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POSTAL RATE AND FEE CHANGES, 1997	Docket No. R97-1

DIRECT TESTIMONY
OF
JOHN C. PANZAR
ON BEHALF OF
UNITED STATES POSTAL SERVICE

AUTOBIOGRAPHICAL SKETCH

My name is John C. Panzar and I am the Louis W. Menk Professor of Economics at Northwestern University, where I hold appointments in the Economics Department and in the Transportation Center. I received my B.A. from Carleton College in 1969 and my A.M. and Ph. D. degrees from Stanford University in 1973 and 1975, respectively. At Northwestern I have taught graduate and undergraduate courses in microeconomics and regulatory economics, while serving as Department Chair (1988-92) and Director of Graduate Studies (1984-88; 1993-). I have also taught at the University of Pennsylvania and the University of California at Berkeley. For nine years I held an appointment as a Member of the Technical Staff at Bell Laboratories, where I also served as Department Head. I have published two books and many articles on subjects related to pricing and other issues concerning regulated enterprises. A copy of my curriculum vitae is appended to this testimony.

I began studying postal costing issues more than a decade ago, when I submitted rebuttal testimony for the American Newspaper Publishers Association in Docket No. R84-1. I have also submitted testimony before this Commission on behalf of the Postal Service in Dockets R90-1, R94-1, and MC95-1. My research in postal pricing and costing issues has intensified over the past several years. Since 1990 I have participated in many international postal conferences and workshops, presenting papers and serving as an invited discussant.

PURPOSE AND SCOPE OF TESTIMONY

In past cases, I have focused on postal costing issues. In the present proceeding, I will again examine the critical role played by two related, but different ways of looking at what causes the Postal Service's costs: the causation of costs at the margin of production, and the incremental costs caused by provision of the entire volume of a particular product or service. In addition, I will discuss the proper method of calculating incremental costs,

and some common errors and fallacies in developing incremental costs which must be avoided. I will analyze the validity of the Postal Service's initial effort to develop incremental costs (in addition to marginal costs) for use in rate-making proceedings before the Commission. Having concluded that the Postal Service's approaches to measuring marginal and incremental costs are appropriate and correct, I will describe the proper use to which the estimated volume-variable/marginal costs, and incremental costs should be put in developing postal rates which are economically sound, socially optimal, and are fair in the sense that they avoid cross-subsidization. I will also discuss the potential dangers inherent in inappropriate use of marginal cost and incremental cost measures in postal rate-making, and caution against such misuse.

Most directly, my testimony presents the theoretical foundations for the empirical analyses of incremental costs presented in the testimony of Mr. William Takis. Although, to my knowledge, the Postal Service has not previously presented comprehensive direct evidence on the incremental costs of various mail subclasses, an understanding of the incremental costs of an enterprise is necessary for rational rate-making. Therefore, much of this testimony is devoted to explaining how the Postal Service's established activity-based cost accounting system can be used to develop accurate measures of the incremental costs for the various subclasses of mail.

However, the analysis cannot start there. Any attempt to determine empirical values for inherently *forward looking* economic cost concepts using historical accounting data must implicitly presume that the process which generated the data will continue to be valid in the future. Thus, in explaining how to use Postal Service cost accounts to measure economic cost concepts, I assume that Postal Service operations follow an operating plan. By this I do not mean a formal document, but rather a set of reasonably stable practices and procedures which the Postal Service uses in order to serve the mail volumes it receives. Under this interpretation, the Postal Service's accounting data

represents the costs of implementing the operating plan under various levels of mail volumes. It is then natural to envision using this structure to calculate the changes in costs which would result from implementing the operating plan for various changes in (the vector of) mail volumes.

There are two especially natural types of changes to consider. The first is an increment of one unit of mail volume of a particular subclass of service. The additional cost of providing this unit of service is the *marginal cost* of the mail subclass in question. It turns out that this amount is equivalent to the concept of *unit volume variable cost*, a measure that has long been calculated by the Postal Service for costing and decision making purposes. Since the marginal costs of the Postal Service must form the basis for any rational rate-making process in the presence of a break-even constraint, my testimony should also be viewed as important background for the testimony of Mr. Peter Bernstein, which presents estimates of efficient, demand-based (Ramsey) prices for the Postal Service.

The second type of volume change to consider is that of an entire mail subclass. The cost savings resulting from removing this volume of mail from the system are the *incremental costs* of that subclass. Having established the theoretical equivalence between the unit volume variable costs of a subclass and its marginal cost, it is then possible to explore the relationship between the Postal Service's cost accounting system and the incremental costs of mail subclasses and groups of subclasses. While no "simple" formulas emerge, my analysis explains how, when viewed in the context of an overall operating plan, Postal Service accounting data can be used to calculate the incremental costs necessary for subsidy analyses of postal rates. The testimony of Mr. Takis further specifies the technical details required and carries out the actual empirical analyses.

I. MARGINAL COSTS AND INCREMENTAL COSTS: ESSENTIAL CONCEPTS FOR RATIONAL POSTAL RATE-MAKING.

Economic theory has established that there are two cost concepts which must play a crucial role in rational rate-making for a regulated enterprise operating under conditions of economies of scale and economies of scope: the marginal costs and the incremental costs of a service. These cost concepts are obviously very closely related, as is explained in more detail below and in the testimony of Witness Takis. However, they have very different roles to play in the rate-making process. In my view, many of the contentious issues in postal costing and pricing have their origin in the attempt to have the statutory notion of attributable costs fulfill both of these roles simultaneously. This attempt is unnecessary and doomed to failure.

The starting point for any pricing analysis is the (vector of) marginal costs of the enterprise's services. The crucial role of marginal costs in rate-making has long been emphasized in testimony before this Commission,[1] and I will not repeat those arguments in detail here. However, the detailed costing procedures of the Postal Service are based on the concept of *volume variable costs,* not the marginal costs of economic theory. Thus one important goal of my testimony is to explain the linkage between the service specific volume variable costs produced by the Postal Service's system of cost accounts and economic marginal costs.

Incremental costs, on the other hand, have not been the focus of postal rate proceedings, and this is the first time that the Postal Service has presented estimates of the incremental costs of all of the various mail subclasses. Thus it is important to explain

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[1] See, for example, the Direct Testimony of William J. Baumol in Docket No. R87-1, USPS-T-3, pages 25-27.

in some detail the appropriate role which incremental costs should play in the rate-making process, as well as to explain how they may be appropriately calculated using the cost data of the Postal Service.

