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COST-OF-SERVICE METHODS FOR INTRASTATE JURISDICTIONAL TELEPHONE SERVICES

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EXECUTIVE SUMMARY

Congestion and queuing theory applied to telephone services provide a theoretical basis for a cost-of-service method to allocate the cost of rendering telephone serivce to broad categories of services. Cost accountants identify cost causation as the primary philosphical criterion underlying costing methods. In assigning costs to services, cost accountants examine the strength of the relationship between the costs incurred by the company and the level of service over the short run and the long term. In the short term, questions of the traceability and variability of the cost with the level of service are relevant. The examination of long-term relationships involve an investigation of the relationship between the level of service and the plant and equipment needed to provide the service. Questions of whether capacity is required to render service necessarily lead the cost accountant directly or indirectly to apply planning criteria in the allocation of most capacity costs. Telephone companies use queuing theory to determine the capacity of switches, trunks, operator stations, the size of the work forces and many other elements affecting the revenue requirements. These blocking probabilities form a cost-causative basis for cost allocation factors for most telephone plant and equipment.

Cost-of-service studies can be used by public utility commissions for three purposes:

1. To determine the revenue requirement for monopoly services offered by a telephone company operating in both monopoly and competitive markets

2. To set a minimum cost below which the price of a competitive service cannot fall[1]

3. To ascertain whether rates are in some sense compensatory

Any one costing method is not appropriate for fulfilling all three of these needs. Instead a variety of costing methods should be used to establish upper and lower bounds on the cost of service. Full costing methods should be used for purposes one and three, while marginal or incremental costing methods should be used for the second purpose. In using cost studies in this way, an upper bound for rates is determined for monopoly services and upper and lower bounds are set for competitive services.

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[1]It is beyond the scope of this report to discuss the circumstances under which a commission might wish to--or even should--set rates for competitive services.

All cost-of-service methods used in telephone regulation today are deficient for regulatory purposes for a number of reasons. First and foremost, allocation factors used are based on annual usage without any recognition for the continued presence of peaks and valleys in the pattern of telephone usage over the hours of the day, days of the week, and weeks of the year. By using annual usage these allocation factors reflect an implicit assumption that the demand for telephone services is uniform over the entire year. Second, the classification of the costs of the subscriber loop and a portion of the local dial switch as "nontraffic sensitive" is inappropriate. The conceptual basis is the problem. The subscriber loop is unique in the fact that it is the subscriber who makes the capacity decision. Clearly the amount of traffic both incoming and outgoing and the resulting congestion experienced by the subscriber and incoming callers is the underlying cost-causative force determining the number of loops a subscriber installs. A better delineation of the costs incurred by a telephone company is between network costs and customer-related costs. Network costs are capacity costs and operating expenses about which the telephone company makes capacity and management decisions, while the latter are costs about which the subscriber makes decisions. This delineation of costs enables the cost analyst to rationally discover the forces of cost causation underlying the incurrence of a cost.

Network costs are properly allocated according to the peak responsibility of the services offered by the company. Network planning criteria are applicable to this task. The Erlang B and Erlang C blocking formulas can provide the basis for developing probability-weighted usage factors to allocate network costs. These blocking probabilities are used by network planners to determine the capacity of specific parts of the telephone plant to meet grade-of-service standards. These standards are stated in terms of the percent of blocked calls lost or probability of a delay no more these T seconds in receiving service. These blocking formulas can be used to compute the probability that a given hour of a typical day is the peak hour. The usage of the various services can be weighted with these probabilities to allocate network costs.

Customer-related costs are primarily the cost of the subscriber loop. A consideration of externalities associated with telephone services is relevant to sorting out the proper allocation of these costs. Two externalities can be identified. One is the familar external benefit accruing to existing subscribers when a new customer subscribes to telephone services. The benefit is the ability to receive calls and place incoming calls to this new subscriber. This externality justifies offering the initial subscription to customers at a price below the marginal costs of subscription. This lower price provides a price signal to the potential subscriber about this benefit accruing to existing subscribers. The resulting deficit is typically argued to be recovered through rates for usage. The second externality has heretofore not been found in the literature. It is the costs of waiting time incurred by people trying to place incoming calls to a sometimes congested loop. This external cost is not necessarily known or considered by the subscriber when making decisions about installing additional loops at his or her end-user premises. The only thing this subscriber can evaluate adequately is the cost of waiting time internal to his or her end-user premises. In order to provide a price signal to the subscriber about the external costs associated with this sometimes congested loop, additional loops should be offered at a discount reflecting the costs of this external waiting time. In doing this, the subscriber only has to evaluate the marginal cost of an additional loop against the costs of waiting time internal to the end-users premises. This pricing scheme for additional loops internalizes the external costs of waiting time to the subscriber's capacity decision. Again the deficit is recovered through prices for usage.

Incorporating these externalites into a cost-allocation scheme for the subscriber loop, one must recognize the role played by incoming calls. For the first externality, the direct benefit is the ability of the existing subscriber to place incoming calls to the new subscriber. In the case of the second externality, the external cost is inability to complete incoming calls to an end-user premises having a sometimes congested loop. Existing cost allocation schemes only consider outgoing subscriber line usage. The importance of incoming usage in properly allocating the costs of the subscriber loop to reflect the cost-causative forces leading loops being added to the telephone system cannot be over emphasized.

Using incoming calls and the associated externalites in a cost-allocation scheme can only be done imperfectly. One solution is to develop a typical day profile for customer class of incoming and outgoing usages on a typical loop for each class. Use the incoming and outgoing usages to develop blocking probabilities for the hours of the typical day for each customer class. With these blocking probabilities, develop probability-weighted usage factors to allocate the costs of the subscriber loop for each class between incoming and outgoing usage. The outgoing portion of a subscriber loop is the costs of access, while the incoming portion is the usage-related portion. The method proposed here, while not perfect, constitutes an improvement in identifying the cost-causative forces related to capacity decisions made by customers regarding loops.

It should be noted that the probability-weighted usage factors for both network- and customer-related costs could be applied to either accounting costs or marginal costs. The improvement suggested relates to assigning these costs in accordance with peak responsibility. It directly reflects the role of congestion and queuing theory in planning the capacity of the telephone network and subscriber loop capacity.

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FOREWORD

The task we took on in preparing this first year report of a 2-year project was to develop a cost-of-service report and manual for intrastate telephone service that would specify a method for allocating the jurisdictional costs to state toll, local exchange, vertical, and other services. This is the report portion of that effort: the manual will come next, and we plan to prepare software for its implementation next year.

The present report finds that congestion and queuing theory applied to telephone services can provide a sound theoretical basis for a cost-of-service method in apportioning the cost of rendering telephone service to broad categories of services. Blocking probability analysis is felt to form a cost-causative basis for allocation factors useful in assigning costs for most telephone plant and equipment.

We hope that this report and the manual and software that are expected to follow will be a contribution to cost-of-service regulation in the telecommunications industry.

Douglas N. Jones
Director
April 15, 1985

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Paul Popenoe	California Public Utilities Commission
Guy Twombly	Maine Public Utilities Commission
Gordon Persinger	Missouri Public Service Commission
Robert Soika	New York Public Service Commission

Their helpful comments were invaluable to the completion of this report. In addition, the NRRI typists, Karen Myers, Janice Hilt, and Shirley Simonton were patient beyond reason in typing the drafts and final version of this report.

CHAPTER 1

PROBLEM STATEMENT AND APPROACH

The restructuring of the American Telephone and Telegraph Company and the emerging competition in formerly monopolized markets are forcing regulators and utility decision makers to reexamine rate structures for telephone services. Regulators are faced with two competing concerns. On one hand, they want to be assured that local exchange customers do not bear the brunt of a telephone company's efforts in competitive markets. On the other hand, regulators want competition to be fair to both the telephone company and its competitors. These tradeoffs raise questions about the fairness and efficiency of rate structures. The main focus of this examination is on the existence of cross-subsidies between competitive and monopoly services. Cost-of-service studies can provide useful information in resolving these issues. In particular, cost-of-service studies can be used in the following three ways:

1. To determine a revenue requirement for monopoly services offered by a telephone company operating in both competitive and monopoly markets

2. To set a minimum cost below which the price of competitive services cannot fall

3. To ascertain whether rates are in some sense compensatory

One costing method is not appropriate for fulfilling all three of these needs. Instead, costing methods should be used to establish an upper or a lower bound on the cost of service. Compensatory rates for the respective services can then be designed to reflect these bounds. If the resulting prices are to be efficient, they must provide signals to consumers about the cost they impose on the telephone company when using a particular service. This means that the costing methods on which each cost estimate is based must attribute costs to the cost causer. Information used in network and operations planning can form the basis for a costing method that would allocate costs to those services causing capacity and operating personnel to be added. The primary purpose of this report is to suggest a set of allocation factors that utilizes planning criteria to attribute costs to broad classifications of service.

A cost-of-service method based on planning criteria is by no means novel, nor does it constitute the definitive costing method. The underlying philosophy is to examine the cost information contained in the efficient prices of various economic models and incorporate these considerations in a costing method. This line of reasoning leads one to congestion pricing and telephone planning criteria. The costing method is not definitive because the presence of shared inputs makes the costing problem theoretically indeterminate. Economists have examined the problem created by shared inputs and derived a set of results for efficient pricing under various circumstances. Practical application of these results has been left for the most part to the cost accounting profession. Cost accountants have developed a set of costing methods that provide decision makers with cost estimates incorporating various degrees of information about the relationship between inputs and outputs. Their allocation of costs, though arbitrary, is governed by a definable set of criteria. The set of allocation factors suggested in this report combine the economists' concern for efficient price signals with the cost accountant's costing criteria. This approach to costing methods for telephone service constitutes an improvement in the current state of the art in telephone price regulation.

Request for Comments on Probability-Weighted Usage Factors

Chapter 9 contains a proposal for probability-weighted usage factors for allocating switching and outside plant to broad categories of service. In the months that follow the issuance of this report, an NRRI research team will incorporate these factors into a cost-allocation manual for intrastate telephone services. Data requests and data reporting requirements will accompany the manual. The goal is to implement this allocation method in one or more states and provide the participating state commissions with software and support training to perform cost studies on an on-going basis. Before proceeding with this plan of work, the NRRI research team would like to receive comments on the proposed allocation factors.

Comments on the allocation method proposed in this report should address the theoretical foundation of the allocation factors, the practicality and feasibility of the proposed methods, and the types of special studies that may be neceessary to implement this allocation plan. Suggested revisions and alternatives to the probability-weighted usage factors and other proposed changes in allocations are also encouraged and will be considered when writing the manual.

Comments on the proposed allocation factors should be addressed to:

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It is unlikely that comments received after June 15, 1985 can be reflected in the manual.

Organization of Report

The remainder of this report is organized into three parts. First, a theoretical overview of cost-of-service methods, in general, and for telephone is contained in chapters 2, 3, 4, and 5. In the second part, chapters 6, 7, and 8 are a review some of the existing cost-allocation methods and a summary of state commission activity in the area of cost-of-service for telephone services. Finally, chapter 9 contains a proposal for telephone cost allocations.

In chapter 2, some economic theory relevant to the design of a cost-of-service method is briefly reviewed. The imposition of a regulatory constraint on a multiproduct firm producing both competitive and monopoly services with facilities and personnel that are shared by two or more services makes the costing problem theoretically indeterminate. With inseparable production, the total and variable costs cannot be definitively quantified. Marginal costs, however, still exist and, in theory, are quantifiable. The theoretical review in this chapter also examines the peak load pricing model and solutions economists have devised to adjust marginal cost price to meet a regulatory constraint.

In chapter 3, four costing methods found in the cost accounting literature are presented. They are direct costing, attributable costing, full costing, and reimbursement costing. Cost accountants have five primary criteria they apply in varying degrees in applying the first three of these methods. They are cost causation and the traceability, variability, capacity-required, and beneficiality criteria. Reimbursement cost requires the application of the inclusive criterion that sometimes conflicts with cost causation.

In chapter 4, the costing methods appropriate to the regulation of public utilities are discussed. In the introduction to chapter one, three uses of cost-of-service methods by public utility commissions were listed. The discussion in this chapter addresses the methods best suited for each of these purposes. The discussion points out that no single method is adequate for all three uses.

In chapter 5, congestion theory is applied to the subscriber loop to ascertain efficient pricing rules for the outside plant. In this chapter a heretofore unidentified external cost of the telephone service is delineated. The value of waiting time to callers placing incoming calls to a sometimes congested loop at the end-user's premises is this external cost. The implication of this externality for efficient pricing of additional subscriber loops is discussed.

In chapter 6, the allocation of the costs of specific plant and equipment by three cost-of-service methods is examined. The allocation methods are the Bell operating companies composite method of Embedded Direct Analysis (EDA), Exchange Cost Study (ECS), and Embedded Cost of State Toll (ECOST), a modified Embedded Direct Analysis offered by John W. Wilson and Associates, and a fully distributed costing method based on separation principles offered by Richard Gabel. The allocation of the traffic sensitive portion of the local dial switch, the subscriber loop, the nontraffic sensitive portion of the local dial switch, and the message exchange trunk portion of outside plant is reviewed and critiqued. A summary of the allocation of all plant accounts by these three methods as well as separations is contained in appendix A.

Chapter 7 contains a review of three marginal costing methods. They are the Levelized Increment Unit Cost (LIUC) model used by Southwestern Bell Company and several other Bell operating companies, a marginal cost study performed by Jeffery Rohlfs of Shooshan and Jackson, Inc. of Washington, D.C., and an econometric estimate of a cost function for Bell Canada performed by Melvyn Fuss and Leonard Waverman.

In chapter 8, a survey of state commission activities in the cost-of-service area for telephone is summarized. Nineteen state commissions responded to a survey letter mailed in early 1984. The survey was undertaken to ascertain which cost-of-service methods were used in telephone ratemaking and how commissions used them in determining rates.

Finally, in chapter 9, a proposal for a fully distributed costing method using peak responsibility allocation of costs is presented. This full costing method uses probability-weighted usage factors to allocate the telephone services to broad categories of services. As previously noted, the allocation factors contained in this chapter will be incorporated into a cost-of-service manual in the near future.

CHAPTER 2

SOME THEORETICAL CONSIDERATIONS RELEVANT TO THE DESIGN OF A COST-OF-SERVICE METHOD

In this chapter, some economic theory relevant to the design of a cost-of-service method appropriate to the price regulation of telephone services are discussed. A local telephone company is a multiproduct firm furnishing interstate and intrastate access service to interLATA carriers, intrastate-intraLATA toll service, private line services, various data transmission services, and local telephone services. It furnishes all of these at any hour of the day, week, or year. A multiproduct utility subject to profit regulation creates theoretical problems for the design of a cost-of-service method. The purpose of this chapter is to gain an understanding of these problems and the nuances of the various forms that models incorporating shared inputs in the provisions of services may take.

This chapter contains four sections. The first two sections deal with two issues common to cost studies in general--the choice between accounting or marginal costs, and the specification of the time period over which costs are measured. The third section contains a discussion of the economic theory regarding the presence of shared inputs in the production of two or more outputs. The imposition of price regulation on a utility in these circumstances creates pricing difficulties. The solutions derived by economists to deal with these problems are briefly reviewed. A reader who is not theoretically inclined may skip this section. Finally, some concluding remarks are offered.

Accounting and Marginal Costs

In this section, the nature of accounting costs and marginal costs is discussed. Accounting costs have traditionally been the cornerstone to the rate base regulation of public utilities. Marginal costs as the basis of public utility regulation has never gained wide acceptance. To an economist, prices equal to marginal cost are the outcome of competitive forces in a properly functioning market rather than an enforced discipline of some visible hand. All that is asserted about marginal cost prices is that they lead to an efficient allocation of resources. The profit resulting from these prices can vary considerably from firm to firm in an industry according to their relative size and efficiency. The point emphasized in this section concerning accounting and marginal costs is that they are both estimates of costs on which to base prices. The appropriateness of either to the price regulation of telephone companies depends on the goals of the regulatory authority.

The accounting costs of the utility are those booked costs allowed in the revenue requirement by the regulatory commission. The accounting cost of a particular service is its revenue requirement and is an allocated cost. Accounting costs are the historical costs of embedded plant in service as of the test year, and test year expenses adjusted to some concept of normal operating conditions. The commission sets an allowed rate of return based on the embedded cost of debt and an estimate of the cost of equity capital.

It should be emphasized that accounting costs are an estimate of past costs incurred rendering a given level of service over some time period in the past. The changing price of inputs, technological advances in rendering service, and variation in managerial and technical efficiency can cause substantial variation in the cost of serving a given future demand. Accounting costs, however, are verifiable and subject to audit which gives them an aura of certainty. Nonetheless, they are an estimate of what the cost of service was at a past point in time.

Marginal costs are future costs. An estimate of marginal costs may be based on actual past costs or on future estimated costs to be incurred by the utility, a set of competitors, or potential competitors. Regulatory commissions could use any or all of these marginal costs for rate-making purposes. The usual practice is to base the marginal cost estimate on those costs to be incurred by the utility. The marginal cost estimate is often referred to as an incremental cost. The incremental cost to the utility is the additional costs to the utility of expanding a service or services. The incremental cost to an existing competitor is defined the same way, but the estimate may be different for a number of reasons as discussed below. The incremental cost to a potential competitor is the cost of de novo entry into the industry. It is the minimum average total cost incurred by the new entrant.

These three incremental or marginal costs are the prospective costs to be incurred in the future and are not historical costs like the accounting costs. The estimate of the incremental cost is uncertain and accurate only within specified probability limits. The cost estimate is neither verifiable nor subject to audit in the same sense as accounting costs, although the costing procedures and data sources may be verifiable and subject to audit. Generally, incremental cost estimates have much less weight than accounting costs in evidential proceedings.

The utility, existing competitors, and potential competitors may each estimate marginal cost, and their estimates may vary substantially one from the other. First, the scale of the firm's operations can have an impact on marginal or incremental costs. Second, the scope of the firm's operations can result in various degrees of cost savings and lead to variation in marginal costs among firms. Third, prices paid for resources necessary to render service can vary among firms. These differences in input factor prices can arise as a consequence of the firm's size and resulting bargaining power with suppliers. The degree of vertical integration can influence cost of materials and supplies to a firm according to whether such integration is organizationally efficient or inefficient. Fourth, technology can vary considerably among firms. Patent rights can have a substantial influence by making the most efficient technologies unavailable to the *de novo* entrant or possibly the major firm. Furthermore, the utility and some existing competitors are saddled with embedded technologies that help shape their future course of expansion and possibly limit the range of choice available to the firm. Finally, business acumen and managerial and organizational efficiency can vary considerably among the utility, existing competitors, and potential competitors. Thus, one would conclude that it is unlikely that incremental cost estimates to these three groups participating in the market would coincide. In fact, one should anticipate a healthy degree of variation in marginal costs among competitors in a competitive market.

The Time Frame for the Costing Method

Another thread running through this discussion involves the time frame over which costs are to be measured. Economists typically differentiate between the market period, the short run, and the long run. The market period is a time span so short that all inputs are fixed and no further output is forthcoming. In this case, optimal adjustments are made by varying the price without reference to costs. The short run is a time span in which plant, equipment, and organizational skills are fixed, but labor, materials, and supplies are variable inputs to production. Optimal adjustments to market conditions can be affected by changing the rate of utilization of the variable inputs, price, or both. The long run is a time span so long that all inputs are variable. In competitive markets the long run is a situation where new firms may enter and existing firms can exit or adjust their production capacity. Thus, all inputs are variable. Optimal adjustments to market conditions in these circumstances are the most flexible.

