for the ancillary service depends on effort the customer exerts. Specifically, we assume that the probability that a given customer needs the ancillary service is given by $\alpha(\varepsilon)$, where $\varepsilon \geq 0$ represents the effort the customer exerts to reduce the likelihood of using the ancillary service. The more effort exerted by the customer the less likely she is to need the ancillary service. That is, $\alpha'(\varepsilon) < 0$. The customer experiences a cost $c(\varepsilon)$ that depends on the magnitude of the effort. We assume $c'(\varepsilon) \geq 0$, $c(0) = 0$, and $\lim_{\varepsilon\to\infty} c(\varepsilon) = \infty$. In what follows, we further suppose that $-c'(\varepsilon)/\alpha'(\varepsilon)$ is strictly increasing. This holds if, for example, both $c(\varepsilon)$ and $\alpha(\varepsilon)$ are convex.

For the firm, the cost of providing the main service to one customer is $\kappa_m < \mu$ and the cost of the ancillary service to one customer is κ_a. The firm sells the service by posting a pair of prices $\{\phi, p\}$. ϕ is the price of the main service and is incurred by all purchasing customers. p is the ancillary service fee and is paid only by those who use the ancillary service. If $p = 0$, we say the firm bundles.

The sequence of events is as follows. The firm first posts its offer $\{\phi, p\}$ and consumers contract for the service. Each customer then sets her individual effort level. Consumers then learn whether or not they need the ancillary service and pay p if they use the ancillary service.

3.1. The social planner's problem

Before turning to the problem faced by the firm, we consider the social planner's problem to establish a benchmark.

Every customer served by the firm provides society with a gain of $\mu - \kappa_m$ for the main service. In terms of the ancillary service, the societal benefit depends on the effort exerted by the customers to avoid the ancillary service. Thus, the social planner must balance the certain cost of trying to avoid the service with the expected cost of providing it. Hence, the social planner sets effort ε to minimize

$$c(\varepsilon) + \alpha(\varepsilon)\kappa_a. \tag{1}$$

We denote the optimal effort that maximizes the social welfare by ε^*. It is implicitly given by

$$-\frac{c'(\varepsilon^*)}{\alpha'(\varepsilon^*)} = \kappa_a,$$

assuming $-c'(0)/\alpha'(0) < \kappa_a$. The optimal effort balances the rate at which the societal cost of avoiding the ancillary service increase with the rate at which the expected cost of providing the service falls. If $-c'(0)/\alpha'(0) \geq \kappa_a$, this trade off is immediately unfavorable and any cost savings from not providing the service is less than consumer effort costs. It would then be socially optimal not to require any consumer effort.

To illustrate these results, suppose $\alpha(\varepsilon) = \alpha_0 (1+\varepsilon)^{-\gamma}$ for $\gamma > 0$ and $0 < \alpha_0 \leq 1$ and that $c(\varepsilon) = c\varepsilon$. We have $\varepsilon^* = \max\left\{0, \left(\frac{\alpha_0 \gamma \kappa_a}{c}\right)^{\frac{1}{1+\gamma}} - 1\right\}$. Effort is then increasing in the cost of providing the ancillary service and in α_0, the base rate at which customers need the service. However, it is decreasing in the customer's effort cost parameter c. If customer costs are sufficiently high (i.e., if $c > \alpha_0 \gamma \kappa_a$), the social planner induces no customer effort.

4. Selling to a single segment

We now consider a profit maximizing firm offering the service under contract $\{\phi, p\}$. The firm's problem is

$$\begin{aligned} &\underset{\phi,p}{\text{Maximize}} && \phi - \kappa_m + (p - \kappa_a)\,\alpha(\varepsilon_p) \\ &\text{Subject to} && \varepsilon_p \in \arg\max_{\varepsilon \geq 0} \left(\mu - \phi - p\alpha(\varepsilon) - c(\varepsilon)\right) \end{aligned}$$

$$\mu - \phi - p\alpha(\varepsilon_p) - c(\varepsilon_p) \geq 0$$

The first constraint assures that the customer chooses her effort to maximize her utility given the posted contract while the second guarantees that it is rational for the customer to participate in the contract.

In analyzing the firm's problem, first note that given our assumptions on $c(\varepsilon)$ and $\alpha(\varepsilon)$, ε_p is uniquely determined by $-c'(\varepsilon_p)/\alpha'(\varepsilon_p) = p$ if $-c'(0)/\alpha'(0) < p$ and is zero otherwise. Thus consumers will exert no effort if the firm sets $p = 0$ and bundles. Next suppose that the customer's participation constraints binds so $\phi = \mu - p\alpha(\varepsilon_p) - c(\varepsilon_p)$. The firm's objective can then be written as

$$\underset{p}{\text{Maximize}}\ \mu - \kappa_m - c(\varepsilon_p) - \kappa_a \alpha(\varepsilon_p),$$

which is equivalent to

$$\underset{p}{\text{Minimize}}\ c(\varepsilon_p) + \kappa_a \alpha(\varepsilon_p). \tag{2}$$

Comparing (2) to (1), one sees that the profit-maximizing firm is left minimizing the societal cost of the ancillary service. That would require $\varepsilon_p = \varepsilon^*$, which implies $p = \kappa_a$ if $-c'(0)/\alpha'(0) < \kappa_a$. Otherwise the firm bundles. We have the following result.

Proposition 4.1 *The two-part tariff that maximizes the profit for the firm also induces the optimal social outcome effort by the customers.*

Intuitively, the firm is offering a two-part tariff. Since the customer exerts effort after contracting, the charge for the main service ϕ is sunk when the customer chooses ε. The firm can then use the charge for the main service to capture all social surplus from the transaction. It then has no incentive to distort the customer's action from the socially optimal level. We emphasize here that the firm is not using the ancillary service fee to segment the market. Rather the only reason to charge for the ancillary service is to shape consumer behavior. The fee aligns the operational incentives of the firm, i.e. reducing the cost of providing the ancillary service, with those of the consumer, i.e. reducing the cost of using the ancillary service.