A. Marginal costs are the basis for rational rate-setting.

The efficiency role of marginal cost pricing in the competitive market model is easy to understand. The market price of a good or service measures the value (in terms of money available to spend on other goods and services forgone) of the marginal unit purchased. If the value of said marginal unit were less than its market price, consumers would spend their money elsewhere. Similarly, if consumers valued the last unit purchased at more than the market price, they would increase their purchases. Thus, in general, maximizing behavior on the part of consumers ensures that no unit purchased is valued at less than the market price and that the marginal unit purchased is valued at the market price.

On the supply side of the market, marginal cost measures the value of the resources required to produce the marginal unit of the service in question. It clearly would be economically inefficient for price to be set below marginal cost, for this would lead to a situation in which consumers valued the goods and services forgone to purchase the marginal unit at less than the resources used in providing that unit. Society would be better off if the last unit were not produced. A similar argument demonstrates the inefficiency associated with pricing above marginal cost. In that case, consumers would value an additional unit of service more than they do the resources which would be used to produce it. Society would be better off if an additional unit were provided.

Unfortunately, the presence of economies of scale makes it impossible for an enterprise to set all of its prices equal to the associated marginal costs and still break-even. That is, when there are economies of scale, the revenues resulting from setting all

prices equal to the associated marginal costs are always less than the total costs incurred.[2] Thus when, as in the case of the Postal Service, the enterprise is required to generate revenues which cover its costs, the prices of some or all services must be set ("marked-up") above the corresponding marginal costs. There are typically an infinite variety of pricing combinations which will generate the revenues required by the enterprise. The precise pattern of mark-ups chosen will be determined by the objectives of the rate-making authority as well as by market considerations. However, the marginal costs of the various services are essential information for the implementation of *any* rational pricing policy. This is a logical consequence of the break-even requirement. Whatever goals the rate-maker wishes to pursue via the prices of various subclasses of mail, they can be pursued effectively only by taking cognizance of the marginal costs of expanding or contracting the relevant mail volumes.

At a minimum, estimates of marginal costs can be used by the rate-making authority to avoid the first type of economic inefficiency discussed above: providing services which consumers value less than the resources used to produce them. In addition, the marginal cost pricing floor plays an important role in allocating output among firms when there are multiple providers of a service. Competitive rivals of the Postal Service would maximize their profits by selecting their output levels to equate their marginal costs to the market price. If that price were below the marginal cost of the Postal Service, productive efficiency could be improved by shifting output from the Postal Service to its rival(s).

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[2]This was established for the multi-output firm in J. C. Panzar and R. D. Willig, "Economies of Scale in Multi-Output Production," *Quarterly Journal of Economics,* 91 3, August, 1977, pp. 481-93.

B. *Incremental costs should be used to evaluate postal rates for cross-subsidy.*

The Postal Reorganization Act stipulates that postal prices should be "fair" and "reasonable," and imposes

> the requirement that each class of mail or type of mail service bear the direct and indirect postal costs attributable to that class or type plus that portion of all other costs of the Postal Service reasonably assignable to such class or type.

Over the last twenty years, the economics literature has come to interpret such strictures as requiring that the rate schedule be free from *cross-subsidy.* The test accepted by economists to determine whether or not any service (or group of services) is receiving a subsidy is

> *The Incremental Cost Test.* The revenues collected from any service (or group of services) must be at least as large as the additional (or *incremental)* cost of adding that service (or group of services) to the enterprise's other offerings.

This test is a very intuitive fairness standard. For if a service's revenues do not cover the additional costs the enterprise incurs in providing it, the users of that service are receiving a subsidy from the enterprise's other customers. On the other hand, if the revenues from all services (or groups of services) are at least as large as their incremental costs, then no user or group of users is burdened by their provision. Indeed, in that case, the provision of each service (or group of services) reduces the amount of revenues which must be collected from the remaining services in order for the enterprise to break even. And, the rate schedule is free from cross-subsidy.

It is important to note that, as a test for cross-subsidization, the incremental cost test described above is calculated only with respect to changes in the *quantity* produced of

a particular service (or group of services). It is certainly possible, in principle, to calculate the incremental costs of providing certain service quality attributes, such as daily delivery. While the results may be important for decision-making purposes, they have nothing directly to say about whether or not a service with *given* quality attributes is being subsidized.

Incremental cost tests may also have an important efficiency role to play. The incremental costs which the Postal Service incurs in providing a mail service measures the costs to society of having that particular service provided as part of the larger Postal Service enterprise. In many cases, alternative supply arrangements may be possible. For example, it is obviously possible to supply parcel or overnight services through separate, stand-alone operations. From a social point of view, stand-alone provision would be desirable whenever the *stand alone costs* of independent provision of a mail service (or group of mail services) are less than the Postal Service's incremental costs of that service (or group of services).

In a world of completely free entry, it would be impossible for an enterprise to successfully offer a tariff schedule that involved cross-subsidy.[3] Entrants would appear to serve those service categories for which revenues were in excess of stand alone costs, because such entrants could envision cutting the going price while still earning a profit. Alternatively, if the revenues received from a group of services were not at least as large as the added costs of providing them, entry would occur by a firm which refused to offer

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[3]See William Baumol, John Panzar, and Robert Willig, *Contestable Markets and the Theory of Industry Structure,* Harcourt, Brace, Jovanovich (1988), for a thorough discussion and demonstration of this result.

such services. Relieved of this cross-subsidy burden, the entrant could under price the established firm in competition for the remaining services.

Of course real world markets are rarely, if ever, so contestable that the slightest divergence between revenues and stand-alone or incremental costs would immediately result in entry as described above. Also, there may be legal limitations to entry such as those embodied in the Private Express Statutes. Nevertheless, it must be borne in mind that the prices of Postal Service and other regulated enterprises are always being scrutinized for profit opportunities by current and prospective competitors and other entrepreneurs. Therefore it is important for Postal Service to be "sending the right pricing signals," both to enhance overall economic efficiency and to retain those markets in which it enjoys a true competitive advantage.