When one turns from theory and tries to apply these ideas to cost estimation, many practical problems make the specification of the time period a key issue. The intermediate run is one concept that has gained acceptability as a bridge between the long-run and short-run period. The time span is a period of sufficient length that in addition to the short-run variable inputs of labor, materials, and supplies, some, but not necessarily all, plant, equipment, and organizational skill are variable as well. In practice, the intermediate run is usually tied to the planning horizon of the economic entity. This linkage of the time period to planning department within the company is an important link between cost accounting and capacity planning in cost allocations.

In addressing issues of cost causation in this and the next chapter, the effect of the time period over which costs are measured on the cost allocation is discussed explicitly. Short-run, intermediate-run, and long-run perspectives on the variability of inputs greatly affect the degree to which cost can be traced and allocated to product lines and services. Whether there exists a socially optimal time period for determining cost causation for industry is doubtful. The specification of the time period is probably best related to the purpose for which the cost study is being performed.[1] Practical considerations such as revenue stability, rate stability, feasibility of application, and public acceptability also have some influence on the specification of the time frame.[2] Thus, a mixture of theoretical and practical considerations will ultimately determine the appropriate time period over which costs are to be measured for a cost-of-service study.

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[1]For the efficient allocation of resources, economists would argue that the short run is optimal. This time frame would allow prices to adjust continuously to variations in supply and demand and allow consumers to make optimal decisions.

[2]See Bonbright's criteria for a sound rate structure in James C. Bonbright, Principles of Public Utility Rates, (New York: Columbia University Press, 1961), p. 291.

Some Economic Theory of Multiproduct Firms and Common and Joint Costs

In this section the economic theory relevant to multi-product firms is discussed. The sharing of inputs by two or more services is assumed to occur in the firm for purposes of this discussion. This sharing of common facilities and personnel gives rise to issues of the separability of the cost function. A cost function is said to be separable if the total cost of producing a number of outputs can be written as the sum of producing each of the outputs separately. This implies that the separate production processes do not share any inputs. Inseparability of a cost function results in common and joint costs of production and is also a necessary, but not sufficient, condition for economies of scope. The optimal pricing of the services for a multiproduct firm is reviewed below. The purpose of this review is to gain insight into how one might devise allocation rules to mimic the optimal prices of economic theory in order to satisfy the cost-causation criterion.

Common Costs and Marginal Cost Pricing

Common costs are incurred when a facility provides several services. A frequently cited example of common costs are those associated with warehouse space. The economic cost of using warehouse space for one purpose is the inability to use it for another purpose. The marginal cost of any particular use can be identified and from this cost-allocation rules can be developed to distribute the cost to various uses.

Application of the cost-causality criterion in these circumstances requires that it must be possible to produce each of the services in varying proportions. Assume a cost function of the form

$$C = C(q_1, q_2, \ldots, q_n, k)$$

where $C(q_i)$ is the long-run cost function and the q_i $(i=1,...,n)$ are the n services provide by the shared capacity k. The marginal cost of any one service q_i is given by

$$\frac{\partial C}{\partial q_i} = \frac{\partial C(q_1, q_2, ..., q_n, k)}{\partial q_i}$$

Stated simply, the marginal cost of any one product is given by the addition to total cost of the combined production processes resulting from the production of one more unit of q_i while the production of all other services is held constant. Therefore, economically efficient pricing for the services provided by this type of common plant is feasible and cost-allocation rules feasible. It should be noted however that the marginal cost of service i depends on the level of production for all other services. If this changes the marginal cost of service i may change. To estimate marginal cost one must use this information.

Another way of measuring the marginal cost of a shared input is the opportunity cost approach alluded to in the warehouse example above. Since the shared input can be used in varying proportions, its use in the production of one service diverts it from another use. If an efficient market allocates the use of this shared input, it will be employed according to the social value of each alternative use. The economic or marginal opportunity cost of an additional unit of service would be the value of the input in its next best alternative use. Thus, measurement of marginal cost may be feasible under this approach as well.

Marginal cost pricing of several services using plant in varying proportions can create problems in two circumstances. First, the existence of economies of scale can result in marginal cost prices failing to recover the total cost of production. Second, the imposition of a regulatory constraint that specifies that total revenues should be set equal to embedded cost can render marginal cost prices unacceptable. Economists have devised solutions for these problems that minimize the impact on economic efficiency when prices must deviate from marginal cost. One solution to this "second best pricing" problem is the "inverse elasticity rule." Another solution is the application of the theory of cooperative cost-sharing games. Application of either one of these solutions to the allocation of common costs not recoverable through marginal cost prices will violate the causation criterion recommended above. Both solutions make use of demand considerations rather than cost factors to insure that total costs are recovered. Thus, one must be willing to accept as a goal the objective of minimizing the impact on economic welfare relative to other potential goals when total costs must be recovered. In this sense, common costs create problems for cost analysts and, in part, are allocated by arbitrary decision rules.[3]

Joint Costs and Marginal Cost Pricing

Joint costs occur when the provision of one service is an automatic by-product of the production of another service. The marginal cost of any particular service in this case cannot be identified because their marginal costs are inseparable. Kahn states that "(t)he economic product is the composite unit; the only definable costs of production....are those of the composite unit."[4] Mutton and wool from sheep farming are a classic example of joint production costs. By rearing sheep, one gets wool and lambs in fixed proportions, and the marginal cost of either product cannot be determined.

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[3]The inverse elasticity rule and game theory solutions are discussed in more detail below.

[4]Alfred E. Kahn, The Economics of Regulation, vol. 1 (New York: John Wiley and Son, Inc., 1970), p. 79.

Production of joint products in fixed proportions implies that

$$q_i = \alpha q_j \quad i \neq j$$

where q_i and q_j are two joint products and α is the fixed proportion between the two products. The cost function for the joint-production process has the following form:

$$C = C(q_j, \alpha q_j)$$

The independent effect on costs of q_i or q_j cannot be distinguished, but the two products do have a joint marginal cost of production. It is given by

$$\frac{\partial C}{\partial q_j} = \frac{\partial C(q_j, \alpha q_j)}{\partial q_j} + \alpha \frac{\partial C(q_j, \alpha q_j)}{\partial q_j}$$

This joint marginal cost of production for the services along with information concerning their respective demand functions allows economists to derive optimal pricing rules. In certain circumstances, cost-allocation rules might be developed to mimic the optimal prices of economic theory. The example of peak load pricing is relevant to telephone and is reviewed in the next subsection.

Time Jointness and Peak Responsibility

The most common occurrence of joint costs in the telephone industry is the time jointness of the costs of production. In this context, time jointness of costs means that capacity installed to serve peak demands is also available to serve demands at other times of the day, week, month, or year.[5] Since telephone service is nonstorable and aggregate demand for services exhibits a marked and predictable diurnal and seasonal pattern, the peak load pricing model of economic theory

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[5]See Bonbright, Principles of Public Utility Rates, p. 357 and Kahn, Economics of Regulation, vol. 1, pp. 89-94.

provides considerable insight into pricing of joint products as applied to the telephone industry.

The pricing prescription of the model is to recover the marginal costs of variable inputs and a capacity cost from customers taking service during peak period and charge only the marginal cost of variable inputs during the off peak period. The solution to the model is[6]

$$P_t = \frac{\partial C(q_t, k)}{\partial q_t} + \lambda_t$$

for the on peak period, where P_t is the on peak price, $C_t(q_t, k)$ is the variable cost function in period t; q_t is the quantity of service demanded during peak period t; k is aggregate capacity used in the joint production process; and λ_t is a rationing cost for scarce capacity for period t. In this model, the peak periods are defined by the condition that $q_t = k$. When this is the case, λ_t must be charged to users of service to choke off potential shortages of capacity. During the off peak period, rationing costs are zero.

A long-run condition for the rationing costs, λ_t, when capacity is optimally adjusted is given by

$$\sum_{t=1}^{n} \lambda_t = \frac{\partial C_t(qt, k)}{\partial k} + \frac{\partial F(k)}{\partial k}$$

Where F(k) is the short-run, fixed-cost function that depends only on the amount of capacity used in the joint production process. In other words, the sum of the rationing cost for one unit of service over

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[6]See William Pollard, "Regulatory Objectives, Peak-load Pricing, and the Long-run Equilibrium of Natural Monopolies," (Memo from Files), for derivation.

the entire demand cycle will just recover the marginal cost of capacity. The marginal cost of capacity is the change in short-run fixed cost as a result of varying capacity plus the change in variable costs that accompanies the change in capacity.

It should be noted that marginal cost pricing for joint products will not recover the total cost of production when economies of scale are present or when a regulatory constraint is imposed and embedded costs differ from current or prospective costs. In such circumstances, second best pricing could minimize the loss of economic welfare. The adjustment of prices during peak periods will have some effect on the level of capacity installed to serve the peak periods.

In sum, the pricing prescriptions for joint products derived from the peak load pricing model provide a cost analyst with valuable insight into cost allocation schemes. Bonbright states that

> The continued presence of peaks and valleys in public utility plant utilization gives qualified support to the system-peak responsibility formula of capacity-cost allocation.[7]

He goes on to state that stochastic methods should be used to assign capacity costs to peak period, and rates for a service should include charges for the probability that service is taken during the peak period.

Economies of Scope and Recovery of Costs

A broader concept regarding the presence of shared inputs is economies of scope. This concept measures the cost advantages to a firm of providing a large number of services rather than specializing in the production of a single service. Economies of scope occur when a firm can produce several services each at a given level of output at a

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[7]Bonbright, Principles of Public Utility Rates, p. 360.

lower total cost than a combination of separate firms each producing the same level of each output separately. A necessary condition for economies of scope is the sharing or joint utilization of inputs.[8]

Formally, economies of scope is expressed as

$$C(q_1,\ldots,q_n,K_1,\ldots,K_n,K) + F(k_1,\ldots,k_n,k)$$

$$< \sum_{i}^{n} [C(q_i,k_i,k) + F(k_i,k)]$$

where all terms are as defined above. In more familiar terms, this equation states that the total cost of providing several services at a given level by one firm is cheaper than the sum of the stand-alone costs of providing the same level of service. This phenomenon occurs as the cost of the shared inputs are spread over more units of the diverse services.

Economies of scope can exist regardless of whether economies of scale, constant returns, or diseconomies of scale are present in production. In fact, there is no single overall meaningful measure of average cost for the total firm with shared inputs because a consistent method of aggregating outputs may not be possible. Furthermore, even if measurable, it is difficult to differentiate between effects of the scale of operations on costs and the composition of output on costs. This problem has some definite implications for cost analysis. Estimation of the cost of providing a given service must explicitly consider the multiproduct nature of telephone companies. Bailey and Friedlaender state that:[9]

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[8]See John C. Panzar and Robert D. Willig, "Economies of Scope," American Economic Review 71 (1981).

[9]See Elizabeth E. Bailey and Ann Friedlaender, "Market Structure and Multiproduct Industries," Journal of Economic Literature XX (September 1982,): 1033.

> Seriously biased estimates may result if the multiproduct nature of output is not explicitly considered. Moreover, only estimation of the multiproduct cost function can provide the information necessary to resolve many pertinent policy issues.

At present, little is known about the cost structure for the provision of telephone services by a single firm.[10] Research should proceed in the direction of gaining useful insight into the cost structure of a telephone company.

When economies of scope exist, a measure of economies of scale for total company is given by[11]

$$\frac{\sum_{i=1}^{n} q_i \frac{\partial C}{\partial q_i}}{C(q_1, q_2, \ldots, q_n, k)} < 1$$

This is also an indication of the extent to which marginal cost pricing fails to recover the total cost of common-use facilities. Although economies of scale for the total company can be ascertained, economies or diseconomies relating to specific services cannot be determined because of the shared inputs. In this case, the average total cost of a specific service does not exist and the variable cost function for all or some subset of services may also not exist.

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[10]Two studies of which I am aware have attempted to estimate marginal costs for telephone service. See Leonard Waverman and Melvyn Fuss, "Multi-product Multi-input Cost Functions for a Regulated Utility: The Case of Telecommunications in Canada," (presented at the National Bureau of Economic Research Conference on Public Regulation, Washington, D.C., December 15-17, 1977; and Jeffrey Rohlfs, Marginal Costs of Telephone Services in Washington, D.C., (Washington, D.C.: Shooshan and Jackson 1983). These two studies are reviewed in chapter 7.

[11]See Bailey and Friedlaender, "Market Structure," pp. 1030-1031.

As noted, prices set equal to marginal costs may recover the total costs for a multiproduct firm. The existence of economies of scale or the imposition of a regulatory constraint can render marginal cost prices unacceptable because they fail to recover the total cost of production. Again, economists have devised two potential methods for dealing with this problem. One solution is the inverse elasticity rule, while the other is a game theoretic approach.

The Inverse Elasticity Rule

Baumol and Bradford[12] have derived pricing rules that can constrain profits to a specified level and at the same time minimize the welfare loss to society. This is best known as the inverse elasticity rule. In its simplest form, it is given by

$$\frac{P_i - \frac{\partial C_i}{\partial q_i}}{P_i} = \frac{1}{|\varepsilon i|} \quad (i=1,\ldots n)$$

In other words, for independent demands the optimal departure of price from marginal cost is equal to the reciprocal of the elasticity of demand for the i^{th} service. If the demands are not independent, some of the goods must be complements or substitutes. In these circumstances, information about the cross elasticities of demand is necessary to apply the inverse elasticity rule. In either case, this rule provides regulators with a method whereby they can adjust prices away from marginal costs to insure the utility does not earn revenues either above or below the allowed rate of return.

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[12]See William J. Baumol and David F. Bradford, "Optimal Departures from Marginal Cost Pricing," American Economic Review 60 (June 1970): 265-283. This rule is also called "Ramsey pricing" after Frank Ramsey whose article "A Contribution to the Theory of Taxation" adumbrated the Baumol and Bradford work. See Economic Journal 37 (March 1927): 47-61.

Two related implications of the inverse elasticity rule are worth commenting on at this point. First, the rule does not assign costs on the basis of cost causality. Instead, demand factors are used. Second, the rule results in an allocation of costs that may not be compatible with notions of fairness. The elasticity of demand is a measure of the responsiveness of the quantity of a service demanded to a change in its price. The absolute value of the elasticity of demand for a particular service depends on the necessity of the service, the postponability of its purchase, the percent of income or budget spent on the service, and the number of substitutes available. This last determinant of the elasticity of the demand suggests that services in competitive markets would be more sensitive to price changes than services offered under monopoly. Thus, if prices are increased to cover total costs, the inverse elasticity rule would tend to distribute a larger portion of costs to the customers of the monopoly services than to those of competitive services. The only assertion economists make about this distribution is that the loss of economic welfare is minimized.[13]

Application of Game Theory To Cost Recovery

Theoretically, the inverse elasticity rule is the most efficient way of covering costs when user prices must be varied from marginal costs. Since customer usage is sensitive to such prices, the major issue is finding the best way to arrange the prices so as to minimize any changes in consumer choices. If it is possible to charge customers a lump-sum fee, a different set of issues needs to be carefully considered. The customer access line charge will be used here as an example to illuminate these issues.

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[13]Economic welfare is traditionally defined as the sum of consumers' and producers' surplus. Consumers' surplus is a measure of the gain to consumers by participation in a market. Producers' surplus is a measure of the contribution to fixed costs over and above the recovery of the variable costs of production.

It should first be emphasized that an access charge is not truly a lump-sum fee if any customers disconnect from the network in response to its imposition. If disconnection is sensitive to access charges, then the issue is similar to the inverse elasticity rule--arrange the access charge so as to minimize any distorting effects on customers' decisions to hook up. Second, if lump-sum fees are indeed possible, the basic issue is how to share fixed costs among customer groups. Such cost sharing is largely an equity question, so reasonable people may disagree upon the answers. The economists' contribution to scholarly research in this area is largely contained in the literature of cooperative, cost-sharing games.

Although the practical usefulness of game theory may be limited, it provides regulators with two kinds of insights. First, since stand-alone costs for various consumer groups ("coalitions" in game theory terms) need to be determined, regulators can develop some sense about what types of pricing policies may be used to maintain all customers on the system and prevent bypass. The set of all such pricing policies that achieve this objective is called the "core" by game theorists. It is commonly defined by marginal cost pricing to recover all usage sensitive costs and lump-sum, hook-up fees that can be increased arbitrarily up to the point where a customer can improve his or her own well being by leaving the system. There is no reason, however, why the core could not be calculated using other pricing policies, such as usage prices that exceed marginal costs, thereby implicitly covering some part of fixed costs. If regulated prices are in the core, no one has any incentive to bypass the system. There is no guarantee that the core contains any regulated price, in which case bypass may be inevitable. If the core can be calculated using prices other than marginal cost prices, and if it exists, regulators would want such prices since they appeal to commonly accepted notions of fairness--no one is asked to pay so much that it would be cheaper to bypass and incur stand-alone costs.

Second, if the stand-alone costs have been estimated and the core exists, regulators may wish to find certain so-called solutions to the pricing game. An example is the Shapley value.[14] If the core exists, there are typically an infinite number of points in it, corresponding to small rearrangements of the lump-sum, hook-up fees among customers. A "solution" is a single point among all of these that has some desirable characteristics. For instance, the Shapley value can be interpreted as an estimate of what might emerge from a negotiation process in which all the customers participate and decide on how to allocate costs. The power of particular groups in such a process might well depend, in part, on how easily they could bypass the system and all participants must respect a viable threat that a particular group will walk out. Consequently, those groups that could most easily bypass the system tend to be somewhat favored in the solution concept embodied in the Shapley value.

These game theory concepts provide useful ways of delineating regulatory policy in telecommunications. Applying them to cost allocation in practice, however, could prove difficult. Estimating stand-alone costs is not a trivial matter. Done properly, it involves finding the optimal reconfiguration of the remaining system after various groups have left. Estimating the cost structure of an existing system, for which we have historical data, is difficult enough. Estimating it for reconfigured systems that have never been actually observed is an order of magnitude more difficult. Engineering models can be used for such estimates, but developing such models is expensive and difficult to incorporate into a practical cost-allocation method.

Conclusion

In sum, the imposition of a profit constraint on a multiproduct firm creates a number of theoretical problems for the recovery of the

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[14]The Shapley value is, for each participatent in the cost-sharing game, the average of the surplus associated with every possible coalition with which the participant could be associated. The surplus is valued at the stand-alone cost positions if the coalition has broken away from the central system or as the average of the surplus for all members remaining on the system. It is, simply, the average over all possible alternative ways of providing telephone service of the individual's economic well being.

cost of service. The nature of the choice between accounting costs and marginal costs as the basis of price regulation is unchanged whether or not the firm produces a multitude of products or a single product. Similarly, the issue of the time frame over which costs are measured remains a practical problem even for an unregulated firm producing a single product. In theory, the regulation of a single product firm creates only a few problems for regulators. The problems are associated with the adjustment of the price to the profit constraint. It is only when the production of several services shares the use of facilities and departments within the utility that the costing of individual services may cause problems. Estimates of marginal costs must account for the interaction among the production levels of various services. The imposition of the regulator constraint on a multiproduct utility introduces the need to distribute the impacts of the profit regulation among the services offered. Economists have formulated some solutions to these problems. The notion of fairness embodied in these solutions and their applicability is not straightforward in the regulatory arena.

The review of this economic theory of multiproduct firms did, however, clarify the costing problem. It indicated that the peak load pricing model is a proper model with which to conceptualize the costing problem and suggested further, that planning consideration may be relevant to the recovery of capacity costs. Practical implementation of these insights, however, is to be found in the cost accounting literature.

