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Abstract: A service provider sells to homogenous risk-averse consumers through a two-part tariff. The consumers have uncertain tastes toward the service. They subscribe the service before the uncertainty resolves. In contrast with the common view that a monopolist's optimal two-part tariff for homogenous consumers should entail a usage rate equaling to the firm's marginal production cost, I show that when consumers have uncertain tastes, the service provider's optimal two-part tariff entails a usage rate that is greater than the marginal cost.

Keywords: Uncertain taste, Risk aversion, Service pricing, Two-Part Tariff

JEL Codes: D4, D8

1. Introduction

Consumers' choices or decisions often depend on some situational variables that are beyond the control of the consumers (Belk, 1975). As long as we cannot identify all the situational variables that affect a consumer's taste, we may have to view the consumer's taste as an uncertain one. The economic significance of uncertain taste or preference is well recognized in the literature (McFadden, 2001). Compared to the microeconometric studies in this area, much less attention is allocated to the analytical modeling of economic mechanism that uncertain tastes affect the behaviors of firms and consumers. Chang (1993) investigates the strategic use of flexible manufacturing technology as an entry-deterring mechanism when consumers' tastes fluctuate probabilistically. It is shown that for relevant parameter values, an incumbent firm holds excess flexibility in manufacturing in order to deter entry into the market. Walsh (1995) develops models of an expected-utility-maximizing consumer faced with the problem of purchasing multiple units for multiple future consumption occasions. The consumer chooses from two consumption alternatives. The utilities of the alternatives to the consumer depend on the state of nature. Walsh shows that the consumer may wish to purchase an assortment of alternatives rather than multiple units of the same alternative. Walsh considers the individual uncertainties in consumer tastes, while Chang focuses on the aggregate uncertainty.

The fact that individual consumers have uncertain tastes may influence the pricing strategies of firms. The issue is particularly interesting in markets where (*i*) trade contracts are signed before the uncertainty in tastes resolves, and (*ii*) the products in consideration are non-storable. Indeed, if transactions occur after the uncertainty resolves, the firms in the markets necessarily face (*ex post*) heterogeneous consumers. This is a typical asymmetric information or second-degree price discrimination issue, which has been extensively discussed in the literature. If the products are storable, consumers may resell unused products or save them for future consumption. Hence the consumers do not take much risk although they have to trade with firms before knowing their tastes in future periods. What really matters to the firms in this case might be the aggregate demand of the consumers. If the individual uncertainties are independent, which means that the aggregate demand is rather stable, the impact of uncertain consumer tastes on firms' pricing strategies would not be significant. Many service industries have the two features mentioned above.

In economic literature, a decision maker is said to face a "risk" if his well-being depends on outcomes that will occur with probabilities. When consumers' tastes toward a service rely on some situational variables, the consumers may face a risk if they have to subscribe the service for future usage. For example, a consumer extracts a large benefit from a piece of bread only when he happens to be hungry. If the consumer is provided with a certain amount of bread each day, he may value the bread differently in different days. Hence the consumer perceives "risk" from subscribing such a stream of bread. In the Arrow-Pratt theory of risk, a consumer's attitude toward risk is portrayed by a Bernoulli utility function (the terminology follows the textbook of Mas-Colell *et al.*, 1995, page 184). Unlike a utility function that is defined on consumption bundles and represents a consumer's ordinal preference, a Bernoulli utility function is often defined on a numeraire good like "money" and represents a consumer's cardinal preference over different quantities of the good (but the *von* Neumann-Morgenstern expected utility can be viewed as ordinal on a space of "money lotteries”). In a market where people make consumption decisions after an uncertain situational variable resolves, one way to capture the role of consumers’ attitude toward risk might be defining a Bernoulli utility function on the *ex post* satisfaction levels that the consumers achieve from the gaming. Indeed, all the “risk” that the consumers care about is the uncertainty in the *ex post* satisfaction levels.

Service industries often have relatively high setup costs but low marginal costs, *i.e.*, increasing return to scale. Such a cost structure implies that compared to a two-part tariff, linear pricing in service trade is typically less efficient since it leads to more deadweight loss. On the other hand, two-part tariffs are often feasible in service markets because it is relatively easy to prevent reselling. Standard service pricing theories, *e.g.*, Oi (1971), often suggest that when consumers are homogenous and firms’ capacities are non-binding, the optimal two-part tariffs should entail usage rates equaling to the firms’ marginal production costs. Such two-part tariffs appear attractive because the deadweight loss is avoided. However, the result is based on the assumption that consumer tastes are constant and anticipatable. It might not hold when consumers have uncertain tastes.

