The following chapter is taken from *Industry Structure and Pricing: The New Rivalry in Infrastructure*, by Mark A. Jamison, Ph.D.
Boston: Kluwer Academic Publishers, 1999.

4
THEORY AND APPLICATION OF SUBSIDY-FREE PRICES

INTRODUCTION

The regulation of utility prices has long addressed issues of cross-subsidization. Views on the meaning of cross-subsidization have varied, but they have generally involved the idea that one set of customers receives favorable prices at the expense of other customers. Faulhaber (1975, p. 966) and Baumol (1979, p. 242) note that cross-subsidization issues existed as long ago as the late 1800s for railroad pricing in the US. In the early part of the 20th century, Glaeser (1939) addressed cross-subsidy issues for allocating joint costs in the Tennessee Valley Authority. US State regulators expressed cross-subsidy concerns in the 1950s and 1960s, during the early development of Separations, the process by which regulators and companies allocate telecommunications costs between the State and federal jurisdictions in the US. The FCC and the telecommunications industry also expressed concerns, but they often disagreed with the State regulators on the direction of the subsidy flow. (Jamison 1999b)

Liberalization and deregulation of utility markets have increased concerns over cross-subsidy. (Baumol 1979, p. 235, Jamison 1997b, p. 113) In telecommunications, cross-subsidy as a competitive issue first developed in 1959 when the FCC allowed private users to build their own microwave systems for transporting their internal communications. AT&T responded to this competitive threat with deep price discounts for customers that might build their own systems, prompting the FCC to launch an extensive inquiry into how to measure service costs. This inquiry spanned three dockets and 15 years. (Bolter 1978, pp. 334, 344; Brock 1981, pp. 204-208) The FCC addressed cross-subsidy issues again when it decided to drop structural separation requirements for the large local exchange companies when they entered non-regulated markets. The FCC developed an accounting separation process in an attempt to prevent the large local exchange companies from cross-subsidizing their non-telephone products and services.

State regulators began developing intrastate telecommunications costing policies when they faced the same competitive pricing issues that the FCC faced. A 1988 survey sponsored by the National Association of Regulatory Utility Commissioners showed that 65% of the States required cost support for pricing decisions. Thirty-seven percent had or were developing policies on segregating costs between regulated and nonregulated services. (Jamison 1988b) More recently in the US, the US Telecommunications Act of 1996 requires regulators to ensure that monies targeted for universal service are not used by telecommunications providers to subsidize other parts of their operations.

Many of the tools and principles that regulators use to address cross-subsidy issues come from Faulhaber (1975), who applied the contestability model, that I describe in Chapter 1, to the cross-subsidy issue. In this chapter, I analyze the effects of multilateral rivalry (MLR) on Faulhaber's view of cross-subsidy. In Chapters 2 and 3, I explain that MLR exists when firms have diverse market contacts, including points of potential market entry. With respect to cross-subsidy, the critical element of MLR is the potential for firms outside the monopoly's markets to enter the monopoly's markets and, in doing so, incur incremental costs that are less than stand-alone cost.

I begin this chapter by explaining the principles that underlie Faulhaber's analysis and conclusions. I then explain the effects of MLR on his definition of cross-subsidy. Lastly, I describe where policy makers and others have applied Faulhaber’s work and how MLR affects these applications.

UNDERLYING PRINCIPLES FOR FAULHABER'S DEFINITION

Cross-subsidization is a fairness issue in that it addresses whether a particular pricing scheme unduly favors some customers at the expense of other customers (Faulhaber 1975, p. 966; Baumol 1979, p. 247). Because fairness is in the eye of the beholder, the fairness standard for determining cross-subsidy has allowed for the development of numerous cost allocation techniques, generally in the form of fully distributed cost. Fully distributed cost is a general name for accounting processes that assign all of a firm's accounting costs among its products. Fully distributed cost techniques are problematic because they give widely varying and conflicting results, appear arbitrary, and, in some instances, allocate more costs to a product than it would cost for a specialized firm to produce the product alone. (Baumol, Koehn, and Willig 1987, pp. 16-17; Zajac 1978, pp. 41-43; Jamison 1988a, pp. 314-317) Also, utilities, their competitors, and customers can use the arbitrary nature of fully distributed cost to advocate self-serving techniques. (Baumol 1979, pp. 238-239)

Distressed with the problems of fully distributed cost, Faulhaber uses contestable market theory to develop a rigorous definition of fairness, based on Pareto optimality, for identifying cross-subsidy. (Faulhaber 1975, p. 966; Baumol 1979, p. 242) He bases his approach on the notion that customers should not have to pay higher prices if served by the utility than if they were served by any other arrangement. Unlike the inverse-elasticity rule[1] and other monopoly pricing schemes, Faulhaber's subsidy-free pricing does not incorporate concepts of welfare maximization or views of social justice. The primary goal of subsidy-free pricing is to encourage least-cost production. (Faulhaber 1975, p. 967; Baumol 1979, pp. 235-236, 245) He explains the theoretical properties of subsidy-free prices as follows:

> "(Subsidy-free prices) provide the appropriate incentives for consumer groups to seek the most efficient means of supply in the presence of joint production."
>
> "…a price structure that is subsidy-free is Pareto superior to what prices would otherwise be for each consumer group or coalition of consumer groups."
>
> "Subsidy-free prices do no more than insure that the production and sale of each commodity makes all consumers at least as well off as they would otherwise be." (Faulhaber 1975, pp. 967, 970 fn. 13, 972)

Taken at face value, the first statement is slightly different from the last two. The first statement applies to the customers of the utility of interest. This statement asserts that subsidy-free prices should ensure that these customers are as happy with the utility's prices as they would be with the prices of their next best alternative in the economy. Baumol (1979, p. 236) explains that it is always in customers' best interests to buy what they want at the lowest available price, so Faulhaber's statement should be read as meaning that customers should not be able to obtain lower prices elsewhere.

The second and third statements appear to apply more generally to all consumers. These statements say that no consumers should be made worse off by the utility's prices. The consumers considered could include consumers who do not buy from the utility, to the extent that they are affected by the utility's prices. It is possible that Faulhaber means for the consumers in the second and third statements to include only the utility's consumers. This is because he intermingles with these statements the assumption that the utility's customers' only alternatives to the utility are firms that serve only a portion of the utility's markets and nothing else. As I explain later in this chapter, this assumption, which I call the restricted choice (RC) assumption, ensures that non-utility customers are also not made worse off by the utility's prices.

In explaining his approach, Faulhaber incorporates the RC assumption without explicitly stating it and without providing justification. He simply incorporates the assumption into his theory's underlying principles:

> "If the provision of any commodity (or group of commodities) by a multicommodity enterprise subject to a profit constraint leads to prices for the other commodities no higher than they would pay by themselves, then the price structure is *subsidy-free*. Thus, a subsidy-free price structure insures that the provision of each commodity by the enterprise is 'Pareto superior' to nonprovision."

> (Faulhaber 1975, pp. 966-967) (Emphasis in original. Footnote omitted.)

He treats this statement, which explicitly incorporates the RC assumption, as equivalent to his other statements of principle, which do not contain the RC assumption. In his explanation of Faulhaber's approach, Baumol (1979, p. 242) also simply includes the RC assumption when stating the objectives of subsidy-free pricing.

FAULHABER'S SUBSIDY-FREE PRICES WITH INDEPENDENT DEMANDS

Using the RC assumption, Faulhaber finds that prices must meet the following criteria if they are to be subsidy free when demands for the utility's products are independent:

1. The utility earns zero profits overall; i.e., total revenue equals total economic cost;

2. All subsets of the utility's products generate revenues that are no greater than their stand-alone costs -- the cost of a specialized firm producing only the product(s) in question; and

3. All subsets of the utility's products generate revenues that are no less than their incremental costs. (Faulhaber 1975, pp. 968-969) Incremental cost refers to the additional cost of adding the entire production of the product (or groups of products) to a firm that does not produce the product(s). (Baumol 1979; p. 241) Chapter 1 provides a more detailed explanation of incremental cost.

The zero-profit constraint is necessary to ensure that all of the utility's customers as a group cannot be made better off by buying from a firm that earns lower profits. The second constraint, called the stand-alone cost test, ensures that groups of customers cannot be made better off by going it alone; i.e., by purchasing from a firm that produces only the products with the offending prices. An important, and strong, assumption is that others can replicate the utility's technology. Baumol (1979, p. 246) justifies this assumption by reasoning that, even if there are barriers that prevent others from replicating the utility, customers should not be made worse off by these barriers.

The third constraint, called the incremental cost test, is redundant with the first two constraints because, as long as the utility earns zero profits and no products (or groups of products) generate revenues in excess of stand-alone cost, then no products (or groups of products) earn revenues that are less than their incremental costs. Appendix 1.1 illustrates this calculation.

It is necessary when applying the stand-alone and incremental cost tests to consider (although not necessarily test)[2] all subsets of the utility's products. It is necessary to consider all subsets because some groups of the utility's products may share some common costs between them, but not with any of the other products.[3] For example, in telecommunications, certain computing capabilities of a central office switch are shared by switched voice services and calling features. However, many dedicated private line services do not use the central office switch and so do not share these costs with the other services. These common costs that are shared by some products but not by others are called shared incremental costs. Shared incremental costs make it necessary to verify that subsets of products pass the stand-alone cost test because products that have shared incremental costs will have a stand-alone cost as a group that is less than the sum of their individual stand-alone costs. As a result, prices for these products that pass individual stand-alone cost tests may be too high to pass a group stand-alone cost test. Likewise, shared incremental costs make it necessary to verify that subsets of products pass the incremental cost test because these products will have a group incremental cost that is greater than the sum of their individual incremental costs. Prices for these products may pass individual incremental cost tests, but be too low to pass a group incremental cost test. Chapter 1 provides a more complete explanation of these cost concepts and provides illustrations.

