# Metering and Access Fee Scheme

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## Ⅰ. Introduction

In the local phone market, we see two kinds of pricing schemes. One is a metering scheme in which a customer is charged according to the phone call usage. The other is allowing unlimited usage and charging a fixed fee per month. For the latter, we will call it access fee scheme in this paper. For several internet services, it is very important to choose the right pricing scheme in order to maximize the profit. Two typical options for pricing in providing services are a metering scheme and an access fee scheme. An Internet service provider can use either a metering scheme or an access fee scheme. That is, it can charge a customer according to the usage amount or a fixed access fee for unlimited usage. An Internet music service providers can charge a customer for each song downloaded or an access fee regardless of the number of songs.

There has been huge amount of research and practice in order to extract consumer surplus. Price discrimination, where applicable, can offer more profit to a firm by extracting consumer surplus. Price discrimination schemes are most effective when a firm can tell the types of each customer. Once the type of a customer is known to a firm, it can offer a customized pricing scheme to

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the customer to maximize its profit. If the type is not known to the firm, the firm might have to try to think of way to distinguish customers according to their types. Here we consider the example of Disneyland. In the spring of 2001, Disney Co. opened an amusement park, California Adventure next to the famous Disneyland. It is an amusement park which focuses on more fun rides than Disneyland. For the first time in its history, Disney offered a discount price for adults and free admissions to young kids in four months after its grand opening. But the special offer is valid only to the Southern Califonia residents. In this case, we know that Disney offered the promotion only to the Southern Californians who are essentially neighbors. Southern Californians have several alternative amusement parks other than the California Adventure and thus rather low valuation with elastic demand. Also Disney can easily verify the type of a customer by asking for its license in order to check its residency. However it is more likely that a firm cannot check the type of a customer. Only the customer knows his type and will not reveal the type unless it is more beneficial to himself. In these cases of asymmetric information, a firm should construct an inducing mechanism for the revelation of customer types.

In this paper, we study these two kinds of pricing schemes for a simple case. There are heterogeneous customers who have different value functions for the service provided. A service provider may need to offer a menu of multiple pricing schemes in order to maximize its profit by utilizing the characteristics of customers. After analyzing a basic case, we extend to the two part tarrif scheme. And then we consider the case where congestion in usage is significant. In the next section, we consider a case where we compare two pricing schemes.

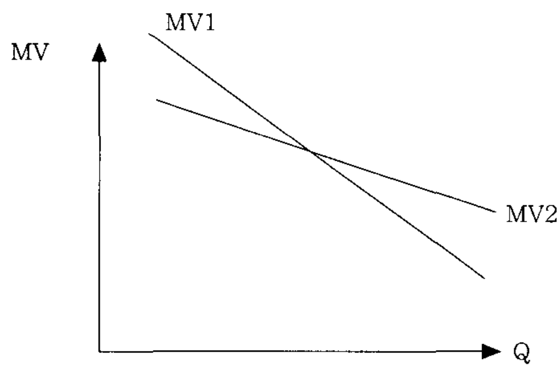
Shaffer[92], using Cobb-Douglas utility function for consumers, shows that demand interdependence in the presence of a two-part tariff may render marginal cost unit pricing inferior from the consumers' standpoint. Edlin and

Epelbaum[93] explore the interactions among firms with increasing returns regulated to breakeven by pricing with two-part tariffs. They provide conditions for existence and for efficiency of general equilibria with n-firms.

## Ⅱ. Two Pricing Schemes

### 2.1 Marginal Value Curve

In this section, we consider the effects of metering and access fee schemes. There exist two typical customers who have marginal value curves for the service provided. The marginal value for the service represents the value for the service added. We assume that the marginal value curve is linear and decreasing in the usage amount. Demands for the service are drawn from the marginal value curves. An example is shown in ⟨Figure 1⟩.




⟨Figure 1⟩

The customer with steeper slope in marginal value curve is to be called customer 1. And the other customer will be called customer 2. In this example, we have three players. One is a service provider who tries to set up optimal pricing schemes. It offers a metering scheme and an access fee scheme. The access fee is denoted as 'A'. In the metering scheme, a customer is charged p per unit. It has the incentive to maximize its own profit. The other two players are the customers with different marginal value curves who try to maximize their own consumer surplus by choosing a more beneficial pricing scheme. The intersection of i's marginal value curve and price axis is denoted as $\overline{p_i}$, where i=1, 2. Likewise i's marginal value curve intersects quantity axis at $\overline{q_i}$

## 2.2 Incentive Compatibility for a Customer

Given two pricing schemes offered by a service provider, a customer will try to maximize its own surplus. Thus when a service provider sets up a pricing scheme, it should consider whether a customer would choose the pricing scheme which the service provider wants him to choose. This is called an incentive compatibility for a customer. Provided that there are two pricing schemes offered by the service provider, there are four scenarios according to which pricing scheme a customer would choose.