This paper considers a simple model where a service provider directly sells to a large number of homogenous risk-averse consumers. The consumers have uncertain tastes toward the service, or equivalently, they attain uncertain benefits from a certain amount of the service. In the game, the service provider moves first by offering a service plan represented by a two-part tariff. The consumers then choose whether to subscribe the service before the uncertainty in their tastes resolves. Finally the uncertainty resolves and the consumers choose consumption bundles to maximize their *ex post* well-being. In the model, a Bernoulli utility function is defined on the consumers' *ex post* benefits from the consumptions. Hence the *ex post* benefits, which depend on the state of nature, play the role of "money lottery" in the Arrow-Pratt theory of risk. The model shows that if the consumers are risk-averse, the service provider's optimal two-part tariff generally entails a usage rate that is greater than the provider's marginal production cost. The provider chooses such a usage rate because it reduces the risk faced by the consumers. The provider faces the tradeoff between insuring the consumers and avoiding the deadweight loss when it chooses the optimal usage rate.

The rest of the paper will proceed as follow. Section 2 presents a monopoly model of a service market. I first consider the case where consumers have constant and anticipatable tastes, then the case where consumers have uncertain tastes. The comparison of the two cases demonstrates how the uncertainty in consumer tastes affects the service provider's pricing strategy. An example that illustrates the main points of the model is given at the end of Section 2. Section 3 concludes the paper.

2. A Model

A service provider sells to a large number of homogenous consumers. The provider's production cost is represented by $C(q) = F + cq$, where $F \geq 0$ is the fixed cost, $c \geq 0$ is the marginal cost, and $q \geq 0$ is the quantity of the service. The provider offers a service plan represented by a two-part tariff (T, p), where T is a lump sum fee and p is the rate of usage charge. The consumers also use a numeraire good that represents their other consumptions. The quantity of the numeraire is denoted as m.

I first consider the case where the homogenous consumers have constant and anticipatable tastes toward the service. Suppose that a consumer obtains benefit of $b(q)+m$ from consumption bundle (q,m). Note that function $b(q)+m$ is a "household production function": consumers use consumption bundles to produce satisfactions measured by the numeraire good. The household production function can also be viewed as a utility function when the consumers have anticipatable tastes. Let $b'(q)>0$, $b''(q)<0$, which mean that the consumer obtains positive but diminishing marginal benefit from using the service. Also assume that $b'(0)>c$ and $b'(\infty)=0$ for simplicity. Finally, each consumer has an endowment of $I>0$ in term of the numeraire good.

The timing of the game is as follow. *First, the provider announces a service plan represented by a two-part tariff* (T,p)*; Second, the consumers decide whether to accept the plan. If the consumers reject the plan, the game is over. Otherwise the consumers pay the lump sum fee T and the game goes to the next stage; Third, the consumers decide how much of the service to use.* Note that the game can be easily extended to a game where consumers subscribe the service for multiple periods, as long as the consumers' demand for the service has zero intertemporary elasticity of substitution.

I will solve the game backward and find the service provider's optimal two-part tariff. Note that the provider would never offer a service plan with a usage rate $p \geq b'(0)$, because that would totally prevent the consumers from using the service. The outcome of the second and third stage of the game is characterized by following lemma.

Lemma 1: *Given the provider's two-part tariff (T, p) with* $p<b'(0)$*, define consumption bundle* (q^*,m^*) *by*

$$b'(q^*) = p \quad and \quad m^* = I - T - pq^* . \tag{1}$$

If $b(q^*) - b(0) \geq T + pq^*$*, the consumers accept the service plan and choose consumption bundle* (q^*, m^*) *; Otherwise the consumers reject the plan.*

Proof: Given tariff (*T*, *p*), a consumer obtains benefit of $b(0) + I$ if he rejects the plan. The consumer's benefit from taking the plan is given by following maximization problem:

$$\underset{q \geq 0, m}{Max} \quad b(q) + m , \tag{2}$$

$$s.t, \quad T + pq + m \leq I , \tag{3}$$

Solving the problem yields consumption bundle (q^*, m^*) prescribed in (1). Obviously, if

$$b(q^*) + m^* \geq b(0) + I , \quad i.e., \quad b(q^*) - b(0) \geq T + pq^* , \tag{4}$$

the consumer prefers accepting the plan, which means (q^*, m^*) is his optimal consumption bundle. Otherwise the consumer prefers rejecting the plan. *Q.E.D.*

The provider does not want to propose a plan that scares the consumers away and results in zero profit. As long as *F* and *c* are not too large, the provider's profit-maximization problem, as shown below, has a non-degenerated solution.

$$\underset{T,p}{Max} \quad T - F + (p - c)q \tag{5}$$

$$s.t., \quad b(q) - b(0) \geq T + pq , \tag{6}$$

$$b'(q) = p , \tag{7}$$

The model can be viewed as a special case of Oi (1971)'s Disneyland model with homogenous consumers (page 80). We have following proposition, which states that the provider's optimal two-part tariff entails a usage rate equaling to the provider's marginal production cost. The proof is easy if one notices that the constraint (6) must be binding at the optimal two-part tariff. Details are omitted.