Example 4.1, which is similar to Faulhaber's (1975, pp. 968-970) example and my own example (Jamison 1996, p. 373), illustrates Faulhaber's tests.

> <u>Example 4.1.</u> Assume that four communities, numbered 1 through 4, wish to provide their citizens with water. Let $C(\cdot)$ represent the cost function for supplying water and q_i represent the quantity of water supplied to town i. The cost of supplying water to the group of communities S, which contains one or more of the towns,[4] is $C(q^S)$. This cost includes the cost of a well, pumping, storage tank, and transport, which is necessary if a town receives water from a well that is located somewhere other than in the town. The cost of supplying water to town 1 alone is $C(q^{[1]})$, which is simply the cost function estimated with town 1's water and with no water for each of the other towns.[5] The cost of serving each town separately would be the sum of each town's individual costs, or $\Sigma^4_{i=1}\ C(q^{[i]})$. In the other extreme, the cost of serving all towns together would be $C(q^{1+2+3+4})$.
>
> Assume for simplicity that each town charges its citizens a uniform price per gallon of water, but each town may charge a price that is different from what other towns charge. For example, one town may charge \$0.08 per gallon to all of its citizens, while another town may charge \$0.075 per gallon to all of its citizens. Let p_i represent the price charged by town i. The quantity of water that

the citizens of town i are willing to buy at price p_i is $q_i(p_i)$, which says that the quantity is a function of the price. Also, the revenue the town receives is represented as $r_i = p_i \cdot q_i(p_i)$.[6]

To make this example more tangible, assume the following costs and demands. Assume that digging a well and installing a storage tank creates $950 in fixed costs and has constant marginal costs of $0.015 per gallon. If water is provided to a town and if the well and the storage tank are not in this town, the water must be transported to the town at a cost of $90 per mile. The towns are located at the corners of a rectangle, which has a width of 4 miles and a length of 8 miles. Towns 1 and 2 are four miles apart and are on the northwest and southwest corners of the rectangle, respectively. Towns 3 and 4 are also four miles apart and are on the northeast and southeast corners of the rectangle, respectively. As a consequence, towns 1 and 3 are eight miles apart, as are towns 2 and 4. Figure 1 illustrates this arrangement.

Within the relevant range of prices, the citizens in each town are willing to purchase 10,000 gallons of water regardless of the price. This gives the following costs for various water supply systems:

$$C(q^{[1]}) = C(q^{[2]}) = C(q^{[3]}) = C(q^{[4]}) = \$1100$$

$$C(q^{1+2}) = C(q^{3+4}) = \$1610$$

$$C(q^{1+3}) = C(q^{2+4}) = \$1970$$

$$C(q^{1+4}) = C(q^{2+3}) = \$2055$$

$$C(q^{1+2+3}) = C(q^{1+2+4}) = C(q^{1+3+4}) = C(q^{2+3+4}) = \$2480$$

$$C(q^{1+2+3+4}) = \$3160 \;\square$$

The most efficient production arrangement in Example 4.1 is for all of the towns to join together in a single system because:

$$C(q^{[1]}) + C(q^{[2]}) + C(q^{[3]}) + C(q^{[4]}) = \$4400$$

$$C(q^{1+4}) + C(q^{2+3}) = \$4110$$

$$C(q^{1+3}) + C(q^{2+4}) = \$3940$$

$$C(q^{1+2+3}) + C(q^{[4]}) = C(q^{1+2+4}) + C(q^{[3]}) = C(q^{1+3+4}) + C(q^{[2]}) = C(q^{2+3+4}) + C(q^{[1]}) = \$3580$$

$C(q^{1+2}) + C(q^{3+4}) = \$3220$

$C(q^{1+2+3+4}) = \$3160$

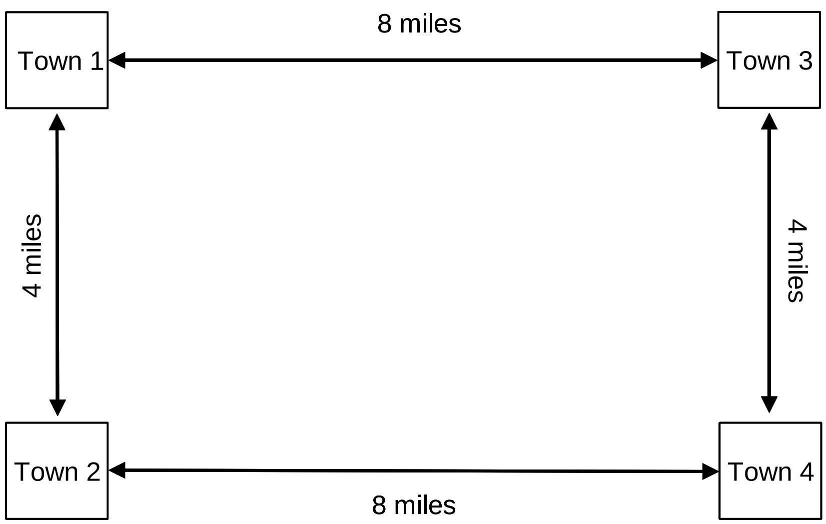

Figure 1. Arrangement of Towns for Examples 4.1 and 4.2

To have subsidy-free prices – i.e., to ensure that no towns' citizens opt to develop their own water system – the towns must adopt a cost sharing arrangement that results in the following revenues:

$$r_1 + r_2 + r_3 + r_4 = \$3160 \qquad (4.1)$$

$$\$1100 \geq r_i \geq \$680$$

$$\$1610 \geq r_i + r_j \geq \$1550 \qquad \text{where } (i, j) \in \{(1, 2), (3, 4)\}$$

$$\$1970 \geq r_i + r_j \geq \$1190 \qquad \text{where } (i, j) \in \{(1, 3), (2, 4)\}$$

$$\$2055 \geq r_i + r_j \geq \$1105 \qquad \text{where } (i, j) \in \{(1, 4), (2, 3)\}$$

$\$2480 \geq r_i + r_j + r_k \geq \$2060$ where $i, j, k \in \{1, 2, 3, 4\}$ and i, j, k all different

Equation 4.1 represents the zero profit constraint. In each of the other expressions, the first member represents the stand-alone cost test and last member represents the incremental cost test. Appendix 1.1 illustrates how to estimate incremental cost.

One solution to this pricing problem is for each town to charge a per gallon price that is equal to the average cost per gallon, or $0.079 per gallon. This results in revenue per town of $790, revenue from any two towns of $1580, and revenue from any three towns of $2370. These results satisfy the subsidy-free pricing constraints.

MLR'S EFFECTS ON STANDARDS FOR SUBSIDY-FREE PRICES WITH INDEPENDENT DEMANDS

In a previous paper (Jamison 1996), I explain that MLR shrinks the range of prices that can be considered subsidy-free by providing customers more economical alternatives to the utility's production than does the RC assumption. Faulhaber assumes that customers can only choose between the utility and an alternative supplier that serves some subset of the utility's markets. With MLR, customers can choose an alternative supplier that serves a subset of the utility's markets and other markets. In some instances, one or more of these alternative suppliers' other products have economies of joint production when produced jointly with the subset of the utility's products.

The alternative suppliers that have these economies of joint production represent more economical alternatives than a stand-alone competitor, and so provide an upper bound for subsidy-free prices that is lower than stand-alone cost. As a result, the stand-alone cost test is unable to identify subsidy-free prices. I call this new upper bound the alternative supplier test. MLR also affects the lower bound for subsidy-free prices by making it higher than incremental cost. I call this new lower bound the aggregate incremental cost test. Therefore, with MLR, a utility's prices are subsidy free as long as:

1. The utility overall earns zero profits; i.e., the prices pass the zero profit test;

2. All subsets of the utility's products generate revenues that are no greater than those generated by the lowest prices a competitor could charge while earning zero profits and charging subsidy-free prices for its other products; and

3. All subsets of the utility's products generate revenues that are no less than the incremental costs they create in the economy. As I explain later, these incremental costs, which I call aggregate incremental costs, may be greater than the incremental costs measured at the firm level.

The first condition is the zero-profit constraint. The second condition is the alternative supplier test. The third condition, which is redundant with the first two conditions, is the aggregate incremental cost test. I explain each of these tests by illustrating them with Example 4.2.