As is well known, one of the functions of marginal cost pricing in competitive markets is to reveal the value of the social resources used to produce the product or service in question to potential entrants. If, based on these price signals, an entrepreneur enters the market, it must be because the productive techniques at his disposal allow him to produce the product or service at a lower social resource cost, otherwise he could not profitably provide service. Prices necessarily lose some of this efficiency role in markets served by a multiproduct monopoly firm operating under conditions of economies of scale. Such an enterprise could not break even if all services were sold at prices equal to marginal costs. Thus there is an inevitable wedge created between the signals sent to potential competitors, which are based on the monopoly's tariffs, and the social opportunity costs of the resources used in providing the goods or services in question.

Yet monopoly tariffs can still play an efficiency enhancing, signalling role by satisfying the constraints imposed by the incremental cost test. If the monopolist's prices are set below per unit incremental costs, firms with superior productive techniques would

be inefficiently deterred from entering the market. Their entry would necessarily improve social efficiency by decreasing the total resource cost of providing industry services. In addition, the monopoly could be required to lower prices on its remaining services and still break even.

C. *Digression: Are Ramsey prices necessarily free of cross-subsidy?*

The previous section has argued that, in addition to their intuitive fairness properties, there are important efficiency reasons for the Postal Service to attempt to set rates that are free of cross-subsidy. Indeed, the reasons offered are quite similar to the rationale for studying efficient pricing in the first place: as part of an attempt for the Postal Service to enhance its inherent competitive advantages in increasingly competitive postal markets. Witness Bernstein presents estimates of the Ramsey optimal postal prices, i.e., those that would maximize the sum of producer plus consumer surplus subject to the constraint that the Postal Service's revenues cover its costs. However, nothing in the underlying mathematics ensures that such economically efficient prices will automatically be free of cross-subsidy. Therefore it is necessary to attempt to determine whether proposed or established prices satisfy these cross-subsidy tests.

It may seem surprising that the question of cross-subsidization remains an issue even if the Postal Service were to engage in Ramsey optimal pricing. The potential conflict between Ramsey prices and cross-subsidization springs from the fact that Ramsey prices are based on marginal costs, while the cross-subsidy tests under discussion are based on incremental and stand-alone costs. A simple hypothetical example will illustrate the difficulty. Suppose a monopoly provides its basic service, service 1, by constructing a facility which has annualized costs of B, after which the service can be produced at constant per unit cost of b. Given that it has incurred the facility costs necessary to offer the basic service, the monopoly can offer an enhanced service by

incurring additional (annualized) facility costs of E, after which the service can be provided at a constant per unit cost of e. Finally, suppose that the demand for the basic service was completely price inelastic at the quantity Q, while the demand for the enhanced service was quite price elastic (perhaps due to extensive competition from providers of similar services).

It is straightforward to calculate the Ramsey pricing outcome in this simple example. All of the enterprise's overhead costs would be recovered from the inelastic basic service, and its price would be given by $p_b=b+(B+E)/Q$. Users of the price elastic enhanced service would be charged an amount equal to the service's marginal cost, so that $p_e=e$. (Suppose that they purchase D_e units at this price.) While this is clearly the social surplus maximizing outcome (deadweight loss is zero in this example), the solution obviously involves cross-subsidization of the enhanced service by users of the basic service. Basic service users end up paying a total of $p_bQ=bQ+B+E$ which is greater than the stand-alone cost of providing basic service, which is only $bQ+B$. Alternatively, the cross-subsidization can be uncovered by observing that the enterprise receives revenues of eD_e from users of the enhanced service while the incremental costs of providing that service are eD_e+E.

The example also serves to illustrate the problems which may emerge when attempting to test Postal Service Ramsey prices for cross-subsidization. Depending on demand elasticities, Ramsey prices for substitute services may be as low as marginal cost, or unit volume variable cost in Postal Service costing jargon. However, in order to avoid being subsidized, a service's prices must be above average incremental cost, which include the specific fixed costs of a service. The above example shows how the presence of product specific fixed costs creates a wedge between marginal cost (or unit volume variable cost) and average incremental cost.

II. DERIVING ECONOMICALLY RELEVANT MARGINAL AND INCREMENTAL COST MEASURES FROM POSTAL SERVICE ACCOUNTING DATA.

Traditional Postal Service costing procedures were designed to measure the total volume variable costs as well as the *specific fixed costs* of individual mail subclasses. Therefore, it is necessary to explain how to adjust these traditional measures in order to calculate an estimate of both the marginal and incremental costs of individual mail subclasses. The economic theory behind these tasks is presented in this section.

A. The challenge: Economic analysis requires forward-looking costs, but accounting measures are based on historical data.

In order to understand the nature of the problems encountered in using accounting costs to generate estimates of marginal costs for pricing purposes, recall that, by its very nature, the pricing analysis is prospective, while accounting costs are inherently retrospective. That is, the analysis must use as its basic input the cost of the resources required to produce one *additional* unit of the service in question. Only through this calculus can the social cost savings from foregoing production of an additional unit of service be weighed against the benefits lost from depriving consumers of the benefits of that unit.

Accounting costs, on the other hand are necessarily constructed from records of *past* expenditures and *past* service levels. Taken in isolation, they cannot even begin to address the forward-looking question required for economically efficient pricing analysis: "How much would costs increase if another unit of some specific service were provided?" Clearly a methodological framework must be constructed to explain how accounting data can be legitimately used to attempt to answer this question.

B. Obtaining economic marginal costs from accounting data presumes an operating plan.

Using historical data to attempt to say anything about the cost impact of prospective output changes requires, at a minimum, that the process which generated the costs in the past will also be operating in the future. In particular I assume that there exists a reasonably well-defined set of operating procedures which determine the steps taken and resources used to process a given volume of mail. This is what I mean by an operating plan. In general, the details of the operating plan may depend on the mail volumes in question and the prices of the inputs used. For example, one would expect different procedures to be used if the planned volume of mail was a billion pieces per year rather than a million. Similarly, the number of workers hired to process a given volume of mail may be quite different if wages are $100 per hour rather than $20 per hour.[4]

The presumption of a well-defined operating plan makes it possible to predict the expenditures required for the Postal Service to handle a given vector of mail volumes *(M)*, at given prices of labor and other inputs *(w)*. This is accomplished by merely "costing out" the operating plan to define a Postal Service cost function, $C(M,w)$. That is, the operating plan yields a list of all the resources required to service the given mail volumes. Postal Service costs are then just the expenditures which must be incurred to obtain the required resources at given input prices.[5]

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[4]Thus the operating plan is a function of the vectors of mail volumes *(M)* and input prices *(w)*: i.e., $OP=OP(M,w)$.

