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Rachel R. Chen, Eitan Gerstner, Yinghui (Catherine) Yang,

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Research Note

Should Captive Sardines Be Compensated?
Serving Customers in a Confined Zone

Rachel R. Chen

Graduate School of Management, University of California, Davis,
Davis, California 95616, rachen@ucdavis.edu

Eitan Gerstner

Business School, Loughborough University, Loughborough, Leicestershire LE11 3TU, United Kingdom,
eitan.gerstner@gmail.com

Yinghui (Catherine) Yang

Graduate School of Management, University of California, Davis,
Davis, California 95616, yiyang@ucdavis.edu

Many services are delivered to a (large) number of customers simultaneously within a confined zone (e.g., restaurants, resorts, trains, and airplanes). Under unexpected high demand, customers experience discomfort from two major sources: (a) the *sardine effect* that arises when too many customers (i.e., sardines) compete for space and service resources, and (b) the *captivity effect* that results from an exit cost incurred by customers who self-select to “escape” the unpleasant service. This paper investigates the optimal compensation and pricing policies under these two effects. We find that offering compensation to sardines can improve profit and social welfare. However, consumers do *not* benefit when compensated for the discomfort from crowding. This paper also provides insights by exploring the impact of changes in the two effects on price and profit.

Key words: service quality; service pricing; customer experience; negative externality; customer discomfort management; compensation; customer satisfaction

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1. Introduction

- A group arrived at a ski resort, only to discover that the place was overcrowded. Considering the extra driving to another ski resort nearby, they decided to stay. In the end they spent more time queuing up at the lifts than on the slopes. Once on the slopes it was easy to get knocked over, while navigating through the crowds without running into people or over their board/skis. Since then, the group has avoided the place.

- A group of friends arrived at a local restaurant, but found it packed and noisy. To avoid the inconvenience of searching for a good alternative, the group decided to stay, despite the expected slow service. At the end of the meal, the manager apologized and offered free desserts.

Many services are delivered to a number of customers simultaneously within a confined zone (e.g., restaurants, theaters, resorts, and airplanes). Under unpredictable high demand, customers are likely to experience discomfort from two major sources. First, with the arrival of many customers, the service facility

tends to be overcrowded, which often results in customer discomfort because of insufficient space, long waits, and inattentive service. We refer to the disutility customers receive when being served in a crowded facility as the *sardine effect*, caused by the *negative externalities* among the many customers who share resources such as space or service employees.

Second, escaping a crowded service facility just before or during service delivery is costly and sometimes impossible. For example, leaving a crowded restaurant after being seated or a noisy hotel after checking in may lead to a confrontation with the manager and to the additional inconvenience of finding an alternative (considering the effort of repacking, carrying luggage, etc.). As a result, customers often decide to bear the discomfort of consuming service in a crowded facility, instead of incurring a high escape cost. We refer to the impact of the escape cost on the customers' decision to stay (and use the service) as the *captivity effect*. The intensity of the sardine and captivity effects varies across services, as shown in Table 1.

Table 1 Sardine and Captivity Effects Across Industries

	High captivity effect	Low captivity effect
High sardine effect	Economy-class services (airlines, trains, buses, cruise lines), popular ski resorts	Popular establishments (restaurants, retail stores, health clubs), popular events (concerts, sports)
Low sardine effect	Upper-class services (first-class airlines, trains, buses, cruise lines), hospital (private rooms)	Services with abundant supply (fast-food restaurants, daytime theaters)

Both the sardine and captivity effects lead to unpleasant customer experiences that are commonly observed when service is delivered in a confined zone. As illustrated in the anecdotes, some providers offer compensation (such as price discounts or free drinks) for the disutility customers receive, while others do not. The extant research on service management does not examine the trade-offs service providers face when considering compensation to customers who experience the sardine and captivity effects. On one hand, service providers may feel it is unnecessary to offer compensation to captive customers who find it costly to look for alternatives. On the other hand, without compensation, service providers may fail to attract consumers, who may expect unpleasant service experiences under high spot demand. Therefore, it is unclear whether a service provider should compensate captive sardines (i.e., customers caught in a service delivered under the sardine and captivity effects), and if so, what should the optimal compensation and price be?

This paper explores optimal compensation and pricing policies for companies that serve customers under the sardine and captivity effects (see Figure 1). We show that by ignoring the profit potential from effective discomfort management, the service provider actually leaves money on the table. For example, by offering free drinks to patrons in crowded restaurants or hotels, the service provider can increase price and earn a higher profit. Also, compensating captive sardines can enhance social welfare.

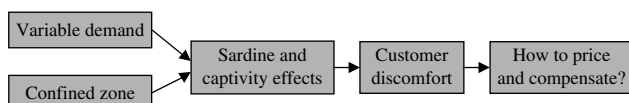
Our paper contributes to the existing literature in several ways. First, we study the management of discomfort that customers may experience upon service delivery. This can be considered part of the literature of dissatisfaction management. Customer satisfaction has been an important goal in business (Anderson 1996, Anderson et al. 1997, Hauser et al. 1994, Westbrook 1981, Woodruff et al. 1983). To keep

existing customers satisfied, companies establish different policies and systems for handling customer complaints. Manufacturers of durable goods typically offer product warranties for limited time periods under which they promise to repair defective products (Corville and Hausman 1979, Kendall and Russ 1975, Lutz 1989, Menezes and Currim 1992, Welling 1989, Padmanabhan and Rao 1993). Some service companies offer compensation such as free fruit baskets in hotels, discount coupons on future airline flights, and free appetizers or desserts at restaurants to customers who complain of service failure (Hart 1988, Chu et al. 1998, Fruchter and Gerstner 1999).