CHAPTER 3

A REVIEW OF COST ACCOUNTING METHODS

A review of cost accounting literature discloses four basic costing methods used by cost accountants.[1] They are

1. Direct, or variable, costing
2. Attributable costing
3. Full, or absorption, costing
4. Reimbursement costing

These methods differ primarily in their treatment of the costs of capacity and/or common costs. Cost accountants divide the total costs of production into two broad categories: direct cost and indirect overhead costs. Direct costs are those costs which can be traced to a revenue-producing object and which tend to vary directly with the volume of production. Indirect overhead costs are the costs of capacity and the costs of support and service centers within the company that are reassigned to revenue-producing objects by using overhead rates. The indirect overhead costs can be divided further between indirect variable and indirect fixed overhead costs. The "indirect fixed overhead costs" are sometimes referred to as period costs in that they are fixed costs of the period in which they are incurred and are charged against income of the period. In this chapter, each of the four costing method's treatment of these various costs will be reviewed.

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[1]John J. Neuner and Edward B. Deakin III, Cost Accounting, (Homewood, IL: Richard D. Irwin, Inc., 1977), and Gordon Shillinglaw, Managerial Cost Accounting, (Homewood, IL: Richard D. Irwin, Inc., 1982).

Cost accountants have three major criteria that apply to all four of these methods.[2] The first criterion delineates the general philosophy of approach, while the other two criteria provide guidance in implementing the first. The criteria are

> Cost causation: costs should be assigned to the revenue-producing objects that cause those costs to be incurred.
>
> Traceability: an attribute of costs that permits the resources represented by the costs to be identified in their entirety with a revenue-producing unit.
>
> Variability: costs, not traceable to a revenue-producing object, that vary in total with variations with some measure of the volume of activity that is associated with the revenue-producing object. These costs are assigned to revenue-producing objects according to the estimated rate of variability.

The second criterion is prima facie evidence of cost causation and, as such, is an operational criterion. Only direct costs are traceable to revenue-producing objects. Variability, the third criterion, applies to "indirect variable overhead costs" which are not traceable to a specific revenue-producing object, even in a superficial way. Application of this criterion to the allocation of a cost constitutes weak evidence of cost causation. All that is required is that the cost be roughly proportional to some characteristic of individual end-product activities. Thus, in applying these criteria to cost allocations, the primary test for cost causation is traceability, while variability is a secondary test.

Direct Costing

Direct costing assigns only those costs that vary with short-run changes in the rate of output. The costs assigned under this method are not only the direct costs but the indirect variable overhead costs as well. The "indirect fixed overhead costs" are considered to be

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[2]Shillinglaw, Managerial Cost Accounting, pp. 664-688.

period costs and are not assignable to revenue-producing objects. This costing method is sometimes referred to as variable costing because the use of the word "direct" in the name can convey the notion that only direct costs are assigned. As noted, indirect variable overhead costs are assigned under this costing method, yet they are neither direct nor traceable.

Variable overhead costs are assigned to revenue-producing objects by means of an overhead rate. The criterion applicable to these assignments is the variability test. Variability can be determined by either a statistical test or through an expert's judgment or both. The overhead rate for these costs should represent the average rate of cost variation within the customary range of production for each of the specific revenue-producing objects.

Direct costing makes available to the management cost data in an uncomplicated, usable form unclouded by the application of indirect fixed overhead costs. Direct costing is useful in cost control, internal pricing decisions, and specific decisions concerning materials, supplies, and utilization of plant and equipment in the short run. Direct costing is particularly useful in situations where physical production and sales volume do not coincide because the indirect fixed overheads do not impinge on the cost-revenue relationships. When using direct-cost information in decision making, management is assumed to have available all necessary market and production information to supplement the direct-cost estimates. This full array of information provides management with the insight into the company's circumstances needed to arrive at pricing or production decisions. Direct costs represent in management's view an accurate measure of the costs of controllable operating conditions.

Direct-cost estimates are primarily used for purposes internal to the company. Neither the Financial Accounting Standards Board (FASB) nor the Internal Revenue Service (IRS) recognize direct costing as a generally accepted accounting practice (GAAP) for inventory valuation or tax purposes.[3] Whether direct costing is appropriate for public utility rate making is discussed in the next chapter.

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[3]Neuner and Deakin, Cost Accounting, p. 458.

Attributable Costing

The attributable cost of providing any service is the costs that could be escaped over time if that service was eliminated and capacity was adjusted accordingly. It is a longer run concept of costing than direct costing. The assignment of some indirect fixed overhead is required to implement this costing method. The criterion of variability however does not adequately deal with the discrete nature of certain costs incurred by the company. It is necessary therefore to introduce an additional criterion for the attributable costing method--the "capacity-required" criterion.

The capacity-required criterion is another secondary operational criterion that is applied in situations when both the traceability and variability criteria fail to provide adequate guidance for developing overhead rates. The criterion is

> Capacity required: costs or capacity are assigned according to whether they are necessary to the performance of the service. The relevant test is that if these costs were not incurred, the service could not be rendered.

According to this criterion, "highly indivisible" costs could not be assigned to services. Indivisible costs are those for which reasonably clear long-term causual relationships are lacking.

Applying this criterion, an estimate of attributable costing includes direct costs, indirect variable overhead costs, and some proportion of the indirect fixed overhead costs. The indirect fixed overhead costs included by this costing method are those capacity costs that are divisible enough so that changes in normal volume will be accompanied, in time, by proportional changes in capacity. Application of this criterion to costing methods requires the use of sound judgment. Cost causality is inferred when it is shown that in the long run a service is supported by a cost.

Attributable costs, by developing overhead rates for indirect fixed overhead costs, must relate the costs incurred to some measure of the activity or volume for the service. The most often mentioned activity measure for allocating these capacity costs to a service is the relative utilization of the capacity by the service when capacity is fully used. This implies that one must consider the utilization of capacity over its life, particularly when that capacity comes in lumps that are so large that unused capacity may be prevalent during part of the useful life of the plant. Usage measures in this case should be based on design utilization or projected utilization.

Attributable costing extends direct costing to provide management with long-run cost estimates with which to assess the long-term impact of their decisions. The direct costing method is asserted to provide management with a proxy for short-run marginal cost. Attributable cost, on the other hand, is said to represent long-run marginal cost. Whether or not accounting-cost estimates provide accurate measures of marginal costs is questionable, particularly when historical costs are used. More likely, these two costing methods provide estimates of the short- and long-run, embedded-variable costs of rendering service.

The primary use of attributable costs is internal to the firm. the FASB and the IRS do not consider attributable costing to be a generally accepted accounting practice. The appropriateness of using attributable costs for public utility rate making is discussed in the next chapter.

Full or Absorption Costing

Full costing is a costing method in which each job or service absorbs a share of each of the costs of rendering service. This method requires the allocation of indirect fixed overhead costs in its entirety. To assign all of these costs to revenue-producing objects, another criterion is necessary. The calculation of predetermined overhead rates is an essential feature of the full-costing approach. Their use leads to discrepancies between the costs actually assigned to a service and costs actually incurred. These discrepancies are called variances, whether costs are over- or underassigned to a service. Analysis of these variances is useful to management for several purposes.

The traceability, variability, and capacity-provided criteria give insufficient guidance for allocating indirect, fixed-overhead costs for which reasonably clear long-term causal relationships to revenue-producing objects are lacking. A criterion of last resort for allocating these costs is the beneficiality criterion.

> Beneficiality: A service is said to benefit from a cost if that cost is necessary to render that service.

The key phrase in this criterion is "necessary to." The benefit is usually not direct, but is often of an indirect nature. General administrative costs and costs of independent research and development are examples of these costs. They are incurred because they are necessary to support current activities or to maintain the continuity of the organization.

The difficulty of ascertaining a common characteristic of end-product activities that can be measured and used hampers the development of overhead rates for costs to which the beneficiality criterion apply. This problem is not as pronounced when costs are assigned according to the variability or capacity-provided criteria. Application of the variability criterion requires that a characteristic of end-product activity be identified and that the costs be roughly proportional to variations in this characteristic. Thus, even for the variability criterion, identifying a common characterstic may be difficult, but the link between the characteristic and the cost was reasonably direct and assumed to be proportional. Application of the capacity-provided criterion is less direct, but, in theory, the characteristic is related to long-term design or planning considerations for end-product activities. With the beneficiality criterion, however, little, if any, guidance is given for choosing the characteristic common to all services to act as denominator in the overhead rate. In this case, accepted practices and principles of cost accounting are useful to the cost analyst even though the choices made depend heavily on the analyst's or management's judgment.

Overhead rates can be based on three concepts of normal operating conditions. They are theoretical capacity, practical capacity, and expected actual volume. Choice of one of these three concepts primarily depends on problems or issues to be analyzed and the decision to be made with information provided by the cost estimate. The measure of activity on which these ideas of normal operating conditions are based is usually one or more of the following six bases:[4]

1. Unit or production
2. Direct material costs
3. Direct labor costs
4. Prime costs
5. Direct labor hours
6. Machine hours

Direct materials and direct labor costs are those costs traceable to a revenue-producing object. Prime costs are the sum of direct labor and direct materials costs. When the concept of normal operating conditions is based on cost measures, it depends on both the price paid, the obtained materials and labor, as well as the quantity used. The use of the quantity measures, direct labor, or machine hours only depends on quantities used that would reflect the technology used in production. Unit of production is usually the best measure to develop overhead rates. It suffers from the fact that there may not exist a single measure of output for the various services produced by the common plant or shared input.

Regardless of the output measure used to develop overhead rates, the discrepancies (variances) between normal operating conditions and actual activity will over- or underallocate costs to a service. A

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[4]One method for assigning the indirect fixed overhead costs of a public utility. This approach has merit, but does not allow the same analytical capabilities of the six measures discussed above.

comparison between the three concepts of normal operating conditions and actual activity discloses the costs of various kinds of efficiencies and inefficiencies, and aids management in assigning responsibility to various cost centers within the firm. Theoretical capacity is the maximum possible activity for plant or equipment and ignores the possibility of idle time and breakdowns for any reason, controllable or uncontrollable. Theoretical capacity is rarely used in computing overhead rates because it would invariably lead to underrecovery of indirect overhead costs. Practical capacity, on the other hand, allows for the possibility of breakdown and scheduled shutdown for maintenance and adjusts the activity level downward from theoretical capacity accordingly. When actual activity falls short or exceeds practical capacity, over- or underrecovery of indirect overhead costs will occur. These discrepancies are attributable to efficiencies and inefficiencies in production of each service. These efficiencies are due primarily to management of circumstances that prevent controllable breakdowns of plant and equipment. Actual expected volume allows for idle time and adjusts the measure of practical capacity downward. Actual expected volume can lead to the over- or underrecovery of indirect overhead costs. Comparison of the costs assigned by using actual expected volume of those assigned using actual activity allows management to identify the cost or savings associated with the efficiency of the sales or forecasting staff. Comparison of the costs assigned by each of the concepts of normal operating condition can enable management to identify the costs associated with breakdowns and idle time. With further detailed information the costs can be categorized as those under the control of management and those that are uncontrollable.

Overhead rates must be developed to perform a cost study whether it employs direct, attributable, or full costing. These concepts of normal operating conditions used in developing overhead rates are reviewed in the section on full costing because the problems of identifying a common characteristic among many services are particularly acute when applying the beneficiality criterion to some costs. This discussion of the practice and principles indicates that there are several accepted practices for developing overhead rates. Each measure results in variances that provide management with a different type of information and each has its pitfalls. The IRS, in particular, requires that any variances resulting from the assignment of indirect overhead costs be reconciled in reports filed for tax purposes.

One of the primary uses of full or absorption costing is external reports. FASB and the IRS consider full costing a generally accepted accounting practice for financial reporting, particularly for inventory valuation. The IRS requires full costing for tax purposes and also specifies procedures for assigning variances to revenue-producing objects. The appropriateness of using predetermined overhead rates in public utility cost-of-service studies and rate making raises several issues, especially when contrasted to direct or attributable costing. These are discussed in the next chapters.

Reimbursement Costing

Reimbursement costing is a costing system used to develop cost-based prices that recover the total cost of production. It employs concepts governing the measurement of costs that are negotiated by customers or their representatives. Insurance company and government reimbursement of health care costs are examples of activities that use this costing method. Rules are generally established by a governing board or some higher authority to govern all costing for a given kind of activity or for a given industry. In 1971, Congress established the United States Cost Accounting Standards Board (CASB) to develop and promulgate uniform cost acounting standards, primarily for use in connection with negotiated defense contracts. The situation confronted by the CASB was the need to establish costing rules for a corporation or its subsidiaries that held a government contract and was also engaged in many unrelated activities. The assignment of of overhead costs to the contract and the allowable profit on the activity were issues for which rules or guidelines needed to be firmly established. These circumstances are similar to those that public utility commissions are confronting today when setting rates for telephone companies operating in both competitive and monopoly markets.

Reimbursement costing requires another concept. It is the inclusive criterion:

> Inclusive: The measurement of the costs of individual activities should be on an all-inclusive basis. The cost of an activity should include a share of all costs necessary to accomplish the activity and provide general support and continuity to the organization undertaking the activity.

This conceptual criterion suggests that all costs necessary to and from which a revenue-producing object benefits should be assigned to that object. Cost causation and the four operational criteria should be brought to bear on the allocation of costs on an all-inclusive basis. The main question to be addressed by the cost analyst is how much of the total cost of rendering all services should be included in the cost of a particular revenue-producing object. If the cost is not included in the cost of service, the company is usually not compensated for the cost. Thus, the all-inclusive criterion is indirectly a question of the allowable profit for the revenue-producing activity.

The cost-causation and inclusive criteria are not necessarily fully compatible. In certain circumstances, the application of the variability and capacity-required criteria to satisfy the all-inclusive criterion may violate of the cost-causality criterion. This occurs when under- or overrecovery of indirect overhead costs is a problem. Variances are perceived as a problem both by people acting on behalf of the customers and by the company rendering service. The representative of the customers does not want them to pay more than the cost incurred to render a service while the company, at minimum, wants to recover all costs it has incurred. Thus, the inclusiveness criteria constrains the application of the cost-causation criterion.

An example of this conflict is the nonlinear variability of costs with some characteristic of productive activity. It can lead to variances under the full-costing method. Overabsorption of indirect variable overhead costs will occur as the incremental overhead rate at the customery range of production exceeds the average overhead rate over the entire range of production from zero to the customary range. Underabsorption will occur when the incremental overhead rate is less than the average overhead rate. These variances violate the inclusiveness criterion, which is the primary conceptual criterion for reimbursment costing. Thus, to meet the inclusiveness criterion when nonlinear costs exist, the average overhead rate must be used to allocate indirect variable overhead costs rather than the incremental overhead rate.

The capacity-required criterion requires some concept of normal operating volume be used in the calculation of the overhead rate and this practice can lead to variances. Recall that the three concepts of normal operating conditions are theoretical capacity, practical capacity, and expected actual volume. When actual volume differs from these measures of capacity, the associated fixed overhead costs will be under- or overrecovered. This potential for variances violates the inclusive criterion but the concept of normal operating conditions satisfies the cost-causation criterion. Reimbursement costing requires the inclusiveness criterion be satisfied. To accomplish this, actual volume should be used in calculating the overhead rate instead of one of the three concepts of normal operating capacity.

Reimbursement costing is applicable to situations where cost-base prices are necessary to compensate a producer for rendering a service, but customers should not pay more than necessary to elicit the service. This view of costing leads to the cost-causation criterion taking a diminished role in costing when strict adherence to it might result in violation of the inclusiveness criterion. The extent to which this method is applicable to public utility pricing is examined in the next chapter.

CHAPTER 4

COSTING METHODS AND PUBLIC UTILITY REGULATION

Which (if any) or which combination of the four costing methods reviewed in the previous chapter is appropriate for public utility regulation? To a large extent, the answer depends on the reasons or purposes for which the cost estimates are needed. Recall that in the introductory chapter three major uses for cost estimates by public utility commissions were identified:

1. To determine the revenue requirement appropriate to each of the monopoly services provided by a telephone company

2. To set a minimum limit below which prices of competitive services cannot be cut[1]

3. To ascertain the extent to which rates for both the competitive and monopoly services are in some sense compensatory

The method or methods appropriate to each of these regulatory concerns is discussed in this chapter.

Revenue Requirement for Monopoly Services

Economics and cost accounting differ considerably in the information each discipline would provide to regulators for rate-making

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[1]The question of whether or not it is appropriate for a public utility commission to regulate a competitive service offered by a utility is not addressed in this report. A commission may at option choose to forebear regulating a utility's competitive offerings. Similarly, where the threat of ruinous competition is ominous, regulators may choose to set minimum prices for competitive services. In either case, consumers of monopoly services are protected by a policy that sets maximum rates for monopoly services. A full discussion of the correct policy to pursue goes beyond the scope of this report.

purposes. Economic theory would indicate that regulators should set prices for monopoly services at the marginal costs of the next units of output. Cost accounting, on the other hand, provides an estimate of the embedded accounting costs of producing the service. Based on this and other pertinent information, regulators set prices for the service. The appropriateness of marginal costs and the four cost accounting methods for setting the revenue requirement for a single service offered by a multiproduct utility is discussed in this section. Particular attention is given to making a costing method conform to traditional regulatory practices.

As noted, economic theory prescribes prices equal to marginal costs for all services offered by a multiproduct firm. The total cost of providing any particular service in theory cannot be determined when inputs are shared among two or more services. Thus, the cost estimates regulators desire cannot in theory be ascertained. All that can be provided, according to economic theory, are estimates of the revenues of a service that would be collected through marginal cost prices for a given volume and composition of output.

So long as constant returns to scale exist for the monopoly services priced at marginal cost, these revenues equal the total cost of providing the service. Unfortunately, economies, diseconomies, or constant returns to scale for a single service cannot be determined because of the inputs shared among the services. They can only be ascertained for the firm as a whole. Thus, if marginal cost prices are unacceptable for the firm as a whole because they do not properly compensate investors, the service or services responsible for the short fall or overage, whether monopoly or competitive, cannot in theory be identified. As a result, all prices must be adjusted according to some predetermined rule. As noted earlier, many economists would recommend the inverse elasticity rule to adjust prices from marginal costs.

Cost accounting methods appropriate for determining the revenue requirement for a given service are either full costing or reimbursement costing. Direct costing or attributable costing leave some or all of the indirect fixed costs unassigned. Since rates for a service must give the utility an opportunity to recover the total cost of providing the service, the choice between the full or reimbursement costing methods and the direct or attributable costing methods is whether indirect fixed overhead costs are explicitly or implicitly assigned to the various services offered by the utility. Since public utility commissions are charged with protecting the public interest in part by preventing undue discrimination, explicit assignment of the indirect fixed overhead costs is considered the best approach to meeting this regulatory obligation. Thus overhead rates to assign indirect fixed overhead costs according to the capacity-required and beneficiality criteria must be developed.

The choice between full or reimbursement costing is largely a question of the appropriate measure of normal operating conditions and the regulatory treatment of over- or underrecovery of the revenue requirement. The distinction between these two costing methods in practice may be more theoretic than real when applied to public utility regulation. Under current regulatory practice, revenue requirements for the total company are based on the costs incurred in a test year, which is usually the most recent 12-month period for which accounting and statistical data are available. In some jurisdictions, forecasts of operating costs and demand are used in conjunction with test year data to determine allowable profits and rates. In still other jurisdictions, allowable profits and rates are based entirely on a future test period. In every case, however, rates are set in advance, not retrospectively. Thus, overhead rates to recover indirect overhead costs, both variable and fixed, are at a minimum based on expected actual volume of the various services offered by a utility.[2] It would seem, therefore, that current regulatory practice rules out some aspects of reimbursement costing, because it requires the use of <u>actual volume</u> to formulate overhead rates.

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[2]Practical capacity could be used to develop overhead rates to encourage efficient utilization of plant and equipment.