Denote $V_i$ as customer i's total value for the service, where i=1, 2. And we represent $S_i(p)$ as i's consumer surplus when customer i chooses a metering scheme with per unit price of p. We note that $S_i(p)\geq 0$. For each scenario, there are two constraints. One is that a customer would choose the pricing scheme(participation constraint). The other is that the pricing scheme of a customer's choice offers at least the consumer surplus coming from the other scheme. These two constraints are in the cell of each scenario.

〈Table 1〉

| 1 \ 2 | access scheme | metering scheme |
|---|---|---|
| access scheme | $V_1\geq A, V_1-A\geq S_1(p)$<br>$V_2\geq A, V_2-A\geq S_2(p)$ | $V_1\geq A, V_1-A\geq S_1(p)$<br>$S_2(p)\geq 0, S_2(p)\geq V_2-A$ |
| metering scheme | $S_1(p)\geq 0, S_1(p)\geq V_1-A$<br>$V_2\geq A, V_2-A\geq S_2(p)$ | $S_1(p)\geq 0, S_1(p)\geq V_1-A$<br>$S_2(p)\geq 0, S_2(p)\geq V_2-A$ |

## 2.3 Service Provider's Problem

For each scenario, a service provider will try to maximize its profit. The profit function depends on the scenario. And the constraints for the maximization are also scenario dependent. We assume that the marginal cost for providing the service is 0. The decision variables for the service provider is A and p. As an example, we consider the scenario where customer 1 and 2 choose the metering scheme and the access fee scheme respectively. In this case, the service provider's problem becomes as follows.

$$\max_{A,p}[A+pq_1]$$
$$s.t.$$
$$S_1(p)\geq 0,$$
$$S_1(p)\geq V_1-A,$$
$$V_2\geq A,$$
$$V_2-A\geq S_2(p).$$

We should note that $q_1$ above is the amount of usage corresponding to $p$ in customer 1's marginal value curve. For sufficiently large $p$ such that $p\geq \overline{p_i}$, we have $S_i(p)=0$. The feasible region of the constraints can be rearranged as $V_1-S_1(p)\leq A\leq V_2-S_2(p)$ with the non-negativity of $S_i(p)$. Therefore, when the feasible region is not empty, i.e. $V_1-S_1(p)\leq V_2-S_2(p)$, the optimal access fee should be $A^*=V_2-S_2(p)$. And thus the optimization becomes $\max_p[V_2-S_2(p)+pq_1]=V_2+\max_p[pq_1-S_2(p)]$. At the optimal solution of $p^*$, we note that the consumer surplus for each customer becomes $S_i(p^*)$.

## 2.4 Example

We consider an example to compare the metering and the access fee scheme. The example is the one shown in ⟨Figure 1⟩. The optimal solutions and optimal objective function values for each scenario are summarized in ⟨Table 2⟩.

〈Table 2〉

| 1 \ 2 | access scheme | metering scheme |
|---|---|---|
| access scheme | $A^*=1,\ p^*\geq 2,\ Z^*=2$ | $A^*=0,\ p^*\geq 2,\ Z^*=0$ |
| metering scheme | $A^*=15/8,\ p^*=3/2,\ Z^*=9/4$ | $A^*\geq 3/2,\ p^*=1,\ Z^*=3/2$ |

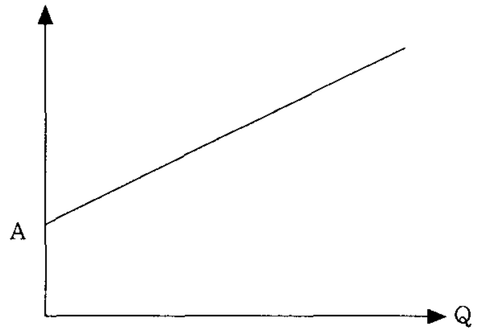
From 〈Table 2〉, we know that the optimal solution is in the third scenario where customer 1 and 2 choose the metering scheme and access fee scheme respectively. The service provider charges a rather high access fee and sufficiently high per unit charge. By doing this for its own profit, it induces the customer 1 to purchase a rather small amount with high price and the elastic customer of 2 to pay for unlimited usage. In this case, the consumer surplus of each customer is $S_1=1/16, S_2=1/8$.