Remark 4.1 *In this setting our risk-neutral customer is a priori indifferent between having the firm using its optimal two-part tariff and having it bundle at* $\{\phi, p\} = \{\mu, 0\}$. *Under either contract, the consumer is* *pushed to indifference and has an expected utility of zero. However, the optimal contract imposes risk on the consumer. If she ultimately does not need the ancillary service, she will have a positive ex post utility. On the other hand, if she needs the ancillary service she will have a negative ex post utility. We consider the impact of risk aversion in Section 6.*

4.1. Generalizing the model

Our results to this point have assumed that all consumers have the same value for the main service and that the firm is a monopolist. We now drop these assumptions and show that the optimal contract continues to offer the ancillary service at its marginal cost resulting in the socially efficient effort level.

4.1.1. Heterogenous willingness to pay We now suppose that customers are heterogenous with respect to their willingness to pay for the main service. Fix the market size at M customers. Each customer's willingness to pay for the service μ is drawn independently from a distribution with cumulative distribution function $G(x)$ and density $g(x)$. Letting $\bar{G}(x) = 1 - G(x)$, the expected demand q when the firm charges $\{\phi, p\}$ is

$$q(\phi, p) = M\bar{G}(\phi + c(\varepsilon_p) + \alpha(\varepsilon_p)p),$$

where ε_p is again the effort level induced by the fee p. The inverse demand function for the price of the main service is then

$$\phi(q, p) = \bar{G}^{-1}\left(\frac{q}{M}\right) - c(\varepsilon_p) - \alpha(\varepsilon_p)p.$$

We can then state the firm's profit maximization problem as follows: choose q and p to maximize

$$q[\phi(q, p) - \kappa_m - \alpha(\varepsilon_p)(\kappa_a(\alpha(\varepsilon_p)) - p)].$$

Using the definition of the inverse demand function, we can re-express the objective as

$$q[\bar{G}^{-1}\left(\frac{q}{M}\right) - \kappa_m] - q[c(\varepsilon_p) + \alpha(\varepsilon_p)\kappa_a(\alpha(\varepsilon_p))].$$

Thus for any q, the firm's profit will be maximized by minimizing $c(\varepsilon_p) + \alpha(\varepsilon_p)\kappa_a$ with respect to p. That is again done by setting $p = \kappa_a$ and inducing consumers to set the socially efficient effort level. Stated another way, any deviation from the social optimality will show up in the total quantity sold, not in the effort and cost of the ancillary service.

The question then is how the quantity sold by the profit-maximizing firm changes with p and in particular whether imposing ancillary service fees results in the firm selling more than if it were forced to bundle. To examine this question we first need to impose some structure on the valuation distribution $G(x)$. Let $H(x) = g(x)/\bar{G}(x)$ denote the failure rate of $G(x)$. We assume $G(x)$ has increasing generalized failure rate (IGFR), i.e., $xH(x)$ is weakly increasing for all x in the support of $G(x)$ (Lariviere, 2006). Next define $f = \phi + c(\varepsilon_p) + p\alpha(\varepsilon_p)$ as the firm's *full price* given $\{\phi, p\}$. The full price represents the total expected cost a customer incurs in contracting for the service. Hence, a customer only buys if her valuation exceeds the full price.

We can now write the firm's profit given p as

$$M\bar{G}(f)\left[f - c(\varepsilon_p) - \kappa_a\alpha(\varepsilon_p) - \kappa_m\right].$$

Differentiating with respect to f, we have that f_p, the optimal full price given p, is given by

$$f_p\left(1 - \frac{1}{f_pH(f_p)}\right) = c(\varepsilon_p) + \kappa_a\alpha(\varepsilon_p) + \kappa_m. \tag{3}$$

The left-hand side of (3) represents the rate at which the service provider's revenue changes with the full price while the right-hand side is the expected marginal cost of serving a customer. The IGFR assumption gives that the left-hand side of (3) is increasing and that there is consequently a unique optimal full price for any given ancillary fee. Further, the optimal full price increases as the firm's marginal cost increases. But the right-hand side is minimized at $p = \kappa_a$. Thus, if the service provider is forced to use any ancillary fee other than κ_a (and, in particular, if it is forced to bundle), it will choose a higher full price and serve fewer customers. Stated another way, pricing the ancillary at its marginal cost both induces the optimal effort from consumers and maximizes the number of customers the profit-maximizing firm serves. In the setting of the airline industry, this means that more people fly.

Remark 4.2 *While homogenous customers were indifferent between bundling and unbundling, heterogenous customers strictly prefer unbundling. When customers have heterogeneous values, only the marginal* *customer is indifferent to consumption. The lower full price makes everyone who would consume under bundling better off. Further, there is a set of customers who do not buy under bundling but who now purchase.*

Remark 4.3 *To this point, we have assumed that the firm does not have a capacity constraint. When customers have homogeneous values, the optimal contract is independent of the capacity constraint. When customers have heterogeneous values, the firm will still charge $p = \kappa_a$ but may increase ϕ (equivalently, increase its full price) if excess demand exists at unconstrained optimum we found here. In particular, if the capacity is a binding constraint under bundling, it will also bind when the firm prices the ancillary service separately. Unbundling will then increase the firm's profit while leaving consumer utility unchanged.*

4.1.2. Competition So far, in this paper, we have considered only monopoly markets. We now examine a market with multiple firms engaged in price competition.

Let there be N firms. The subscript i denotes a quantity associated with the i^{th} firm. If the i^{th} firm posts prices $\{\phi_i, p_i\}$, then, as discussed above, the full price observed by the customers choosing firm i is

$$f_i = \phi_i + c(\varepsilon_{p_i}) + p_i \alpha(\varepsilon_{p_i}),$$

where ε_{p_i} is the effort exerted by the customers to minimize $c(\varepsilon) + p_i\alpha(\varepsilon)$. Let $\hat{f} = (f_1, ..., f_N)$.

We assume that competition is in full prices. Thus, the quantity sold by firm i q_i is solely a function of $\hat{f}$ and is unchanged if firm j changes its offering from $\left\{\phi_j, p_j\right\}$ to $\left\{\phi'_j, p'_j\right\}$ as long as $\phi_j + c(\varepsilon_{p_j}) + p_j\alpha(\varepsilon_{p_j}) = \phi'_j + c(\varepsilon_{p'_j}) + p'_j\alpha(\varepsilon_{p'_j})$. Competition in full prices is a reasonable assumption if customers seek to minimize their expected costs. It is not an appropriate assumption if, for example, customers have lexicographic preferences that result in them choosing from the set of providers who have the lowest ancillary service fee.