Service failures are typically caused by inadequate employee training, flawed service processes, or ineffective service delivery. Our study examines a specific service failure caused by the negative externalities that naturally arise under unexpected high demand among customers, who find it costly to escape. Given that demand is uncertain and customers are often served simultaneously in a confined zone, such service failures are quite common yet have not been addressed in the literature of dissatisfaction management. We focus on pricing and compensation policies that help manage customer discomfort from the sardine and captivity effects.

The sardine effect in our study results from negative externalities created when consumption occurs in congested zones. Previous studies on this subject explored optimal capacity and fee structures for public goods, welfare implications, and the existence of market equilibrium (Vickrey 1969, Diamond 1973, Reitman 1991, Hackner and Nyberg 1996). None of the studies considered the possibility of offering compensation for the disutility consumers experience under unpredictable high demand, which is the subject of this study. As Shugan (2002) pointed out, service delivery under predictable high demand can be improved using tools such as reservation systems and peak-load pricing, but options are limited when it comes to addressing the discomfort caused by unpredictable high demand. We show that compensating sardines under unpredictable high spot demand allows the service provider to implement contingent pricing, which can improve profit and social welfare.

Our paper is also related to both temporal and quality-based price discrimination (Phlips 1983). Temporal price discrimination allows sellers to profit by charging different prices over different periods of time (Lilien and Rangaswamy 2004, p. 429). In general, demand needs to be predictable to implement such price discrimination strategies (e.g., peak-load pricing, airline pricing, seasonal pricing, markdown pricing). In our paper, the price also changes over time, but the demand is unpredictable; price discrimination is implemented through contingent pricing. Under

Figure 1 Customer Discomfort Under the Sardine and Captivity Effects

our compensation policy, an effective lower price (i.e., price minus compensation) is charged for a lower quality service when the service facility is crowded. Such a pricing scheme is also related to quality-based price discrimination, which in general requires heterogeneous customers so that products of different quality are sold to different customer segments (Mussa and Rosen 1978), such as software versioning (Varian et al. 2004). By contrast, our price discrimination is implemented on a homogenous customer base while the service quality varies with the demand. Our paper shows that quality-based price discrimination can be profitable even when customers have the same willingness to pay for quality.

Finally, our study is related to the behavioral science research aimed at understanding how to manage customer physical discomfort (for example, prolonging a colonoscopy or immersing hands in uncomfortable cold water; see Kahneman 2000). Chase and Dasu (2001) pointed out the practical implications of such research for companies trying to perfect their service operations. While behavioral science research is based on field experiments, we use an analytical model to study the impact of the commonly observed sardine and captivity effects on discomfort management.

2. The Model

Our model investigates optimal pricing and compensation policies when (a) a service provider faces an uncertain number of visiting customers, and (b) the service is delivered to a number of people simultaneously in a confined zone. Our goal is to improve understanding of how the sardine and the captivity effects influence service provider strategies as well as consumer surplus.

We consider a setting where spot demand for the service is random. Under high demand, the service provider finds it hard to provide a pleasant experience to each of the visiting customers because available service resources are insufficient to serve all consumers in a comfortable fashion. Such unexpected high spot demand may arise from spur-of-the-moment decisions by consumers, for instance, in response to unexpected good weather or a sports team surprise win.¹

¹ Previous studies have examined pricing policies given predictable peak and off-peak time periods (see discussions in Shugan 2002). By contrast, our model focuses on optimal pricing and compensation policies under unpredictable spot demand. Although consumers are likely to build expectations of peak and off-peak demand and sometimes shift their demand from peak to off-peak hours depending on prices and expected service quality, spot demand can still be quite unpredictable during either peak or off-peak hours. This means that consumers may experience poor service during off-peak hours (if the restaurant is unexpectedly too crowded) or good service during peak hours (if the restaurant is unexpectedly not too crowded).

For simplicity, we assume only two possible scenarios: comfort and discomfort. Let q be the probability that spot demand is unexpectedly high so that service consumption is uncomfortable (i.e., there is a sardine effect), and let $1 - q$ be the probability that spot demand is normal so that service consumption is comfortable (no sardine effect). The number of customers that can be simultaneously served without a sardine effect is normalized to 1, and the number of customers creating a sardine effect is $1 + \alpha$, where α represents excess demand. We assume that this excess demand can be squeezed in the given confined zone (i.e., $1 + \alpha$ is smaller than the physical capacity of the confined zone).² However, because consumers can leave if the place is too crowded, ultimately the number of customers being served is determined by the sardine effect.

Consumers

A consumer decides to participate if the expected surplus from consuming the service is nonnegative.³ Upon arrival, the consumer observes whether the sardine effect exists. If it does, the consumer may leave (without being served) depending on the price and compensation for consuming the service with discomfort. An escape cost, E , is incurred if the consumer leaves without being served.