Proposition 1 (Oi, 1971): *With constant and anticipatable consumer tastes, the service provider's optimal two-part tariff* (T^*, p^*) *is* $(b(q^*) - b(0) - cq^*, c)$, *where* q^* *is given by* $b'(q^*) = c$.

Now suppose that the consumers have uncertain but independent tastes toward the service. Specifically, a representative consumer's taste depends on the state of nature *s*, which is a random variable with cumulative distribution function *G*(.) on $[\underline{s}, \overline{s}]$ where $\underline{s} < \overline{s}$. In state *s*, the consumer has *ex post* "household production function" of $b(s,q) + m$. Note that the household production function is definitely not a Bernoulli utility function. Hence the quasi-linearity of the function does not imply that the consumer is risk-neutral. I assume $b_q(s,q) > 0$, $b_{qq}(s,q) < 0$, $b_s(s,q) > 0$ and $b_{sq}(s,q) = b_{qs}(s,q) > 0$ for all $s \in [\underline{s}, \overline{s}]$ and $q \geq 0$. Hence both the consumer's benefit and marginal benefit from using the service increase with variable *s*. To simplify the exposition, I assume that $b_q(s,0) = \overline{b} > c$ for all $s \in [\underline{s}, \overline{s}]$. Hence the consumer would not use the service at all if the usage rate is higher than $\overline{b}$. We view the *ex post* benefit of the consumer $b(s,q) + m$ as a "money lottery" against the state of nature *s*. Therefore we can define a Bernoulli utility function $u(x)$, where $x \equiv b(s,q) + m$ and $u'(x) > 0$ for all $x \in R$. The risk-aversion of the consumer implies that $u''(x) < 0$.

The timing of the game with uncertain consumer tastes is as follow. *First, the service provider announces a two-part tariff* (T, p); *Second, the consumers decide whether to* *accept the plan. If the consumers reject the plan, the game is over. Otherwise the consumers pay the lump sum T and the game goes to the next stage; Third, the uncertainty in tastes resolves and the consumers decide how much of the service to use.*

Given the provider's service plan (*T*, *p*) with $p < \bar{b}$, if a consumer accepts the plan, he chooses (*q*, *m*) to solve following problem after the state of nature realizes.

$$\underset{q \geq 0, m}{Max} \quad b(s,q) + m\,, \tag{8}$$

$$s.t., \quad T + pq + m \leq I\,, \tag{9}$$

Conditional on the service plan (*T*, *p*) being accepted by the consumer, the optimal consumption bundle in state *s*, denoted as $(q(s,T,p), m(s,T,p))$, satisfies

$$b_q(s, q(s,T,p)) = p \quad \text{and} \quad m(s,T,p) = I - T - pq(s,T,p)\,. \tag{10}$$

To simplify the exposition, I denote the consumption bundle $(q(s,T,p), m(s,T,p))$ as $(q(s), m(s))$ hereafter. A consumer's "*ex post* benefit" in state *s* is thus $b(s,q(s)) + m(s)$. The main result of the model is presented in following proposition.

Proposition 2: *When the risk-averse consumers have uncertain tastes toward the service, the service provider's optimal two-part tariff (*T^**, *p^**) entails a usage rate* $p^* > c$.

Proof: At the first stage of the game, the service provider's profit-maximization problem is

$$\underset{T,p}{Max} \quad T - F + \int_{\underline{s}}^{\bar{s}} (p-c)q(s)dG(s)\,, \tag{11}$$

$$s.t., \quad \int_{\underline{s}}^{\bar{s}} u(b(s,q(s)) + m(s))dG(s) \geq \int_{\underline{s}}^{\bar{s}} u(b(s,0) + I)dG(s)\,. \tag{12}$$