From 〈Figure 1〉, we know that customer 1 has higher marginal value for each quantity used and thus larger total value for the service than customer 2. From this characteristic, we note that there can not be an incentive compatible pricing mechanism where customer 1 and 2 adopt access pricing and metering pricing respectively.

## Ⅲ. Extensions

### 3.1 Two-Part Tariff

Although we distinguished a metering scheme from an access fee scheme, these two schemes can be dealt within the same category. The two part tariff scheme has fixed cost for positive usage amount and per unit usage charge. 〈Figure 2〉 shows an example of two-part tariff scheme.




⟨Figure 2⟩

The access fee scheme we dealt with is a special case where the per unit usage charge in two-part tariff scheme is zero. And the metering scheme is the two-part tariff scheme where the fixed cost is zero.

Through two-part schemes, a service provider can increase its profit by extracting more of consumer surplus. We now consider manipulating the optimal solution found in the example such that it has fixed entrance fee. From the constraints for customer 1, we note that customer 1 compared $1-(2-1/8)=-7/8$ with $(1/2)(2-3/2)(1/4)=1/16$. Since $1/16 > -7/8$, customer 1 would choose the metering scheme and enjoy consumer surplus of 1/16. If the service provider newly impose a fixed fee of 1/16 for positive amount of usage, customer 1 would still choose the metering scheme with the surplus reduced to zero. This reduced surplus of 1/16 of customer 1 is transferred to the service provider. Now considering the constraints of customer 2, the service provider can increase the access fee by 1/16 without violating customer 2′s incentive constraints. Therefore the service provider can extract 1/16 again from the customer 2′s surplus. All together the service provider can increase its profit by 1/8 by using two part tariff schemes. The new optimal pricing schemes are $A=31/16, 1/16+(3/2)q$ with the service provider′s profit being 19/8. Each customer′s consumer surplus is reduced by 1/16 compared with the case before two part tariff scheme is introduced, and this amount is added to the service provider′s profit.

But we have to note that the solution above is not actually optimal when we consider two distinct two-part tariff schemes for each customer. In a more general case, a service provider can offer two kinds of two-part tariff schemes which a customer may choose. This problem is a more complicated optimization model than our case of access fee versus metering scheme. Solving this case for our example, we get A=7/4 and 1/4 + q with the resulting profit of 5/2. Rather elastic customer 2 chooses to pay an access fee of 7/4 and use up-to 2. Inelastic customer 1 pays entrance fee of 1/4 and per unit price of 1. Customer would use 1/2. In this optimal solution, the consumer surpluses of customers 1 and 2 are 0 and 1/4 respectively. Here we have very interesting fact in that the service provider with optimal two-part tariff schemes has more profit and the total consumer surplus is larger than before. When we allow a uniform two-part tariff scheme for both customers, the optimal scheme is 9/16 + (1/2)q and the profit becomes 9/4.

### 3.2 Congestion Effect

Up to now we have assumed that the marginal cost for production is zero. This assumption is one of the characteristics of information economy. In several cases in information economy, the cost for development of information goods is huge but the reproduction cost is minimal. We can consider the case of software development and its reproduction, or the composition of a music and copying it through the Internet.

But this perspective considers only for the production side. Even though it costs virtually zero for supplying the additional usage of service, heavy usage of customers may induce queueing congestion in the system and thus degrade the service resulting in reduced value for the customer. This may be called the cost from the demand side. Unlike the conventional marginal cost of production, this congestion cost is borne by the customer, but it will eventually suffer the service provider's profit. In this sense, it can be called another kind of marginal cost depending on the usage amount.

With limited capacity, the congestion effect may be enormous and thus should be incorporated in offering a menu of pricing schemes. Let $W(u|k)$ denote the congestion cost to the service provider due to waiting where $u$ is the customers' total usage amount and $k$ is the capacity of the service provider. In general, $W$ is increasing in $u$ and decreasing in $k$. It is usually assumed that $W$ diverges to $\infty$ as $u \rightarrow k$. When we assume exponential distributions on customer inter-arrival time and service time, the expected waiting time is derived as $W = 1/(k-u)$. As an example, we consider the third scenario of our model. In this case, we have $u = \overline{q_2} + q_1(p)$. From the assumption that $W$ is increasing, a service provider now has the incentive to reduce the total amount of usage than before. Therefore its new optimal pricing scheme would induce less than or equal to the usage amount in the previous case.