[5]That is, $C(M,w)=w\,x(M,w)$, where $x(M,w)$ is the vector of resources specified by the operating plan.

The basic logic of the process is as follows. Given projected mail volumes M, the operating plan generates a list x of resources required to service M. Postal Service costs, $C(M,w)$, are then determined by the expenditures required to obtain those resources at current input prices w. M and w are the exogenous variables which drive this process, but the key assumption required to establish a functional relationship between M and Postal Service costs is the existence of an established set of operating procedures. These procedures need not necessarily be "optimal" in the economist's sense, but they must be reproducible and relatively stable for accounting data to be useful in establishing the properties of $C(M,w)$.

Once an operating plan is specified, it can be used to determine such economic magnitudes as incremental costs and marginal cost. This is conceptually straight forward. Given a base forecast of mail volumes M^0, the operating plan can be used as described above to predict the associated Postal Service costs $C^0=C(M^0,w)$. Now suppose that the base forecast is altered by the vector Δ of changes in the volumes of mail in each service category. In theory, it is quite straightforward to repeat the whole process, applying the operating plan to $M^1=M^0+\Delta$, yielding the revised cost prediction $C^1=C(M^1,w)$. Thus it is conceptually straightforward to calculate the change in Postal Service costs, C^1-C^0, associated with any change in forecasted mail volumes; i.e., the vector Δ.

Thus far, Δ has been merely an arbitrary vector of mail volume changes. This has made the discussion appear somewhat abstract. However, matters become much more concrete when particular types of changes are considered. First suppose that the only change posited was the elimination of mail class j from the base forecast. Then Δ would be a vector with $-M_j$ in the jth position, with zeros everywhere else. Then the difference C^0-C^1 would be the *incremental cost of service j;* i.e., the reduction in Postal Service costs accompanying the complete elimination of mail class j. Incremental cost is an

important concept which will be discussed in more detail below. Here, I merely wish to illustrate how, in principle, it can be calculated from the enterprise operating plan.

Now suppose that the increment in question is just one piece of mail of class *j*. In this case the same reasoning establishes that the expenditure difference C^1-C^0 measures the cost of one additional unit of service *j*, or the marginal cost of service *j*. (The incremental cost of an increment of one unit is just marginal cost.)[6]

C. A digression on economic cost minimization, Postal Service efficiency, and economic pricing and subsidy analyses.

The process I have just described is perfectly consistent with the economic textbook story of cost minimization. Clearly, the Postal Service cost function I have defined, *C(M,w)* will coincide with the *minimum* cost function of economic theory if the operating plan always specifies the most cost efficient possible way of providing service for the given mail volumes. However, it is important to emphasize that it is not necessary to assume perfect cost efficiency to apply the methodology being developed here to the calculation of Postal Service marginal costs. Nor is it necessary to assume that the Postal Service is perfectly cost efficient for pricing analysis to be meaningful. It is worthwhile to elaborate on this point so that the strengths and the limitations of the methodology I am describing are perfectly clear.

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[6]This is the discrete version of marginal cost. Given $\Delta=(0,\ldots,0,\Delta_j,0,\ldots,0)$ then $\partial C/\partial M_j$ is the limit of $(C^1-C^0)/\Delta_j$ as Δ_j approaches zero.

Economically efficient pricing falls under the mathematical category of constrained optimization problems. An objective, such as social surplus,[7] is maximized subject to a set of constraints. These constraints may be economic, technological, political or institutional. In monopoly pricing applications, the focus is usually on the economic constraint which requires that the enterprise break even. If it were not required that the firm cover costs, lower prices could be charged which would yield a greater social surplus. But other constraints are usually operative as well. For example, if the Postal Service were not bound by institutional constraints to pay what appear to be high union wage rates, social surplus could undoubtedly be increased through lower rates which allowed the firm to break even.

Similarly, when performing an analysis of postal pricing it must be recognized that the analysis is subject to the institutional constraint that Postal Service is going to produce the mail services in question using its established practices and procedures: what I have dubbed its operating plan. How close these practices and procedures come to achieving economic cost minimization is undoubtedly an important determinant of the efficiency of Postal Service. And, of course, the closer the operating plan comes to true cost minimization, the greater will be the maximized level of social surplus resulting from optimal pricing. However, the efficiency of the Postal Service operating plan is not an issue for the analyst. *As long as it is given that postal services will be produced following Postal Service practices and procedures, the relevant marginal and incremental costs for pricing purposes are those calculated based on the Postal Service operating plan.*

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[7]Social surplus is traditionally defined as the sum of consumers' and producers' profits in the markets served by the enterprise. See the testimony of Witness Bernstein for a thorough discussion of the use of consumer surplus as an objective function in optimal pricing analysis.

D. The operating plan implicit in the Postal Service cost measurement system.

The message of the previous two sections can be summarized succinctly: The operating plan of an enterprise provides a description of how one determines the expenditures required *by that enterprise* to produce any specified levels of service. The task now is to explain the operating plan implicit in Postal Service cost accounting and show how Postal Service estimates of volume variable costs can be used to estimate marginal costs.[8]

Postal Service costing procedures are based upon some 20 cost segments, which are further subdivided into identifiable cost components.[9] Thus the first step involved in using the Postal Service cost measurement system to compute marginal costs is to think in terms of an underlying operating plan that divides the list of resources required to produce a given vector of mail volumes into cost component categories such as Purchased Transportation, Rural Carriers, Motor Vehicle Service, etc. This means that there exists a Postal Service cost function which describes the relationship between mail volumes and costs for each cost component *i*. Let $C_i(M)$ denote such component cost functions.[10]

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[8]This portion of the analysis relies heavily on Bradley, M., Colvin, J. and Smith, "Measuring Product Costs for Rate-making: The United States Postal Service," in Michael Crew and Paul Kleindorfer, eds., *Regulation and the Evolving Nature of Postal and Delivery Services: 1992 and Beyond*, Kluwer (1992).