> Example 4.2. Consider the water supply problem in Example 4.1. Assume that everything about the example remains the same except for the cost of transporting water. Now, the cost is \$100 per mile instead of \$90 per mile. The costs of various water supply systems are now:
>
> $$C(q^{[1]}) = C(q^{[2]}) = C(q^{[3]}) = C(q^{[4]}) = \$1100$$
>
> $$C(q^{1+2}) = C(q^{3+4}) = \$1650$$
>
> $$C(q^{1+3}) = C(q^{2+4}) = \$2050$$
>
> $$C(q^{1+4}) = C(q^{2+3}) = \$2144$$
>
> $$C(q^{1+2+3}) = C(q^{1+2+4}) = C(q^{1+3+4}) = C(q^{2+3+4}) = \$2600$$
>
> $$C(q^{1+2+3+4}) = \$3339$$
>
> The following show the costs of the various arrangements for serving all of the towns:
>
> $$C(q^{[1]}) + C(q^{[2]}) + C(q^{[3]}) + C(q^{[4]}) = \$4400$$
>
> $$C(q^{1+4}) + C(q^{2+3}) = \$4288$$
>
> $$C(q^{1+3}) + C(q^{2+4}) = \$4100$$
>
> $$C(q^{1+2+3}) + C(q^{[4]}) = C(q^{1+2+4}) + C(q^{[3]}) = C(q^{1+3+4}) + C(q^{[2]}) = C(q^{2+3+4}) + C(q^{[1]}) = \$3700$$
>
> $$C(q^{1+2+3+4}) = \$3339$$
>
> $$C(q^{1+2}) + C(q^{3+4}) = \$3300 \ \square$$

In contrast with Example 4.1, the most efficient production arrangement in Example 4.2 is for towns 1 and 2 to form their own system and for towns 3 and 4 to form their own system. These systems have subsidy-free prices as long as revenues satisfy the following:

$$r_1 + r_2 = r_3 + r_4 = \$1650 \tag{4.2}$$

$$\$950 \geq r_i \geq \$700 \qquad \text{where } i \in \{1, 2, 3, 4\} \qquad (4.3)$$

Equation 4.2 represents the zero profit constraint. In each of the other expressions, the first number represents the alternative supplier test and the last number represents the aggregate incremental cost test. The following two subsections explain these tests in more detail.

The Alternative Supplier Test

To explain the alternative supplier test, consider the prices charged for towns 1 and 2. The alternative supplier test requires prices for these towns to be no greater than the lowest prices another firm could charge while also charging subsidy-free prices for its other products. The most economical alternative available to either town 1 or town 2 is to join the group formed by towns 3 and 4. Assume that the prices for towns 3 and 4 satisfy equations 4.2 and 4.3, but that town 2 asks town 1 to pay \$1000 for their joint system. Faced with the resulting price of \$0.10 per gallon, the citizens of town 1 could ask towns 3 and 4 if their coalition could offer a better price. It turns out that their coalition can do so. The incremental cost of adding town 1 to towns 3 and 4's system is only \$950; i.e., $C(q^{1+3+4}) - C(q^{3+4}) = \$950$. Therefore, towns 3 and 4 can charge town 1 \$950 while continuing to charge subsidy-free prices to their own citizens.

Compare the alternative supplier test to Faulhaber's stand-alone cost test. According to the stand-alone cost test, town 2 should have been able to ask town 1 to pay up to \$1100, town 1's stand-alone cost. This is clearly not subsidy free because MLR from the coalition of towns 3 and 4 gives town 1 a more economical alternative than going it alone. In Example 4.2, the alternative supplier test gives an upper bound that is \$150 lower than the stand-alone cost test.

In Example 4.2, the alternative supplier test is the incremental cost of the alternative supplier. This is true because the alternative supplier, the system serving towns 3 and 4, exists as part of an efficient market structure; i.e., a market structure that represents the cost minimizing means of production for all products in the economy. Because this system is efficient and has subsidy-free prices, it can add either town 1 or town 2 and charge the town an amount equal to its incremental cost without disturbing prices for towns 3 and 4.

In certain situations, firms that are not part of an efficient market structure can also create an upper bound for prices that is lower than the stand-alone cost test. This bound is not a bound on subsidy-free prices because, absent a subsidy, these firms cannot expand into other markets and charge subsidy-free prices. Examples of such a subsidy include direct payments from governments and revenues from prices that are above subsidy-free levels, such as a firm might charge if it is protected from competition and has little regulation. Firms that are not part of an efficient market structure need such a subsidy to be able to charge subsidy-free prices because, if all prices in the economy are subsidy-free, then the revenues the economy generates are just equal to the costs of the efficient market structure. A firm that is not part an efficient market structure represents an extra cost that subsidy-free prices are inadequate to cover.[7] Example 4.3 illustrates this situation.

> Example 4.3. Consider a firm α that produces products a_1 and a_2, and that is part of the efficient market structure for an economy. Assume that this efficient market structure is unique. α's cost of production is $C(q_{a1}, q_{a2})$.[8] Assume that there is also a firm β, which is part of the efficient market structure, and which produces products b_1 and b_2 at a cost of $C(q_{b1}, q_{b2})$. Because of MLR from firms other than α, subsidy-free prices for β are below stand-alone cost. Further assume that a firm producing a_1 with b_1 would have economies of joint production, but that a firm producing the following arrangements would experience diseconomies: a_1 or a_2 with b_2; a_1 and a_2 with b_2; or a_2 with b_1. Let $C(q_{a1}, q_{b1})$ represent the cost of a firm δ that could be formed to produce q_{a1} with q_{b1}. Because this example assumes that α and β belong to the efficient market structure, δ cannot belong to the efficient market structure as its products are produced by α and β when the market is operating efficiently. By assumption, $C(q_{a1}, q_{b1}) < C(q_{a1}) + C(q_{b1})$, but further assume that the government provides a subsidy r_δ such that $C(q_{a1}, q_{b1}) < C(q_{a1}) + r_\delta + p^{max}{}_{b1}$, where $p^{max}{}_{b1}$ is the b_1's highest subsidy-free price. □

In Example 4.3, the firm δ provides a limit price for a_1 that is less than the stand-alone cost of q_{a1}. Depending on the size of the subsidy, this price may be greater than δ's incremental cost of producing q_{a1}. This limit price for a_1 is the lowest price that δ could charge for q_{a1} and still earn zero profits; i.e., $C(q_{a1}, q_{b1}) - r_\delta - p^{max}{}_{b1}$.

The Aggregate Incremental Cost Test

To understand the aggregate incremental cost test, recall that the aggregate incremental cost test is redundant with the alternative supplier test and the zero profit constraint. For subsidy-free prices for towns 1 and 2 in Example 4.2, the alternative supplier test requires prices for these towns to be no greater than \$950. This means that the minimum price that a firm earning zero profits can charge is $C(q^{1+2})$ - \$950 = \$700. Therefore, as a matter of arithmetic, the aggregate incremental cost test states that prices can be no lower than \$700, which is greater than the system's \$550 incremental cost, and still be subsidy-free.[9]

The economic reason why the aggregate incremental cost test provides a price floor that is above the firm's incremental cost is that, with MLR from economies of joint production, the firm's incremental cost for a product is lower than the economy's incremental cost for the same product. I first explain why the economy's incremental cost is greater than a firm's incremental cost. I then explain why it is the economy's incremental cost that serves as the minimum subsidy-free price.

Explanation of Aggregate Incremental Cost and Its Importance

Consider again the firms α and δ from Example 4.3. Both firms can produce product a_1 and have economies of joint production. If α produces a_1, the economy gains the scope economies that α offers, but gives up the scope economies that δ offers. Recalling that α is the most efficient arrangement for producing a_1, the net gain to the economy from having α rather than δ produce a_1 is the difference between α's production economies and δ's production economies. Therefore, the economies of joint production realized by the economy when a_1 is added are less than the economies of joint production realized by α when it adds a_1 to the production of a_2.[10] Because the economy's net economies of joint production are less than the firm's joint production economies, the economy's incremental cost is higher.

Example 4.2 illustrates the point just made. Assume that initially there are only three communities, which are towns 2, 3, and 4. The most efficient service arrangement is for them to share a single system, which would cost \$2600. The economies of joint production gained from serving town 2 on the same system as towns 3 and 4 are the difference between the costs of the next most efficient arrangement and the cost of a common system; i.e., $C(q^2) + C(q^{3+4}) - C(q^{2+3+4}) =$ \$150. Now introduce town 1. With the addition of town 1, the most economical service arrangement is for towns 1 and 2 to share a system, and for towns 3 and 4 to share a system. The economies of joint production gained by having towns 1 and 2 share a system are the difference between the costs of separate systems and the cost of the common system; i.e., $C(q^1) + C(q^2) - C(q^{1+2}) =$ \$550. The net gain to the economy is the net gain in production economies, or \$400.

The agreement on the cost sharing arrangement determines which customers receive the benefits of joint production. If the customers in town 1 capture all of these net gains, they pay their minimum subsidy-free price; i.e., their contribution to covering the cost of the system is the difference between their stand-alone cost and net gain to the economy, or $C(q^1)$ - \$400 = \$700. If customers elsewhere in the economy capture all of these net gains in production economies, the customers in town 1 pay their maximum subsidy-free price. That is to say, the customers in town 1 pay their incremental costs to the system plus the economy's gains in economies of joint production; i.e. their contribution to the system is $[C(q^{1+2}) - C(q^2)]$ + \$400 = \$950.

The incremental cost to the economy of adding town 1 is equal to the economy-wide cost of an efficient market structure with town 1, which is \$3300, minus the economy-wide cost of an efficient market structure without town 1, which is \$2600. This makes the economy's incremental cost of adding town 1 to be

$$C(q^{1+2}) + C(q^{3+4}) - C(q^{2+3+4}) = \$700.$$

Because the example has symmetry, each town has this aggregate incremental cost.