Since rates for utility services embody predetermined overhead rates, overrecovery and underrecovery of the revenue requirement is bound to occur as actual volume varies from expected actual volume. Public utility regulation, however, only gives the utility the opportunity to earn its allowed rate of return; it does not guarantee it.[3] When a utility earns either more or less than it is allowed, there is not an immediate reconciliation with its customers. There might, however, be a rate case initiated by the utility, the commission, or the consumer group to reduce the imbalance for future periods. Regulatory review of the costs incurred by the utility, however, is inclusive in that all allowable costs incurred in rendering the service are included in the service's revenue requirement. This inclusive aspect of regulation eliminates direct and attributable costing as appropriate methods. Reimbursement costing is eliminated because its underlying philosophy is to guarantee a cost will be recovered. Regulation only offers the opportunity; rates are not set to recover costs retrospectively. Thus, full costing would seem to be the appropriate cost-accounting method for determining the revenue requirement for each of the monopoly services offered by a telephone company.

Minimum Limit for Competitive Services

A multiproduct utility operating in both competitive and monopoly markets has an incentive to subsidize competitive services with

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[3]Bonbright, Principles of Public Utility Rates, p. 53. The lack of a guaranteed profit is viewed by Bonbright as positive incentive for efficient operation. Paul J. Garfield and Wallace F. Lovejoy, Public Utility Economics, (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1964), p. 2, also note this lack of a guaranteed return as part of the characteristics that differentiate public utilities from other activities affected with the public interest.

revenues recovered from monopoly services. Regulators can guard against such subsidies by setting minimum-price standards for competitive services and maximum-price standards for monopoly services. As noted in the preceding section, maximum-price standards for services are set using full-costing methods. Their primary concerns when setting minimum rates are to compensate adequately the utility for services rendered and simultaneously to promote competition. In theory, the short-run marginal cost is the price standard for competitive markets and the standard against which the quality of competition can be measured. If the minimum price a utility can charge for a competitive service is set above the industry's marginal cost,[4] the ability of the utility to compete effectively for customers is limited and the entry and expansion of less efficient competitors is encouraged. The mimimum price in this case creates a price umbrella to protect competitors and promote their growth. If the minimum price a utility can charge for a competitive service is set below the industry's marginal cost, competitors will be driven from the market and the utility's share of the market will expand accordingly. In both cases, an _ex post_ examination of the mimimum price approved by the commission might conclude that regulators in fact set the price at the _industry's_ (as opposed to utility's) marginal cost. However, the firms (and plants) in the industry have adjusted their capacity such that the marginal firm (plant) is just earning zero economic profits,[5] and the minimum price is just equal to the marginal (firm's) plant's marginal cost and minimum average total cost. Thus, when setting minimum prices for the utility participating in a competitive market, regulators must be cognizant of the fact that they may be setting the market price and, in fact, determining the industry's revealed marginal cost.

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[4]The industry's marginal cost is usually defined as the minimum average cost to the marginal firm that just earns zero economic profits.

[5]Zero economic profits occur when a firm is just covering all costs of production, including interest expenses and dividends needed to attract and maintain capital.

The minimum price therefore, should be set with reference to the utility's marginal cost. Minimum price set below the utility's marginal cost would result in the utility rendering additional units of service at a loss.[6] This would correspond to an economist's idea of a subsidy if some other service is priced above its marginal cost to the utility. This control over the price charged by the utility would have competitive impacts as noted above, but the utility's marginal cost, as a standard, would not result in economic subsidies among services offered by the utility.

This practice of using the utility's marginal cost as the appropriate measure for minimum price may be difficult to implement, because the marginal cost may be difficult to estimate. Cost accounting methods, on the other hand, may not have adequate support in economic theory to allay regulator's concerns that workably competitive markets can be maintained. The use of direct and attributable costing as a proxy for the utility's marginal costs is examined below. It should be recalled from chapter 2, that accounting costs are the costs of historical, embedded plant and of test year expenses, whereas marginal cost are forward looking. These differences may have a more significant impact on competition than those due to the problems of method of assignment.[7]

Full and reimbursement costing are not appropriate methods for setting minimum prices for competitive services for several reasons. First, and foremost, the beneficiality criterion is not applicable. Costs that cannot be causally linked to the expansion, contraction, or

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[6]In other words P = MC implies that more is added to costs than to revenues.

[7]A full discussion of these problems goes beyond the scope of this report. It is sufficient here to note that the test year expenses would probably produce adequate proxies for the associated marginal costs. The costs of embedded plant and equipment and the associated embedded debt is the crux of the problem. The costs of plant additions and retirements for the test year might be used to generate estimates of marginal costs. Such estimates, however, would be subject to greater uncertainty than with expenses.

withdrawal of a service are not properly included in marginal cost. Second, reimbursement costing can be eliminated because of its inclusive criterion. Marginal cost prices do not insure costs are recovered through retrospective reconciliation of revenues and cost. They are prospective prices to recover costs to be incurred. Full costing, as the method appropriate to determining the revenue requirement for a monopoly service, is most appropriate to setting a maximum price for a service because prices above this cost would violate the profit constraint imposed on the utility.

The difference between direct and attributable costing is the application of the capacity-required criterion. Recall that this criterion provides guidance in identifying costs and assigning them to revenue-producing objects when those costs represent inputs or capacity necessary to the provision of the service. Direct costing applies the traceability and variability criteria to identify costs to be allocated to services. It is often said to provide an estimate of short-run marginal costs. Direct costing estimates the costs that are controllable by management when they vary the level of service while leaving capacity unchanged. Attributable costing takes direct costing one step further and assigns costs that are divisible in the intermediate run which can be identified as necessary to rendering a service. By applying the capacity-required criterion, it is said to be a proxy for long-run marginal cost. It measures those costs that the company would escape or incur if the service is withdrawn or added and sufficient time is given to adjust capacity. Thus, the time perspective is a central issue in choosing between direct or attributable costing. This issue has been thoroughly discussed in the economic literature pertaining to marginal cost pricing[8] and the major points are briefly summarized here. It should first be pointed out that in theory the long-run and short-run marginal costs coincide when capacity is optimally adjusted to the rate of output. Thus, in theory, a choice is required only when there is an excess or scarcity of

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[8]For instance, see Kahn, The Economics of Regulation, vol. 1, p. 70 or Bonbright, Principles of Public Utility Rates, p. 331.

productive capacity. In a world where inputs are indivisible and capacity is added in lumps, the likelihood that a prudently managed firm will have excess or scarce capacity increases and short-run and long-run marginal costs will not coincide. Thus, the considerations relevant to choosing between the long-run or short-run marginal costs must be examined.

Prices charged customers for services rendered may be viewed as conveying signals to consumers about the social value of the resources used. Consumers assimilate this information in planning their expenditures for durable and nondurable goods. With nondurable goods their planning horizon is short and consideration of the long run is incorporated only if the expenditure is recurring or if price changes are expected and the product is storable. Durable goods, on the other hand, are consumed in the immediate period and in the future. As a result, long-run considerations are relevant to the purchase of durable goods. One particular consideration is the price of complementary goods.[9] For instance, a company considering the purchase of a computerized information system that depends on satellite transmission of voice and data would be influenced by the expected price of transmitting signals over the life of the investment when choosing among other technological alternatives. In each case, the price charged consumers is assumed to convey the information necessary to make rational decisions in consumption and investment.[10]

In setting the price, the regulator should consider the excess or scarcity of capacity. Excess capacity can be eliminated in the long run by retiring or selling capacity. In the short run, however, excess capacity can be better utilized by pricing at short-run marginal costs rather than at long-run marginal costs. This strategy, however, may not recover the total cost of production. Out-of-pocket costs must be covered for production in the short run to be rational. These

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[9]Complementary goods are two or more goods consumed in conjunction with one another. For example, PBX trunks and PBX equipment are complementary goods.

[10]This logic is extended to the pricing of the loop and a customers choice about loop capacity in the next chapter.

out-of-pocket costs are those identified and assigned by direct costing. In theory, marginal cost pricing with excess capacity may make some contribution to the indirect fixed overhead costs as well as recover variable costs. This occurs when the marginal cost functions are nonlinear.

In figure 4-1, the cost curves for a typical firm are depicted. For output q*, the vertical distance between the average variable cost curve (AVC) and average total cost curve (ATC) is the average fixed cost (AFC)[11]. The average fixed costs can be viewed as the indirect fixed overhead costs if variable costs of production are separable. When direct costing is used to set a minimum price, price is set equal to AVC. In this case, none of fixed overhead costs are recovered. With marginal cost price (MC) as the minimum price, some fixed overhead costs can be recovered. At the output q*, the portion per unit of output that is recovered is represented by the vertical distance between the AVC and MC curve. The only exception occurs when production is subject to constant returns in the short run. In this case, minimum prices set according to marginal costs and direct costing

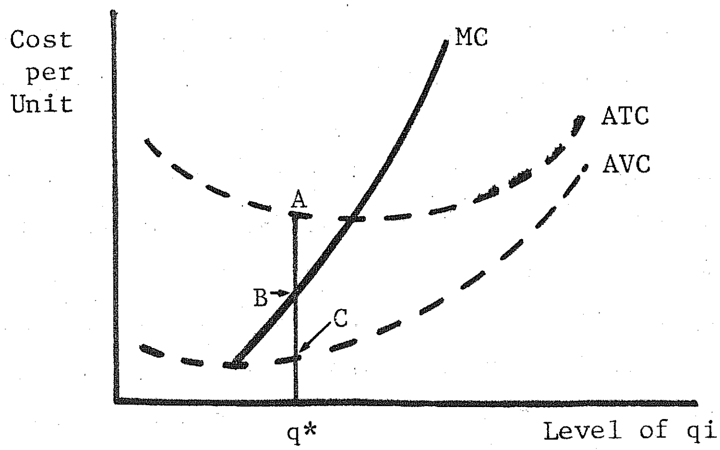

Fig. 4-1. Cost curves of product qi

[11]The average total cost and average variable cost curves are depicted with dotted lines to emphasize the fact that these curves do not exist, in theory, for a single product offered by a multiproduct firm. The average variable cost curve may exist for a single product if production processes are separable. This is assumed here for convenience of exposition.

will coincide regardless of the level of output that the fixed capacity is capable of producing. In lieu of constant costs the costs estimated by direct costing will be less than marginal cost. Therefore, attributable costing would be a better proxy for marginal costs than direct costing.

With a shortage of capacity, the consequences of additional consumption must be considered. Recall that with optimally adjusted capacity, additional production imposes the costs of additional materials, labor, and capacity on the firm in the long run. In the short run, however, capacity cannot be adjusted and rationing costs must be imposed to choke off additional demands that otherwise could not be satisfied.[12] These rationing costs are not properly identified and measured by applying the capacity-required criterion. This criterion identifies the costs associated with expanding capacity from one situation of optimal capacity to another. To quantify the rationing costs would require an examination of the magnitude of the shortage and the costs associated with leaving the demands unsatisfied. Identifying and measuring these costs is difficult if not impossible. This holds true whether attributable costing, direct costing, or some marginal costing technique is used. Thus, attributable costing may be a standard for minimum prices and marginal costs when capacity is optimally adjusted. When there is a shortage of capacity, however, both attributable and direct costing fail to measure rationing costs and will understate the minimum price.

In sum, it would seem that attributable costing may be an appropriate proxy for marginal costs. This costing method's ability to generate reasonable approximations is an empirical question and is highly dependent on the considerations used in generating overhead rates. Planning considerations would seem crucial to their formulations.

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[12]See the discussion of the peak load pricing model in chapter 2, pp. 15-17.

Standards for Compensatory Rates

A rate-of-return study based on a cost-accounting study for a test year is the typical method used to determine whether rates are compensatory. The revenues received by a service for the test year are compared to operating costs and ratebase allocated to that service. The rate of return actually earned by the service is compared to the overall rate of return earned by the utility and judged compensatory or not. The economic theory of a multiproduct firm, however, suggests that such a procedure is arbitrary and rates can only be judged compensatory for all services taken as a whole. This theoretical result has frustrated attempts by regulatory authorities to ascertain whether rates of the various services are compensatory and some parties to hearings have used it as an excuse to perform allocations regardless of their reasonableness. This theoretical result however does not mitigate the fact that rates for specific services based on both marginal costs and accounting costs need standards of comparison to answer questions raised about their ability to adequately compensate investors. In this section, the applicability of cost-accounting methods and their criteria as standards for compensatory rates is examined.

As discussed earlier,[13] each service offered by a multiproduct firm in theory does not have an identifiable total cost or, necessarily, a total variable cost. Marginal costs, however, do exist and can be identified and measured. The shared use of plant and equipment and administrative services are the crux of the problem. These facilities and expenses must be assigned to services in some manner and it is argued that any such assignment is arbitrary. Judgmental assignments of these costs, however, are things about which reasonable men can disagree, but for which rules may be developed and applied to achieve some overall objective.[14]

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[13]See chapters 2 and 3.

[14]The objective adopted for this report as discussed in the introductory chapter is to assign cost to the cost causer. Bonbright expressed this as "let the beneficiary bear the burden." Other objectives can be adopted but they are not necessarily harmonious with our six criteria.

One standard of compensatory rates might be a legal standard for insolvency. When a firm cannot generate revenues sufficient to cover its operating and other expenses including interest expenses, it goes into receivership or bankruptcy.[15] This short-term standard for compensatory rates applies to the firm as a whole and not to a single service offered by a multiproduct firm.[16] In the last section, direct costing, attributable costing, and marginal costs were discussed as standard for a minimum rate without regard to this insolvency issue. Consideration of this insolvency issue may impose some constraints on a minimum price for specific service if a compensatory rate for that service must cover some share of utility's interest expenses.

For the firm as a whole in the long run, both interest and dividend expenses must be covered to make production rational. The familiar Hope Natural Gas Case of 1944[17] is the leading precedent. The standard is

> Rates which enable the company to operate successfully, to maintain its financial integrity, to attract capital, and to compensate its investors for the risk assumed certainly cannot be condemned as invalid, even though they might produce only a meager return on the so-called "fair value" rate base...[18]

According to this dictum, the commission, in determining the allowed rate of return on the rate base, must consider a number of factors relating to the long-run viability of the utility. This legal

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[15]II USC sec. 21 (As amended 1978) Actually there are two definitions. One is to have a negative net worth. The second is when one is unable to meet current liabilities.

[16]The public utility cost-recovery standard relates to the firm as a whole being allowed the opportunity to earn a reasonable rate of return, but does not impose a similar requirement for any particular service.

[17]Federal Power Commission v. Hope Natural Gas Co. 320 U.S. 591 (1944).

[18]Ibid., p. 605.

standard also conforms to an economist's notion of zero economic profits or potential returns above zero economic profit if capital attraction is a major concern. These considerations, when applied to a particular service offered by the firm, imply that full costing and the revenue-requirement considerations may be relevant. Thus, long-run considerations surrounding the issues of compensatory rates suggest that the rate of return earned on a full costing of the rate base (for a service) may be a standard for a maximum rate. Variation in the allowed rate of return that would be deemed compensatory must vary among services according to the need to attract capital for expansion and replacement investment.

Assuming that the considerations relevant for the company as a whole apply to each service taken separately, a zone of reasonableness for rates charged for a service has been established. At a minimum, the return earned on the rate base must be adequate to cover a service's share of the interest expenses. At a maximum, the return earned on a service must be sufficient to enable it to attract capital and retain investors by compensating them for risks they incur. This latter standard might require a rate of return higher than that allowed for the company as a whole. The implied costing method for both bounds is the full-costing method; the same costing method that was deemed appropriate for computing the revenue requirement for a service. This should not be surprising since the issue of the revenue requirement for a service is a question of the maximum allowable profit. The question of compensation, however, introduces the idea of a minimum allowable profit on a full costing of the rate base and expenses. This idea allows one to assess the ability of minimum prices to compensate investors for the interest expenses incurred in rendering service. Thus, full costing is appropriate to address the issue of compensatory rates.

In developing cost allocation procedures to spread the fixed overhead costs of rendering the various services, cost causation should be the guiding principle. This requires careful application of the capacity-required and beneficiality criteria to the costing problem. Planning considerations are paramount to the application of the capacity-required criterion. Overhead rates for costs that are divisible in the intermediate run should be based on the idea of peak responsibility either over the demand cycle or over the life of the capacity.[19]

The application of the beneficiality criterion to the development of overhead rates for the remaining fixed overhead costs is a major source of controversy where issues of compensatory rates are involved. Recall that a service is said to benefit from a cost if the cost is necessary to render that service or maintain the continuity of the organization. Stated differently, the beneficiary of the cost should bear the burden. The major source of controversy in applying this criterion to develop overhead rates for the relevant fixed overhead costs is identifying some measure of end-product activites common to all services. A practice common to utilities is to allocate these indivisible costs according to the allocation of plant and equipment. This procedure uses the capital-intensive nature of utility service to allocate these costs. Compensatory rates could also be judged according to more than one measure of end-product activities under normal operating conditions. This practice, to the extent it is cost effective, could with proper analysis disclose the sensitivity of rates of return to the allocation of these fixed overhead costs to a service. In this manner, the overall importance of the allocations of these fixed overhead costs to compensation issues could be determined and appropriate regulatory authority exercised by the commission.

In sum, full costing is the cost-accounting method appropriate for allocating costs to a service to determine whether rates are compensatory in the sense of meeting the legally imposed revenue requirement. A subsidy can be said to flow to a service in the short

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[19]This reference to the economic life of the capacity may suggest depreciation practices different from those currently used for regulatory and tax purposes.

run when revenues are insufficient to cover operating expenses and interest expenses. A service is the source of a subsidy when the rate of return earned by that service exceeds the rate of return earned by the company as a whole by more than an adequate allowance for growth. In the long run, a service should cover some portion of the dividend expenses on average. What proportion is appropriate cannot be determined by any scientific principle. However, an examination of the risks incurred by offering a particular service, relative to those incurred by the firm as a whole, could provide some insight to the assignment of interest expenses and dividends to the various services.

CHAPTER 5

CONGESTION AND EFFICIENT PRICING OF THE SUBSCRIBER'S LOOP

The purpose of this chapter is to explore pricing issues surrounding the subscriber's loop capacity. Current cost allocation and pricing practices treat the cost of the subscriber line as insensitive to the amount of traffic that is incoming and outgoing from the subscriber's premise. Consequently, the total cost of the telephone company's investment in subscriber loops is assumed to increase proportionally with the number of customers connected to the network. This view of the subscriber loop has led the FCC, many state regulators, and some prominent economists to conclude that the appropriate way to recover loop costs is though a lump-sum, monthly hook-up fee. This conception of the subscriber's loop, however, ignores the fact that the subscriber loop can become congested. As a result, the pricing signals transmitted to incoming and outgoing callers by a hook-up fee may not lead subscribers of telephone service to make efficient decisions concerning the loop capacity servicing their premise.

This chapter contains four sections. In the first, the argument in favor of treating the subscriber's loop as insensitive to traffic is presented. Second, a conceptualization of the telephone system is presented that stresses the fundamental distinction between the pricing issues regarding the subscriber loop and the rest of the telephone network. In the third section, an informal theoretical model is presented to examine efficient pricing rules to control congestion on the loop and lead a subscriber to make efficient decisions about loop capacity. Finally, the implications for pricing and cost allocations are summarized.

The Nontraffic Sensitivity of the Loop

Subscription to telephone service requires that a subscriber loop be connected between a subscriber's premise and the central office switching equipment. The traditional view of this investment by the telephone company is that once it is installed, it is a fixed cost. The investment and other expenses incurred by the telephone company with respect to a loop do not vary with usage. This view of the loop is discussed in this section.

The loop between a subscriber's premise and the central office is simply a sheathed pair of wires capable of carrying an electronic signal. From the standpoint of a depreciation engineer, this investment deteriorates as a function of the wear and tear of elements. It is not used up as the result of incoming and outgoing usage. The deterioration that occurs does not depend on the present or absence of an electronic signal over the sheathed pair of wires. The inevitable conclusion is, therefore, that the investment in the loop is independent of the usage of a loop.