Given this framework, the revenue for the i^{th} firm given $\hat{f}$ is given by

$$\begin{aligned} &q(\hat{f})[\phi_i - \kappa_m - \alpha(\varepsilon_{p_i})(\kappa_a(\alpha(\varepsilon_{p_i})) - p_i)] \\ &= q(\hat{f})[f_i - \kappa_m - c(\varepsilon_{p_i}) - \alpha(\varepsilon_{p_i})\kappa_a(\alpha(\varepsilon_{p_i}))]. \end{aligned}$$

Thus, it is easy to see that for a fixed f_i the firm chooses p_i to minimize

$$c(\varepsilon_{p_i}) + \alpha(\varepsilon_{p_i})\kappa_a(\alpha(\varepsilon_{p_i})).$$

Hence for an arbitrary full price vector, the competing firms will choose specific contracts that minimize the overall societal cost for ancillary service and thus maximizes the social surplus given the quantity sold. This logic leads to the following proposition.

Proposition 4.2 *Let $\hat{f}^*$ be an equilibrium under full price competition. Then, given $\hat{f}^*$, the i^{th} firm posts $p_i = \kappa_a$ and the resulting customer effort maximizes the social surplus given the quantity sold.*

Note that the above proposition states that given an equilibrium, the effort induced by the customers indeed maximizes the social welfare. That is, given that full price determines the demand each firm sees for its main service offering, the demand for the ancillary service placed on each firm will maximize social welfare.This does not mean that the overall social welfare is maximized since the demand level for the main service may be above or below the one prescribed by the social planner.

5. Selling to multiple segments

We have so far shown the service provider can use an ancillary service fee to sway customer behavior in a way that is both socially efficient and profit enhancing. Of course, this does not mean that fees cannot also be used to segment customers and extract additional rents. The claim put forth by Ben Baldanza of Spirit Airlines likening ancillary service fees to dessert at a restaurant may in fact be relevant. Here we analyze a setting in which the firm faces two segments that differ in their ability to react to ancillary service fees. We examine how this impacts the contracts the firm offers and compare the resulting pricing policies to what prevails in the market place.

We suppose that there are two customer segments H and L. The segments have the same value for the main service μ but are endowed with segment specific effort cost functions $c_H(\varepsilon)$ and $c_L(\varepsilon)$ and effort response functions $\alpha_H(\varepsilon)$ and $\alpha_L(\varepsilon)$. Let η denote the fraction of class H customers in the market. Segment H is made up of high cost customers, i.e., $c_H(\varepsilon) \geq c_L(\varepsilon)$ and $\alpha_H(\varepsilon) \geq \alpha_L(\varepsilon)$ with at least one inequality being strict. These customers find it more difficult to avoid the ancillary service either because they find effort onerous, have a high base rate of needing the service (i.e., $\alpha_H(0) > \alpha_L(0)$), or do not see a rapid decrease in needing the ancillary service as they expend effort. In the world of airline travel, a road-warrior business traveler adept at living out of a small carry-on bag would be in segment L while a leisure traveler going on an extended vacation would belong to segment H. The former can easily avoid a checked bag fee while the latter would be hard-pressed to do the same.

Let $\varepsilon_i^*(p) = \arg\max_{\varepsilon} [p\alpha_i(\varepsilon) + c_i(\varepsilon)]$ and $U_i(p) = p\alpha_i(\varepsilon_i^*(p)) + c_i(\varepsilon_i^*(p))$. Our assumptions on the segments' characteristics imply

$$U_H(p) > U_L(p) \text{ for } p > 0. \tag{4}$$

To simplify the analysis, we further assume

$$U_H'(p) > U_L'(p) \text{ for } p \geq 0 \tag{5}$$

Several formulations lead to (5). For example, one could have $c_H(\varepsilon) = \delta c_L(\varepsilon)$ and $\alpha_H(\varepsilon) = \gamma\alpha_L(\varepsilon)$ for $\delta > \gamma \geq 1$. Alternatively, one could assume that $c_H'(\varepsilon) > c_L'(\varepsilon)$ for $\varepsilon \geq 0$ with $\alpha_H(0) \geq \alpha_L(0)$ and $\alpha_H'(\varepsilon) > \alpha_L'(\varepsilon)$ for $\varepsilon \geq 0$.

We assume that the firm cannot distinguish between the segments. It then faces the choice of truly segmenting customers by posting a menu of prices or posting a single contract acceptable to both segments as in Oi (1971).[1]

Proposition 5.1 *Suppose (4) and (5) hold.*

1. *If the firm offers two contract $\{\phi_H, p_H\}$ and $\{\phi_L, p_L\}$, then $p_L = \kappa_a > p_H$ and $\phi_H > \phi_L$. Further, $\mu = \phi_H + U_H(p_H) \geq \phi_L + U_L(p_L)$.*
2. *If the firm offers a single contract $\{\phi_S, p_S\}$, then $p_S < \kappa_a$ and $\phi_S + U_H(p_S) = \mu$.*

Proof: Let $\hat{\alpha}_i(p) = \alpha(\varepsilon_i^*(p))$. When offering two contracts, the firm's problem is

$$\max_{\phi_H, p_H, \phi_L, p_L} \eta(\phi_H + (p_H - \kappa_a)\hat{\alpha}_H(p_H)) + (1-\eta)(\phi_L + (p_L - \kappa_a)\hat{\alpha}_L(p_L)) \tag{6}$$

Subject to:

$$\mu - \phi_H - U_H(p_H) \geq 0$$
$$\mu - \phi_L - U_L(p_L) \geq 0$$

[1] There is in fact a third choice: Sell to only the low cost segment. That reduces to the single segment problem studied above.

$$\mu-\phi_H-U_H(p_H)\geq\mu-\phi_L-U_H(p_L)$$
$$\mu-\phi_L-U_L(p_L)\geq\mu-\phi_H-U_L(p_H)$$
$$\phi_H,p_H,\phi_L,p_L\geq 0$$

Standard arguments give that $\phi_H=\mu-U_H(p_H)$ and $\phi_L=\phi_H+U_L(p_H)-U_L(p_L)$. Substituting these into (6) and differentiating gives $p_L=\kappa_a$ and

$$p_H=\max\left\{\kappa_a+\frac{1-\eta}{\eta}\frac{U_H'(p_H)-U_L'(p_L)}{\hat{\alpha}_H'(p_H)},0\right\}.$$

Noting that $\hat{\alpha}_H'(p_H)$ is negative together with (5) gives that $p_H<p_L$. That in turn implies that $\phi_H>\phi_L$. $\mu\geq\phi_L+U_L(p_L)$ follows from (4).