The consumption bundle $(q(s), m(s))$ is given by (10). Since there is no direct constraint on *T* or *p*, the problem must have an interior solution. It can be transformed into following optimization problem:

$$\underset{T,p,\lambda\geq 0}{Max} \quad L(T,p,\lambda) = T - F + \int_{\underline{s}}^{\bar{s}} (p-c)q(s)dG(s)$$

$$-\lambda \int_{\underline{s}}^{\bar{s}} [u(b(s,q(s)) + m(s)) - u(b(s,0) + I)]dG(s), \qquad (13)$$

where $L(T,p,\lambda)$ is the Lagrangian function of the original problem. The optimal two-part tariff must satisfy the first order conditions, as shown below.

$$\frac{\partial L(T,p,\lambda)}{\partial T} = \int_{\underline{s}}^{\bar{s}} [1 - \lambda u'(b(s,q(s)) + m(s))]dG(s) = 0, \quad \text{and} \qquad (14)$$

$$\frac{\partial L(T,p,\lambda)}{\partial p} = \int_{\underline{s}}^{\bar{s}} [q(s) + (p-c)\frac{\partial q(s)}{\partial p}]dG(s)$$

$$-\lambda \int_{\underline{s}}^{\bar{s}} u'(b(s,q(s)) + m(s))[b_q(s,q(s))\frac{\partial q(s)}{\partial p} + \frac{\partial m(s)}{\partial p}]dG(s)$$

$$= \int_{\underline{s}}^{\bar{s}} [q(s) + (p-c)\frac{\partial q(s)}{\partial p}]dG(s) - \lambda \int_{\underline{s}}^{\bar{s}} u'(b(s,q(s)) + m(s))q(s)dG(s)$$

$$= \int_{\underline{s}}^{\bar{s}} q(s)(1 - \lambda u'(b(s,q(s)) + m(s)))dG(s) + (p-c)\int_{\underline{s}}^{\bar{s}} \frac{\partial q(s)}{\partial p} dG(s) = 0. \qquad (15)$$

Note that $1 - \lambda u'(b(s,q(s)) + m(s))$ is strictly increasing with respect to *s* because

$$\frac{\lambda \partial u'(b(s,q(s)) + m(s))}{\partial s} = \lambda u''(b(s,q(s)) + m(s)) \cdot b_s(s,q(s)) < 0. \qquad (16)$$

Hence equation (14) implies that there exists $s^0 \in (\underline{s}, \bar{s})$ such that

$$1 - \lambda u'(b(s,q(s)) + m(s))\Big|_{\underline{s}\leq s<s^0} < 0,$$

$$1 - \lambda u'(b(s,q(s)) + m(s))\Big|_{s=s^0} = 0,$$

$$\text{and} \quad 1 - \lambda u'(b(s,q(s)) + m(s))\Big|_{s^0<s\leq \bar{s}} > 0. \qquad (17)$$

Meanwhile, from $b_q(s,q(s)) = p$ of (10), we have

$$\frac{\partial q(s)}{\partial p} = \frac{1}{b_{qq}(s,q(s))} < 0 \quad \text{and} \quad \frac{\partial q(s)}{\partial s} = -\frac{b_{qs}(s,q(s))}{b_{qq}(s,q(s))} > 0. \qquad (18)$$

Hence the quantity demanded increases with the state of nature *s*. We have

$$\int_{\underline{s}}^{\bar{s}} q(s)[1 - \lambda u'(b(s,q(s)) + m(s))]dG(s)$$

$$= \int_{\underline{s}}^{s^0} q(s)[1 - \lambda u'(b(s,q(s)) + m(s))]dG(s) + \int_{s^0}^{\overline{s}} q(s)[1 - \lambda v'(b(s,q(s)) + m(s))]dG(s)$$

$$> q(s^0)\int_{\underline{s}}^{s^0} [1 - \lambda u'(b(s,q(s)) + m(s))]dG(s) + q(s^0)\int_{s^0}^{\overline{s}} [1 - \lambda u'(b(s,q(s)) + m(s))]dG(s)$$

$$= q(s^0)\int_{\underline{s}}^{\overline{s}} [1 - \lambda u'(b(s,q(s)) + m(s))]dG(s) = 0 . \qquad (19)$$

The inequality is obtained by using (17) and (18). From (19) and (15), we have $(p-c)\int_{\underline{s}}^{\overline{s}} \frac{\partial q(s)}{\partial p} dG(s) < 0$. Since $\frac{\partial q(s)}{\partial p} < 0$, we have $p^* > c$. *Q.E.D.*

Proposition 2 suggests that when consumer tastes are uncertain, the usage rate in the service provider's optimal two-part tariff is greater than the providers' marginal production cost. Compared to a plan with a usage rate equaling to the marginal cost, the optimal plan reduces the risk faced by the consumers. The provider balances between insuring the consumers and avoiding the deadweight loss caused by a high usage price. Note that the service provider does not take much risk under the optimal tariff because the individual uncertainties are independent and thus the aggregate taste is almost certain. The consumers obtain zero expected surpluses and all the benefit from the trade goes to the monopolistic service provider. The formulation of the provider's profit-maximization problem also suggests that with the optimal tariff, the market outcome is allocative efficient *ex ante*, though it is normally inefficient *ex post*. The model can also be used to discuss the case where consumers are not risk-averse. From the proof of Proposition 2, we can easily obtain following result.