It should be noted that this argument is couched in terms of a single loop. The telephone company's total investment in loops does increase as the number of loops installed increases. This is viewed as occurring as additional customers are added to the system. Consequently, the company's loop investment is a function of the number of lines and not the usage of these lines.

Subscriber Versus Network Costs

The nontraffic sensitivity of the subsriber loop is used in cost allocations to differentiate between two classes of telephone plant--traffic sensitive and nontraffic sensitive. This conceptualization of the company's costs explicitly accepts the foregoing argument regarding the nature of loop costs and carries it forward to cost allocation and rates. This approach, however, distracts from the essential nature of telephone plant. A better delineation of the costs of telephone plant and equipment is between network- and customer-related costs.

Switching and trunking equipment are commonly available to a large group of customers simultaneously. The costs of these shared facilities are network costs for which the telephone company makes capacity decisions. A successful connection between two subscribers' premises does not necessarily exclude another connection between two other subscribers' premises. In fact, it is only when the average demand for these facilities at a point in time approaches the capacity of the network that distinct pairs of subscribers are denied use of these network facilities. These network costs, commonly available to all subscribers, should be recovered from all subscribers through traditional peak load prices. Such a pricing structure would indicate periods in which congestion of the network is likely and ration its use according to subscribers' willingness to pay.

Local loops are fundamentally different. They are a customer cost about which the subscriber makes capacity decisions rather than the telephone company. Although loops are used in common to provide services, each can accommodate only one conversation at a time. From the standpoint of economic theory, the public-good nature or joint consumption nature of the facility is distinctly localized.[1] It is a public good, but only over a small set of callers. It does not have the same widespread, or joint-use, characteristics as does the central switching office. By way of example, most local public goods, such as local parks or fire protection, are best provided locally; national financing is not typically considered to be efficient in the opinion of most economists. Truly national public goods, such as national defense, are best financed by the entire country. Hence, system-wide cost sharing of central office equipment, and local provision of individual loops has some precedent in the public finance literature.

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[1]This use of the words "localized" and "local" in this dicussion is a technical use. It is not used to distinguish between local annd toll calling, but to indicate the extent of the loop's ability to accommodate additional calling.

Despite the local public good nature of the facility, it is possible for a subscriber's loop to be congested. Incoming calls are blocked during ongoing conservations, and other users in the same household or small business can not call out if the line is tied up. Congestion, in general, has the special property of converting a public good into a private good. In other words, an uncongested loop will accommodate an additional user with no degradation in service to previous users. A congested loop, on the other hand, can serve an additional user only with a serious reduction in service quality or perhaps complete denial of service to another. It is up to the subscriber to make decisions about loop capacity. The denial or impairment of services to others on a congested loop enables efficient pricing policies to be fashioned.

Congestion and the Subscriber's Loop

In this section an informal theoretical model is developed to delineate the parameters of an efficient pricing policy for the subscribers loop. Congestion pricing for the subscriber's loop is theoretically justified, but it is likely to take an exotic form and is impractical. In particular, a specific type of auction for the right of access at times when the loop is in use may improve economic efficiency. The goal here, however, is to outline the pricing considerations relevant to the rationing of the loop and to enable the subscriber to weigh efficient decisions regarding loop capacity at his or her premises.

Before explaining both the concept of this auction and its application to loop pricing, however, a digression to explain the weakness of ordinary peak load pricing for telephone loops is helpful as background discussion.

Using electricity as an example, when demand in kilowatts begins to approach capacity in kilowatts, the usual prescription is to identify periods when the peak is likely to occur and to charge a higher price for average consumption (in kilowatt-hours) during peak as compared to off peak periods. Importantly, the pricing policy prescribes average prices per kilowatt-hour when instantaneous capacity, in kilowatts, is likely to be inadequate. The policy is successful because demand throughout the period is close to capacity, and consequently average demand during the period is approaching capacity. A high price on average demand effectively rations the capacity only to those with highest willingness to pay. It is the improvement in rationing that constitutes the efficiency gain in peak load pricing policies. A separate, but important, byproduct is that such a policy can generate sufficient revenues to cover costs under some circumstances. These circumstances are that capacity can be built with constant cost and that capacity has been optimally adjusted. Peak load pricing would improve efficiency even in the absence of such circumstances, however.

An analogous average demand price in telephone would be a charge per call-minute. Even supposing it possible to identify in advance the times when an individual's loop is likely to be in use, a policy of charging an average-type peak load usage price is unlikely to be a first best pricing policy. The reason is that such a price is ill-designed for reducing the type of congestion experienced on a local loop. Serious congestion problems occur long before average use infringes on capacity. For example, if loop use conforms to the usual assumptions made about telephone traffic that are embodied in the Erlang B blocking formula, the probability of a call being blocked is 20 percent during any period when the loop is utilized 25 percent of the time and is 47 percent as the average utilization rate approaches 90 percent.[2] Hence, serious congestion or blocking occurs well below 100

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[2]If the loop is used 25 percent of the time, the probability of observing it as being busy is clearly 25 percent. An observer not making any attempt to call would observe the 25 percent as the probability that the line is busy. The stochastic process of actually calling, however, involves mean time between attempts and length of conversations. A participant in the stochastic process of making actual calls would observe, with many repeated trials, that some 20 percent of his calls are blocked on a line busy 25 percent of the time.

percent utilization rates. By contrast, typical peak prices are efficient if they restrict the utilization rate to 100 percent. That is, in the absence of a peak price, average demand would exceed capacity. Such is unlikely to be the case for a telephone loop.

The loop congestion is not of the average-use variety. Rather, it is a problem of sequencing the calls. Two or more callers want simultaneous access to the loop. Under current technologies, blocked calls are not retained by the system, but are simply lost. The frustrated caller may try again later, at his or her option.[3] From the economist's perspective, assuming loop capacity is fixed, there is only one way to improve economic efficiency and that is by arranging the order in which the calls are served so that the caller with the highest willingness to pay is served first. There is no practical way of accomplishing this with current technology. Even with simpler queuing phenomena such as check-out counter waiting lines at grocery stores, there is not a mechanism ordinarily used for sorting the lines in order of willingness to pay. Indeed, many people might take offense if asked to abandon the time honored principle of "first come, first served," and adopt instead the practice of paying in order to be served first. Despite this displeasure, it is nonetheless true that for a fixed number of servers, that is "capacity," the only pricing policy that improves economic efficiency is one that sorts people in order of willingness to pay.

Simple and Complex Auctions

There is no practical way to implement an auction for telephone loop access with the current technology. The following discussion is an unrealistic, perhaps even fanciful, but logically sound suggestion for doing it. There are three distinct situations for which an auction

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[3]When newer technologies that permit automatic redialing of busy telephones become widespread, the resulting change in the underlying stochastic process will require a modification of the conventional Erlang formula.

could be used to improve efficient access to a loop. They are

1. Two or more individuals at a subscriber's premises simultaneously wish to make outgoing calls or receive incoming calls

2. Two or more individuals simultaneously wish to place incoming calls to a subscriber's premises, and each wishes to speak with the same individual

3. Two or more individuals simultaneously wish to place incoming calls to a subsciber's premises, but wish to speak with different individuals

The first situation involves individuals who are at the same location; hence, the congestion is internal to the premises. Typically this type of congestion is easily recognized by these users and can be handled by some prearranged rationing scheme. A formal auction is typically not needed, although some type of informal auction takes place in actuality. If, of course, internal congestion becomes serious, it may be beneficial for the premises to have an additional loop hooked up. Whether or not this is efficient depends on the quality of the price signal the hook-up fee gives this set of subscribers. In the discussion that follows, internal congestion and the resulting auctions are mentioned. More important for the purpose at hand, however, are the last two situations. For the second situation, a simple auction could be fashioned to deal with the external congestion. It is described in the next subsection. The congestion in the third situation is more complex and the resulting auction is more sophisticated. It is described in the subsequent subsection. These auctions have important implications for pricing policies for the subscriber loop.

Simple Auctions

Suppose that each telephone user has a device that not only indicates when a local line is in use or access is desired, but also allows each user to bid for the right to be connected to the loop when two or more parties desire access. An efficient form of bidding would be a "Vickery auction" (defined below). Suppose a subscriber's loop is in use and a second caller attempts to access the line, wishing to talk with the person currently on the line. The two competing incoming callers might be asked to pay for the right to access the subscriber's loop. In this case, the new caller would bid to interrupt the ongoing conservation, while the original incoming caller would bid to remain on the line. A light might flash and both incoming callers would enter the dollar amount of their bid.[4] To cut through the time consuming process of each party successively increasing their bid until one drops out, each would be asked to reveal their maximum willingness to pay. The auction becomes a Vickery mechanism, named after the economist William Vickery,[5] when it uses the following rule: the winner is the person with the higher bid; however, he or she actually pays the amount bid by the next highest bidding opponent. In such an auction, everyone has an incentive to immediately reveal his maximum bid since the element of gamesmanship, trying to guess the opponent's maximum bid, is eliminated. The proceeds of the auction could be paid to the party being called or to the telephone company.

The important consequence of the auction is that it arranges incoming callers in order of the importance attached to or willingness to pay for access to the called party's subscriber loop. It correctly rations the immediate use of the loop to those who value it the highest.

If more than two incoming callers are in the queue, an auction would be held for each position in the line. For example, if the three

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[4]This could be easily modified so that the called party enters his or her willingness to talk with each of the competing callers. With such modifications the joint amount bid by pairs would be relevant where the called party is a member of both potential conversation pairs.

[5]William Vickery, "Counterspeculation Auctions and Competitive Sealed Tenders" Journal of Finance 16 (March 1961,) 8-37.

people were willing to pay 25, 15, and 5 cents respectively, for the right to access a subscriber's loop, the top bidder would pay 15 cents to talk first, while the second bidder would pay 5 cents for the right to be second in line. The low bidder would pay nothing, but would have to wait till the first two incoming callers were finished. Note that the proceeds of the auction exactly equal the social opportunity cost, or annoyance costs incurred by the incoming callers who must wait. That is, the auction yields 20 cents, which is the value of the waiting time of the second and third callers.[6] The 25 cents that the winner is willing to pay is not collected, which is also appropriate, since it reflects the aggravation he would have suffered if asked to wait. Since he talked first, he suffered no such irritation, but did pay 15 cents for the right to be first.

The ordinary type of congestion pricing, peak load pricing can produce revenues sufficient to cover capacity costs, as explained earlier. The same is true for the Vickery auction when applied to ordinary queueing processes such as grocery check-out counter lines. When there is a shortage of servers (that is, check-out counters), lines will be long, irritation will be ample, and the Vickery action proceeds will be large. If check-out counters were supplied competitively, a new one would be installed if it appeared to be profitable to do so. Thus, if the annual auction proceeds were larger than the capital cost (annualized) of the counter, a competitive firm would install one. Such a decision would be socially optimal because it involves a comparison of the social opportunity cost of those who must wait to be served with the social cost of installing an additional server.

The same basic link between Vickery auction proceeds and capacity decisions can be reached with regard to a subscriber's loop, but not without some important modifications. A second loop should be installed if the relevant social opportunity cost of waiting exceeds

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[6]Assuming each is willing to pay such an amount in order to avoid the aggravation of waiting, which seems reasonable.

the costs of installing an additional loop. The revelant social opportunity cost, however, does not include the proceeds of the auction previously described. The reason is that every telephone conversation, like every tango, takes two. Since both incoming callers wish to speak to the same person, an additional loop will not reduce the congestion. What matters for the decision to install a second loop is that pairs of conversers be ordered correctly.

With the simple auction, there are two incoming calls for the same person. Social efficiency is improved merely by insuring that the incoming caller with the greatest need has the first access right. The previously described Vickery auction accomplishes this rationing. The proceeds from such auctions, however, are irrelevant in any comparison with the cost of a second telephone loop, since the called party could not talk with both in any case.[7] A capacity to make a conference call might help, if all three parties had a reason to converse together. Ordinarily, the incoming calls are likely to be independent and, hence, the rationing virtue of the Vickery auction has no bearing on the optimal capacity decision. Thus, the previous auction, although it improves economic efficiency, is irrelevant to the decision to install a second loop.

With the simple auction, the truly scarce resource in this instance is a single human being capable of talking with only one person at a time. Additional loops do not alleviate this scarcity. Consequently, the proceeds from the simple type of Vickery auction are distributed efficiently if they are neutral with respect to the investment decision. There are three possible distributions. One is to give the proceeds to the person whose loop is congested. To the extent that this would appear to reduce the price and thereby encourage the installation of another loop, it is inefficient. If, however, such a person recognized that an additional loop would not reduce such congestion, since he himself could do no better than take the calls in

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[7]The call waiting feature could be viewed as a method of enhancing the capacity of the loop by making the subscriber aware of incoming calls waiting in a queue.

sequence, even on multiple lines, he would regard the proceeds simply as income to be spent on other goods. If all people were this logical, disbursing the proceeds to people with congested loops would be neutral with respect to the investment decision, and hence efficient. The possibility that some customers might mistakenly believe that another loop would relieve such congestion, however, suggests that some other disbursment may be superior.

It follows from this discussion that, in the absence of the Vickery auction, there is no appropriate telephone pricing policy for dealing with this type of congestion. That is, suppose a time-of-day access fee for incoming calls could be designed separately for each loop. An example might be to charge a higher rate for a minute of use between 8:00 P.M. and 9:00 P.M. for calls to a household with a teenager. Such a policy might reduce congestion in the sense that a few of the half a dozen friends might be unwilling to pay the higher price. But it does not alleviate the basic problem that is that the teenager could talk to only one at a time, even with multiple lines. It is time that needs rationing, not the telephone loop. Peak load pricing to relieve this type of congestion is simply inappropriate.

A second way to dispose of the simple Vickery auction proceeds would be to give these to the telephone company. Whether such income improves economic efficiency depends, in part, on the relationship between marginal cost and the actual prices needed due to the revenue requirement. If prices must exceed marginal cost in order to cover costs, then additional income would allow these pricing distortions to be reduced. Hence, even though there is no first best, that is marginal cost-based, reason for returning the proceeds to the company, second best considerations due to the revenue requirement may be relevant.

A third way would entail the winner of such auctions simply paying the loser, which could be arranged by adjusting the phone bills of the competing outside callers. Such a payment seems sensible since it is precisely what is needed to compensate the person who must wait. It is neutral with respect to the investment decision, and could easily be preferred by society and regulators because it seems equitable and fair. The fairness of compensating the loser must be compared to the second best efficiency gains of reducing telephone rates in general.

Complex Auctions

A second or competing call to a different party in the house, however, would be relevant to the capacity decision. In such case, the appropriate Vickery auction is between an incoming caller and the called party for each pair. The device attached to the telephone that was described before now needs additional sophistication. It needs a capability to signal the subscriber's premise two bits of information: who is calling and to whom the potentially interrupting call is directed. All four people, then, need to bid for use of the telephone line. The rules would be the same as described before, except for pairs. The highest amount bid by a pair wins. They, then, pay the amount bid by the losing pair. How such a payment would be divided between members of the winning pair needs to be established ahead of time--a point that is developed later. Only the proceeds from such auctions among pairs are relevant to the capacity expansion decision. The reader should be assured that the electronic auctioning device imagined in this flight of fancy is sufficiently sophisticated so as to distinguish auctions among pairs from the simpler variety. The proceeds from the complex auction are relevant to the loop-expansion decision since this type of external congestion is eased by installing more loops. The question now raised is which disposition of the proceeds from complex auctions best internalizes the costs of external congestion.

The proceeds of this complex auction could be paid directly to the called subscriber or given to the telephone company. The choice between these two distributions of the proceeds has an impact on economic efficiency. If paid to the telephone company (via an itemized charge on the telephone bill of each party in the winning pair), the telephone company would receive the amount jointly bid by the losing pair and paid by the winning pair. If the premise being called by two outside parties receives the proceeds, only the incoming caller of the winning pair would pay, since there is no need for the called person of the winning pair to pay his or her own self. This transfer of funds from one subscriber to another could be accomplished by offsetting credits and charges on the two phone bills. These two procedures have different efficiency implications. Payment of the auction proceeds directly to the subscriber is undoubtedly inefficient.

To understand why, suppose first that the proceeds from complex auctions are given to the owner of the sometimes congested loop. The socially efficient decision rule is for the customer to order an additional loop from the telephone company when the annual proceeds from complex auctions (representing avoidable outside waiting time) plus the customer's own internal evaluation of waiting time within the household or business is greater than the cost of the loop. Suppose, in this case, the customer pays the full cost of the loop. Such a scheme--that is, the customer receives the externality congestion proceeds and pays the full cost of the loop--would almost certainly result in inefficient decisions and too few loops in particular. The reason is that the called party's revenues from complex auctions are directly tied to the external congestion. As the subscriber adds more loops, his marginal cost will include the loop price (paid to the phone company), plus the reduction in Vickery auction proceeds that accompanies the decrease in external congestion. That is, the marginal price of a loop from the viewpoint of a customer installing an additional one is actually greater than 100 percent of the company's cost. The customer's marginal benefit is his or her own reduction in internal waiting for a free line. In such a case, a rational customer would add a loop if the marginal internal congestion (a positive benefit) equals or exceeds the engineering cost of the loop (a positive cost) plus the marginal external congestion (another positive benefit). This is not the correct, socially efficient, decision rule. Instead, the correct rule is to install another loop as long as the reduction in the internal plus external marginal congestion (positive benefits) equals or exceeds the marginal loop cost. This scheme directs the flow of Vickery auction proceeds opposite to that required for economic efficiency. An example may help to clarify this explanation.

Imagine a customer with a single loop that has complex auction proceeds equal to 50 percent of the cost of a loop and internal waiting time also valued at 50 percent of loop cost. The socially optimal decision is to install a second loop. If it is installed, congestion will be successfully reduced to some low level, which we assume to be zero for ease of exposition. Hence, after the second loop is added, the revenue from complex auctions is reduced from 50 units (expressed as a percent of loop cost) to zero. Assuming that the customer can anticipate this revenue reduction, his rational choice would be to have only one loop. The incremental benefit of the second loop, from the customer's perspective, is the 50 unit reduction of internal congestions. The incremental cost is actually 150 units. This is because the customer initially pays 100 units to the phone company for the loop itself, and receives fifty units from various paid auctions. His net cost is 50 units for one line. With 2 lines, he pays the company 200 units and receives no auction revenue because of the success of the additional line in reduction the external congestion. The incremental cost is thus 150, or 200 less 50. In such circumstances, the customer would not install an additional line, even though the total social benefits and costs justify its installation. The price signal conveyed by the payment of the Vickery auction proceeds is incorrect. Only if the congestion is composed solely of internal waiting will the customer make the correct decision.

The conclusion to be drawn from this case is that the policy of giving the complex auction proceeds directly to the called parties at the congested line is inherently inefficient, and indeed, is perverse. An efficiently designed policy would place the burden of the external congestion on the party being called, as long as the loop price is 100 percent of cost. Such an external burden would then be lifted as more lines are added. The customer, then, would perceive a benefit from the additional line of both a reduction in internal and external congestion. There is no obvious way, however, to fashion a payment scheme that places the external burden on the party being called. It makes no sense, for example, to have the called party pay the external person who must wait. Such an idea is negated by the moral hazard that people would tend to inflate their bids to gain access knowing that someone else (the party being called) would pay whatever is bid. Hence, there appears to be no viable payment scheme either to or from the party whose line is congested.[8]

The limitations described above can be overcome by directing the payments associated with external congestion through a disinterested third party, in this case the regulated telephone company. This approach to internalizing an external cost has been analyzed in the public finance literature.[9] The basic arrangement would have two parts. First, the proceeds of complex auctions paid by callers placing incoming calls would be paid to the telephone company. The company, however, cannot make correct decisions about additional loops since it does not know the extent of internal waiting within the customer's premises. To finesse this lack of information, the second part of the arrangement would include an offer by the company to install an

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[8]It could be argued that a small-business, telephone customer fully appreciates the external blocking of calls since these represent lost sales. Such a phone subscriber would bear the external burden without any special need for an access auction. Such an argument is incorrect, however, to the extent that a buyer or user of the small-business' services receives any consumer surplus from the transaction. That is, the existence of a consumer surplus in the phone transaction that sells the services offered by a small business means that the consumer suffers some loss when a call is blocked that can not be internalized by the small business.