A subsidy-free price of a product must cover the incremental cost that the product imposes on the economy if customers of other products are not to be made worse off by the production and pricing of the product in question. To illustrate this point, consider the water example with transport equal to $100 per mile, which is Example 4.2. Assume that town 1 insists on paying no more than its incremental cost for the system that serves towns 1 and 2. This means that customers from town 2 would have to pay their stand-alone cost of $1100 if the system is to be financially viable. Because town 2's customers can buy from the town 3-4 system for an incremental cost of $950, town 2 is clearly worse off with town 1 and town 1's proposed price than it would be in a system with towns 3 and 4.

Implications for the Allocation of Common Costs

It is worth noting that MLR creates a result that is contrary to a long-held belief in economics; namely, that the assignment of common costs to a product, except through a Ramsey formula, results in a loss of economic efficiency. (Baumol 1979, p. 238; Baumol, Koehn, and Willig 1987; Berg and Weisman 1992, p. 457) With MLR from economies of joint production, *not* assigning some portion of common costs to each product can result in a loss of economic efficiency by giving customers price signals that encourage a market structure that is not cost minimizing. Example 4.2 illustrates this point. In this example, each town must make a contribution of $150 to its systems' common costs. The common costs of each system are $C(q^i) + C(q^j) - C(q^{i+j}) = \$550$, where $(i,j) \in \{(1,2) \text{ or } (3,4)\}$.[11] The contribution each town must make is the difference between its minimum subsidy-free price and its firm incremental cost; i.e., $700 - $550 = $150.

SUBSIDY-FREE PRICES WITH INTERDEPENDENT DEMANDS

Faulhaber (1975, pp. 974-976) and Baumol (1979, pp. 241-244) explain how Faulhaber's tests for cross-subsidy apply in the case of interdependent demands. With interdependent demands, the stand-alone cost test considers the net stand-alone cost and the incremental cost test considers the net incremental cost.[12] These are called “net” because they incorporate the changes in costs that occur because of changes in demand for the utility's other products, changes caused by altering the production of the products in question. For both tests, the revenue considered is the net incremental revenue, which includes the changes in revenue for the utility's other products.

To illustrate their result, consider Example 4.4.

> Example 4.4. Consider the firms and products in Example 4.3. For this example, assume that a_1 has economies of scope with no other product but a_2, and vice versa. □

In Example 4.4, α's net incremental revenue of producing and selling q_{ai} is the revenue from its own sales, plus the revenues it stimulates (represses) in sales of a_j. More formally, $r_{ai} + p_{aj}(q_{aj} + \Delta q_{aj}(q_{ai})) \cdot (q_{aj} + \Delta q_{aj}(q_{ai}))$, where $\Delta q_{aj}(q_{ai})$ is the change in the demand for a_j that results from q_{ai} and $r_{ai} = p_{ai} \cdot q_{ai}$. α's net incremental cost of producing q_{ai} is the extra cost of its own sales, plus the cost of supplying the demand it stimulates (represses) in sales of a_j. More formally, the net incremental cost is $C(q_{ai}, q_{aj} + \Delta q_{aj}(q_{ai})) - C(0, q_{aj} + \Delta q_{aj}(0))$.

Subsidy-free prices with interdependent demands in the MLR context are more complex because there are more choices in the types of firms that may produce the utility's products. These firms may sell more or less output than the utility, depending upon these firms' production economies and product demands. Also, demand interdependencies may depend upon which firm produces which product.[13]

To illustrate the situation in the MLR framework, consider Example 4.3. It is feasible that α sells more of a_1 if it also sells q_{a2}, but its sales of a_1 are unaffected by q_{a2} if q_{a2} is produced and sold by δ. An example may be a telephone company which sells more calling features if it sells local telephone service, but does not sell more calling features if a competitor produces and sells the local telephone service. The reverse could also be true. A large customer may be willing to purchase more public telecommunications services if it can diversify its supply by purchasing from multiple suppliers. Without the option to have multiple suppliers, the customer may construct a private network and then use the private network for most of its traffic in order to spread the private network's fixed costs over more traffic units. Finally, it may not matter who produces and sells the complementary products. For example, some customers of energy savings devices may view the devices as reasonable substitutes for energy consumption regardless of who provides the devices.

Now consider the firms and cost structures from Example 4.3. Assume that customer demand for a_1 for α depends upon the production of a_2 and b_1 and on who produces and sells them. Specifically, assume that customers prefer to purchase a_1 and a_2 from the same firm and prefer to buy a_1 and b_1 from separate firms. Let q_j^k represent the quantity of j produced and sold by firm k. Then α's net incremental revenue from q_{a2}^{α} is

$$r_{a2} + p_{a1}(q_{a1}^{\alpha} + \Delta q_{a1}^{\alpha}(q_{a2}^{\alpha})) \cdot (q_{a1}^{\alpha} + \Delta q_{a1}^{\alpha}(q_{a2}^{\alpha})).$$

α's net incremental cost of producing q_{a2}^{α} is the extra cost of its own sales, plus the cost of supplying the demand it stimulates in sales of a_1; more formally

$$C(q_{a2}^{\alpha}, q_{a1}^{\alpha} + \Delta\, q_{a1}^{\alpha}(q_{a2}^{\alpha})) - C(0, q_{a1}^{\alpha} + \Delta\, q_{a1}^{\alpha}(0)).$$

α's net incremental revenue from choosing $q_{b1}^{\alpha} = 0$ is the revenue forgone by not selling b_1, plus the extra revenue from a_1 that is created by β's sales of b_1; more formally

$$- p_{b1}(q_{b1}^{\alpha}) \cdot q_{b1}^{\alpha} + p_{a1}(q_{a1}^{\alpha} + \Delta q_{a1}^{\alpha}(0, q_{b1}^{\beta})) \cdot (q_{a1}^{\alpha} + \Delta q_{a1}^{\alpha}(0, q_{b1}^{\beta}))$$

where $\Delta q_{a1}^{\alpha}(q_{b1}^{\alpha}, q_{b1}^{\beta})$ is the change in demand for a_1 that is caused by q_{b1}^{α} and q_{b1}^{β}. α's net incremental cost of producing $q_{b1}^{\alpha} = 0$ is the extra cost of its own sales of a_1, minus the costs saved by not producing b_1; namely

$$C(q_{a1}^{\alpha} + \Delta\, q_{a1}^{\alpha}(0, q_{b1}^{\beta}), q_{a2}^{\alpha}, 0) - C(q_{a1}^{\alpha}, q_{a2}^{\alpha}, q_{b1}^{\alpha}).$$

COMPETITIVE ENTRY AND SUBSIDY-FREE PRICES

Baumol and Faulhaber (1988, p. 596) explain that competitive entry, with the RC assumption, is at the core of their thinking about subsidy-free pricing. They state:

> "The basic idea is that in an industry characterized by economies of scale and scope, because marginal cost pricing is not viable, consumers are appropriately protected in terms of pricing if no price or combination of prices is sufficiently high to make it profitable for a hypothetical efficient entrant to undertake the supply of the combination of services in question. When, in a market in which entry is not in fact free, prices nevertheless pass this hypothetical entrant test, consumers must obviously be receiving price benefits at least as great as would have accrued to them had entry barriers been totally absent. That, in essence, is the logic of the stand-alone cost test which requires prices to be such that no combination of the supplying services yield revenues exceeding the stand-alone cost of those services – the cost of a hypothetical efficient entrant serving them alone."

However, in the case of MLR, the stand-alone cost and incremental cost tests do not ensure that consumers receive the price benefits of the hypothetical efficient entrant. With MLR, the hypothetical entrant is not a stand-alone competitor. Instead, the entrant produces products that the utility does not produce. Furthermore, the entrant has economies of scope and charges subsidy-free prices. This type of entrant imposes a maximum subsidy-free price that is below stand-alone cost. As Example 4.2 illustrates, this maximum subsidy-free price may be as low as the hypothetical entrant's incremental cost. The result of MLR for the utility's customers is that they will share the economies of scope of the utility by sharing the utility's common costs. In contrast and as Trebing (1984a) explains, the Faulhaber stand-alone cost and incremental cost tests give all of the benefits of joint production to the competitive markets and force the non-competitive markets to cover all of the utility's common costs. In Jamison (1997b, p. 126), I extend Trebing's conclusions by explaining that this result is counter to the purpose of regulation. Regulation is generally intended to protect captive customers from paying prices that are higher than would exist in competitive markets. Considering MLR contributes to solving this dilemma because the MLR framework provides a rationale for giving non-competitive markets a share of the economies of joint production through a price cap that is less than stand-alone cost.

Even though competitive entry is at the center of Faulhaber's view of subsidy-free prices, even with MLR, Chapter 5 explains that subsidy-free prices are inadequate to ensure that entry is efficient. The true competitive issue is whether prices are sustainable. Sustainability is the key because, whereas subsidy-free pricing considers whether products or customers can be made better off with entry by a hypothetical efficient firm, sustainability recognizes that entrants can target portions of a market and portions of a customer's demand. Chapter 5 explains this in more detail.

EXISTENCE OF SUBSIDY-FREE PRICES

Faulhaber (1975, pp. 969, 974) and Baumol (1986, p. 121) explain that the space of Faulhaber's subsidy-free prices is called the core in game theory parlance. James W. Friedman (1990, p. 17) explains that the core "is based on the notion that an outcome agreeable to all players must give as much to each single player and to each coalition as it (the player or coalition) can achieve for itself."[14] Faulhaber also explains that there can be times when the core is empty; i.e., there are circumstances in which subsidy-free prices do not exist and coalitions of customers will, therefore, defect to a stand-alone competitor.