Let V denote the consumer's valuation of the service under no crowding (relative to the outside alternative, which is normalized to zero), and let P denote the service price. It is assumed that the consumer sees a posted price prior to arrival, and that the provider is committed to honor advertised prices.⁴ The marginal cost of serving a customer is c .

When no sardine effect is present, consumer surplus is $V - P$. Under a sardine effect, $V - dX$ is the consumer's valuation of the service, and the surplus is reduced to $V - P - dX$. Here, X is the *number of customers served*, and d is the *sardine factor*. The higher the value of d , the higher the disutility (to a customer) resulting from the presence of other customers who stay and share the same service resource. Consumers leave the service under a sardine effect if the surplus received from staying is less than the escape cost (i.e., $V - P - dX < -E$). We also refer to E as the *captivity factor*. The higher the value of E , the harder it is for the consumer to escape the service. The service provider

² Note that this assumption may not always hold (e.g., airplanes), but it does apply to many service settings such as restaurants, ski resorts, golf courses, etc.

³ We study an equilibrium in which the consumer expectation is formed over time through repeated purchase or word of mouth.

⁴ Price commitments are common in many services such as restaurants, ski resorts, exercise clubs, and entertainment events (Shugan and Xie 2000, Xie and Shugan 2001, Lee and Ng 2001).

considers offering a *sardine effect compensation* (or compensation, in short), R , to consumers who agree to be served under the sardine effect (we refer to those consumers as sardines).

Next we derive equilibrium under (1) No compensation and (2) Compensation to sardines. We compare the equilibria to determine whether offering compensation can be profitable and beneficial to consumers.

2.1. No Compensation

Under *no compensation*, the service provider sets price, P , to maximize profit.

Consumer decisions

There are two stages of consumer decisions. First, they decide whether to participate (i.e., to visit with the intention of purchasing the service). Second, once they participate (e.g., drive to the restaurant), they choose whether to consume the service or leave without using it. We derive the equilibrium solution via backward induction.

Stage 2: Consumer decision to stay or leave

In this stage, the consumer has already decided to participate. If the sardine effect is present upon the consumer's arrival, the surplus from service consumption is $V - P - dX$. The consumer stays and consumes the service if this surplus exceeds the utility loss from escaping the service, $-E$ (i.e., $V - P - dX \geq -E$). Under self-selection, the number of consumers who stay and consume the service, X , increases until Equation (1) holds.

$$V - P - dX = -E \quad (1)$$

(i.e., $X = (V - P + E)/d$, and we assume $1 < X \leq 1 + \alpha$).

If the sardine effect is not present when the consumer arrives, the surplus from consuming the service is $V - P$, so the consumer stays if $V - P \geq -E$. Equation (1) implies that $V - P > -E$, therefore every customer consumes the service if the sardine effect is not present.

Stage 1: Consumer decision to participate

The consumer's expected surplus in Stage 1 is

$$\begin{aligned} CS &= (1 - q)(V - P) \\ &+ q \left[\frac{X}{1 + \alpha}(V - P - dX) + \frac{1 + \alpha - X}{1 + \alpha}(-E) \right] \\ &= (1 - q)(V - P) - qE. \end{aligned} \quad (2)$$

The first term of Equation (2) is the expected consumer surplus without a sardine effect, and the second term is the expected surplus when the sardine effect is present (under which the likelihood of a consumer being served is $X/(1 + \alpha)$, and the likelihood that the consumer leaves is $(1 + \alpha - X)/(1 + \alpha)$). Consumers participate only if the participation constraint (3) is satisfied.

$$CS = (1 - q)(V - P) - qE \geq 0. \quad (3)$$

(Participation Constraint)

Note that if valuation is really low compared with the escape cost ($V < (q/(1 - q))E$), consumer expected surplus is negative ($CS < 0$) even at price 0. So consumers do not participate even if the service is free. For the rest of the analysis, we assume $V \geq (q/(1 - q))E$.

In the absence of the sardine effect, profit is $P - c$, whereas under this effect, profit is $(P - c)X$. Therefore, the provider's expected profit is

$$\begin{aligned} \pi &= (1 - q)(P - c) + q(P - c)X \\ &= (1 - q)(P - c) + q(P - c) \left(\frac{V - P + E}{d} \right). \end{aligned} \quad (4)$$

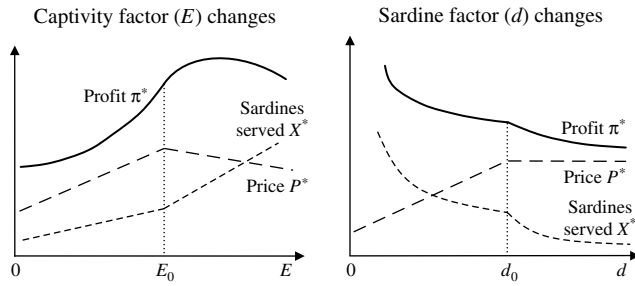
Equilibrium under no sardine effect compensation

The equilibrium price, P^* , and the number of served customers, X^* , maximize the expected profit Equation (4) subject to the constraints (1) and (3). The optimal profit, π^* , is obtained by plugging P^* and X^* back into Equation (4). Depending on the value of d , there are two sets of equilibrium solutions as summarized in Table 2 (see the appendix for details). For any level of escape cost E , $d_0 = [V - c - ((1 + q)/(1 - q))E]q/(1 - q)$