[9]The interested reader is invited to read James Buchanan and W. Stubblebine, "Externality," Economica 29, November 1962): 371-84 William Baumol, "Taxation and the Control of Externalities," American Economic Review 69 (3) (June 1978): 307-322; or Herbert Mohring and J.Hayden Boyd, "Analyzing 'Externalities': 'Direct Interaction' vs. "Asset Utilization' Frameworks," Economica 38 (November 1971): 347-361.

additional loop for its cost net of the aforementioned proceeds collected from the the complex auctions. Faced with such a price, the customer would add a loop if the internal congestion exceeds the company's offer. This is equivalent to the economically efficient decision rule.

Strictly speaking, it is probably best that the phone company collect complex auction payments only from the external members of the winning pairs. The reason is that the telephone subscribers at a premise with a congested line can rationally add up all sources of waiting including the time spent waiting to place an outgoing call and the time spent waiting to complete a call that was preempted by the pairs auction. These two sources of internal aggravation plus the external aggravation portion or delayed calls (collected by the phone company) comprise 100 percent of all congestion. A customer comparing the two types of internal waiting with the company's offer would have all of the information needed to make the correct decision.

If, however, only the external callers pay for the right to access the local loop, a question naturally arises of how much they pay. The following rule is a suggestion--and perhaps the only efficient one. Bear in mind that the enabling device for the pair auction can record the four amounts bid, two each from each pair. The suggested rule is: the external winner pays the amount bid by the external loser, up to a maximum of his own bid. As long as the amount paid under this rule is less than the external party's own bid, the rule has an appealing logic. The external party's payment plus the actual value of internal waiting adds up to the social cost of the pairs who must wait. Note that the former is paid by a winner and the latter is suffered by a loser.

An example may help. Suppose the complex auction resulted in the following bids:

	External	Internal	Total
Winner	1.00	.60	1.60
Loser	.25	.75	1.00

Efficiency requires that the winners pay what the loser bid, or $1.00. Splitting this amount between the various parties is a separate question. The espoused rule, in this example, results in the external winner paying .25 to the telephone company. The phone company then converts this, and many other complex auctions, into an offer to discount the price of loop installation. The customer receiving such an offer compares it to the internal value of waiting. In this example, the internal member of the losing pair is the individual who actually waited, the value of whose time was .75. This plus the external winner's payment adds to the social value of the congestion. Other arrangements do not have this property. For example, the external winner might pay the losing pair bid of $1.00, less the amount bid by his own conversation partner, .60, or a sum of .40. Such an amount plus the actual value of internal waiting of .75, however, exceeds the total value of waiting. The espoused rule implicitly assumes that the customer will evaluate actual internal waiting when considering the company's offer, as opposed to the bid by the internal member of the winning pair.

Implications for Pricing Policies

The importance of this fanciful excursion into exotic congestion pricing is the conclusion that a first best, socially efficient price for multiple telephone loops would be less than the marginal cost of the loop. As a practical matter, the analytical device of the Vickery auction among pairs is not available. In its absence, a first best policy would lower the price of an additional loop by the extent of the external congestion. Additional loops would be installed when the value of the internal waiting to place outgoing calls exceeds this price. If both external and internal waiting have about equal value, the correct pricing policy could be approximated by charging a fraction of the loop cost equal to the ratio of internal to total congestion. To estimate such a fraction, a traffic study of incoming and outgoing blocking might be useful. The two types of blocking probabilities might be estimated from a knowledge of the corresponding traffic in terms of completed calls. If internal and relevant external blocking occur at about the same frequency, the correct loop pricing policy would be approximated if the phone company were to offer to install additional loops at a price of one half of its cost.

It is very important to understand the limitations of this conclusion. It concerns additional loops only. That is, the optimal price for a second, third, or additional loop is less than the cost. Nothing at all is implied about the appropriate price of the initial loop. The logic used in this analysis does not apply to the decision of whether to install the first loop. That is, the waiting line type of congestion is not an issue until at least one server is installed. Waiting lines do not exist for nonexistent grocery counters. They do not exist on routes where buses never run. The purpose of the first phone line connection is not to reduce telephone congestion--it is to enable any call at all, either incoming or outgoing. The benefits associated with the decision to step from zero to one phone line include the insurance benefits of being able to communicate rapidly with emergency services such as police, fire, and ambulance, as well as the more frequent benefits of placing and receiving calls. The device of the Vickery auction which led to the conclusion of pricing second or additional loops at some fraction of its cost, is not an appropriate analytical construction with regard to the first loop since there is no queue that needs to be sorted.

The conventional economic analysis of customer charges is appropriate for the first line. In particular, a customer will decide to connect to the network if his marginal benefit is not exceeded by the customer charge. The efficient customer charge is based partly on the cost of connection and partly upon any external benefits accruing to others from their ability to place incoming calls. These externalities associated with expanding the telephone network are well-known and have been analyzed by Littlechild.[10] Such externalities

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[10] Stephen C. Littlechild "Two-Part Tariffs and Consumption Externalities," Bell Journal of Economics and Management Science 6 (2) (Autumn 1975): 661-670.

are associated with the extensive margin of the network (adding new lines). The analysis developed in this section has considered the intensive margin of the network (adding duplicate lines).

This discussion thus far has considered first best pricing. That is, in the absence of any constraints, this analysis suggests that external congestion of a local loop can be internalized by a pricing policy that charges customers only the internal portion of overall congestion for a second or additional loops. Such a policy clearly would not cover the cost of such subsequent loops. The regulatory requirement to cover costs means that prices must be greater than their first best level. In this context, the imposition of the revenue requirement means that prices for all services should be raised in order to recover the external congestion portion of subsriber loop costs. Hence, optimal second best prices would increase usage prices above their first best level, and in addition would increase the price of a second loop above its first best level. In practice, this might take the form of allocating the external congestion portion of the cost of duplicate loops to the local exchange and toll networks on the basis of relative usage. In this case, the prices of other services are raised to cover these externalities of the subscriber loop. This type of cost allocation practice has the advantage of avoiding the use of demand elasticities to adjust first best prices. Such elasticities are known only imperfectly, which complicates their presentation and use in rate cases.

The initial discussion of the auctions for access suggested that preset, time-of-day usage pricing is unlikely to improve economic efficiency. That is, charging a higher price per call-minute when the loop is likely to be busy is unlikely to correctly order the competing calls. The Vickery auction accomplishes this directly. It is true, however, that higher usage prices would tend to reduce the length of conversations and thus indirectly reduce the probability of blocking on a loop. If such a time-of-day usage pricing policy improves economic efficiency, it could be adopted along with the loop pricing policy of charging for only the internal congestion portion of costs. That is, the two policies are quite independent. If external congestion is reduced by a time-of-day usage price, it should be adopted as long as the congestion improvement is worth the additional administrative and metering cost. Whether it is or not is an empirical question.

CHAPTER 6

A REVIEW AND CRITIQUE OF THREE COST-OF-SERVICE METHODS

In this chapter, the allocation of the cost of specific plant items by three cost-of-service methods is examined. One method is a composite of studies used by the Bell operating companies (BOC). The BOC method consists of the Embedded Direct Analysis (EDA),[1] the Exchange Cost Study (ECS), and the Embedded Cost of State Toll study (ECOST).[2] The ECS and ECOST extend the EDA and are used in tandem with it to draw conclusions about the direction of subsidies in the state toll and local exchange markets. The other two methods are offered by consultants and are usually entered in opposition to a BOC's rate structure. The J. W. Wilson method[3] (JWW) is a full-costing approach based on the EDA procedures and is offered by J. W. Wilson and Associates. The third method is offered by Richard Gabel. Gabel's method, a full-costing approach, has been adopted by the Kansas Corporation Commission as the appropriate method to determine the cost

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[1]The information presented in this section on the BOC's Embedded Direct Analysis is based on American Telephone and Telegraph, 1982 EDA Executive Overview, (New York: American Telephone and Telegraph), vol. 12, Level II.

[2]The information concerning the Exchange Cost Study (ECS) and the embedded cost of state toll (ECOST) is based on the testimony of James J. Hager, Docket 5220, (The Public Utility Commission of Texas, June 1983), presented on the behalf of Southwestern Bell of Texas.

[3]The information on the John W. Wilson and Associates method was taken from the testimony of Dr. John W. Wilson, Case No. 7661, (The Public Service Commission of Maryland, November 1982), and conversations with Alan Buckalew in July 1984.

of telephone service.[4] The allocation of local dial switching equipment, the subscriber loop, and exchange trunk plant by these three methods is reviewed and critiqued using the economic and cost-accounting concepts presented in chapters 2 and 3.

In table 6-1, the service categories for separations procedures, EDA, JWW, and Gabel are presented. An examination of this table discloses several interesting points. First, note that both EDA and JWW methods reallocate the costs associated with the federal jurisdiction in accordance with their assumptions and methods, while Gabel only allocates the state jurisdictional costs. This practice of reallocating federal jurisdictional costs makes audit, verification, and reconciliation of the cost study more difficult. In addition, the revenue-cost relationships derived by these two costing methods are distorted because the rates in both the federal and state jurisdiction are designed to recover the revenue requirements based on jurisdictional separations. Second, note that EDA uses an access line and a common category, while the JWW or Gabel methods use neither of these categories. This difference is rooted in the underlying costing approaches. EDA, by itself, is a mixture of the direct-costing and attributable-costing approaches, whereas both the JWW and Gabel methods are full-costing approaches. Note further that the JWW and Gabel methods use service categories that can be directly identified with groups of services for which rates are designed. EDA, on the other hand, has two "service" categories that do not correspond to services for which rates are charged. The use of these two categories, in part, make EDA difficult to neatly classify as either a direct- or an attributable-costing procedure. The classification hinges on whether the capacity-required criterion is applied, and if so, how consistently. Recall that costs are assigned to the common category by an attributable-costing method when the beneficiality criterion is

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[4]Richard Gabel, "Southwestern Bell Telephone Company Intrastate Cost of Service Study-Kansas," Docket No. 117,200-U, (1978, Kansas Corporation Commission).

TABLE 6-1

SERVICE CATEGORIES FOR SEPARATIONS AND THREE COST-OF-SERVICE METHODS

Service Category	Separations	EDA	J.W. WILSON	GABEL
Interstate	1. Toll Message Service including WATS Access Lines 2. Private Line	1. Toll Message Service 2. Private Line	1. Toll Message Service 2. Private Line	Not Used
State	Not Used	1. Toll Message Service including WATS Access Lines 2. Private Line	1. Toll Message Service 2. Private Line	1. Toll Message Service including WATS Access Lines 2. Private Line
Local	Not Used	Local Exchange	Local Exchange	Local Exchange
Access Line	Not Used	Access Line	Not Used	Not Used
Common	Not Used	Common	Not Used	Not Used
Other Service Categories	Not Used	1. Supplemental Service A. Residential B. Business 2. Other	1. Centrex 2. Other	1. Vertical 2. Other

Source: Supra footnotes 1, 3, and 4 and NARUC-FCC Separations Manual [illegible] ons, pa[illegible] rejected as an appropriate rule of thumb for assigning costs. With direct costing, the longer-term concepts of cost causation are rejected and costs that would be assigned by the capacity-required criterion are not assigned and labelled common costs. Costs are assigned to the access line category in EDA because the BOCs assert that these costs are not assignable to service categories.[5] Instead, cost causation is evidenced when a customer subscribes to telephone service. The issues surrounding this practice are discussed in detail in the sections dealing with the subscriber loop and local dial switching equipment.

The remainder of this chapter is organized into four sections. In the first section, the relationships between the EDA, ECS, and ECOST are described. This discussion lays the groundwork for the next three sections in which the allocation of specific plant items by the BOC's composite method, JWW method, and Gabel method are presented and critiqued. In the second section, the allocation of the traffic sensitive portion of local dial switching equipment by these three methods is covered. In the third section, the allocation of the subscriber loop and the nontraffic sensitive portion of local dial switching equipment is discussed. Finally, the allocation of exchange trunk plant is treated.

The BOC Composite Method of Embedded Direct Analysis (EDA), Exchange Cost Study (ECS), and Embedded Cost of State Toll (ECOST)

In this section, the relationships between EDA, ECS, and ECOST are briefly discussed. The purpose of this brief review is to ascertain the degree of consistency among these methods in their rationale for assigning costs to service categories and to determine also the

[5]Costs that are truly unassignable except under the beneficiality criteria are considered indivisible and consequently common to all services offered by the firm. Recall that direct costing is used primarily to give management an idea of the short-run costs of production that are under their immediate control. Management is left with the task of determining the assignment of the common costs according to their informed judgment of how to achieve corporate financial goals.

consistency with which the cost-accounting criteria are applied. Related to this latter objective is the determination of whether the BOC's composite method is a direct-costing or an attributable-costing approach.

EDA by itself is purported to develop the relationships between costs and revenues of a past calendar year for a broad number of service categories for the total operations of an operating company in a regulatory jurisdiction. It is claimed that EDA does not represent a burden test nor does it provide costs for pricing decisions. Instead, it is claimed to identify service categories where more detailed analysis may be necessary.

The ECS and ECOST are two methods of providing further analysis of the relationships between costs and revenues developed in EDA. The ECS develops relationships between costs and revenues of providing local exchange usage and network access service for various customer classes and grades of service. The ECOST study determines the embedded cost of intrastate Direct Distance Dialed (DDD) messages and is used to evaluate relationships between costs and revenues for a test year. Together, the ECS and the ECOST study are used by the BOC to perform rate of return studies for local exchange and state toll DDD services, and to draw conclusions about the flow of subsidies between these services.

The costs assigned to the common category in EDA are left unassigned by both the ECS and ECOST. Administrative, legal, financial, and personnel expenses are examples of costs included in the common category. Because of this common category, the composite method is not a full-costing approach. The issue then is whether or not the capacity-required criterion is applied and, if so, is the method consistent in the application of this criterion.

The access line service category is represented in EDA documentation as not being assignable to local exchange or toll services. These costs are defined to represent costs that are <u>common</u> to both exchange and toll services. They are labelled nontraffic sensitive costs and are claimed not to vary with the volume or type of use. Instead, they are costs of facilities used in common to provide access to the network.

This characterization of the access line category belies its ultimate treatment by ECS and ECOST. In ECS the access line category is assigned in its entirety to a service category called local exchange usage and network access service. None of the access line category is allocated to state toll by ECOST, nor is any of it allocated to the interstate jurisdiction by direct assignment or other studies. This practice raises several issues, most of which are discussed in the section on the allocation of the subscriber loop and NTS portion of local dial switching equipment. In this section, it suffices to point out an apparent inconsistency between the EDA and the ECS. As noted previously, it is claimed in EDA that these costs are not assignable to either toll or local exchange services. Instead, the facilities represented by these costs are used in <u>common</u> by these services. It is further stated that these costs do not vary with the usage of the facility. Much of this reasoning is verbal legerdemain.

The costs of the loop and NTS portion of the local dial switch are assigned to exchange services. Using the ECS and ECOST results to perform burden tests for toll and exchange services is misleading. With rate of return studies, the service categories should correspond to broad groups of service for which rates are directly charged to customers. Facilities used in common by one or more services may be assigned to the service according to the capacity-required criterion or, if this is insufficient, assigned according to the beneficiality criterion. By dumping the costs in a redefined service, and discussing it as if it were the same as exchange service, the BOC's composite method ends up yielding distorted relationships between costs and revenues. The relationships are distorted because the service categories to which costs are assigned do not have a one-to-one correspondence to service categories from which revenues are collected.

The Traffic Sensitive Portion of Local Dial Switching Equipment

The treatment of local dial switching equipment by EDA, JWW, and Gabel is based on the allocation of these costs by separations procedures. The cost subcategories for local dial switching equipment (DR category 6) are delineated by switching technology and an assumed sensitivity to measures of usage. Switching technologies are step-by-step, crossbar, and electronic. Each of these subcategories is divided between traffic sensitive and nontraffic sensitive costs. The allocation of the traffic sensitive costs is discussed in this section, while the alloction of the nontraffic sensitive costs is discussed along with the allocation of the costs of the subscriber loop in the next section. A critique of this split between traffic sensitive and nontraffic sensitive costs is deferred until chapter 7 where the Levelized Incremental Unit Cost model for calculating marginal costs is discussed.

The allocation of the traffic sensitive portion of local dial switching equipment by separations and the three methods is presented in table 6-2. EDA and Gabel extend the separations treatment of local dial switching equipment to the state jurisdiction by using weighted dial equipment minutes of use. The weight used in separations is 1.5, which is supposed to reflect differences between the average costs per toll minute of use and the average cost per exchange minutes of use.[6] The JWW method departs from this standard practice by using peak adjusted message minute miles to allocate the traffic sensitive portion of category 6 costs.

The label of "peak adjusted," as used by the JWW method is slightly misleading and somewhat ad hoc. "Peak adjusted" refers to the practice of doubling the toll message minute miles while leaving the exchange usage unchanged. This practice is justified by J. W. Wilson and Associates as being consistent with Mountain Bell studies that indicated the busy-hour toll traffic was twice as heavy as exchange

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[6]This weighting procedure is discussed and critiqued in chapter 6.

TABLE 6-2

THE ALLOCATION OF THE TRAFFIC SENSITIVE PORTION OF THE LOCAL DIAL SWITCHING EQUIPMENT BY SEPARATIONS AND THREE COST-OF-SERVICE METHODS

(1)	(2) Separations	(3) EDA		(4) J.W. Wilson		(5) Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Category 6 includes all local dial switching equipment not included in other categories. Each subcategory is divided between nontraffic sensitive and traffic sensitive by the NTS Factor for each type of equipment.							
Category 6A - Panel - One or more central office units group.	Traffic Sensitive - weighted DEM		Traffic Sensitive	Traffic Sensitive		Traffic Sensitive	
		Other	Direct Assignment (DR)				
		SR	Direct Assignments of Res.	E,ST	Peak Adjusted	ST,E	Dial Equipment
			TT & CCF inv. (Spec. Studies #9 & 10).	IST Centrex	Message, Minute Miles	V	Minutes of Use
Category 6B1 - No. 1 Crossbar - One or more central office units served by the same common originating market group.		SB	Direct Assignments of Bus. TT. & CCF inv. (Spec. Studies #9 & 10). Direct Assignment of CTS Fixed BC (Spec. Study #6). CTX-CO usage inv. assigned based on DEMs.				
Category 6B2 - No. 5 Crossbar - One or more central office units served by the same marker group.		ST,IST	Based on Weighted DEMs.				
Category 6C1 - Step-by-Step - (0-5,000 working lines) - One or more central office units served by the same marker group.		E	Based on DEMs.				
Category 6C2 - Step-by-Step (Over 5,000 working lines) - One or more central office units having a common distributing frame.							
Category 6E - Electronic - One or more central office units served by the same central control.							

Source: Supra, footnotes, 1, 3, and 4 and NARUC-FCC Separations Manual traffic.[7] This judgmental adjustment to message minute miles allocates more traffic sensitive costs to toll than would be allocated if unadjusted message minute miles were used.

The use of message minute miles rather than dial equipment minutes of use by JWW also departs from standard practice. This measure of usage makes the average distance of a call an important factor in the allocation of the traffic sensitive costs. More costs would be allocated to toll than would be allocated by dial equipment minutes of use and relatively more costs would be allocated to interstate toll than to intrastate toll. This would occur as the average distance of an interstate toll call exceeds that of an intrastate toll call, and both have an average distance greater than an exchange call.