Sharkey (1982b, pp. 123-134) provides a technical explanation of conditions that ensure that the core is non-empty; i.e., that subsidy-free prices do exist. In general, subsidy-free prices exist if there are uniformly increasing returns to scale; i.e., economies of scale continually increase as production increases. Sharkey also explains that subsidy-free prices do not exist if returns to scale increase up to a certain level of production and then decrease if production increases beyond this level. This pattern of returns to scale can result from various factors; for example, a persistent imbalance in demand and aggregate production capacity. Examples 4.5 and 4.6 illustrate the concepts of existence and non-existence of subsidy-free prices.

> Example 4.5. Consider three towns -- 5, 6, and 7 --similar to those in Example 4.2. As Figure 2 illustrates, the towns form the vertices of an equilateral triangle and are 4 miles apart. Each town has citizens who purchase 10,000 gallons of water within the relevant price range. Cost functions are the same as in Example 4.2 -- wells have fixed costs of \$950 per well and transport costs \$100 per mile -- except for the costs of building capacity for wells. In this example, building a well is more costly than it is in

Example 4.2 and there are diseconomies of scale beyond 20,000 gallons of well capacity. Specifically, the cost of capacity is now \$0.02 per gallon up to capacity of 20,000 gallons, the capacity necessary to serve two towns. If the well capacity exceeds 20,000 gallons, special permits and drilling are required that increase the cost to \$0.035 per gallon.

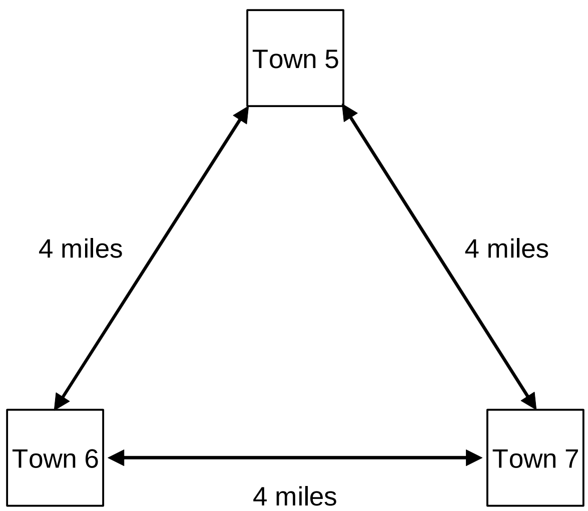

Figure 2. Arrangements of Towns for Examples 4.5 and 4.6

The costs of various water supply systems are:

$$C(q^{[5]}) = C(q^{[6]}) = C(q^{[7]}) = \$1150$$

$$C(q^{5+6}) = C(q^{6+7}) = C(q^{5+7}) = \$1750$$

$$C(q^{5+6+7}) = \$2693$$[15]

The following show the costs of the various arrangements for serving all of the towns:

$$C(q^{[5]}) + C(q^{[6]}) + C(q^{[7]}) = \$3450$$

$$C(q^{i+j}) + C(q^{k}) = \$2900$$

$$C(q^{5+6+7}) = \$2693 \square$$

The most efficient production arrangement in Example 4.5 is for all three towns to share a single system. The cost savings over the next lowest cost arrangement are \$207. Unfortunately, there exists no cost sharing arrangement that can induce this outcome; i.e., there are no subsidy-free prices. Because there is no MLR in this example, subsidy-free prices would only have to satisfy the following constraints on revenues:

$$r_5 + r_6 + r_7 = \$2693$$

$$\$1750 \geq r_i + r_j \geq \$1543 \quad \text{where } i \neq j \tag{4.4}$$

$$\$1150 \geq r_i \geq \$943 \tag{4.5}$$

Consider, for example, prices for towns 5 and 6. According to equation 4.4, their prices must jointly collect no more than \$1750. According to equation 4.5, their prices must separately collect at least \$943. It is impossible for the prices to do both because \$943 + \$943 > \$1750. Therefore, the core is empty, meaning that there are no subsidy-free prices.

Now consider Example 4.6, which is an extension of Example 4.5 and illustrates a situation in which there are subsidy-free prices.

> <u>Example 4.6.</u> Consider towns 5, 6, and 7 from Example 4.5. The only difference between this example and Example 4.5 is that, in this example, if the well capacity exceeds 20,000 gallons, the cost per gallon is \$0.03, \$0.005 lower than in Example 4.5. As a result, the costs of various water supply systems are:
>
> $$C(q^{[5]}) = C(q^{[6]}) = C(q^{[7]}) = \$1150$$
>
> $$C(q^{5+6}) = C(q^{6+7}) = C(q^{5+7}) = \$1750$$
>
> $$C(q^{5+6+7}) = \$2543$$
>
> The following show the costs of the various arrangements for serving all of the towns:
>
> $$C(q^{[5]}) + C(q^{[6]}) + C(q^{[7]}) = \$3450$$
>
> $$C(q^{i+j}) + C(q^{k}) = \$2900$$
>
> $$C(q^{5+6+7}) = \$2543 \square$$

The most efficient production arrangement in Example 4.6 is still for all three towns to share a single system. But in contrast to Example 4.5, subsidy-free prices exist for this example. As in Example 4.5, there is no MLR, so subsidy-free prices simply have to satisfy the following revenue constraints:

$r_5 + r_6 + r_7 = \$2543$

$\$1750 \geq r_i + r_j \geq \$1393 \qquad \text{where } i \neq j$

$\$1150 \geq r_i \geq \$793$

Several cost sharing arrangements could satisfy these criteria. For example, a uniform price of $0.0848 per gallon would generate $848 per town, which is subsidy free.

MLR increases the likelihood of encountering situations in which subsidy-free prices do not exist. This is because with MLR, the utility's cost structure and the cost structures of the alternative suppliers determine the existence of subsidy-free prices. The alternative suppliers place upper bounds on subsidy-free prices that are below stand-alone cost, and place lower bounds on subsidy-free prices that are above incremental cost. These more restrictive bounds make it more likely that the bounds will be incompatible; i.e., that there will be no set of prices that can satisfy both. Without MLR (i.e., in the framework assumed by Faulhaber), the utility's own cost structure is the only factor affecting whether subsidy-free prices exist. In Faulhaber's framework, all alternative suppliers are assumed to use the same technology as the utility and to supply only subsets of the utility's products.

Examples 4.7 and 4.8 illustrate how it is possible for a utility to have a non-empty core for its own production and prices, and yet have no subsidy-free prices. Example 4.7 establishes the initial situation, which does not have MLR and has subsidy-free prices. Example 4.8 introduces MLR, which causes there to be no subsidy-free prices.

> <u>Example 4.7.</u> Consider three towns – 8, 9, and 10 – which are arranged in a triangle. Figure 3 illustrates the arrangement. Towns 8 and 9 are eight miles apart. Town 10 is 4.62 miles from town 8 and 4.62 miles from town 9. In other words, the towns form an Isosceles triangle. As in previous examples, these towns need to provide their citizens with 10,000 gallons of water each. As in Example 4.1, the cost of transporting water is $90 per mile and the fixed cost of constructing a well is $950 per well. Well capacity costs are $0.02 per gallon for wells up to and including 30,000 gallons. This capacity is sufficient for serving all three towns.

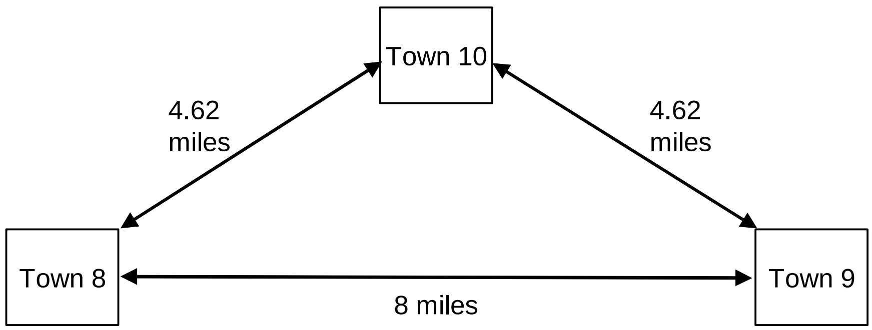

Figure 3. Arrangement of Towns for Example 4.7

The costs of various water supply systems are:

$$C(q^{[8]}) = C(q^{[9]}) = C(q^{[10]}) = \$1150$$

$$C(q^{8+9}) = \$2070$$

$$C(q^{8+10}) = C(q^{9+10}) = \$1766$$

$$C(q^{8+9+10}) = \$2381$$

The well is located in town 10 when all three towns share a well. The following show the costs of the various arrangements for serving all of the towns:

$$C(q^{[8]}) + C(q^{[9]}) + C(q^{[10]}) = \$3450$$

$$C(q^{8+9}) + C(q^{10}) = \$3220$$

$$C(q^{i+10}) + C(q^{j}) = \$2916 \quad \text{where } i, j \in \{8, 9\} \text{ and } i \neq j$$

$$C(q^{8+9+10}) = \$2381 \; \square$$

The most efficient production arrangement in Example 4.7 is for all three towns to share a single system. Because there is no MLR in this example, subsidy-free prices only have to satisfy the following revenue constraints:

$$r_8 + r_9 + r_{10} = \$2381$$

$$\$2070 \geq r_8 + r_9 \geq \$1231$$

$\$1766 \geq r_i + r_{10} \geq \$1231$ where $i \in \{8, 9\}$

$\$1150 \geq r_i \geq \$616$ where $i \in \{8, 9\}$

$\$1150 \geq r_{10} \geq \$311$

Subsidy-free prices exist for this arrangement. For example, with rounding, towns 8 and 9 can each charge \$0.10 per gallon and town 10 can charge \$0.0381 per gallon. With these prices, towns 8 and 9 each covers \$1000 and town 10 covers \$381 of the total cost of \$2381.