Table 2 Equilibrium Solutions Under No-Compensation Strategy

Equilibrium values	Small sardine factor $d \leq d_0$	Large sardine factor $d \geq d_0$
Price	$P^* = \frac{V + E + c}{2} + \frac{d(1 - q)}{2q}$	$P^* = V - \frac{qE}{1 - q}$
Sardines served	$X^* = \frac{V + E - c}{2d} - \frac{(1 - q)}{2q}$	$X^* = \frac{E}{d(1 - q)}$
Profit	$\pi^* = \frac{[q(V + E - c) + d(1 - q)]^2}{4dq}$	$\pi^* = \left(V - c - \frac{qE}{1 - q} \right) \left[1 - q + \frac{qE}{d(1 - q)} \right]$
Consumer surplus	$CS^* \geq 0$	$CS^* = 0$

Figure 2 Impact of Sardine and Captivity Factors Under No Compensation



is defined as the cutoff value of the sardine factor between the two sets of equilibrium solutions. When the sardine factor is small ($d \leq d_0$), consumers' participation constraint (3) is not binding, and the equilibrium solution is reached by maximizing the profit Equation (4). When the sardine factor is large ($d \geq d_0$), the participation constraint is binding, from which we solve for the equilibrium price P^* . Thus, d_0 represents the cutoff point between positive and zero consumer expected surplus at the equilibrium. (Note that for any sardine factor d , there is a corresponding cutoff value of the escape cost $E_0 = [V - c - ((1 - q)/q)d](1 - q)/(1 + q)$, such that $d \leq d_0$ ($d \geq d_0$) is equivalent to $E \leq E_0$ ($E \geq E_0$). Table 2 gives the equilibrium results based on the sardine factor cutoff.)

Figure 2 shows how price, profit, and the number of sardines served change with the captivity and sardine factor, respectively. Interestingly, profit does not always increase with the captivity factor. Initially, a higher captivity factor helps capture more customers, which leads to a higher price and profit. However, when E gets large, the consumer participation constraint becomes binding (expected surplus becomes zero), so price starts to decrease with E . The decrease in price eventually outweighs the increase in the number of sardines served, which drives profit down. Conventional wisdom suggests that higher exit (i.e., switching) costs help improve the profit through customer retention. Our model shows that increasing exit costs beyond a critical level actually hurts profit.

2.2. Compensation to Sardines

Under *compensation*, the service provider sets price, P , and offers compensation, R , to consumers who consume the service under a sardine effect. Table 3 describes the two-stage decision process.

The two stages of consumers' decisions are parallel to those under no compensation, so we only present the difference here. In Stage 2, the number of consumers who stay and consume the service when the sardine effect is present, X , increases until Equation (5) holds.

$$V - P - dX + R = -E \quad (5)$$

Table 3 Two-Stage Decision Process Under Compensation Strategy

Stages	Service provider's decisions	Consumer's decisions or actions
1	P	Whether to participate given the price P and compensation ^a R .
2	R	Whether to consume the service or leave given the price P , the compensation R , and the observed number of customers being served, X .

^aNote that our model describes an equilibrium state. The service provider may or may not state the compensation policy explicitly, but customers learn over time compensation policies through repeated purchases or word of mouth.

(i.e., $X = (V - P + R + E)/d$, and we assume $1 < X \leq 1 + \alpha$).

Again, if the sardine effect is not present upon arrival, all consumers consume the service. Similarly, the consumer's expected surplus in Stage 1 must be nonnegative

$$\begin{aligned} CS &= (1 - q)(V - P) + q \\ &\cdot \left[\frac{X}{1 + \alpha}(V - P - dX + R) + \frac{1 + \alpha - X}{1 + \alpha}(-E) \right] \\ &= (1 - q)(V - P) - qE \geq 0 \end{aligned} \quad (\text{Participation Constraint}). \quad (6)$$

The provider's profit is $P - c$ in the absence of the sardine effect and $(P - c - R)X$ under this effect. Thus, expected profit is $(1 - q)(P - c) + q(P - c - R)X$.

Equilibrium under compensation

We define the subgame perfect equilibrium as a price, P_R^* , and compensation, R^* , that satisfy the following conditions. In Stage 2, the compensation, R^* , maximizes the profit from serving customers under the sardine effect. In Stage 1, the price, P_R^* (together with R^*) maximizes the expected profit. Equilibrium values under the compensation strategy are summarized in Table 4 (see the appendix for the detailed derivation).