Critique

The allocation of the local dial switching equipment by all three methods and separations is not strictly according to cost causation. The switching matrix is sized in order to meet peak demands with a given probability of having a call blocked or of experiencing a delay of a certain length. These planning criteria are labelled "grade of service" standards by the telephone planning engineers.[8] This knowledge of planning criteria allows the cost analyst to impute cost causation to the coincident demands of customers for a path through the central office. This knowledge of planning criteria can be used directly in a cost allocation scheme and is the basis for the allocation procedures presented in chapter 9.

The use of message minute miles by the JWW method does not seem to be the proper measure of usage to allocate local dial switching

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[7] Telephone conversation with Alan Buckalew of J. W. Wilson and Associates, July 5, 1984.

[8] See J. Gordon Pearce, Telecommunications Switching, (New York: Plenum Press, 1981), p. 146.

equipment. The distance that a call is carried once it leaves the central office has little to do with the costs incurred for switching equipment in the originating or terminating central office. Use of this activity measure by JWW has the effect of shifting costs away from exchange users toward toll services. Dial equipment minutes of use, on the other hand, seem more closely related to cost-causative forces affecting the capacity of the local dial switch. More aspects of the allocation of local dial switching equipment are discussed in detail in chapter 9.[9]

The Allocation of the Subscriber Loop and the Nontraffic Sensitive Portion of Local Dial Switching Equipment

In this section, the allocation of the costs of the subscriber loop and nontraffic sensitive portion of local dial switching equipment by the three methods is examined. All three methods use the same cost categorization scheme for these costs as the one used in separations procedures. The cost of the subscriber loop are in DR category KSC for the 240 series accounts while the nontraffic sensitive costs of local dial switching equipment are in DR category 6 of account 221. All of the three methods, however differ in their allocation of these costs.

Tables 6-3 and 6-4 summarize the allocation of the nontraffic sensitive costs of local dial switching equipment and the allocation of the subscriber loop, by separations and three methods respectively. The first thing to note in the table 6-3 is the different service categories used by the three methods. It has already been pointed out that the Gabel method does not reallocate the cost as determined by separations as the EDA and the JWW methods do. However, note also that the NTS portion of local dial switching equipment is only allocated to state toll and exchange without any assignment to Gabel's vertical service category. The vertical costs are identified by Gabel and assigned on the basis of dial equipment minutes of use rather than

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[9]See chapter 9, Infra., p. 158.

TABLE 6-3

THE ALLOCATION OF THE NONTRAFFIC SENSITIVE PORTION OF THE LOCAL DIAL SWITCHING EQUIPMENT BY SEPARATIONS AND THREE COST-OF-SERVICE METHODS

(1)	(2) Separations	(3) EDA		(4) J.W. Wilson		(5) Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Category 6 includes all local dial switching equipment not included in other categories. Each sub-category is divided between nontraffic sensitive and traffic sensitive by the NTS Factor for each type of equipment.							
Category 6A - Panel - One or more central office units group.	Nontraffic Sensitive equipment-subscriber plant factor		Nontraffic Sensitive	Nontraffic Sensitive		Nontraffic Sensitive	
		Other	Direct Assignment (DR)				
		SR	Direct Assignment of Res. TT inv. (Spec. Study #9).	E,ST,IST Centrex	Demand Availability Allocator	ST,E	Subscriber Plant Factor
Category 6B1 - No. 1 Cross-bar - One or more central office units served by the same common originating market group.		SB	Direct Assignment of Bus. TT inv. (Spec. Study #9). Direct Assignment of CTX Fixed BC (Spec. Study #6). Distributive Assignment to VB based on theoretical qty. of CTX-CO intercom lines.				
Category 6B2 - No. 5 Cross-bar - One or more central office units served by the same marker group.		ST,IST,AL	CO access line quantities.				
Category 6C1 - Step-by-Step - (0-5,000 working lines) - One or more central office units served by the same marker group.		Offl.	Offl. portion of AL based on Offl. portion of total subscriber lines less WATS, TWX, CTX,-CO lines and PBX-CTX-CU trunks. Offl. portion of CTX-CO based on Offl. portion of totl. CTX-CO lines & PBX/CTX-CU trunks.				
Category 6C2 - Step-by-Step (Over 5,000 working lines) - One or more central office units having a common distributing frame.	Traffic Sensitive - weighted DFM						
Category 6E - Electronic - One or more central office units served by the same central control.							

Source: Supra, footnotes, 1, 3, and 4 and NARUC-FCC Separations Manual

TABLE 6-4

THE ALLOCATION OF THE SUBSCRIBER LOOP BY SEPARATIONS AND THREE COST-OF-SERVICE METHODS

	Separations	EDA		J.W. Wilson		Gabel	
Subaccount	Basis of Apportionment to Interstate	Service Category	Assignment Method	Service Category	Assignment Method	Service Category	Assignment Method
Category KCS Exchange Subscriber Loops							
Message Telephone (including WATS)	Subscriber plant factor	AL, ST, IST	Based on Loop quantities. St and IST are the costs of WATS access lines.		Divided into Access portion and Direct portion	E, ST	Intrastate Subscriber Plant Factor is used to determine ST portion
Interstate Private Line nonbroadband services	Assigned directly to Private Line Interstate	Other, ISPL, SPL	Direct Assignments, plus PL-like services.	E,ST, IST, Centrex	Access portion Allocated by Demand Availability	SPL	Number of working loops
State Private Line nonbroadband services	No assignment	SB	CTX-CO assignment based on equivalent CTX-CO intercom. loop.			V	Centrex-CU Number of working loops
ENFIA COCF	Directly assigned to interstate	Offl.	Offl. portion of AL based on Offl. portion of total subscriber lines. Offl. portion of CTX-CO based on Offl. portion of CTX lines and trunks.	ST,SPL, IST, ISPL	Direct portion Allocated by COE category 8KCS ST and IST are the costs of WATS access lines	Offl.	Direct Assignment
		(Optional) All	Based on Special Study #20				

Source: Supra, footnotes 1, 3, and 4 and NARUC-FCC _Separations Manual_ allocated in the same manner as the nontraffic sensitive costs.[10] JWW, on the other hand, uses the "CENTREX" service category as well as the exchange, state, and interstate service categories. The nontraffic sensitive costs of the local dial switch are allocated by the same factor to all these service categories. EDA adds still more complexity to the allocation by identifying the costs for "supplemental services-business" and "supplemental services-residential" categories and assigning the associated costs to these service categories directly. The supplemental business category corresponds generally to JWW's "CENTREX" category and Gabel's "vertical" category. However, the allocation of these costs differs among the methods and would affect some of the conclusions about relationships between costs and revenues of exchange service and toll services. EDA's "supplemental residence" service category gets a direct assignment of touch tone and customer calling costs. The direct assignment of costs to the "other" service category in EDA removes the costs of leased facilities from the allocation. Thus, the remaining nontraffic sensitive costs of local dial switching equipment to be allocated among the service categories for message telephone service may differ between EDA and JWW. These differences in NTS costs must be kept in mind when the impact of the various allocation factors is discussed, even though "armchair theorizing" might suggest that these differences are insignificant.

Turning attention to table 6-4, all three methods have their full array of service categories that were originally discussed in the introduction of this chapter for allocating the costs of the subscriber loop. However, in this case the costs assigned to the "message telephone service" cost category by EDA and the JWW method are more easily reconciled. The treatment of CENTREX and WATS access lines is the primary difference in the costs assigned to the "message telephone service" cost category for the subscriber loop. Again, these differences should be kept in mind when the impact of the allocation is discussed.

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[10] See table 6-2, column (5) for an entry in the vertical category.

In examining the allocation of the nontraffic sensitive portion of local dial switching equipment and the allocation of the subscriber loop by EDA, one must also consider the treatment of these costs in the ECS and ECOST. These costs are assigned to the access line, state and interstate service categories by EDA. The assignments to state, and interstate are the direct assignments of the costs associated with WATS service that are included in the "message telephone service" cost category. As previously noted, the costs assigned to the access line service category are treated further in the Exchange Cost Study (ECS). These costs are labelled common costs by EDA, but are essentially assigned in total to the local exchange usage and network access service category by ECS. As a result, state and interstate toll are not allocated any costs of the subscriber loop and the resulting relationships between costs and revenues are misleading.

The JWW method and the Gabel method allocate the costs of the subscriber loop and the nontraffic sensitive portion of local dial switching equipment to both toll and exchange service categories. The JWW method, as presented, seems less direct than the Gabel method, However, recall that the JWW method is based on the EDA method.

The JWW method takes the costs of the subscriber loop in cost category KCS and divides it into a direct portion and an access portion. The direct portion is made up of direct assignments of costs to the state and interstate private line service categories and direct assignments to state and interstate WATS services. These direct assignments are done on the basis of loop counts for these services. The access portion of the cost of subscriber loops corresponds roughly to the costs allocated to the access line category by EDA. However, the JWW method allocates these costs and the nontraffic sensitive costs of local dial switching equipment by a demand-availability allocation factor. Furthermore, it considers the costs of the subscriber loop to be nontraffic sensitive like the costs of local dial switching equipment.

These nontraffic sensitive costs are not necessarily allocated by a standardized calculation in the JWW method. In one rate case in Maryland[11] J. W. Wilson and Associates submitted a cost-of-service study in which nontraffic sensitive costs were allocated in four different ways:[12]

1. An equal weighting of demand availability, number of calls, and message minute miles

2. An equal weighting of demand availability and logarithmic message minute miles

3. Demand availability based on an equal access to the network

4. Demand availability according to the FCC's allocation factor for phased-in separations procedures

Demand availability in all four of these alternative allocation factors refers to the fact that the presence of the nontraffic sensitive facilities enable the customer to access the exchange, state toll, or interstate toll networks. In the first three formulations of demand availability, access to each network had a one-third weighting for interstate toll, intrastate toll, and local exchange. For instance, in option number 3, exchange receives one-third of the nontraffic sensitive costs as does state toll and interstate toll. In the last option demand availability is calculated according to the FCC's allocation factor for nontraffic sensitive costs. In this case, exchange receives half of the nontraffic sensitive costs, while both toll services share equally in the remaining half. This is the 50 percent-25 percent-25 percent allocation factor adopted by the FCC that is to be phased-in to separations procedures beginning January 1, 1985. J. W. Wilson and Associates now recommend the FCC's formulation for

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[11]Dr. John W. Wilson, In the Matter of the Application of the Cheasapeake and Potomac Telephone Company of Maryland for Authority to Increase and Restructure its Schedule of Rates and Charges, Case No. 7661, (Public Service Commission of the State of Maryland, November 1982) pp. 31-32.

[12]Ibid., Exhibit JW5.

demand availability as the most reasonable method by which to allocate the nontraffic sensitive costs.

The Gabel method uses an intrastate subscriber plant factor to allocate the message telephone portion of the costs of the subscriber loop and the nontraffic sensitive portion of local dial switching equipment. The subscriber plant factor is computed according to a formula adopted in the Ozark Plan in 1971 to further the goal of toll rate parity between state and interstate toll rates. The Gabel method uses this factor on the basis of it being "fair and equitable." The subscriber plant factor (SPF) is calculated as

$$SPF = .85 * SLU + 2 * CSR * SLU$$

where SLU is intrastate toll subscriber line usage for outgoing calls only; CSR is the composite station ratio. The composite station ratio is the state industry-wide initial 3-minute station charge at the study area average intrastate length of haul to the nation, industry-wide average total toll initial 3-minutes station charge at the nationwide average length of haul for all toll traffic for the total telephone industry. The .85 is the ratio of the subscriber plant assignable to exchange operation per minute of exchange use to the total subscriber plant costs per toll minute of use of subscriber plant. The intrastate SPF values were published annually in the NARUC Annual Report of the Communications Committee.[13]

Critique

In examining the approach of each of these three methods to allocating the nontraffic sensitive costs of local dial switching equipment and the costs of the subscriber loop, one should focus on the application of either the capacity-required or beneficiality criterion. The relevant test for the capacity-required criterion is whether

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[13]For instance, NARUC, 1981 Report of the Communications Committee, (NARUC, Washington, D.C.: 1981), pp. 48, 52-57.

service could be rendered if the costs were not incurred. The relevant test for the beneficiality criterion is whether the costs are necessary to support current activities or to maintain continuity of the organization. Since the test for the capacity-required criterion is more restrictive in its requirements, its applicability is examined first. The applicability of the beneficiality criterion is examined only where the capacity-required criterion is found inapplicable.

According to the test for the capacity-required criterion, the withdrawal of a service or its addition should result in some change in the plant necessary to render the service. When this occurs, a causal relationship between the quantity of service rendered and the costs of these facilities can be developed. In the case at hand, suppose that both state and interstate toll service are withdrawn. The appropriate question to ask would be: what are the costs of reconfiguring the local exchange if toll services were withdrawn from the system? It should be noted that a similar question could be asked with respect to the withdrawal of exchange service.

This approach to developing overhead rates has been explored by Richard Gabel, William Melody, Robert Warnek, and J. William Mihuc on behalf of the Kansas Corporation Commission.[14] The initial design of their study was to isolate "on a cost-causative basis the investments associated with provision of plain old telephone service (POTS) and the investments required to modify common use exchange plant in order to accommodate to various premium services." This approach, however, proved to be impractical. They noted that "with the passage of years and the physical integration of premium requirements into the common plant, it has become virtually impossible to disaggregate the cost of components designed for distinctive uses."[15]

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[14]Richard Gabel et al., The Allocation of Local Exchange Plant Investment to the Common Exchange and Toll Services on the Basis of Equalized Relative Cost Benefits, (Kansas Corporation Commission, May 23, 1983).

[15]Ibid., p. 4.

This impasse led to the stand-alone cost approach. With this approach, they estimated the costs of providing facilities to meet the existing toll and exchange traffic separately.[16] System planning and grade or quality of service planning criteria were used to determine the investment needed to provide state toll, interstate toll, and local exchange service separately. These stand-alone costs were used to develop overhead rates to allocate costs according to the cost savings realized by the joint provision of these services using common facilities.

Although not quite according to the prescription of the capacity-required criterion, this approach has some merit when compared to allocations based strictly on usage. The use of planning criteria as an intermediate step in the allocation of costs introduces elements of cost causation into the problem. However, the inability to distinguish between which portions of the investments were made for toll and which for local exchange services dilutes this desirable attribute somewhat. As a result, the allocation procedures revert to equity considerations to allocate the costs.

The line of reasoning inherent in the capacity-required criterion led Gabel and others to this stand-alone approach. This logic dictates that both state and interstate toll services have had an impact on the investments and costs associated with the subscriber loop and the local dial switch used to render local exchange service. Consequently, some of these costs should be borne by toll services and such costs are not necessarily insensitive to usage in the long run. The BOC composite method does not recognize this impact. The JWW and Gabel methods presented previously allocate some of these costs to the toll service, but not necessarily for the correct reasons.

The question to be addressed when allocating costs that are assumed to be nontraffic sensitive has two parts. First, can the capacity-required criterion be properly applied to the allocation of the subscriber loop and local dial switching equipment? If not, is the

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[16]The study cited above only did this for local dial switching equipment in four locations in Kansas.

stand-alone cost approach an adequate alternative? The answer to this second question may lead to debates concerning the fairness of the allocation procedure, rather than focusing on issue of cost causation. Most of the problem with trying to apply the capacity-required criterion may be the result of the costs of the loop and the local dial switch being sufficiently indivisible so that obtaining a clear long-term causal relationship is next to impossible. In such circumstances, the beneficiality criterion may be applicable, particularly when the cost-of-service study is undertaken to determine the revenue requirement for a broad categories of service. In this case, the stand-alone approach has considerably more merit.

The test for the beneficiality criterion is a test of "last resort" to assign a cost to a service. Such costs are incurred because they are necessary to support current activities or to maintain the continuity of the organization. It is indisputable that the costs of the local dial switch and the subscriber loop meet these requirements.

For a majority of customers, the loop is necessary to render both toll and exchange services, and both benefit from its presence. If a customer bypasses the operating company's central office for toll purposes, he may use the loops to terminate this call at the other end of the network. If, however, he completely bypasses the loops and central office for all toll needs, then the costs of the loop and local dial switch should be allocated to exchange services for this particular "class" of customer. All other customers not in this class experience benefits from sharing the use of the loop between toll and exchange services. The majority should not be denied these benefits, nor should they subsidize customers with special characteristics. As discussed in the previous chapter, both incoming and outgoing callers benefit from the loop and line-link network, no matter the length of haul or whether the call is transmitted over state boundaries. Stand-alone costs may be one method appropriate for developing an overhead rate for the costs of the loop and line-link network.

A clear picture regarding the allocation of the subscriber loop according to cost-accounting principles and practices emerges from this discussion. First, these costs can be and should be assigned to both toll and exchange service when the purpose of the study is to determine revenue requirements for a service or to do a rate-of-return study. Second, such assignment can be made, with limited support, according to the capacity-required criterion. The problem in applying this criteria in a straightforward manner is more of a practical problem than a theoretical problem. In fact, theoretical support for the application of the capacity-required criterion seems strong. Third, the application of the beneficiality criterion lends unqualified support to the assignment of the costs to both toll and exchange services. The debate about the appropriate method, however, may be a prolonged one.

In light of these conclusions, the allocation of the costs of the subscriber loop and the nontraffic sensitive portion at local dial switching equipment by the BOC composite method must be rejected, while only little support can be given to the JWW and Gabel methods. The BOC method is rejected because none of these costs are allocated to toll services. The JWW and Gabel methods receive some support because some of these costs are allocated to toll services. However, the rationale behind these allocations is not necessarily in accordance with cost causation. The subscriber plant factor used in the Gabel method came about as the result of a political compromise that helped to achieve toll rate parity. Thus, cost causation cannot be asserted. All that can be claimed is that the cost allocation is reasonable because it was part of an agreement among experts, businessmen, and regulators. Similar statements can be made about the 50 percent-25 percent-25 percent allocation used in the JWW method. However, one line of reason compatible with stand-alone costs could be applied to this allocator. First one must assume that the loop and local dial switching equipment needed to serve toll or local exchange separately are identical. In this case, the stand-alone costs for toll services and local exchange service would be identical. Thus, 50 percent would be the allocation factor for state and interstate toll and 50 percent for local exchange. If this line of reasoning is carried further to include separate state and interstate toll markets, however, one might conclude that the allocation factor should be 33 percent to each of the services; that is interstate toll 33 percent, state toll 33 percent, and local exchange 33 percent. Such after-the-fact reasoning, however, does not fully justify the allocation factor. The 25 percent to interstate toll was settled upon most likely because it was near the national average for the frozen subscriber plant factor for interstate services.

In conclusion, the allocation of the costs of the subscriber loop and nontraffic sensitive portion of local dial switching equipment by the three cost-of-service methods is difficult to support. Cost-accounting practices and principles are not applied and cost causation, either short- or long-term seems to be only a secondary or tertiary consideration. Instead, political or competitive and financial considerations appear to have shaped the allocation procedures.

The Allocation of Exchange Outside Plant Message Exchange Trunks

In this section, the allocation of the message exchange portion of the exchange trunks by the three methods is examined. DR cost category KCT-2 is message exchange trunks used wholly or in part for toll traffic and exchange trunk portion of WATS access lines. These facilities are used in the provision of interstate and intrastate toll service and exchange service. Each of the three methods allocates these costs by the same activity measure used by separations.

In table 6-5, the allocation of DR cost category KCT-2 by the three cost-of-service methods is summarized. Each method allocates these costs to intrastate toll, state toll, and local exchange with exchange trunk minutes of use. The JWW method duplicates EDA for this cost category.