However it is not necessarily true that the access fee and the per unit charge would increase than before the introduction of congestion cost. Incorporating congestion cost in the service provider's optimization model makes an access fee scheme less attractive since it induces a large amount of usage. Therefore depending on the functional form of congestion cost, the optimal pricing scheme may be switched to a metering scheme only(scenario 4) in our example. We note that the optimal per unit price in scenario 4 is smaller than that in scenario 3 in the example.

We should note the variability of the congestion cost. Although the capacity of a service system, $k$, is fixed in the short-run, it is radically affected by techology development in the long-run. Thus it is likely that offering a metering scheme which used to be optimal in the old technology becomes no longer optimal. With the new technology enabling much more capacity, it may be more beneficial for the service provider to offer an access fee scheme to the customers.

### 3.3 Resale Opportunity

One complication may occur when a service provider allows an access fee for unlimited usage. When there is an opportunity for resale, a customer may abuse the privilege of unlimited usage and resell some of the service to other potential customers. In our example, customer 2, after purchasing an unlimited usage privilege, would retrieve 1 if it can resell the privilege to customer 1. This resale opportunity can incur several potential problems. First it can reduce the profit of the service provider by taking away potential customers. In addition to this obvious problem, it can incur a larger total amount of usage of service and thus more congestion in the system. Considering the case where a customer paying an access fee for unlimited usage can sell the usage without any difficulty, he is now a competitor to the service provider. And he has the cost advantage in that he does not need to pay for the huge development cost except only paying the access fee. From the liberal resale of the service, the usage amount would be much larger than the service provider at first expected from the customer.

Therefore when there is a possibility of resale, a service provider should cope with the problem. It may try to make it inconvenient to resell the service. Or it may try to make it technically impossible to resell the service. We can think of an on-line version of Wall Street Journal. By detecting and making it impossible for multiple usages simultaneously under one user name, Wall Street may try to reduce the resale of its service. For the Internet music downloading service, the service provider may make it impossible for a customer to send the music files to others after downloading them.

In the Internet economy, the problem of resale can be more serious than in the traditional economy. A consumer who purchases a book or a video tape has the right for unlimited usage. However it is not easy to resell the right to several people. It is rather difficult to locate potential customers. And it is costly to deliver the usage right. In the Internet, it is much easier and less costly to resell the file to many people. Therefore the resale opportunity, when it exists, deserves much more attention of a manager in the Internet economy than in the traditional market.

# Ⅳ. Concluding Remarks

As a way of price discrimination, two part tariff schemes have been extensively studied. In this paper, we considered two special forms of two part tariff scheme, which are a metering scheme and an access fee scheme. In case of homogeneous customers, the pricing problem is rather simple. We only have to construct an optimal pricing scheme for every customer. However the pricing problem becomes complicated when there exists heterogeneity in customers. Where there are heterogeneous customers, it is usually the case that a service provider does not know the exact type of the customers. If a service provider knows the exact type of a customer, it can apply the pricing scheme developed for each specific type and realize the maximum profit possible.

We considered the case where there are two distinct customers with different marginal value functions. But due to asymmetric information on the type of a customer, a service provider can not tell which is the customer with a specific marginal value function. Each customer has an incentive to tell a lie about its marginal value function if it is more beneficial to do so. Therefore what the service provider can do is to offer a menu of pricing schemes to the customers. Considering each customer's incentives, the service provider tries to construct pricing schemes to maximize its profit. By considering a customer's incentives, the service provider induces a customer to self-select a pricing scheme best for the customer himself. Depending on the characteristics of each customer, it may be more profitable for a service provider to offer a menu of pricing schemes and induce a customer to choose one of them. Sometimes a service provider does not know the type of the customer a prior, but can tell it by looking at his choice for pricing scheme.

In order to generalize the model, we also considered a two-part tariff scheme, cogenstion cost due to usage, and resale opportunity. In practical applications, a metering scheme has the disadvantage compared with an access fee scheme in that it requires a monitoring system and data base for the usage amount for each customer. Thus it is sometimes better for the service provider to let customers use without limit since it saves cost of maintaining the data base necessary for monitoring.

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