As can be seen from Table 4, the optimal compensation decreases with the captivity factor and the

Table 4 Equilibrium Solutions Under Compensation Strategy

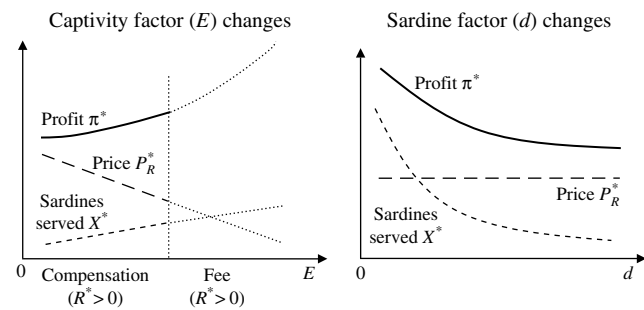
Price	$P_R^* = V - \frac{qE}{1 - q}$
Compensation	$R^* = \frac{1}{2} \left[V - c - \frac{1 + q}{1 - q} E \right]$
Sardines served	$X_R^* = \frac{V + E - c}{2d}$
Profit	$\pi_R^* = (1 - q)(V - c) - qE + \frac{q(V + E - c)^2}{4d}$
Consumer surplus	$CS^* = 0$

marginal cost, and it can be positive or negative. When the escape cost or marginal cost is small relative to the valuation (i.e., $E < ((1 - q)/(1 + q))(V - c)$ or $c < V - ((1 + q)/(1 + q))E$), the optimal compensation is positive ($R^* > 0$), which encourages consumers to stay when a sardine effect is present (i.e., the provider pays customers to stay). When the escape cost and the marginal cost are relatively high (i.e., $E > ((1 - q)/(1 + q))(V - c)$ or $c > V - ((1 + q)/(1 + q))E$), the optimal compensation is negative ($R^* < 0$); i.e., the service provider finds it profitable to tax customers who consume the service under the sardine effect by charging them a *sardine effect fee*. This fee, rationalized by the negative externality a consumer imposes on the other consumers when consuming the service, helps alleviate the congestion by motivating consumers to leave.⁵ Nevertheless, a contingent fee for crowded service might be hard to implement because the service provider can be viewed as greedy (even if the outcome is welfare enhancing).⁶ If a sardine effect fee is not an option, the service provider is better off not offering any compensation. That is, when the marginal cost and the escape cost are sufficiently high, there will be no compensation to sardines. To study the impact of compensation, we now focus on the region where the optimal compensation is positive ($R^* > 0$).

Under sardine effect compensation, the *effective* high-demand price, $P_R^* - R^*$, is actually lower than the price for low-demand periods, P_R^* . Such a pricing scheme can be justified by the different experiences of consumers: Those who have a pleasant service (without the sardine effect) are charged a high price, whereas under the sardine effect, consumers are compensated for the discomfort caused by the negative externalities. This result is in contrast to the principle of peak-load pricing, where a higher price is charged for predictable high demand periods (Desiraju and Shugan 1999, Radas and Shugan 1998, Shugan and Radas 1999). The lower price under unpredictable high demand in our model is a direct consequence of the negative externalities among customers, which are typically not modeled in the peak-load pricing literature (Gerstner 1986).

Figure 3 illustrates how the optimal values under compensation change with the sardine and captivity

Figure 3 Changes in Optimal Values (Under Compensation)



Note. A comparison of equilibrium with and without compensation follows.

levels. Under compensation, optimal price is determined by the binding participation constraint. Thus, a captivity factor increase leads to a lower price. However, many more sardines are willing to be squeezed under compensation. As a result, the expected profit is higher. By contrast, under no compensation, the expected optimal profit first increases, then decreases with the captivity factor. As shown in Figures 2 and 3, it is always profitable to reduce the sardine factor.

2.3. The Profit Advantage of Sardine Effect Compensation

Table 5 gives the equilibrium value differences under the two strategies. CS^* and CS_R^* denote the equilibrium consumer surplus, and W^* and W_R^* denote the equilibrium social welfare under no compensation and compensation, respectively.

PROPOSITION 1 (PROFIT AND WELFARE ADVANTAGE OF COMPENSATION). Under positive sardine effect compensation, more sardines use the service ($X^* \leq X_R^*$) under a higher price ($P^* \leq P_R^*$), and

- (a) Expected profit is higher, $\pi^* \leq \pi_R^*$.
- (b) Expected consumer surplus is lower, $CS^* \geq CS_R^*$.
- (c) Expected welfare is higher, $W^* \leq W_R^*$.

(See the appendix for proofs of the propositions.)

Proposition 1 is insightful. It suggests that offering compensation during high service congestion allows the service provider to serve more consumers, charge a higher price, earn a higher profit, and increase social welfare. Evidently, compensation motivates sardines to put up with a higher level of service discomfort even though the price is higher than that under no compensation. Here, compensation allows the service provider to apply a contingent pricing strategy (Biyalogorsky and Gerstner 2004) in which a high price is charged when the sardine effect is not present (i.e., the service is more pleasant), and a low price (price less compensation) when the sardine effect is present (i.e., the service is less pleasant). As compensation is contingent on high

⁵ An example of such a sardine effect fee is the fixed gratuity fee charged when a large group of customers arrive at the restaurant. The exit cost for a whole group is relatively high, and the group certainly imposes high negative externalities on all customers at the restaurant, which is consistent with our result.

⁶ Alternatively, the provider can offer compensation to consumers who give up service (i.e., pay customers to leave). However, if the cost of showing up to consume the service is low, this incentive to avoid consumption under a sardine effect can encourage opportunistic behavior by consumers who may show up simply to receive compensation.