Example 4.8 illustrates how MLR can remove the possibility of subsidy-free prices from a utility that, absent MLR, would have subsidy-free prices. Example 4.8 is an extension of Example 4.7.

Example 4.8. Consider the towns in Example 4.7. Now add a fourth town – town 11. Town 11 is eight miles from town 8, eight miles from town 9, and 4.62 miles from town 10. In other words, towns 8, 9, and 11 form an equilateral triangle with sides of 8 miles, and town 10 lies in the center of the triangle. Figure 4 illustrates this arrangement. The costs are the same as in Example 4.7, with the additional information that well capacity costs are \$0.04 per gallon for wells exceeding 30,000 gallons. The single well constructed for Example 4.8 has a capacity of 30,000 gallons. The costs for systems involving combinations of towns 8, 9, and 10 only are the same as in Example 4.7. Adding town 11 gives the following system costs:

$C(q^{[8]}) = C(q^{[9]}) = C(q^{[10]}) = C(q^{[11]}) = \$1150$

$C(q^{i+j}) = \$2070$ where $i, j \in \{8, 9, 11\}$ and $i \neq j$

$C(q^{i+10}) = \$1766$ where $i \in \{8, 9, 11\}$

$C(q^{i+j+10}) = \$2381$ where $i, j \in \{8, 9, 11\}$ and $i \neq j$

$C(q^{i+j+k}) = \$2990$ where $i, j, k \in \{8, 9, 11\}$ and i, j, and k are all different

$C(q^{8+9+10+11}) = \$3797$

The following show the costs of the various arrangements for serving all of the towns:

$C(q^{[8]}) + C(q^{[9]}) + C(q^{[10]}) + C(q^{[11]}) = \$4600$

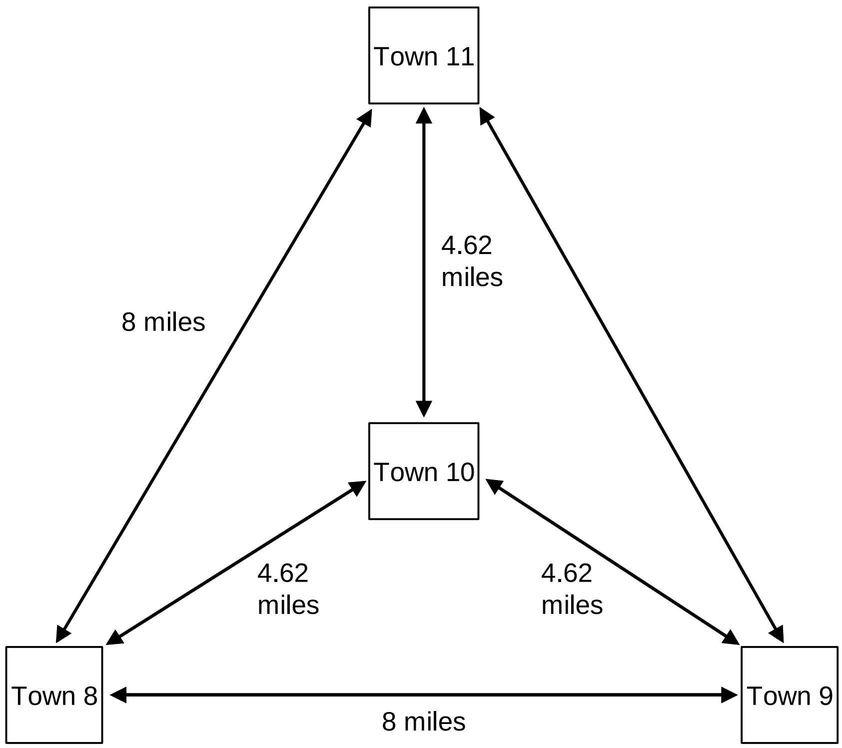

Figure 4. Arrangement of Towns for Example 4.8

$C(q^{i+j}) + C(q^{k}) + C(q^{10}) = \$4370$ where $i, j, k \in \{8, 9, 11\}$ and i, j, and k are all different

$C(q^{i+j+k}) + C(q^{10}) = \$4140$ where $i, j, k \in \{8, 9, 11\}$ and i, j, and k are all different

$C(q^{i+10}) + C(q^{j}) + C(q^{k}) = \$4066$ where $i, j, k \in \{8, 9, 11\}$ and i, j, and k are all different

$C(q^{i+j}) + C(q^{k+10}) = \$3836$ where $i, j, k \in \{8, 9, 11\}$ and i, j, and k are all different

$C(q^{8+9+10+11}) = \$3797$

$$C(q^{i+j+10}) + C(q^k) = \$3531 \text{ where } i, j, k \in \{8, 9, 11\} \text{ and } i, j, \text{ and } k \text{ are all different}$$

The most efficient production arrangement for Example 4.8 is essentially the same as in Example 4.7. Two of the three perimeter towns – towns 8, 9, and 11 – should share a well with town 10 and the remaining perimeter town should have its own system.

Example 4.8 has no subsidy-free prices. Recall that a product's minimum subsidy-free price is the incremental cost of adding the product (in this case a town) to the economy. In Example 4.8, adding a perimeter town to the economy brings no new economies of joint production, so its minimum subsidy-free price must generate revenues equal to its stand-alone cost of $1150. Because towns 8, 9, and 11 are perimeter towns, each has this same minimum subsidy-free price. However, the maximum subsidy-free price for two perimeter towns cannot generate revenues greater than the incremental cost of adding the two towns to a system supplying all three perimeter towns, or $C(q^{i+j+k}) - C(q^i) = \$1840$, where $i, j, k \in \{8, 9, 11\}$ and i, j, and k are all different. This is less than $2300, which is the sum of revenues that two towns' individual minimum subsidy-free prices must generate. It is impossible for a single set of prices to generate revenues that are both no greater than $1840 and no less than $2300, so no subsidy-free prices exist.

Further research is needed to develop definitive conditions in a MLR context that either ensure the existence of subsidy-free prices or determine when subsidy-free prices do not exist. Example 4.8 illustrates one situation where they do not exist. The key feature of this example is that the product that is added to the economy adds significantly fewer economies of scope than existing products, and that the added product is a substitute (in a production sense) for some of the existing products. In other words, the economy, rather than the firm, is exhibiting first increasing returns to scale and then decreasing returns to scale. Sharkey (1982b, p. 134) shows that a firm with such returns to scale does not have subsidy free prices. Example 4.8 shows that this result also applies to the economy as a whole.

Utility regulators rarely, if ever, encounter the issue of non-existence of subsidy-free prices. There appear to be at least two reasons. First, contestable markets do not exist in practice (Shepherd 1984, pp. 576-585), so the danger of large coalitions of customers instantly defecting to a competitor because of the non-existence of subsidy-free prices appears remote. Second, if subsidy-free prices do not exist and the markets are sufficiently close to contestable that the pricing problem matters, then it is unlikely that the utility ever served the grand coalition of customers (i.e., all of the customers) and neither the utility nor the regulator would be likely to know that the problem existed.

APPLICATIONS: PREVENTING ANTI-COMPETITIVE CROSS-SUBSIDY

Regulated companies and regulators frequently apply Faulhaber's theory in addressing competitiveness issues. There are two basic approaches. One approach is to set minimum prices that utilities can charge in competitive markets. The other approach is to set maximum prices that utilities can charge in non-competitive markets. I discuss these applications in this section. I first describe situations where regulators have applied Faulhaber's theory. I then describe economic research and policy analysis that also has applied Faulhaber's theory. Lastly, I explain how MLR affects these applications and the difficulties of applying economic principles of cross-subsidy.

Applications in Regulatory Settings

Local exchange telephone companies and their competitors in the US often apply Faulhaber's theory by proposing that regulators use incremental costs as price floors in competitive markets to protect against cross-subsidization.[16] To implement this proposal, the regulator identifies which products are competitive, requests incremental cost studies for these products, and adopts procedures for ensuring that the local telephone companies' competitive prices do not go below incremental cost. Procedures may include minimum prices that are stated in the companies' tariffs, or confidential incremental costs that are known only to the regulated companies and the regulator. The regulated companies are free to adjust prices in response to competition as long as the prices do not fall below their incremental costs. According to Faulhaber's theory, the regulator should establish price floors for groups of services as well as individual services, but this is rarely done in practice.