In considering the case of a single contract, note that any contract acceptable to a high-cost customer is also acceptable to a low-cost customer. That gives that $\phi_S=\mu-U_H(p_s)$. The firm's objective is then to choose p_S to maximize

$$\begin{aligned}\Pi(p_S) &= \mu-U_H(p_S)+(p_S-\kappa_a)(\eta\hat{\alpha}_H(p_S)+(1-\eta)\hat{\alpha}_L(p_S))\\ &= \eta(\mu-U_H(p_S)+(p_S-\kappa_a)\hat{\alpha}_H(p_S))+(1-\eta)(\mu-U_L(p_S)+(p_S-\kappa_a)\hat{\alpha}_L(p_S)) \quad (7)\\ &\quad +(1-\eta)(U_L(p_S)-U_H(p_S)). \quad (8)\end{aligned}$$

Note that the two terms on line (7) are unimodal and are maximized at $p_S=\kappa_a$. The third term on (8) is decreasing in p_S for any $p_S\geq 0$ by (5). Hence we must have $p_S<\kappa_a$. ■

Not surprisingly, information asymmetry between the service provider and its customers costs the firm money. It lowers the fee for the ancillary service for the high cost segment to extract surplus from the low cost customer (since $\phi_L\leq\mu-U_L(p_L)$). Intuitively, the high-cost segment is more sensitive to the ancillary service fee than the low-cost segment. A contract that induces significant effort from high-cost customers would have to discount the main service significantly and would thus appeal to the low cost segment. When two segment-specific contracts are offered, the firm lowers p_H, inducing inefficiently low effort from high cost customers but enabling a higher main service fee for both segments. A similar logic holds when a single contract is offered. Lowering the fee for ancillary service increases the high-cost segment's utility more than it increases the low-cost segment's. The firm captures this increase through a higher main service fee but also incurs higher cost as customers are more likely to consume the ancillary service. Indeed, customers may exert no effort at all. The fee for the ancillary service must be non-negative and the firm's profit may be maximized by bundling the services for the high-cost segment (when two contracts are offered) or both (when one contract is offered).

Remark 5.2 *For simplicity, we have assumed that all customers have the same reservation value for the primary service. Alternatively, we could assume that there are segment specific distributions for the main service valuations similar to what was discussed above. This would not change the basic flavor of our results. As long as the customers of the low-cost segment are the preferred type with whom to contract, they will be offered efficient terms of trade with $p_L = \kappa_a$. To dissuade low-cost customers from taking the terms designed for high-cost customers, the firm would lower p_H while raising the full price imposed on the high-cost segment.*

We illustrate our results through a numerical study. We assume $\kappa_a = 5$, $\kappa_m = 0$, $\mu = 100$, $c_i(\varepsilon) = \varepsilon$ and $\alpha_i(\varepsilon) = \tilde{\alpha}_i (1+\varepsilon)^{-1}$. We fixed $\tilde{\alpha}_L = 0.25$ and vary η and $\tilde{\alpha}_H$. The results are summarized in Table 1. The left-hand panels for a uniform price correspond to second part of the proposition while the right-hand panels correspond to the first part. It is useful to first consider when $\tilde{\alpha}_H$ is close to $\tilde{\alpha}_L$. Here, low – or even no – effort from the high-cost segment is not particularly costly when they make up a relatively small part of the market. The firm thus finds it optimal to bundle the ancillary service with the main service. When only one contract is offered, this implies that the main service is offered at a price equal to the customers' value (i.e., $\phi_S = \mu$) and neither segment exerts effort. When two contracts are offered, the high-cost segment is offered a bundle while the low-cost segment pays an ancillary fee. The low-cost segment here receives no information rents in either case but the overall system is inefficient because at least one segment exerts no effort.

As $\tilde{\alpha}_H$ increases, bundling becomes too costly for the firm. It now imposes an ancillary service fee on the high cost customers. Under both a uniform price or a price menu, the firm opts to induce more and more effort from the high-cost segment as $\tilde{\alpha}_H$ increases which must be offset by a lower main service fee. This leads to increasing information rents for low-cost customers. Also, in the uniform price case, the posted ancillary service fee may not be high enough to induce effort from the low-cost customers.

In summary, whether the firm decides to post two contracts and separate the segments or offer one contract and pool the segments, the presence of multiple segments results in lower fees for the ancillary service. Indeed, it is possible that bundling for at least one segment is optimal. The final question is how well this matches with what is observed in the market place. At first glance, it would seem that airlines generally pool their customers since all coach passengers face the same price for checking a bag. On the other hand, most airlines waive the checked-bag fee for elite-status frequent fliers. Thus we have one segment paying a relatively high baggage fee while the other receives bundled service. Further, to the extent that most elite frequent fliers are experienced business travelers, they generally pay higher fares than leisure travelers. The difficulty is that our high-cost segment most naturally maps to leisure travelers while road warriors are a better fit for our low cost segment. Thus, while our results fit the structure observed in the market place, it predicts that the discounted baggage fees will go to the wrong segment.

There are several ways to explain this result. First, segmenting airline customers may be more relevant along other dimensions than the need to check bags. For example, it is likely more effective to segment customers on whether they or their employer is paying for their ticket. When the employer is paying for the ticket and the baggage fee, the latter may be irrelevant in inducing effort and can be set essentially arbitrary. Alternatively, airlines may segment primarily on time of purchase and therefore price the ancillary separately for each segment. If late-purchasing business travelers have a sufficiently low probability of checking a bag, bundling would be the optimal contract.

6. When does the service provider fee not induce socially efficient effort?

To this point, we have shown that a profit-maximizing service provider will set its ancillary service fee in a way that maximizes social welfare. Even if the firm faces two customer types and opts to post a menu of contracts, it still induces the efficient level from at least one segment. This, however, does not establish that one expects that firms are necessarily pricing ancillary services efficiently in practice. Market features we have not considered to this point may interfere with socially optimal pricing. Here we highlight two such issues, taxes and consumer risk aversion.

Table 1 Contrasting the price menu with uniform pricing.