Table 5 Comparison Between Compensation and No-Compensation Strategy

Differences	Small sardine factor $d \leq d_0$	Large sardine factor $d \geq d_0$
Prices $\Delta P = P_R^* - P^*$	$\Delta P = \frac{1}{2} \left[V - c - \frac{1+q}{1-q} E - \frac{d(1-q)}{q} \right] \geq 0$	$\Delta P = 0$
Sardines served $\Delta X = X_R^* - X^*$	$\Delta X = \frac{1-q}{2q} \geq 0$	$\Delta X = \frac{1}{2d} \left[V - c - \frac{1+q}{1-q} E \right] \geq 0$
Profits $\Delta \pi = \pi_R^* - \pi^*$	$\Delta \pi = (1-q)\Delta P + \frac{d(1-q)^2}{4q} \geq 0$	$\Delta \pi = \frac{q}{4d} \left[V - c - \frac{1+q}{1-q} E \right]^2 \geq 0$
Consumer surplus $\Delta CS = CS_R^* - CS^*$	$\Delta CS = -(1-q)\Delta P \leq 0$	$\Delta CS = 0$
Social welfare $\Delta W = W_R^* - W^*$	$\Delta W = \frac{d(1-q)^2}{4q} \geq 0$	$\Delta W = \Delta \pi \geq 0$

demand, the flexible pricing scheme improves the profit.

In practice, service operators seem to resist the idea of compensating customers for poor service because they may view it as a zero-sum game on a transaction-by-transaction basis. As Proposition 1 shows, this approach is shortsighted—offering compensation enables a service provider to extract more consumer surplus through contingent pricing. The compensation can be offered as a cash discount or as free products or services. For example, restaurants can profit by offering free drinks or desserts to customers who arrive on a crowded evening.

Conventional wisdom suggests that consumers would benefit when compensated for discomfort resulting from service congestion. Our results show that in equilibrium this may not be the case. The intuition is that with compensation, more consumers self-select to stay and endure the discomfort when the sardine effect is present, which eventually drives up the discomfort (such that the consumer surplus remains at $-E$). That is, compensation does not improve the consumer surplus when service is crowded. On the other hand, because the price is higher under compensation policy, it helps to extract more consumer surplus when the sardine effect is not present. Therefore, consumers are worse off even when they are compensated for the sardine effect. However, the profit gain under compensation more than offsets the loss in consumer surplus, so compensation actually increases social welfare (i.e., it is economically efficient).

Proposition 2 examines how the profit and welfare advantages of the compensation strategy change with the sardine and captivity factors.

PROPOSITION 2 (COMPENSATION ADVANTAGE CHANGES).

(a) *The profit advantage of compensation decreases with both sardine and captivity factors.*

(b) *The consumer surplus disadvantage shrinks with both sardine and captivity factors when they are not too large, and remains flat at zero otherwise.*

(c) *The welfare advantage first remains the same, then decreases with the captivity factor. With the sardine factor, it first increases then decreases.*

With a small sardine factor, a modest compensation can help squeeze more sardines during crowded service times, and the profit advantage of compensation is high. When the captivity factor is small, price under compensation is much higher than that under no compensation, which contributes to a higher profit advantage as well.

Under compensation, a higher price is set to extract more consumer surplus. As the sardine factor increases, the equilibrium price differential (with and without compensation) decreases. Therefore the consumer surplus disadvantage decreases. Similarly, the equilibrium price differential is smaller under a larger captivity factor, leading to a smaller difference in the expected consumer surplus.

The welfare advantage first increases with the sardine factor because more sardines are served under compensation. When the sardine factor is sufficiently large, however, the expected consumer surplus under no compensation drops to zero, and the welfare enhancement comes solely from profit improvement, which decreases with the sardine factor. For a small captivity factor, the profit advantage more than offsets the loss in consumer surplus. The welfare advantage remains the same. With a larger captivity factor, consumer surplus advantage remains at zero, so the welfare advantage decreases together with the profit advantage.

3. Discussion and Conclusion

Many services are delivered to a number of customers simultaneously in a confined zone. Under unexpected high demand, customers experience discomfort from

two sources: (a) the sardine effect caused by congestion when too many customers are served at the same time, and (b) the captivity effect that occurs when escaping the crowded service is costly. This paper investigates the optimal compensation and pricing policies under these two effects. We show that compensation to sardines can improve profit for services that are likely to cater to unexpected large crowds. The compensation motivates more sardines to stay and consume the service despite the inconveniences they experience. Also, compensating sardines upon service failure enables a service provider to extract more surplus through the use of contingent pricing, which sets a higher price if the service is more pleasant in the absence of the sardine effect, and a lower price (i.e., price less compensation) if the service is less pleasant because of the sardine effect. However, not offering compensation is advisable when marginal cost is high, or when it is hard for customers to escape the service.

Our results apply to service settings where crowding under high spot demand deteriorates service quality (e.g., restaurants, ski resorts, hotels, concerts, skate parks, bowling centers, billiard rooms, etc.) Based on our findings, a service provider can set observable standards that trigger compensation when the service quality deteriorates because of the sardine effect. For example, the insurance company Empire of America buys lunch for customers who have to wait in line for more than five minutes. Delta Hotels promised one-minute check-in or a free room (Hart 1994). A ski resort could consider offering hot chocolate or vouchers when the wait for the lifts is more than thirty minutes. Depending on industry characteristics, marketers can tailor their compensation by offering products/services instead of straight financial compensation (Brandenburger and Nalebuff 1996). In addition, our model suggests that it is always profitable to reduce the sardine factor (e.g., adjust the service environment so that customers feel less squeezed). This does not necessarily mean adding more space. Sometimes music, interior decoration, or fresh air can ease the perception of congestion, and reduce customer defections because of the sardine effect.