The Interstate Commerce Commission (ICC) in the US and the Independent Pricing and Regulatory Tribunal (IPART) of New South Wales in Australia have applied Faulhaber's theory when establishing maximum prices. The ICC determined that maximum prices for captive rail shippers should be at stand-alone cost. (Tye 1991, pp. 259-261; Faulhaber and Baumol 1988, p. 596) IPART reached a similar conclusion for industrial customers of energy. Prices for these customers had been above stand-alone cost. IPART determined that this was unreasonable given Faulhaber's theory, and lowered the prices to just below stand-alone cost. (Jamison 1997b, p. 125)

The FCC in the US used the concept of the core in developing its policies for allocating costs between regulated and non-regulated services. (Faulhaber and Baumol 1988, p. 596; Jamison 1988a, p. 308) The FCC found that Faulhaber's theory was a useful guide, but chose to apply fully distributed cost, falsely believing that this was consistent with choosing a cost sharing arrangement that was consistent with Faulhaber's theory.

Applications in Economic Analysis

Policy advisors and researchers also apply Faulhaber's analysis in addressing competitive pricing issues. Baumol (1979) uses it to explain minimum and maximum pricing principles for utility pricing. Berg and Weisman (1992) rely upon Faulhaber's theory in dispelling myths that they believe regulators and other policy practitioners sometimes hold about cross-subsidization. They identify Faulhaber's theory as providing the basic economic principles underlying portions of their work. Karen Palmer (1992) uses the theory to test for cross-subsidies in New England Telephone's prices. New England Telephone is a wholly-owned subsidiary of Bell Atlantic. She finds that the company's business services subsidized residential services in the 1980s and concludes that entry would result in competitors targeting the business markets and ignoring the residential markets. The consulting company OXERA (1999, pp. 1-2) applies Faulhaber's theory in advising companies and regulators on how to prevent utilities from subsidizing their competitive businesses.

T. Randolph Beard, George H. Sweeney, and Daniel M. Gropper (1995) analyze cross-subsidy issues in the context of interruptible power contracts. An interruptible power contract is a contract between a customer and an electricity provider, which allows the provider to turn off the customer’s power at times when demand is so great that the provider’s system cannot provide all of the energy demanded. Applying Faulhaber’s definition of cross-subsidy, they develop a model for estimating incremental and stand-alone costs for a stylized market with two types of customers (low priority customers and high priority customers), constant capacity costs, and constant non-capacity volume sensitive costs, which they normalize to zero. They find that low priority customers do not receive a subsidy as long as they pay at least their non-capacity volume sensitive costs. They also find that the low priority customers pay a subsidy when their contributions to capacity costs exceed a fraction determined by the relative size of their demand and the difference between the service reliability they receive and the service reliability that the high priority customers receive.

Missing from the Beard-Sweeney-Gropper model are opportunities for customers to receive electricity from other sources outside the system. For example, if retail competition is allowed, customers may be able to purchase power from other energy producers. Even if retail competition is not allowed, it is at least technically feasible to obtain energy from other systems at a cost that is less than stand-alone cost. Chapter 2 describes one approach, called distributed generation. Consistent with cross-subsidy theory, the most cost efficient technically feasible alternative should be the basis for determining maximum subsidy-free prices.

Christopher C. Klein (1993) examines results of fully distributed cost allocation procedures proposed by two natural gas distribution utilities to the Tennessee Public Service Commission. Applying Faulhaber’s definition of subsidy-free prices, he finds that both utilities proposed pricing schemes that would cause some customers to pay prices that provide revenues in excess of stand-alone cost. An analysis incorporating opportunities for customers from MLR would further emphasize the cross-subsidy problems with the utilities' pricing proposals.

Effects of MLR on Competitive Pricing Issues

MLR affects the use of price floors and price ceilings for protecting against anti-competitive cross-subsidy. Regarding price floors, MLR makes incremental-cost-based price floors impractical. One reason is that price floors based on a firm's incremental costs are inadequate to protect against cross subsidization. Even competitive services should contribute to covering a firm’s common costs if prices are to be subsidy free. However, determining the appropriate amount of contribution is difficult at best because the regulator would need to estimate aggregate incremental cost. Estimating aggregate incremental cost requires knowledge of the regulated company's costs, the costs of actual competitors, and the costs of would-be competitors. Also, prices can venture below the firm's incremental costs at specific points and still be subsidy-free as long as revenues over time are adequate to cover incremental costs (Berg and Weisman 1992, p. 453) and make the necessary contribution to common costs.

A further problem with price floors in competitive markets is that, as utility markets become more competitive and regulators allow utility companies more pricing flexibility, the number of cost studies required to protect against cross-subsidy increases. In other words, deregulation prompts increased regulatory work. This is counterintuitive. Competition and deregulation should decrease, not increase, the regulator's work load. A practical solution to this problem may be to focus on maximum subsidy-free prices for non-competitive services. This is essentially a version of a regulatory model recommended by Trebing (1984b).[17] The Trebing model limits economic regulation to markets with residual monopoly power where competition does not appear to be sustainable and uses regulation of market structure to stimulate competition where feasible. This model would cause the scope of regulation to decrease as competition increased.

In addition to affecting the use of price floors, MLR affects the use of maximum prices. With MLR, maximum prices based on stand-alone cost are too high to be subsidy-free. Consider the ICC's maximum prices for captive shippers. If it were technically feasible for a rail company, or some other company, to provide transport to a captive shipper at less than stand-alone cost, then this more economical service arrangement should serve as the maximum price. The same is true for IPART's maximum prices. It should generally be true that industrial customers can join together to find alternative sources of energy supply that cost less than stand-alone cost. Also, they can engage in energy-saving practices. In either case, the most economical alternative should serve as the maximum subsidy-free price.

Administrative Burdens

Recall that Faulhaber's incremental cost and stand-alone cost tests, and my own alternative supplier and aggregate incremental cost tests, require that various combinations of products be tested to ensure that prices are indeed subsidy-free. Edward E. Zajac (1978, p. 46) points out, and the examples in this chapter confirm, that this requirement can be computationally burdensome. He states that if a utility has only six products, it has 63 possible combinations of products that must be examined; if the utility has 10 services, it has 1023 possible combinations. For the alternative supplier and aggregate incremental cost tests, the economy, rather than the firm, determines the number of combinations that should be considered, making the potential number of combinations imponderable.

For at least some situations, the preceding discussion overstates the computational burden. The only groups of products that need to be checked are those that have shared incremental costs. For example, in the telecommunications example I mention earlier in this chapter, it is necessary to test switched voice services and calling features as a group. However, it is probably unnecessary to test calling features and dedicated private line services as a group because it is unlikely that they have shared incremental costs. Also, as Example 4.2 illustrates, it may be unnecessary to test for groups that have relatively weak economies of scope. Testing towns 1 and 4 as a group and towns 2 and 3 as a group is unnecessary because towns 1 and 2 as a group and towns 3 and 4 as a group have much greater economies of scope, and this is obvious without engaging in computations. In general, tests for groups that have shared incremental costs that are very small in relative terms can often be omitted. Nevertheless, MLR increases exponentially the number of computations that must be performed, relative to Faulhaber's framework. This means that simplified approaches can be quite valuable, such as focusing on maximum prices for a few key products.

APPLICATION: UNIVERSAL SERVICE OBLIGATIONS

Universal Service Obligations or USOs generally take the form of government requirements to charge subcompetitive, non-cost covering prices in certain markets to further some social objective, or obligations to provide a level of product quality that customers are unwilling to pay for. Traditionally, governments have allowed utilities to fund USOs by charging supercompetitive prices in other markets. Market liberalization makes this traditional funding system unworkable because competition drives down the supercompetitive prices. When devising new USO funding systems, governments must resolve the issue of the amount of money that is needed. This is generally a new issue because, under the old arrangement, the amount of subsidy was not identified.

There are two basic types of USOs to consider: historical USOs and ongoing USOs. Historical USOs are those that have been fulfilled in the past and, for which, utilities may not have been fully compensated. Ongoing USOs include ongoing or future requirements to price some services at unprofitable levels, to maintain uneconomic levels of infrastructure in order to stand ready to serve, and to place a nonremunerative technology in order to facilitate community or economic development. Paul Joskow (1996) describes compensation for stranded costs. I discuss ongoing USOs for the remainder of this section.

Regulators addressing ongoing USOs have applied both Faulhaber's approach and my approach to identifying cross-subsidy. The choice between the two approaches has depended upon how the USO provider is chosen. There are two basic paradigms for designating USO providers. Most countries identify the incumbent utility as the single USO provider in an area. Only this provider has the USO burden and can obtain USO subsidies. Governments in Australia and the UK use this approach. Other countries use competition to designate USO providers. Chile uses a competitive process to select USO providers for telecommunications, as does Peru. (Wellenius 1996) The US for telecommunications plans to have multiple USO providers in an area.[18] In the US, the new subsidy framework adopted by the FCC under the Telecommunications Act of 1996 targets customers. This means that the subsidy can go to any eligible service provider that the customer chooses.