[9]Each component may also be composed of several sub components. See Bradley, Colvin, and Smith, Table 2.

[10]Because the analysis is conducted under the assumption that input prices are not changing, henceforth I shall omit w as an argument of C_i.

Then, if there are n cost components the Postal Service total cost function is given by

$$C(M) = \sum_{i=1}^{n} C_i(M).$$

Rather than attempting to specify the component cost functions directly, the Postal Service cost measurement system identifies *cost drivers* which determine the costs incurred in any component (or sub component) category. For example, the cost driver for the sub component Purchased Air Transportation has been determined to be the number of ton miles purchased. Postal Service cost analysts then empirically determine a functional relationship between required ton miles and component costs. In this case the relationship is essentially linear; i.e., Postal Service purchases air transport at a constant cost per ton mile.[11]

For each component this exercise establishes a functional relationship between component costs and the level of that component's cost driver. Thus, $C_i(D_i)=F_i+G_i(D_i)$, where F_i is the level of component fixed cost and $G_i(D_i)$ is component variable costs. However efficient pricing analysis requires a causal relationship between costs and the service categories M_j which are priced. Therefore the next step is to establish relationships between the component cost drivers and mail service categories: $D_i = D_i(M)$. Often this relationship is determined (or assumed) to be linear, so that $D_i = \sum_{j=1}^{m} a_{ij} M_j$, where the weights a_{ij} represent the amount of component i cost driver required by each unit of mail of service class j, for j=1 through m. For example, one such weight would be the number of ton miles of purchased air transportation required by the

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[11] See Bradley, Colvin, and Smith. In other words the cost elasticity of this component is one.

typical piece of First Class mail. Now it is possible to express total and component costs as functions of mail volumes: $C(M) = \sum_{i=1}^{n} C_i(D_i(M))$.

Before getting bogged down in mathematics, it is important to recast this analysis in terms of the basic Postal Service operating plan discussed above. The story goes as follows. In order to deliver a specified vector of mail volumes M, the operating plan requires that levels of cost drivers D_i be provided which results in expenditures C_i being incurred in cost component i. In other words, the cost drivers of the Postal Service cost measurement system are *intermediate inputs,* goods and services which are not directly valued by customers but are required for the production of final goods and services. Thus the Postal Service operating plan specifies the quantities of intermediate inputs (cost drivers), such as ton miles of airline service, required to provide any vector of mail volumes. The functional relationship between the levels of these intermediate inputs and the cost of the resources used to provide them, i.e., the $C_i(D_i)$, are specified on the basis of empirical estimates, operational studies, or introspection.

Taken together, the specification of the relationships between mail volumes and cost drivers, and that between component costs and their drivers, provide an internally consistent, logical description of a Postal Service operating plan which is directly related to the accounting data produced by the Postal Service cost measurement system. This means that, at least in principle, it is possible to calculate Postal Service marginal costs for the various categories of mail in a manner appropriate for pricing analysis *and* consistent with the available data. Let us be clear about what is being assumed. I am assuming that the Postal Service provides mail services in a manner at least approximately consistent with the operating plan I have described. It is *not* necessary to assume that this operating plan is the most cost efficient way to provide the mail services in question.

III. UNIT VOLUME VARIABLE COSTS ARE ECONOMIC MARGINAL COSTS

The benchmark cost concept used in postal rate cases is unit volume variable cost. The purpose of this section is to explain why the unit volume variable cost values produced by the Postal Service cost measurement system are valid estimates of mail service marginal costs.

The Postal Service process of cost attribution begins with the concept of *volume variable cost.* The volume variable cost associated with cost component *i* is its component variable cost multiplied by the elasticity of component variable cost with respect to its cost driver. That is, $V_i = G_i \varepsilon_i$ where $\varepsilon_i = (D_i/G_i)(dG_i/dD_i)$. When there is a linear relationship between component costs and the cost driver, ε_i is equal to one, and all of the component variable costs are volume variable. When component variable costs exhibit economies of scale, ε_i will be less than one and only a fraction of component variable costs will be classified as volume variable. For example, if a 10% increase in the ith component's cost driver resulted in only a 9% increase component variable cost, then $\varepsilon_i = .9$, and only 90% of component *i* variable costs are treated as volume variable.

The procedure is illustrated in Figure 1. The horizontal axis measures the quantity of the cost driver. Component costs are on the vertical axis. Total component cost associated with quantity *OD* of the cost driver is given by the distance *OE.* The distance *OA* represents any component specific fixed costs. These are set up costs which must be incurred before any positive level of the intermediate input (cost driver) can be provided. Constructing the tangent to C_i at *D,* and extending it to the vertical axis at point *B* provides a measure of volume variable costs for this component. These are given by the distance *BE,* which is equal to marginal component cost times the quantity of the cost driver. Whenever marginal costs are a declining function of the level of the cost driver, a component's volume variable costs will be less than its total variable costs *(AE),* which,

in turn, will be less than total component costs *(OE)*. That is, point *B* will lie between points *A* and *E*.