Compensating captive sardines also helps increase customer lifetime value and long run profits by improving customer equity. In his book *Negotiating Skills for Managers*, Steven Cohen reflected on his personal encounter of slow service because of high spot demand "...my wife and I had dinner (without reservations) at a Japanese restaurant. We patiently waited for a table. Once seated, the food came very slowly; obviously the kitchen was overburdened... Our waitress brought us an extra carafe of sake on the house." He further noted that, "you could argue

that no one was at fault (for our waiting). But the voluntary compensation in the Japanese restaurant will build our loyalty as customers" (Cohen 2002, p. 160). In response to a recent New York Times article on compensation for long wait times, a reader commented that "A little kindness goes a long way. To put it bluntly, a restaurant will save more by offering up a free round of drinks, appetizers, and/or dessert, thereby keeping a patron and developing repeat business than losing a patron by not offering these gratis touches" (see comment by Matt 2007).

Our results are based on two parsimonious models that include several simplifying assumptions. First, our models assumed that the service provider's capacity is fixed and large enough to accommodate all the excess demand. This assumption, although applicable to many service settings such as restaurants, ski resorts, and golf courses, does not always hold (e.g., airlines). The service provider may be able to achieve higher profit by optimizing capacity, price, and compensation together taking into account the cost of adding capacity, the size of excess demand, and the intensity of the sardine and captivity effects. Second, in the analysis we considered spot demand only. Future analysis could consider a mixture of reservation, advance selling, and spot demand in which the service provider adjusts price and compensation accordingly. Third, we assume homogeneous consumers in our study. The model can be further generalized to settings where consumers differ in their valuations and sensitivity to crowding. Another limitation is that our results apply primarily to the segment of the service industry where managers are concerned with the quality deterioration under the sardine and captivity effect.

Future research could also explore the following directions. Instead of compensating customers who stay and endure the sardine effect (i.e., pay to stay), it is possible to redirect some sardines to less busy periods with compensation (i.e., pay to delay). For example, restaurants could offer discounts to customers who agree to delay their dining time. This would help reduce crowding and improve capacity utilization. Also, sometimes customer utility is positively associated with the crowding level. "The more, the merrier" applies when watching sports events in stadiums or bars. Exploring optimal pricing and service strategy under positive externalities could be an interesting direction for future research.

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Appendix

Derivation of the Equilibrium Solution Under No Compensation (Table 2)

Under no compensation, the service provider's problem can be written as

$$\text{Max } \pi = (1-q)(P-c) + q(P-c)X \quad (7)$$

$$\text{s.t. } V - P - dX = -E$$

$$(1-q)(V-P) - qE \geq 0 \quad (8)$$

$$1 < X \leq 1 + \alpha.$$

Maximizing π in Equation (7) yields $P_1 = (V + E + c)/2 + d(1-q)/2q$. Note that the optimal price P needs to satisfy constraint (8), which is equivalent to $P \leq V - qE/(1-q)$. Let $P_2 = V - qE/(1-q)$, the price such that constraint (8) is binding. The equilibrium solution then depends on whether $P_2 \geq P_1$.

Case 1. $P_2 \geq P_1$ (i.e., $d \leq [V - c - ((1+q)/(1-q))E] \cdot (q/(1-q))$).

When $P_2 > P_1$, P_1 maximizes profit π while satisfying constraint (8). Thus, the optimal price, the number of sardines served, and the optimal profit are

$$P^* = \frac{V + E + c}{2} + \frac{d(1-q)}{2q}, \quad X^* = \frac{V + E - c}{2d} - \frac{(1-q)}{2q},$$

$$\text{and } \pi^* = \frac{[q(V + E - c) + d(1-q)]^2}{4dq}.$$

For this optimal solution to hold, the number of customers under overcrowded service needs to be between 1 and $1 + \alpha$. That is, $1 < X^* \leq 1 + \alpha$, which implies $q(V + E - c)/(2q\alpha + 1 + q) \leq d < q(V + E - c)/(1 + q)$. We assume that this condition holds in this region.

Case 2. $P_2 \leq P_1$ (i.e., $d \geq [V - c - ((1+q)/(1-q))E] \cdot (q/(1-q))$).

When $P_2 \leq P_1$, P_1 violates constraint (8). Since the profit π is concave in P , the optimal price is achieved at the boundary and $P^* = P_2$. The equilibrium values are

$$P^* = V - \frac{qE}{1-q}, \quad X^* = \frac{E}{d(1-q)}, \quad \text{and}$$

$$\pi^* = \left(V - c - \frac{qE}{1-q} \right) \left[1 - q + \frac{qE}{d(1-q)} \right].$$

Similarly, for the optimal solutions to hold, we need $1 < X^* \leq 1 + \alpha$, which is equivalent to $E/(1+\alpha)(1-q) \leq d < E/(1-q)$. We assume that this condition holds in this region.

Derivation of the Equilibrium Solution Under Compensation Strategy (Table 4)

In Stage 2, the service provider's profit under the sardine effect is $(P - c - R)X = (P - c - R)((V - P + R + E)/d)$. The optimal compensation that maximizes this profit is given by $R^* = P - (V + E + c)/2$.