	Uniform Price					Price Menu						
$\tilde{\alpha}_H$	ϕ_S	p_S	ε_L	ε_H	Profit	ϕ_L	p_L	ε_L	ϕ_H	p_H	ε_H	Profit
$\eta = 0.7$												
0.30	100.00	0	0	0	98.5750	98.76	5	0.12	100.00	0	0	98.5792
0.35	100.00	0	0	0	98.4000	98.76	5	0.12	100.00	0	0	98.4042
0.40	100.00	0	0	0	98.2250	98.76	5	0.12	100.00	0	0	98.2292
0.45	100.00	0	0	0	98.0500	98.76	5	0.12	100.00	0	0	98.0542
0.50	100.00	0	0	0	97.8750	98.76	5	0.12	100.00	0	0	97.8792
0.55	100.00	0	0	0	97.7000	98.76	5	0.12	100.00	0	0	97.7042
0.60	97.98	3.79	0	0.51	97.5563	97.70	5	0.12	97.98	3.79	0.51	97.5605
0.65	97.89	3.72	0	0.55	97.4195	97.58	5	0.12	97.89	3.72	0.55	97.4237
0.70	97.80	3.66	0	0.60	97.2880	97.48	5	0.12	97.80	3.66	0.60	97.2922
0.75	97.71	3.6	0	0.64	97.1614	97.38	5	0.12	97.71	3.60	0.64	97.1655
0.80	97.62	3.56	0	0.69	97.0390	97.28	5	0.12	97.62	3.56	0.69	97.0431
0.85	97.54	3.52	0	0.73	96.9204	97.18	5	0.12	97.54	3.52	0.73	96.9246
0.90	97.46	3.48	0	0.77	96.8054	97.09	5	0.12	97.46	3.48	0.77	96.8096
$\eta = 0.9$												
0.30	98.57	4.91	0.11	0.21	98.5506	98.55	5	0.12	98.57	4.91	0.21	98.5506
0.35	98.39	4.85	0.10	0.30	98.3546	98.36	5	0.12	98.40	4.83	0.30	98.3546
0.40	98.23	4.79	0.09	0.38	98.1722	98.18	5	0.12	98.23	4.78	0.38	98.1722
0.45	98.08	4.75	0.09	0.46	98.0010	98.02	5	0.12	98.08	4.73	0.46	98.0011
0.50	97.93	4.72	0.09	0.54	97.8391	97.87	5	0.12	97.94	4.69	0.53	97.8392
0.55	97.79	4.68	0.08	0.60	97.6851	97.72	5	0.12	97.80	4.66	0.60	97.6853
0.60	97.66	4.66	0.08	0.67	97.5381	97.58	5	0.12	97.67	4.63	0.67	97.5382
0.65	97.53	4.63	0.08	0.73	97.3971	97.45	5	0.12	97.54	4.61	0.73	97.3972
0.70	97.41	4.61	0.07	0.80	97.2614	97.32	5	0.12	97.42	4.59	0.79	97.2616
0.75	97.29	4.59	0.07	0.86	97.1305	97.20	5	0.12	97.30	4.57	0.85	97.1307
0.80	97.17	4.58	0.07	0.91	97.0039	97.08	5	0.12	97.18	4.55	0.91	97.0041
0.85	97.06	4.56	0.07	0.97	96.8812	96.97	5	0.12	97.07	4.54	0.96	96.8815
0.90	96.95	4.55	0.07	1.02	96.7621	96.86	5	0.12	96.97	4.52	1.02	96.7624

6.1. Taxation

That taxation may interfere with market efficiency is not a novel observation but a quirk of the Unites States tax code is worth examination. Specifically, revenue from passenger tickets (ϕ in our model) are subject to a 7.5% excise tax while revenues from ancillary services (p in our model) are not. Indeed, the Internal Revenue Service has recently clarified that this is so following a request from American Airlines (Hughes, 2010).

We now examine how this differentiated tax treatment affects the firm's pricing decisions. To consider a general case, we assume that revenue from selling the main service is taxed at rate τ_m while ancillary service fee revenue is taxed at rate τ_a. Under current US policy, $\tau_a = 0$. In analyzing the firm's problem it is convenient to assume that the firm's decisions are ϕ and ε. That is, the firm chooses what effort level to induce from customers which implies that the posted ancillary service fee will be $p(\varepsilon) = -c'(e)/\alpha(\varepsilon)$. (Note we are implicitly assuming that we are in a regime in which the firm that the firm finds it profitable to induce customer effort in the absence of taxes.) The firm's profit is then

$$\begin{aligned} \Pi(\varepsilon) &= (1-\tau_m)\phi + (1-\tau_a)p(\varepsilon)\alpha(\varepsilon) - \kappa_m - \kappa_a\alpha(\varepsilon) \\ &= (1-\tau_m)(\mu - c(e)) + (\tau_m - \tau_a)p(\varepsilon)\alpha(\varepsilon) - \kappa_m - \kappa_a\alpha(\varepsilon). \end{aligned} \tag{9}$$

The first two terms of (9) illustrate the issues raised by differential tax rates. If the service provider chooses to induce more effort from customers it must reduce the price of the main service (i.e., $\mu - c(e)$ must fall). However, part of that price cut is born by the government. Further, if $\tau_m > \tau_a$, the firm benefits from shifting consumer spending from paying for the main service to paying for the ancillary service because of the favorable tax treatment. Also, note that even if $\tau_m = \tau_a > 0$, the firm will want to impose an ancillary service fee since the operational savings from inducing $\varepsilon > 0$ accrue to the firm and are not taxed.

We assume that $p(\varepsilon)\alpha(\varepsilon)$ is sufficiently well-behaved that $\Pi(\varepsilon)$ is unimodal and that first-order conditions are sufficient. The optimal effort to induce ε_τ then is implicitly found from

$$p(\varepsilon_\tau) = \frac{\kappa_a}{1-\tau_a} - \frac{\tau_m - \tau_a}{1-\tau_a}\frac{\alpha(\varepsilon_\tau)p'(\varepsilon_\tau)}{\alpha'(\varepsilon_\tau)}.$$

Since $p'(\varepsilon) > 0$ and $\alpha'(\varepsilon) < 0$, we have that $p(\varepsilon_\tau) > \kappa_a$ if $\tau_m \geq \tau_a$. Taxing the main service at a rate higher than the ancillary service thus results in the firm inducing too high an effort level. If $\tau_m = \tau_a$, the firm does not just post a positive ancillary fee (as argued above), it continues to induce too much consumer effort. Indeed, setting $p(\varepsilon_\tau) = \kappa_a$ and recalling that ε^* is the socially efficient effort level, we see that the tax on ancillary service fee revenue would need to increase to

$$\tilde{\tau}_a = \tau_m \frac{\alpha(\varepsilon^*)p'(\varepsilon^*)}{\alpha(\varepsilon^*)p'(\varepsilon^*) + \kappa_a\alpha'(\varepsilon^*)} > \tau_m.$$

A few points are worth making. First, there are other markets in which sharing revenue for one good or service distorts pricing on another offering. Consider concessions at movie theaters. Theaters must share ticket revenue with movie studios. However, they keep all concession revenue. This is one reason offered for why theater concessions are priced high relative to outside purveyors of popcorn and soda (McKenzie, 2008).