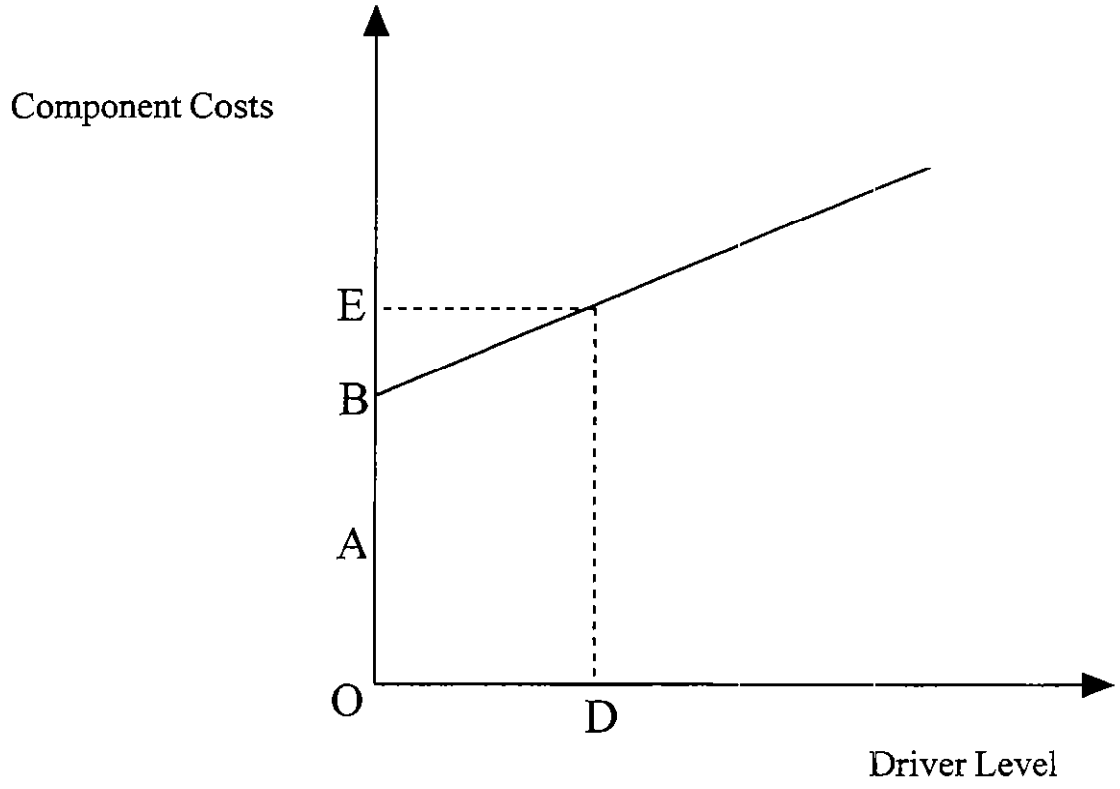

Figure 1

Once volume variable costs for each component are determined, they are distributed across the various categories of mail. This requires determining an amount, V_{ij}, of component *i* volume variable cost to be distributed to each mail class *j* such that $\sum_{j=1}^{m} V_{ij} = V_i$. Bradley, Colvin, and Smith discuss three distribution procedures: the distribution key method, the constructed marginal cost method, and the parallel component method. However they are all based on taking the volume variability concept one step further, to reflect the dependence of the cost drivers on various classes of mail.

The general formula is $V_{ij}=V_i\sigma_{ij}=G_i\varepsilon\sigma_{ij}$, where σ_{ij} is the elasticity of cost driver i with respect to the volume of mail class j: i.e., $\sigma_{ij}=(M_j/D_i)(\partial D_i/\partial M_j)$.[12]

Applying this procedure to all cost components yields the total volume variable costs distributed mail class j: $v_j = \sum_{i=1}^{n} V_{ij}$. This analysis may seem somewhat convoluted, since these volume variable costs bear no obvious relationship to standard economic cost constructs. But observe what happens when the volume variable costs distributed to service class j are expressed on a per unit basis:

$$c_j = \frac{v_j}{M_j} = \left(\frac{1}{M_j}\right)\sum_{i=1}^{n} G_i\varepsilon_i\sigma_{ij} = \left(\frac{1}{M_j}\right)\sum_{i=1}^{n} G_i\left(\frac{D_i}{G_i}\right)\left(\frac{\partial G_i}{\partial D_i}\right)\sigma_{ij} = \left(\frac{1}{M_j}\right)\sum_{i=1}^{n} G_i\left(\frac{D_i}{G_i}\right)\left(\frac{\partial G_i}{\partial D_i}\right)\left(\frac{M_j}{D_i}\right)\left(\frac{\partial D_i}{\partial M_j}\right).$$

Performing the requisite cancellations yields:

$$c_j = \sum_{i=1}^{n}\left(\frac{\partial G_i}{\partial D_i}\right)\left(\frac{\partial D_i}{\partial M_j}\right) = \sum_{i=1}^{n}\frac{\partial G_i(D_i(M))}{\partial M_j} = \frac{\partial C(M)}{\partial M_j}.$$

That is, the per unit volume variable costs of mail service j are precisely equal to the marginal costs of that service derived from the Postal Service operating plan I have described!

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[12] $D_i(M)$ must be linearly homogeneous if the adding up property, $\sum_{j=1}^{m} V_{ij} = V_i$, is to be satisfied. This general formula reduces to Bradley, Colvin, and Smith's distribution key method when the cost driver is a weighted sum of mail volumes: i.e., $D_i = \sum_{j=1}^{m} a_{ij}M_j$. Then $\sigma_{ij}=a_{ij}M_j/D_i$ so that mail service j's share of the component i cost driver is also its share of component i volume variable cost. However, the parallel component method assumes that the component which is paralleled (e.g., carrier supervisor salaries) increases proportionally with the base component (e.g., carriers). In effect, the base component is the cost driver for the paralleled component with an cost elasticity equal to one.

IV. USING POSTAL SERVICE COST DATA TO MEASURE INCREMENTAL COSTS.

The previous section explains why traditional Postal Service measures of unit volume variable costs are an economically sound starting point for rational postal rate-making: i.e., they are designed to measure marginal costs. However, in view of the efficiency properties of subsidy free pricing discussed above, it is also important to explain how incremental costs can be estimated using Postal Service cost data. This process is explained in detail by Witness Takis. Here, I shall merely explain the theoretical issues which arise.

Moving from marginal costs to incremental costs was a rather simple matter in the illustrative example of Section I.C. One merely multiplied the marginal cost of a service times its volume, and added any service specific fixed costs. Since the marginal costs of a service are approximated by its per unit volume variable costs, it then would seem that one could then approximate a service's incremental costs by the sum of its volume variable and specific fixed costs. This, is indeed the basic approach which must be followed. In particular, the specific fixed costs of a service must always be included as part of its incremental cost. However, even in the absence of specific fixed costs, the volume variable costs of a service will tend to systematically understate its incremental costs whenever significant cost components exhibit declining marginal costs with respect to their cost drivers.