In Stage 1, the service provider chooses the price (together with the compensation) to maximize the expected

profit. The problem can be written as

$$\text{Max } \pi = (1-q)(P-c) + q(P-c-R) \frac{V - P + R + E}{d}$$

$$\text{s.t. } R^* = P - \frac{V + E + c}{2}$$

$$(1-q)(V-P) - qE \geq 0$$

$$1 < X \leq 1 + \alpha.$$

It is easy to verify that with $R^* = P - (V + E + c)/2$, the expected profit is linearly increasing with P . Thus the optimal price is set at $P_R^* = V - qE/(1-q)$ to extract all the consumer surplus (i.e., $CS^* = 0$). We then calculate the equilibrium values: $R^* = \frac{1}{2}[V - c - ((1+q)/(1-q))E]$, $X_R^* = (V + E - c)/2d$, and $\pi_R^* = (1-q)(V - c) - qE + q(V + E - c)^2/4d$. Again, we assume parameter values that satisfy $1 < X_R^* \leq 1 + \alpha$. This implies $(V + E - c)/2(1 + \alpha) \leq d < (V + E - c)/2$.

PROOF FOR PROPOSITION 1. When $d \leq d_0$, $\Delta X = (1-q)/2q \geq 0$. When $d \geq d_0$, $\Delta X = 1/2d[V - c - ((1+q)/(1-q))E] \geq 0$ if $R^* \geq 0$. Therefore, $X^* \leq X_R^*$. To compare the price, first note that $P_R^* = P_2$. Based on the derivation of the equilibrium under no compensation, we have $P^* = P_1 \leq P_2$ when $d \leq d_0$, and $P^* = P_2$ when $d \geq d_0$. Thus, $P^* \leq P_R^*$.

We now compare the profit, consumer surplus, and welfare under the compensation and no compensation strategies. Because the profit varies depending on the value of d under the no compensation strategy, we compare in two different regions of d .

(1) When $d \geq d_0$,

$$\pi_R^* - \pi^* = (1-q)(V - c) - qE + \frac{q(V + E - c)^2}{4d}$$

$$- \left(V - c - \frac{qE}{1-q} \right) \left[1 - q + \frac{qE}{d(1-q)} \right],$$

which can be simplified to $q/4d[V - c - ((1+q)/(1-q))E]^2 \geq 0$. So in this region, the profit under the compensation is always better than the profit under no compensation. Since $CS_R^* - CS^* = 0$, social welfare is also enhanced under compensation policy.

(2) When $d \leq d_0$, the profit difference under no sardine effect is $P_R^* - P^*$. Under the sardine effect, the difference is $(P_R^* - R^* - c)X_R^* - (P^* - c)X^*$, which is equal to

$$\left[\frac{V + E - c}{2} \right] \left[\frac{V + E - c}{2d} \right] - \left[\frac{V + E - c}{2} + \frac{d(1-q)}{2q} \right]$$

$$\cdot \left[\frac{V + E - c - (1-q)}{2d} - \frac{(1-q)}{2q} \right] = \frac{d}{4} \left(\frac{1-q}{q} \right)^2.$$

Hence, $\pi_R^* - \pi^* = (1-q)(P_R^* - P^*) + q(d/4)((1-q)/q)^2$. We have shown $P^* \leq P_R^*$, also $(qd/4)((1-q)/q)^2 \geq 0$ always holds; therefore the profit differential is nonnegative. $CS_R^* - CS^* = (1-q)(P^* - P_R^*) \leq 0$. It is easy to verify that $\Delta W = \Delta P + \Delta CS = d(1-q)^2/4q \geq 0$. This completes the proof. \square

PROOF OF PROPOSITION 2.

(1) When the sardine factor is small ($d \leq d_0$), by the proof of Proposition 1, $\Delta \pi = (1-q)(P_R^* - P^*) + d(1-q)^2/4q = (1-q)((V - E - c)/2) - qE - d(1-q)^2/4q$. It is easy to verify that $\partial \Delta \pi / \partial d \leq 0$, $\partial \Delta \pi / \partial E \leq 0$.

$\Delta CS = -(1-q)\Delta P$. Since $\Delta P = \frac{1}{2}[V - c - ((1+q)/(1-q))E - d(1-q)/q]$ decreases with the sardine factor d and

captivity factor E , the consumer surplus difference shrinks with either d or E . $\Delta W = d(1 - q)^2/4q$ increases with d in a linear fashion until d_0 . It does not change with the captivity factor E in this region.

(2) When the sardine factor is large ($d \geq d_0$), by the proof of Proposition 1, $\Delta\pi = (q/4d)[V - c - ((1 + q)/(1 - q))E]^2 \geq 0$. The profit advantage decreases with the sardine factor d . When V is not too small relative to E ($V \geq ((1 + q)/(1 - q))E$), a positive compensation will be offered and $\partial\Delta\pi/\partial E = (q/2d)[V - c - (1 + q)/(1 - q)E][-(1 + q)/(1 - q)] \leq 0$. That is, the profit advantage decreases with E . $\Delta CS = 0$ holds always for this region. $\Delta W = \Delta\pi$ so it changes the same way as the profit differential. \square

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