Second, our risk neutral consumers are utterly indifferent to how the government taxes main and ancillary revenue. They face a full price of μ for any taxation scheme. This, of course, depends on customers being homogeneous in their valuation of the main service. Alternatively suppose that M customers have heterogeneous valuations drawn independently from an IGFR distribution $G(x)$. The firm's profit when imposing a full price of f and an ancillary service fee of p is

$$M\bar{G}(f)(f - c(\varepsilon_p) - \tau_m\phi - (\tau_a p + \kappa_a)\alpha(\varepsilon_p) - \kappa_m).$$

Differentiating with respect to f, the analog to (3) is

$$f_p\left(1 - \frac{1}{f_p H(f_p)}\right) = c(\varepsilon_p) + \tau_m\phi + (\tau_a p + \kappa_a)\alpha(\varepsilon_p) + \kappa_m$$

where $H(\varepsilon)$ is again the failure rate of $G(x)$.

As with (3), the right-hand side gives how the firm's revenue changes with its full price and the left-hand side is its marginal cost. Now, the marginal cost is increasing in τ_m implying that a higher excise tax on the main service hurts customers because it results in a higher full price. The ancillary service fee that minimizes the marginal cost of service is, however, independent of τ_m but increasing in τ_a. Thus, the current US policy of taxing only ticket revenue distorts the quantity sold but not the pricing of the ancillary service if customers have heterogeneous valuations and capacity does not bind. This last caveat is important. If capacity binds, the full price will again be fixed and the firm will have an incentive to shift how it receives its revenue. That is, the current US tax policy results in inefficiently high baggage fees when demand for travel is strong.

6.2. Risk aversion

We now turn to another issue that may keep the profit-maximizing firm from inducing the socially optimal effort, consumer risk aversion. As we noted above, risk neutral customers are indifferent between having the firm bundle or having it impose an ancillary service fee as long as they impose the same full price. In reality, customers may prefer bundling since it imposes no risk. The consumer's attitude toward risk is relevant since ancillary fees can be significant relative to the cost of the main service. A recent analysis found that spending on ancillary fees for a passenger with two checked bags ranged from 21% to 153% of the price of the base fare on four popular itineraries (Consumer Travel Alliance, 2010).

Here we assume that customers have a mean-variance preferences. If the firm charges p and the customers exert effort ε, their utility is given by

$$U(\varepsilon|\beta) = \mu - c(\varepsilon) - p\alpha(\varepsilon) - \beta\sigma^2(p,\varepsilon),$$

where $\beta \geq 0$ is the weight given to the variance in the mean-variance utility and $\sigma^2(p,\varepsilon) = p^2\alpha(\varepsilon)(1-\alpha(\varepsilon))$ is the variance in the customer's payment. Note that customer's distaste for risk does not change the effort the social planner would want to implement. That is, the social planner would still instruct customers to exert effort ε^* found from $-c'(\varepsilon^*)/\alpha'(\varepsilon^*) = \kappa_a$ (where we assume an interior solution is optimal).

It is, however, a different story if one must induce effort by posting an ancillary service fee. First, if β is strictly positive, the firm must compensate customers for imposing risk on them. The full price then is not simply the sum of the expected cost of the transaction and the customer's effort cost. Second, holding effort constant, $\sigma^2(p,\varepsilon)$ increases with the ancillary service fee. Inducing effort from the customer thus may be in conflict with inefficiently imposing risk on the customer.

Of course, the consumer's effort level will not remain fixed as problem parameters change. The change in the consumer's utility potentially has counter-intuitive implications. In particular, consumers may put in less effort as the fee for the ancillary service goes up.

Lemma 6.1 *Let ε_p be the consumer's optimal effort given an ancillary service fee of p.*

1. $\frac{\partial \varepsilon_p}{\partial \beta}$ *is positive if* $\alpha(\varepsilon_p) \leq \frac{1}{2}$ *and is negative otherwise.*
2. $\frac{\partial \varepsilon_p}{\partial p}$ *is positive if* $\alpha(\varepsilon_p) \leq \frac{1}{2} + \frac{1}{4\beta p}$ *and is negative otherwise.*

Proof: We take the cross partials of $U(\varepsilon)$:

$$\frac{\partial U(\varepsilon|\beta)}{\partial\varepsilon\partial\beta} = -p^2\alpha'(\varepsilon)(1-2\alpha(\varepsilon))$$
$$\frac{\partial U(\varepsilon|\beta)}{\partial\varepsilon\partial p} = -\alpha'(\varepsilon)(1+2p\beta(1-2\alpha(\varepsilon))).$$

The results then follow from implicit differentiation. ■

For intuition, note that $\sigma^2(p,\varepsilon)$ is not monotonic in effort if $\alpha(0) > 1/2$. If the chance of needing the ancillary service when no effort is exerted is greater than one half, exerting effort first increases the variance in payments and only decreases the variance when $\alpha(\varepsilon_p) \le \frac{1}{2}$. At the extreme, if $\alpha(0) = 1$, customers can eliminate any variance in their payments by simply exerting no effort. We then have that increased risk aversion (i.e., a higher value of β) leads to more effort only when the probability of needing the ancillary service is sufficiently small. The range over which effort increases with price is slightly larger because an increase in price affects both the expected cost of the service as well as the variance.

Turning to the firm's problem, two points seem intuitive. First, if customers are sufficiently risk averse, the firm may choose to bundle. Bundling will increase the cost of providing the ancillary service but eliminates having to compensate customers for bearing risk. The latter should outweigh the former when β is sufficiently large. Second, if customer effort is increasing in price, the firm would induce too much effort from risk-averse customers if it posts $p = \kappa_a$. Hence, one would expect that the ancillary service fee to be lower than its risk-neutral level. The following proposition shows that these conjectures are in fact true.