Ongoing USOs in the UK

There are two USO providers in the UK: BT and, in Hull, Kingston Communications. These companies are obligated to provide voice telephony services to customers even when it is uneconomic to do so. Using Faulhaber's theory of subsidy-free prices, the Oftel, the UK telecommunications regulator, undertook an investigation of the costs that these obligations impose on BT and Kingston Communications. (Oftel 1995) Oftel's consultant, Analysys, identified two aspects of BT's and Kingston Communications' USOs that create USO costs: the cost of provision in uneconomic areas and the cost of provision to uneconomic residential customers in all other areas. (Analysys 1995) In considering how to fund these USOs, Oftel concluded that it is necessary to deduct USO benefits from USO costs so as not to advantage BT and Kingston Communications. Specifically, Oftel has stated that BT and Kingston Communications might receive commercial advantage or financial benefit in the form of: (Oftel 1995)

- enhancement of corporate reputation
- marketing and brand recognition
- information on how customers use the telephone
- benefits associated with customer life cycles
- benefits associated with ubiquity
- the avoidance of loss of business through poor image and loss of trust due to disconnecting or discouraging subscribers
- avoidance of the costs of disconnection, and
- minimization of planning costs.

Analysys estimated that the annual financial cost of serving uneconomic residential customers and uneconomic areas is between £58 million and £89 million for BT, and between £0.39 million and £0.41 million for Kingston Communications. Taking into consideration the benefits, the net costs for BT are between £4 million and £25 million, or between £9 and £40 million depending on the interpretation of the USO. For Kingston Communications, the net cost is approximately £400,000. Based on these estimates, OFTEL decided that the net costs of USOs are sufficiently small to merit no USO subsidy. (Oftel 1997)

Ongoing USOs in Australia

Australia has also followed Faulhaber's theory in estimating USO costs for Telstra. Telstra is the incumbent operator and is the only USO provider in Australia. In 1989, in its first estimate of USO costs, Austel, the regulator at the time, examined both embedded, fully allocated costs and forward-looking incremental costs of USOs. Austel chose the incremental cost method and found costs of A$237 million for general USOs, A$8 million to A$10 million for concessions to charitable organizations and the disabled, A$4.5 million for emergency service, and A$48 million for telephone rentals to pensioners. (Australia 1989) The Australian Communications Authority (ACA, formerly Austel) has recently conducted an updated study of the costs of Telstra’s USOs. In this study, the ACA is estimating Telstra’s net incremental cost of providing standard telephone services and payphones.

Ongoing USOs in Chile and Peru

Chile and Peru auction subsidies for USO obligations, which implicitly incorporates MLR because competition for the market determines the subsidies. Chile was one of the first countries to open its telecom markets to competition. But in 1995, 10% of the population had no access to a telephone. To remedy this, the Chilean government identified unserved areas and estimated potential profitability. It informed telecommunications companies of areas that appeared to be potentially profitable and auctioned subsidies for the apparently unprofitable areas. For the auction, the government set maximum subsidies and price caps for each area. The auction was conducted in 1995-1996. In areas where there was competitive interest, subsidies were bid to zero, reflecting the effects of MLR. In areas with no or only token competition, subsidies were bid at or near maximum, or not bid at all. Prior to the auction, the government had estimated the necessary subsidy would be US$4.2 billion. The auction resulted in actual subsidies of US$2.2 billion granted, although not all of the areas in the US$4.2 billion received bids. (Wellenius 1996) Peru's results have been similar.

Ongoing USOs in the US

In the US, the FCC and State regulators are developing methods for estimating net USO costs that will be portable among eligible carriers. For the FCC, estimating these net costs involves four steps: (1) Estimate the forward-looking economic costs of providing universal service for rural, insular, and high cost areas; (2) Establish a nationwide revenue benchmark calculated on the basis of average revenue per line; (3) Calculate the difference between the forward-looking economic cost and the benchmark; and (4) Estimate the federal support at 25 percent of that difference.[19] The figure of 25 percent represents the percent of local loop costs in the US that are assigned to the federal jurisdiction through the Separations process. The Separations process is the US accounting and cost allocation process for dividing telephone companies' costs between the federal and State jurisdictions.

The FCC has determined that proxy cost models will be used to estimate forward-looking economic costs.[20] A proxy cost model is an engineering process model that estimates costs of a representative company as opposed to a specific company. As of the time of this writing, the FCC is still working on its proxy cost model, but it has reached several decisions regarding how the model should work. One decision is that the subsidy amount will cover some joint and common costs.[21] This is consistent with subsidy-free prices based on MLR.

CONCLUSION

This chapter describes the effects of MLR on subsidy-free prices in the contestable market model. In general, MLR narrows the range of prices that should be considered subsidy free. This implies that the Faulhaber definition is overly generous to incumbent utilities, allowing them pricing latitude in competitive markets and high maximum prices in non-competitive markets that might be contrary to economic efficiency.

This analysis also implies that it is infeasible for regulators to establish subsidy-free prices with any degree of confidence. Establishing subsidy-free prices requires knowledge of the utility's cost function, its competitors' cost functions, their competitors' cost functions, and so on until all combinations of products which could have economies of joint production and that could be affected by the utility's prices, have been considered. This is clearly an impossible task. To the extent that regulation of prices is needed, it seems reasonable that regulators should narrow their interest to products that are non-competitive and that have some definable social importance. For these products, regulators would establish maximum prices that provided these customers with a share of the economies of joint production. All other prices would be deregulated. Chapter 5 describes sustainability issues that should be considered in this framework, and also describes other sustainability issues.

ENDNOTES

[1] Prices are set according to the inverse elasticity rule if "for each service the percentage deviation of quasi-optimal price (is) inversely proportionate to its own price elasticity of demand." (Bonbright, Danielsen, and Kamerschen 1988, p. 533)

[2] I explain later in this chapter why in some circumstances it is unnecessary to test all subsets of the utility's products.

[3] As I explain in more detail later in this chapter, it may be obvious that some products share few if any costs, making it unnecessary to perform formal tests of their prices as a group.

[4] More formally, $S \subseteq \{1, 2, 3, 4\}$.

[5] More formally, $C(q^{[1]}) = C(q_1, 0, 0, 0)$.

[6] Generally I suppress notation showing that demand for a product is a function of its own price.

[7] In an earlier paper (Jamison 1996, pp. 381-382), I analyze how an inefficient firm might constrain subsidy-free prices for an efficient firm. In retrospect, I should have included a subsidy for the inefficient firm. My analysis in this chapter corrects this error.

[8] Because of the assumption of contestable markets, all technologies are freely available to all firms. This makes it unnecessary to use notation to identify a cost function as belonging to a particular firm.

[9] Using the system for towns 1 and 2 as an illustration, the system's incremental cost for town 2 is calculated as $C(q^{1+2}) - C(q^1) = \$550$.

[10] Recall that the incremental cost of the firm for producing q^i is $C(q^N) – C(q^{N\text{-}i})$, where N represents all of the products produced by the firm.

[11] That this is equal to each town's incremental cost is simply an anomaly of this example.

[12] When demand interdependency is ignored, stand-alone cost is called gross stand-alone cost and incremental cost is called gross incremental cost.

[13] This would also apply in the Faulhaber framework, but has not been discussed in the literature.

[14] Susan S. Hamlen, William A. Hamlen, Jr., and Tschirhart (1977) provide a good explanation of the application of core theory.

[15] In this system, the well is in the center of the triangle. It is 2.3 miles from each town, so there are 6.9 miles of transport.

[16]*See, for example,* William E. Taylor (1995, pp. 15-16); Kolb (no date, pp. 1258-1259); Oregon Public Utility Commission (1997, p. 179) citing US West's arguments; and Southwestern Bell (1994, p. 2).

[17] The Trebing model: (1) limits economic regulation to markets with residual monopoly power where competition does not appear to be sustainable; (2) incorporates clear welfare guidelines for social policies pursued through regulation, such as pricing for universal service; and (3) uses regulation of market structure to stimulate competition where feasible. This model could be viewed to assume more stable technologies and markets than we have today. Also, its third element should be adapted to reflect the revolution in market structure that liberalization of telecommunications markets has unleashed. Given these, an appropriately modified Trebing model would appear to have the following elements (Jamison 1999b):

1. Limited economic regulation to markets where there is residual market power, and to services that are well established in the minds and lives of ordinary citizens as essential for living and

engaging in normal economic activity.

2. Explicit welfare objectives and transparent welfare mechanisms that do not distort the competitive market process.

3. Removal of regulatory barriers, based on geography, technology, or other boundaries, that limit companies' markets and their abilities to merge and divest.

One of the key differences between this modified Trebing approach and the Faulhaber stand-alone cost test is that the modified Trebing approach incorporates welfare and other social objectives, which the Faulhaber tests omit. (Faulhaber 1975, pp. 967) The modified Trebing approach considers welfare and social objectives in pricing and pursues these objectives in ways that do not interfere with competition or deregulation.

[18] This may not be true for all USOs. The obligations in the US may not be symmetric among all competing USO providers. In the past, some regulators have required incumbent local exchange carriers to maintain an uneconomic level of infrastructure in order to stand ready to serve or to place a nonremunerative technology in order to facilitate community or economic development. Continuation of these obligations without either the regulator or the market placing a symmetric burden on new entrants, will make this portion of the US USOs be of the single-provider type.

[19] Federal Communications Commission, Federal-State Joint Board on Universal Service, CC Docket No. 96-45, and Forward-Looking Mechanism for High Cost Support for Non-Rural LECs, CC Docket 97-160, *Further Notice of Proposed Rulemaking*, FCC 97-256 (rel. July 18, 1997) , par. 1 (FNPRM).

[20] Federal Communications Commission, Federal-State Joint Board on Universal Service, CC Docket No. 96-45, *Report and Order*, FCC 97-157 (rel. May 8, 1997), par. 6 (Order).

[21]FCC, Order, par. 250.