Corollary 1: *If the consumers are risk-neutral, the service provider's optimal two-part tariff* (T^*, p^*) *entails* $p^* = c$.

Proof: If the consumers are risk-neutral, we have $u'(x)$ being a constant for all $x \in R$. From (14) we have $1 - \lambda u'(b(s,q(s)) + m(s)) = 0$. Inserting it to (15), we immediately have $p^* = c$. *Q.E.D.*

Moreover, one can show that if the consumers are risk-seeking, the optimal usage rate should be less than the marginal cost. The proof of the conclusion is parallel to that of Proposition 2. Risk-seeking consumers prefer a relatively lower usage rate because it increases the variation in their *ex post* satisfaction levels. The results also suggest that whether the usage rate is greater than the provider's marginal cost does not depend on the household production function. To give a brief illustration of the key idea of the model, I will discuss a stylized example as follow.

Example: A monopoly telephone company has zero marginal cost. Consumers are homogenous and strictly risk-averse. In each period, a consumer needs to make either one call or none, depending on the state of nature. Each case occurs with probability of 0.5. The value of a call is \$10 to the consumer. It is important to realize that the market is not like a health care or auto repair market, in which consumers benefit from the services only after they suffer a loss. In the current story, consumers need to use the service just because they find themselves in certain situations.

If the monopoly company uses linear pricing, it apparently should charge \$10 for each call. The consumers take no risk since they obtain zero *ex post* benefit from the service in either state of nature. The company earns (gross) expected profit of \$5 from each consumer.

On the other hand, if the company offers a flat fee of T>0 dollars per period, the consumer has equal chances to loses T dollars (no call) and gain $10-T$ dollars (one call) of benefit in each period. The uncertain *ex post* benefit suggests that the consumer takes some risk in this service plan. Since the "expected *ex post* benefit" is $-\frac{1}{2}T+\frac{1}{2}(10-T)=5-T$ dollars, the optimal flat fee T must be strictly less than 5 otherwise the risk-averse consumer would not take the plan. Hence the flat fee plan generates less expected profit than the linear price plan, which means a flat fee plan cannot be optimal although the company has zero marginal cost.

More generally, suppose the company offers a two-part tariff (T, p). A consumer who has signed up the plan obtains *ex post* benefit of either $-T$ dollars (no call) or $10-T-p$ dollars (one call), each with probability of 0.5. The consumer's expected *ex post* benefit is $-\frac{1}{2}T+\frac{1}{2}(10-T-p) \;\; =5-T-\frac{p}{2}$ dollars. Because the consumers are risk-averse, they are willing to pay less than $5-T-\frac{p}{2}$ dollars for the service plan as long as $-T\neq 10-T-p$. To make the plan attractive to the consumers, the company's two-part tariff must satisfy $5-T-\frac{p}{2}\geq 0$ (or $T+\frac{p}{2}\leq 5$), with the equality holding if and only if $-T=10-T-p$, *i.e.*, $p=10$. Note that with usage price $p=10$, the lump sum fee T must be zero. Since the company's expected profit from each consumer is exactly $T+\frac{p}{2}$ dollars, a two-part tariff is optimal if and only if it degenerates to a linear price scheme with $p=10$.

3. Concluding remarks

This paper considers a service market where a provider sells to homogenous risk-averse consumers through a two-part tariff. The consumers' tastes toward the service depend on an exogenous situational variable. It is shown that the service provider's profit-maximizing two-part tariff entails a usage rate that is greater than the provider's marginal production cost. Compared to a two-part tariff with a usage rate equaling to the marginal cost, the optimal pricing scheme allows the risk-averse consumers to take less risk. The service provider balances between insuring the consumers and avoiding the deadweight loss when it chooses an optimal usage rate.

The finding may help to understand why it is common for usage rates to be greater than firms' marginal costs in service industries. It may as well help to justify the linear prices observed in public utilities, video rental, toll roads, banking, and other industries where consumers do not subscribe the services in advance. Indeed, linear pricing in industries with increasing return to scale may not be as inefficient as previous theories recommend when consumers have uncertain tastes.

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