Figure 2 helps provide a simple, intuitive analysis of why this is so. Component marginal costs are plotted as a decreasing function of the level of the cost driver. Consider a level of cost driver activity D^T. The volume variable costs of this component would be given by the rectangle $V = O \cdot D^T \cdot MC(D^T) \cdot A$. However, in the absence of component specific fixed costs, the total costs, C, of this component would be given by the entire area under the marginal cost curve, the larger area $O \cdot D^T \cdot MC(D^T) \cdot E$. The

difference, the triangular area $A \cdot MC(D^T) \cdot E$, is was what has traditionally been described as an *institutional cost* in the Postal Service cost measurement system, and not allocated to any service.

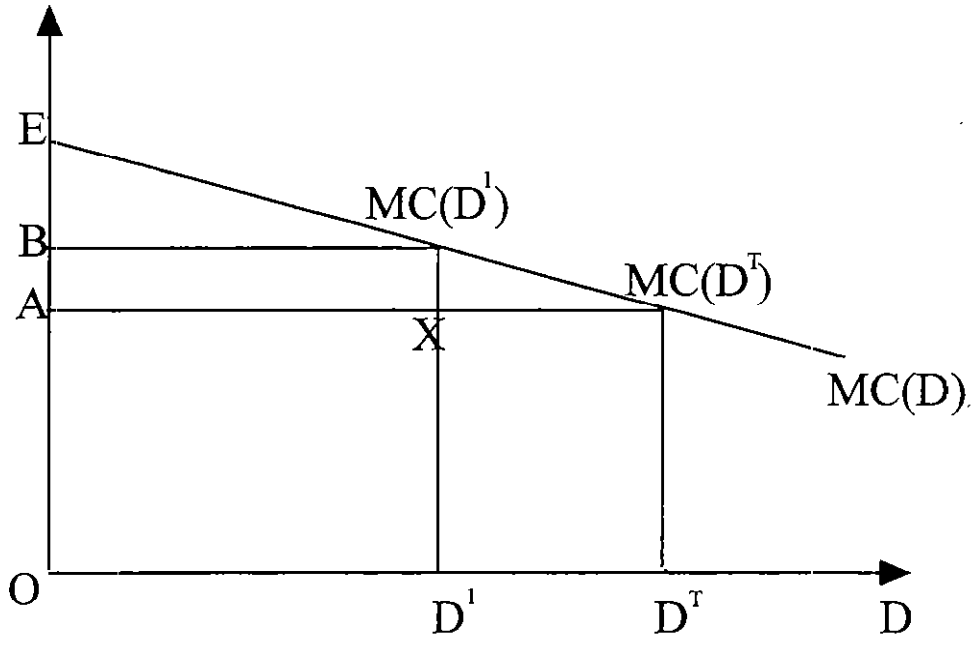

Figure 2

Next consider how the costs of this component would be assigned to various mail services by the Postal Service cost measurement system. To keep the discussion simple, suppose that there are just two mail services and that service 1 accounts for D^1 units of driver activity. Then service 2 accounts for $D^2=D^T-D^1$ units of driver activity. In this situation, the component costs distributed to services 1 and 2 are given by areas $O \cdot A \cdot X \cdot D^1$ and $D^1 \cdot X \cdot MC(D^T) \cdot D^T$, respectively.

To examine any component's contribution to the incremental costs of a service, I must begin by determining what component costs would be if the service was not offered. In the example depicted in the diagram, if service 2 were no longer offered, only D^1 units

of the cost driver would be required and total component costs would be given by area $O{\cdot}E{\cdot}MC(D^1){\cdot}D^1$. Then the incremental costs of service 2 for this component is just the difference between total component cost when both services are provided and the component cost incurred when providing service 1 alone. In this example, that difference is the area $D^1{\cdot}MC(D^1){\cdot}MC(D^T){\cdot}D^T$, which is larger than the volume variable costs distributed to service 2 by the triangular area $X{\cdot}MC(D^1){\cdot}MC(D^T)$. This result is quite general. A cost component's contribution to a service's incremental costs will always exceed the amount of that component's volume variable costs distributed to that service whenever marginal component costs are a decreasing function of the cost driver.[13]

While the direction of this bias is known (i.e., incremental costs exceed volume variable costs when component marginal costs are falling), it is very difficult to get a quantitative handle on its likely magnitude. To consider the simplest plausible case, suppose that (1) there are no component specific fixed costs, (2) the component cost function has been found to have a constant cost elasticity of α, and (3) the proportion of driver activity due to service j is given by σ_j. Then the ratio, r_j, of incremental costs to volume variable costs for service j is given $r_j=[1-(1-\sigma_j)^{\alpha}]/\alpha\sigma_j$. This is a rather complicated formula. Indeed, it is difficult to conclude much about the divergence between incremental cost and volume variable costs without substituting in numerical values for α and σ_j.

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[13]Note that it would be incorrect to use the areas $O{\cdot}E{\cdot}MC(D^1){\cdot}D^1$ and $O{\cdot}B{\cdot}MC(D^1){\cdot}D^1$ to compare incremental costs and volume variable costs for service 1. To do that would require subtracting D^2 from D^T and comparing the resulting cost levels. In other words, incremental cost calculations must always be made by treating the service in question as the "last" service added.

As one would expect intuitively, r_j tends to unity as mail category j's driver share goes to zero. Thus there is little error in approximating incremental costs by volume variable costs for mail services which give rise to only small proportion of cost driver activity. Similarly, r_j approaches $1/\alpha$ as σ_j approaches one. In that case, service j accounts for all driver activity and the difference between volume variable costs and incremental costs is exactly the same as that between volume variable costs and total component costs. Finally, for any component for which $\alpha=1$, volume variable costs are exactly equal to that component's contribution toward the incremental cost of each service. This can be seen most easily using Figure 2. When $\alpha=1$, the *MC* curve is flat, $MC(D^I)=MC(D^T)$, and the amount by which volume variable cost understates incremental cost (triangle $MC(D^I)\cdot X\cdot MC(D^T)$) shrinks to zero.

The complications illustrated by the above formula are the subject of the detailed analysis in Witness Takis's testimony. For each cost component, he estimates what component costs would be with and without the volumes of the subclass in question. The difference is the amount that that cost component contributes to the incremental cost of the subclass. These contributions are summed over all cost components and added to any subclass specific fixed costs to obtain the incremental costs of the subclass.