Proposition 6.2 *Let p_β denote the service provider's optimal ancillary fee given the risk aversion parameter β.*

1. *If the firm bundles when facing risk neutral customers, it bundles when facing risk averse customers, i.e., $p_0 = 0$ implies that $p_\beta = 0$ for all $\beta > 0$.*
2. *If $\alpha\left(\varepsilon_{p_\beta}\right) \le \frac{1}{2} + \frac{1}{4\beta p}$, then $p_\beta < \kappa_a$.*
3. *If $\alpha(0) < 1$ and $\alpha(\varepsilon) > 0$ for all ε, then $p_\beta \to 0$ as $\beta \to \infty$.*

Proof: For the first part, the firm's optimal profit is then given by: choose p to maximize

$$\Pi(p|\beta) = U(\varepsilon|\beta) + \alpha(\varepsilon_p)(p - \kappa_a) - \kappa_m.$$

where ε_p denotes the optimal customer effort when the firm charges p. Note that $\Pi(p,\beta) < \Pi(p,0)$ for all $\beta > 0$ and $p > 0$. However, $\Pi(0,\beta) = \Pi(0,0)$. Hence, if $p_0 = 0$, $p_\beta = 0$.

For second part, differentiating $\Pi(p,\beta)$ with respect to p yields

$$\frac{\partial \Pi(p,\beta)}{\partial p} = \frac{\partial \varepsilon_p}{\partial p} U'(\varepsilon_p|\beta) + (p-\kappa_a)\frac{\partial \varepsilon_p}{\partial p}\kappa_a \alpha'(\varepsilon_p) - \beta \frac{\partial \sigma^2(p,\varepsilon_p)}{\partial p}.$$

Because $U'(\varepsilon_p|\beta) = 0$, an optimal ancillary price p_β must satisfy

$$(p_\beta - \kappa_a)\left.\frac{\partial \varepsilon_p}{\partial p}\right|_{p\to p_\beta} \kappa_a \alpha'\left(\varepsilon_{p_\beta}\right) = \beta \left.\frac{\partial \sigma^2(p,\varepsilon)}{\partial p}\right|_{p \to p_\beta}.$$

$p < \kappa_a$ then follows because the right-hand side is positive while $\alpha(\varepsilon)$ is decreasing and ε_p is increasing by assumption.

For the final part, first note that $\alpha(\varepsilon_p)$ is bounded between $\alpha_\mu > 0$ and $\alpha_0 < 1$ where $\alpha_\mu = \alpha(c^{-1}(\mu))$ and $\alpha_0 = \alpha(0)$. The lower bound holds because an effort level of $c^{-1}(\mu)$ would require $\phi < 0$. Let $\zeta = \min\{\alpha_0(1-\alpha_0), \alpha_\mu(1-\alpha_m)\}$. Next, for $p_\beta > 0$ to be optimal, it must be that $\Pi(p_\beta,\beta) > \Pi(0,\beta)$, which implies

$$-c(\varepsilon_{p_\beta}) + \kappa_a\left(\alpha_0 - \alpha(\varepsilon_{p_\beta})\right) > \beta\sigma^2(p, p_\beta)).$$

The left-hand side is bounded above by κ_a while the right-hand side is bounded below by $\beta p^2 \zeta$. We thus have

$$p_\beta \le \sqrt{\frac{\kappa_a}{\beta\zeta}},$$

and $p_\beta \to 0$ as $\beta \to \infty$. ■

The most interesting finding here is that a service provider facing risk averse customers may choose to bundle. This, however, is a limiting result. We now show numerically that bundling may in fact occur at finite values of β. We fix $\alpha(\epsilon) = 0.6e^{-\epsilon}$ and $c(\epsilon) = 2\epsilon$. We consider two values of κ_a and several values of β. Table 2 reports the results. The left-hand panel shows the case where providing the ancillary service is relatively cheap. Here we see that for values of β over 1.5, the firm bundles. This depends on the cost of providing the ancillary service. When $\kappa_a = 12$, the service provider prices the ancillary service separately for all the values of β considered here.

Three other points are worth making. First, while the proposition shows that the ancillary service fee will be less than κ_a, the example shows that in this setting the price falls monotonically in β. Second, the

Table 2 Comparing the effort between the Risk Neutral setting and Risk Averse setting.

	$\kappa_a = 10$				$\kappa_a = 12$			
β	p_β	ϕ	$\alpha(p_\beta)$	$\sigma^2(p_\beta, \epsilon_{\kappa_a})$	p_β	ϕ	$\alpha(p_\beta)$	$\sigma^2(p_\beta, \epsilon_{\kappa_a})$
0.5	4.29	95.47	0.206	3.01	4.6	95.21	0.174	3.04
1	3.4	95.27	0.188	1.77	3.6	95.04	0.162	1.76
1.5	-	100	0.6	-	3.08	94.96	0.156	1.24
2	-	100	0.6	-	2.74	94.91	0.152	0.97
2.5	-	100	0.6	-	2.49	94.87	0.15	0.79

induced effort may be above or below the effort induced from risk-neutral customers. With risk neutral customers, we would have $\alpha(\varepsilon_{10}) = 1/5$ and $\alpha(\varepsilon_{12}) = 1/6$. From the table, we see that at low levels of risk aversion (i.e., $\beta = 0.5$) customers are induced to put in less effort than in the risk neutral case. For higher values (assuming the firm does not bundle), more effort is induced. Finally, note that as customers become more risk averse, the firm adjusts its pricing so that the reduced price and resulting effort lower the variance of customer utility. However, $\beta\sigma^2$ still increases resulting in a lower ϕ.

7. Conclusion

So would the social planner let bags fly free? We would argue no. It is socially optimal to balance the consumer's cost of avoiding the ancillary service with the firm's cost of providing it. When customers are risk neutral, ancillary service charges such as checked bag fees are an effective way of accomplishing this. Further, a profit maximizing firm will choose a service charge that induces the socially efficient effort level. That is, while acting in its own interest, the firm induces socially optimal behavior. This outcome is robust to variations in consumer valuation of the main service or to competition in the market place. Thus, as Michael O'Leary of Ryanair has claimed, baggage fees are not just about revenue. They serve to alter consumer behavior in a manner that is beneficial to both the firm and customers. The firm enjoys lower costs and passes some of these savings on to customers.