V. PITFALLS TO AVOID IN USING MARGINAL AND INCREMENTAL COSTS IN THE POSTAL RATE-MAKING PROCESS.

To this point, I have focused on explaining how the Postal Service's cost accounting system can be used to measure the economic concepts of marginal and incremental cost. In doing so, it is clear that these two concepts are closely related, and that both reflect economic cost causality. Yet, they have very different roles to play in a rational rate-making process. Marginal costs are the starting point for any rational

determination of rates subject to a budget constraint.[14] Incremental costs form the basis of tests for cross-subsidy. It would be foolishly inappropriate to use one concept in the other's domain. It is just as erroneous to seek to use incremental costs as a starting point to apply the mark-ups required for the enterprise to break-even, as it would be to conclude that cross-subsidy was absent from the fact that prices were at least as great as marginal cost for all services.

A. Incremental costs should not form the basis for the mark-ups required to satisfy the break-even constraint.

In this proceeding the Postal Service is presenting estimates of the incremental costs of serving the various subclasses of mail. As I have emphasized repeatedly in my testimony,[15] it is imperative that the Commission recognize that (per unit) incremental costs should be used for evaluating rates for the presence of cross-subsidization, and should *not* be starting point for the application of the mark-ups required to enable the Postal Service to cover its costs. Applying mark-ups to average incremental costs instead of to marginal (unit volume variable) costs reduces economic efficiency unnecessarily. This is because, as explained above, the efficient pursuit of *any* objective subject to a break-even constraint requires that one trade-off costs and benefits at the margin. Marginal costs provide relevant information for conducting this trade-off, while average incremental costs do not.

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[14]For example, it is the starting point for the calculations of Ramsey prices presented in the testimony of Peter Bernstein.

[15] I have also made this point in the specific context of city carrier access costs in my testimony in R90-1.

B. The sum of subclass incremental costs has no relevance for pricing.

Once incremental cost estimates are available for all mail subclasses, some may be tempted to engage in the following meaningless exercise:

> Calculate the sum of subclass incremental costs and deduct it from the total costs of the Postal Service. The difference, the argument goes, is a measure of the "institutional costs" which must be recovered by marking-up rates over subclass average incremental costs.

There are two fallacies contained in the above statement. First, as discussed in the previous section, marginal costs, and not average incremental costs, are the economically correct base to which any necessary mark-ups should be applied. Second, the difference between total costs and the sum of all subclass incremental cost is a reflection of the *economies of scope* enjoyed by the Postal Service,[16] not a deficit to be recovered.

The above difference should not be confused with the difference between the total costs of the Postal Service and the sum of subclass volume variable costs. This difference, traditionally referred to as the amount of Postal Service *institutional costs,* is a result of the *economies of scale* enjoyed by the Postal Service, and does have a legitimate pricing interpretation. It represents the deficit which would result if the prices of all mail subclasses were set equal to their respective marginal (unit volume variable) costs. As such, it does indeed represent an amount which must be recovered through the mark-ups resulting from the rate-setting process.

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[16] Indeed, that difference has been used to define the *degree of economies of scope* in Baumol, Panzar, and Willig.

VI. SUMMARY AND CONCLUSIONS

In this proceeding the Postal Service has presented, for the various mail subclasses, estimates of the two economic cost measures required for rational rate-making: marginal costs and incremental costs. My testimony has dealt with but two issues. First, I explained the economic framework which allows estimates of the forward-looking, economic concepts of marginal and incremental costs to be calculated consistently using Postal Service accounting data. It turns out that the traditional Postal Service measures of unit volume variable costs can be expected to accurately measure economic marginal costs. Determining economic incremental costs using Postal Service measures of volume variable costs and subclass specific fixed costs is much more complicated. I explained the general outline of the approach required, leaving the detailed calculations to the testimony of Witness Takis.

Second, I explained the important, but distinct, roles which marginal cost and incremental costs should play in any rational rate-making process. These can be summed up quite succinctly:

- Marginal costs are the basic cost data to be used in setting rates.
- Average incremental costs should be used to evaluate rates for cross-subsidization, but should not form the basis for mark-ups.

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WRITTEN WORK

I. Journal Publications:

"Vindication of a 'Common Mistake' in Welfare Economics," (with R. D. Willig), *Journal of Political Economy 84 6,* December 1976, pp. 361-64.

"A 'Neoclassical' Approach to Peak Load Pricing," *Bell Journal of Economics 7 2,* Autumn 1976, pp. 521-30.

"Free Entry and the Sustainability of Natural Monopoly," (with R. D. Willig), *Bell Journal of Economics 8 1,* Spring 1977, pp. 1-22.

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III. Publications in Conference Proceedings and other Volumes

"Some Thoughts on the Market Implications of the Federal Aviation Act of 1975," Printed in *Regulatory Reform and the Federal Aviation Act of 1975,* DOT-TST-76-59.

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IV. Book Review

NonlinearPricing. By Robert Wilson. Oxford University Press, 1993. *Journal of Economic Literature, XXXIII 4* (September 1995), pp. 1339-41.

V. Work in Progress

Incentive Regulation in the U.S. Telecommunications Industry; (with Ronald R. Braeutigam) monograph in preparation for the American Enterprise Institute.

"Using USPS Accounting Data for Pricing Decisions and Cross-Subsidy Calculations," with M. Bradley and J. Colvin journal article in preparation.

"Rate Base Valuation and Incremental Costing in a Competitive Environment;" journal article in preparation.

"Efficient Postal Discounts," journal article in preparation

PROFESSIONAL ACTIVITIES

Memberships:	American Economic Association European Association for Research in Industrial Economics (E.A.R.I.E.) Econometric Society International Telecommunications Society AEA Commission on Graduate Education in Economics Board of Directors, Telecommunications Policy Research Conference, 1991-95, Chair 1994-95
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Program Committees:	Eighth Annual Telecommunications Policy Research Conference, 1979 Econometric Society 1980 North American Winter Meetings. E.A.R.I.E. Annual Conference 1984 Econometric Society 1985 World Congress. American Economic Association Annual Meetings 1987. Econometric Society 1991 North American Summer Meetings Chair, 20th Annual Telecommunications Policy Research Conference, 1992
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National Science Foundation, "Efficient Regulatory Pricing under Competition," SES-8409171, Principal Investigator, 1984-87.

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Andrew Mellon Foundation, "Economics of the Scholarly Publishing Industry." Co-Principal Investigator, 1995-97.