We should note that there is some evidence baggage fees have dramatically reduced the number of checked bags. The Government Accountability Office reports that some airlines have seen the number of checked bags drop by 40 to 50 percent (Government Accountability Office, 2010). The consequence of this has shown up in a number of ways. For example, the rate at which airlines lose bags has fallen as has the rate at which baggage handlers are injured (Negroni, 2010).

We have also shown that ancillary service fees could be used for segmenting customers. In this setting, low-cost customers who do not have much need for the ancillary service are charged an efficient ancillary service fee and a low price for the main service while those who are more likely to use the ancillary service receive a discount on its use but pay a higher price for the main service. The difficulty is that this pricing structure does not correspond to what we see in the marketplace. More typically one sees business travelers who rarely check bags getting a break on ancillary fees while leisure travelers pay significant charges. We conclude that airlines are segmenting customers on some dimension other than the need to check a bag.

While our motivating examples come from the airline industry, our model does not cover everything airlines do. The phrase "ancillary revenue" covers a wide variety of charges that these service providers impose. These range baggage fees and (potential) lavatory charges to selling seats with additional legroom or priority in boarding. Our model applies to the former since the rate at which consumers use these services has real cost consequence for the firm. Given the seating configuration of the plane, who gets to sit in the row with extra space has no impact in the cost of the service. Here, charging a premium for more space is clearly in line with conventional segmentation.

Some readers might object to our model for not putting an explicit consumer value on the ancillary service. We have done so since we wanted to highlight an explicit customer action. However, one could get very similar results from a model in which customers valued the main service at a known value μ and the ancillary service at some random value ν. The customer's total value for the transaction is then $\mu + E[\nu]$. If the realized value of ν was not known at the time of contracting, the service provider would prefer selling the main service at $\mu + E[\max\{\nu - \kappa_a, 0\}]$ and charging an ancillary service fee of κ_a to offering a bundle at $\mu + E[\nu]$. Profit-maximizing unbundling would again induce socially optimal consumption. In addition when offering a price menu to segments that differ in how their value for the ancillary service is distributed, the service provider would offer a low ancillary service fee to those who are likely to have a high value for the ancillary service while imposing a high fee on those who would have a low value. Again, this does not conform to what one sees in the market.

Finally, we should note that our model ignores externalities that could compromise our findings of social efficiency. For example, Smarte Carte, a firm that rents luggage carts at several airports, has seen its revenue decline 25% - 30% since 2007 and in some cases has had to renegotiate contracts with airports, (Martin, 2011). Alternatively, fewer checked bags means more carry ons and that increases the load on the governmental screeners. Homeland Security Secretary Janet Napolitano recently testified that increased demand for carry-on screening increased the Transportation Security Administration costs by a quarter of a billion dollars annually (Negroni, 2011). Such costs are, of course, relevant to society but ignored by the firm and would lead the firm to induce too much effort from customers.

References

Amadeus. 2011. Ancillary revenue reported by airlines grew to 15.11 billion EUR in 2010 and has almost doubled since 2008. Press release. June 1.

Armstrong, M. 2006. Recent developments in the economics of price discrimination. *Advances in Economics and Econometrics: Theory and Applications: Ninth World Congress*, vol. 2. 97–141.

Bureau of Transportation Statistics. 2011. BTS releases 2010 airline fee data; airlines collected almost 5.7 billion dollars from fees in 2010. Press release. June 13.

Cachon, G.P., P. Feldman. 2008. Pricing Services Subject to Congestion: Charge Per-Use Fees or Sell Subscriptions? *Operations and Information Management, The Wharton School, University of Pennsylvania* **1969**.

Carey, S. 2011. Spirit air's new first: Levying fee for passes. Wall Street Journal. June 22.

Consumer Travel Alliance. 2010. Analysis of hidden fees on four popular air travel routes. Onsumertravelalliance.org/?p=338.

DeGraba, P. 1995. Buying Frenzies and Seller-Induced Excess Demand. *The RAND Journal of Economics* **26** 331–342.

Essegaier, S., S. Gupta, Z.J. Zhang. 2002. Pricing access services. *Marketing Science* **21**(2) 139–159.

Government Accountability Office. 2010. Consumers could benefit from better information about airline-imposed fees and refundability of government-imposed taxes and fees. GAO-10-785. July.

Hayes, B. 1987. Competition and two-part tariffs. *Journal of Business* **60**(1) 41–54.

Hughes, J. 2010. U.s. airlines' baggage-fee revenue isn't taxable. Bloomberg.

Lariviere, M. A. 2006. A note on probability distributions with increasing generalized failure rates **54**(3) 602–604.

Martin, H. 2011. Airfare bargains to become rarer. Los Angeles Times.

McKenzie, R. B. 2008. *Why Popcorn Costs So Much at the Movies: And Other Pricing Puzzles*. Springer, New York.

Michaels, Daniel. 2009. O'leary pilots Ryanair into lead with 'mad' ideas for cost cuts. Wall Street Journal. December 9.

Negroni, C. 2010. Less baggage, big savings to airline. New York Times. April 6.

Negroni, C. 2011. More fees, more carry-ons. New York Times. March 28.

Netessine, S., C. Tang. 2009. *Consumer-Driven Demand and Operations Management Models*. Springer, New York.

Oi, W.Y. 1971. A Disneyland dilemma: Two-part tariffs for a Mickey Mouse monopoly. *The Quarterly Journal of Economics* **85**(1) 77–96.

Png, IPL, H. Wang. 2010. Buyer Uncertainty and Two-Part Pricing: Theory and Applications. *Management Science* **56**(2) 334–342.

Sharkey, J. 2008. That Bag Is Suddenly 15 Dollar Heavier. *New York Times* . June 15.

Shulman, J., X. Geng. 2011. The impact of hidden add-on fees and consumer bounded rationality. *working paper, University of Washington* .

Talluri, K.T., G. van Ryzin. 2005. *The theory and practice of revenue management*. Springer Verlag.

van Ryzin, G., Q. Liu. 2008. Strategic capacity rationing to induce early purchases. *Management Science* **54** 1115–1131.

Xie, J., S.M. Shugan. 2001. Electronic tickets, smart cards, and online prepayments: When and how to advance sell. *Marketing Science* **20**(3) 219–243.