TABLE 6-5

THE ALLOCATION OF OUTSIDE PLANT COST CATEGORY KCT-2
BY SEPARATIONS AND THREE COST-OF-SERVICE METHODS

Method	Service Category	Method of Allocation
Separations	IST	Allocated to interstate by applying the percent of long distance interstate of exchange trunk minutes of use
EDA	IST E,ST Offl.	Direct Assignment (DR) Based on KCT-2 Trunk Minutes of Use Base on Official portion of total Original + Term. Busy Hour CCS.
JWW	E,ST, IST	Allocated according to exchange trunk Minutes of Use
Gabel	E,ST	Relative Minutes of Use
	Offl.	Ratio of Busy-Hour CCS

Source: Supra footnotes 1, 3, and 4 and NARUC-FCC, Separations Manual

The Gabel method in this case would yield results identical to EDA and the JWW method. This occurs because the costs assigned to the interstate jurisdiction by separations are a direct assignment of costs by these two methods.

Critique

In critiquing the allocation factor used by all methods to allocate these costs, one must focus on the issue of cost causation. Exchange trunks are added to the network when existing capacity is unable to handle busy-hour traffic with acceptable levels of blocking. The use of exchange trunk minutes of use for the entire demand cycle fails to reflect cost-causative forces unless it can be shown that the aggregate demand for an exchange trunk is uniformly distributed over the demand cycle. This is highly unlikely. Cost causation in this case implies a peak-responsibility method of allocating the costs of exchange trunks to each service. This idea is developed fully in chapter 9.

CHAPTER 7

METHODS FOR QUANTIFYING THE MARGINAL COST OF TELEPHONE SERVICE

In this chapter, methods for estimating the marginal costs of telephone service are examined. Three methods are reviewed; they are:

1. The Levelized Incremental Unit Cost (LIUC) model
2. Jeffery Rohlfs' Econometric procedure
3. A cost function approach

The Levelized Incremental Unit Cost model was obtained from Southwestern Bell under an agreement of confidentiality[1] and is used by them to generate estimates of the incremental costs of local measured service. The Rohlfs[2] procedure was obtained from Rohlfs at Shooshan and Jackson, Inc., a consulting firm in Washington, D.C. His study was undertaken to estimate the marginal costs of service for Chesapeake and Potomac Telephone company operating in Washington, D.C.. The cost function approach refers to a paper by Melvyn Fuss and Leonard Waverman entitled: "Multi-products, Multi-input Cost Functions for the Regulated Utility: The Case of Telecommunications in Canada."[3] This

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[1]The agreement was not to disclose the method in sufficient detail to enable anyone to duplicate the method. This has been done. Since the document is proprietary there are no footnotes with reference to the Model for Usage Sensitive Incremental Costs (MUSIC) manual in which the LIUC model is contained.

[2]Jeffery H. Rohlfs, Marginal Costs of Telephone Services in Washington, D.C. (Washington, D.C.: Public Service Commission of the District of Columbia, 1983).

[3]Fuss and Waverman, "Multi-product Multi-input Cost Functions.

type of study is useful for understanding the cost structure of an industry. Of these three methods only the LIUC model generates estimates that are directly useful in ratemaking. The Rohlf and Fuss and Waverman approach, however, provide valuable insights into the cost of service.

In the sections that follow, each of the marginal cost methods is discussed. The first section contains a discussion of the LIUC model. In the second section, the Rohlf's paper is reviewed. Finally, the Fuss and Waverman cost function approach is reviewed.

The Levelized Incremental Unit Cost (LIUC) Model

The Levelized Incremental Unit Cost (LIUC) model is used by Southwestern Bell to estimate the marginal cost of providing local measured service. The LIUC model is part of a larger model called Model for Usage Sensitive Incremental Cost (MUSIC). MUSIC is used to estimate the effect a change in tariff structure has on an operating company's cash flows. The new tariff structure used in MUSIC must include rates for local measured service. It can, however, include changes in rates for other exchange services, in toll rates, and in access charges. Imposition of the new rate structure in MUSIC is introduced in the form of a new set of usage characteristics for the various classes of service.[4] These changes in customer-usage characteristics induce changes in the operating company's construction and operating program over the planning horizon. The LIUC model uses this new network configuration, traffic pattern, and operating plan to estimate the cost consequences of a given percentage increase in the number of mains and equivalent mains subscribing to local measured service. This stimulation generates additional lines, accounts, messages, and usage, which increases the costs of providing local

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[4]Class of service is delineated according to tariff definitions.

measured service. A comparison of the costs of providing local measured service between the original (Case 1) and "stimulated" case (Case 2) yields an estimate of the added cost of meeting this increase in demand.

The LIUC model consists of six major modules:

1. Comptrollers module
2. Service center module
3. Operator services module
4. Switching module
5. Measurement equipment module
6. Trunking module

The comptrollers module estimates the change in revenue accounting expenses as a result of customers subscribing to and utilizing local measured service. The service center module approximates the added costs of converting and maintaining customers on local measured service. The operator services module estimates the costs of providing additional traffic service positions and operators to render operator services, not separately tariffed to local measured service customers. The switching module provides an approximation of the additional switching costs of meeting the given percentage increase in lines, usage, and messages. The measurement equipment module estimates the costs of additional measurement equipment needed to handle the additional demands for measurement service. Finally, the trunking module approximates the incremental costs of additional trunking plant and equipment needed to meet the additional use of local measured service. Table 7-1 summarizes the relationships between messages, minutes of use and lines, and the incremental costs for each of the six modules of the LIUC model. An "X" in a column indicates that an incremental cost per message, conversation minute, or line is calculated by the module corresponding to the row. These cost estimates, generated by the LIUC model, include only those switching and network costs, measurement costs, and departmental costs that are considered sensitive to usage as the number of lines subscribing to measured service increase. This means that costs not directly attributable to usage, such as loop costs and departmental expenses

TABLE 7-1

THE RELATIONSHIPS BETWEEN "STIMULATED" LINES, MINUTES OF USE AND LINES, AND INCREMENTAL COSTS IN THE LIUC MODEL

Module	Messages	Minutes Of Use	Lines
Comptrollers	X	—	X
Service center	—	—	X
Operator services	X	—	—
Switching	X	X	—
Measurement equipment	X	X	—
Trunking	X	X	—

Source: Drawn from the LIUC manual

common to all basic exchange customers are excluded. This practice maintains the distinction between traffic sensitive and nontraffic sensitive costs and maintains a common cost category.

In the discussion that follows, the six modules of the LIUC model are reviewed. At times it is necessary to discuss the corresponding module in MUSIC to clarify the computations performed in the LIUC model. This is particularly true for the switching module. When references are made to the algorithms used in MUSIC the reader should exercise caution in maintaining the distinction between what is being estimated by each of the models. MUSIC estimates the impacts on the company's cash flows, while the LIUC model estimates the incremental costs attributable to additional lines subscribing to local measured service for a given level of other services. These are not the same. The changes in cash flows include changes in tariffs other than local measured service, and some services related to measured service that are tariffed separately. The LIUC model, on the other hand, includes only the additional costs incurred from adding lines to measured service once local measured rates have been implemented. An important conceptual procedure in MUSIC and the LIUC model's subsequent utilization of MUSIC's results will clarify this distinction.

MUSIC calculates the total cost of providing switching, network, measurement, and departmental services under two different tariff structures. One run is labelled the "baseline case," while the second run is called the "proposed tariff case." In the baseline case, a configuration of switching, network, and measurement plant and equipment needed to render service to the existing subscribers at current rates, and an accompanying construction program for the planning horizon are worked out. The departmental costs and future operating budgets for revenue accounting and service centers are also predicted, given present and predicted customer usage of these services. It should be noted that the model calculates the baseline costs rather than inputting this baseline case information. Such costs are predictive of actual costs incurred in the base year only to the extent that the model reasonably approximates actual planning and operating procedures. This, of course, is an empirical question that might be tested.

The proposed tariff case calculated by MUSIC assumes a new rate structure has been imposed with consequent impacts on customer usage characteristics. MUSIC utilizes the new demand information to reconfigure switching, network, and measurement plant and equipment to meet these demands, and reworks the contruction program to meet future demands. Departmental costs and plans are also predicted for the proposed tariff case. The total costs predicted in the proposed tariff case approximate future costs incurred under the new rate structure only to the extent that the demand projections are valid and the model generates reasonable estimates of costs in the baseline case. If either one of these qualifications fails to hold, the costs generated in the proposed tariff case are suspect. The changes in cash flows experienced by the operating company are calculated as the differences in costs between the baseline and proposed tariff cases.

The LIUC model uses the proposed tariff case from MUSIC as its base case, which is referred to as Case 1. A run of the LIUC model consists of increasing the number of lines in the proposed tariff case by given percentage and holding the usage of all services except local measured service constant. By a similar set of procedures the LIUC model approximates the total cost of meeting this new set of demands for local measured service. The differences between Case 1 and Case 2 costs are the total incremental costs of rendering local measured service.

With this distinction between MUSIC and the LIUC model in mind, the six modules of the LIUC model are discussed in the next six subsections. This brief review of these modules is followed by a discussion of the cost recovery factor used in LIUC to convert investment costs to annual cash flows. Finally, the major strengths and weaknesses of the LIUC model are briefly discussed.

Comptrollers Module

The comptrollers module is used to calculate changes in revenue accounting expenses associated with the handling and processing of an increment in the number of measured service accounts and in the volume of messages billed under the local measured service rates. Incremental revenue accounting expenses reflect changes in activities in three areas. First is the entry of data into the automatic message billing process. Second, changes in the costs of processing billing data are estimated. These costs are divided between rating expenses and those expenses associated with the billing master file. The third cost is the incremental costs of providing customers with their bills. These expenses of data entry, rating, master file, and billing are based on the proposed tariff expenses from MUSIC (Case 1). The LIUC model generates these expenses for Case 2. The differences between Case 1 and Case 2 represent the incremental revenue accounting expenses.

The outputs of the comptrollers module report the incremental costs on a per message and per line basis. Data entry, rating, and master file expenses are modelled as a function of the number of billed messages for local measured service. The incremental unit costs are reported on a per message basis. Billing expenses are modelled as a function of the number of mains plus equivalent mains used in local measured service is increased. After converting mains and equivalent mains to lines, the incremental unit billing expenses are reported on a per line basis.

Service Center Module

The service center module calculates the additional expense attributable to billing inquiries by and bill adjustments for the additional customers subscribing to local measured service. In the service center module, calculations are performed for residential and business customers separately. Billing inquiries require additional personnel to handle the increase in customer contacts. The personnel needed to handle the new level of billing inquiries is calculated as the product of the time per inquiry and the number of inquiries that occur. The incremental billing inquiry expense is the difference between Case 1 and Case 2 expenses. The incremental unit cost is reported on a per line basis for both business and residential lines and in total. The incremental billing adjustment expenses are calculated as a function of the increase in the number of local measured-service accounts requiring billing adjustments. The number of accounts requiring billing adjustments times the annual cost per adjustment yields the incremental billing adjustment expense. The additional accounts needing billing adjustments are converted to lines by a proportional factor. The incremental unit billing adjustment expenses are reported on a per line basis.

Operator Services Module

The operator services module of the LIUC model estimates the incremental cost of handling additional traffic to the Traffic Service Position System (TSPS) and considers only those services that are recovered through rates for local measured service. Additional costs of operator services are divided between those costs for additional TSPS equipment and those costs for additional personnel. The operator services included in the local measured service rates are requests for local credit and requests for local rates. Operator services for such things as credit card calls, collect calls, and billing to a third number are tariffed separately and therefore are not included as an incremental cost of local measured service. The algorithms for estimating the costs associated with additional operators and TSPS investments are outlined below.

The additional number of operators is a function of the additional number of calls for credit and rate requests. The number of calls for each service is multiplied by the average holding time for each service. This product yields the additional operator time needed to handle the increase in calls for these services. In translating this from additional work time to the number of operators, such things as operators waiting time to service, average tour length, and time off for vacations and training are considered. The outcome of these adjustments is the number of additional operators needed to handle the additional traffic that is directly attributable to local measured service. The incremental operator expense is calculated as the product of the number of additional operators and the annual expense per operator. The incremental unit costs attributable to additional operators are reported on a per message basis.

The Traffic Service Position System (TSPS) investment attributable to local measured service is calculated in four separate parts: (1) TSPS Base unit investment; (2) TSPS position investment; (3) TSPS trunk investment for circuit equipment; and (4) TSPS investment for trunking facilities. The TSPS base unit investment is calculated as a function of busy-hour trunk seizures. The TSPS position investment is calculated as a function of the number of additional operators per occupied busy-hour position. Both the TSPS trunk investment for circuit and facilities is modelled as a function of busy-hour trunk seizures. The number of additional trunks is calculated by adjusting the busy-hour trunk seizures by average work time per TSPS trunk. This practice assumes the number of trunks is proportional to the holding time during the busy hour of the busy season. The incremental investment is calculated as the product of the additional number of trunks and the investment per TSPS trunk and related circuit equipment.

The total TSPS investment is the sum of the base unit, position, trunking facilities, and related circuit investments. These TSPS investment costs are reported on both a message and busy-hour message basis.

Switching Module

The switching module of the LIUC model calculates the additional investment in switching equipment that is needed to accommodate an increase in the number of lines subscribing to local measured service. The switching module of the LIUC model has the capability to consider the expansion or replacement of the Western Electric (AT&T Technologies) 1-ESS (CC and SP), 1A-ESS, 2-ESS, 2A-ESS, and 5X-Bar switches. The Northern Telecom DMS-100 switch is scheduled to be added to the LIUC model in the future. The computation of the incremental switching costs in the LIUC model differs from the planning algorithm of MUSIC. The differences between the switching modules of these two models highlight the differences assumed to exist between traffic sensitive and nontraffic sensitive switching costs. The LIUC model assumes that the incremental costs of switching are a function of the number of calls and CCS of usage. MUSIC, on the other hand, attributes the total costs of a switch to the number of lines terminating at the switch, the number of calls, and the CCS usage. In addition, it is assumed in MUSIC that a start-up cost is incurred if a switch is replaced or retrofitted. The fundamental difference regards the investment related to the number of lines terminating at the switch. The similarities involve the call- and CCS-related investments.

The discussion of the switching module is divided into four parts and is representative of the algorithms for a 1A-ESS switch. The first two parts of this subsection contain a discussion of the CCS-related and call-related costs, respectively. In third part, the processor investment calculated in the LIUC module is covered. This cost is not explicitly treated in MUSIC. Finally, the line-related investments that are excluded from the LIUC model are discussed.

CCS-Related Investments

The incremental costs for CCS usage for a 1A-ESS in the LIUC model are separated between those attributable to intraoffice usage and those costs attributable to interoffice usage, where interoffice usage is the sum of incoming and outgoing usage. The intraoffice investment is calculated as a linear function of the usage per line and nonlinear function of the number of lines and the line-link concentration ratio. The algorithm used in MUSIC indicates that the investment in intraoffice usage-related switching equipment is a lumpy process that appears to depend on configuration of the line-link network termination equipment. The interoffice investment is calculated as a linear function of incoming and outgoing usage. The total incremental investment attributable to CCS usage is reported for intraoffice and interoffice separately. Each is calculated as the sum of the differences (Case 1 less Case 2) between investment related to CCS for all ESS investments divided by the annual change in minutes of use.[5]

Call-Related Investments

A part of the incremental costs of switching attributable to the number of calls is divided among those costs related originating, terminating, incoming, and outgoing calls. The distinction between an incoming and terminating call and an outgoing and originating call is an engineering distinction that relates to the type of equipment that must be installed to handle a call. The originating-call investment is a nonlinear function of the number of calls and the percentage of lines subscribing to touch-tone service. This function is not continuous nor does it seem well-behaved. It does appear however that there are mild economies with respect to call volume, but it is inconclusive with respect to touch tone percentage. The terminating call investment is a non-linear function of the number of terminating calls. The module incorporates some mild economies of scale with respect to the volume of terminating calls. The outgoing call investment is a nonlinear function of the volume of outgoing calls. Here again the model attributes economies with respect to call volume and they are relatively more pronounced than in the case of terminating calls. The incoming-call investment is also a nonlinear function of the call volume. The economies of scale are again incorporated in the module and are greater than in the case of terminating calls, but less than those modelled for outgoing calls. The total incremental investment related to the volume of calls cannot be calculated until the costs of the processor are calculated.

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[5]Of course, the investments are multiplied by a capital recovery factor to convert these investment costs to annual cash flows. This factor is covered later in this section.

Processor Investment

As previously noted, the costs related to the processor are not explicitly calculated in MUSIC. Instead, they appear in the switching module of the LIUC model. The cost of the processor are separated between intraoffice and interoffice calls. The interoffice processor investment is further delineated by the volume of incoming and outgoing calls. The calculation is done in three parts because the number of cycles required to handle an intraoffice, outgoing, and incoming call is different for each.

The processor investment needed to handle the intraoffice call investment is modelled as a linear function of the volume of intraoffice calls and the investment cost per cycle. This latter cost parameter is an input to the LIUC model. The interoffice calls are similarly modelled as a linear function of the volume of interoffice calls and the investment per cycle.

The incremental costs of switching equipment attributable to call volume are reported in two parts: intraoffice costs and interoffice costs. The incremental costs attributable to additional intraoffice calls are the sum of the intraoffice processor investment, the originating call investment, and the terminating call investments for all types of ESS switches divided by the change in annual intraoffice call volume.[6] The incremental ESS switching investments attributable to interoffice call volume are the difference (Case 1 less Case 2) of the interoffice process investment and the originating, terminating, incoming, and outgoing call investments divided by the change in annual interoffice call volume.[7]

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[6]See footnote 5.

[7]See footnote 5.

On the Nontraffic Sensitivity of the Local Dial Switch

As can be seen from the discussion above, the switching module of the LIUC model calculates incremental costs for intraoffice, interoffice calls, and CCS separately. The question that is now raised is whether this characterization of incremental switching costs is complete. Are the costs modelled as nontraffic sensitive in the LIUC model really not sensitive to the amount of usage? To answer this question the portion of the switching module in MUSIC that calculates the line-related investment is presented. Following this presentation, the procedures for generating Case 2 in the LIUC model are reexamined. The conclusion is that the assumption of the nontraffic sensitivity of these costs may not be justified.

The line-related investment for an 1A ESS switch in MUSIC consists of two parts: the investment in lines, and the line-link network termination investment. The line investment is modelled as a linear function of the number of lines terminating at the switch. The line-link terminations investment depends on the line-link concentration ratio, the number of lines, and the originating and terminating CCS per line.

There are economies associated with increasing the line-link concentration ratio. That is, as the line-link ratio increases, the line-link termination investment per line declines. It should be noted that the line-link concentration ratio at a given location is an input to the model. From an engineering standpoint, this model for the line-link network termination equipment implies that network engineers have a limited ability to vary design parameters when the switch is installed. This line-link termination investment experiences a diseconomy with respect to the originating and terminating CCS per line. As the originating and terminating CCS per line increase, the line-link termination investment increases. If originating and terminating CCS per line increase or decrease beyond some point, a change in the line-link concentration ratio may be cost effective, even when considering the costs of replacing or retrofitting a switch. The algorithm and input procedures for MUSIC do not consider this possibility. (See mathematical expression on p. 109.)

What is important to note from this review of the line-related investment is that the originating and terminating CCS per line weigh into an engineer's consideration of the line-link termination investment. It is modelled as an investment decision relating to capacity acquired in lumps. If the originating and terminating CCS per line are greater than some amount that varies with the line-link concentration ratio, additional line-link network termination investments are necessary. Clearly then from the standpoint of a planning engineer, these switching costs are not insensitive to usage per line. Instead, these switching costs vary with respect to the number of lines and the usage per line. The question then can be asked whether or not the LIUC model properly models the costs associated with an increase in CCS usage for switching.

Recall that the difference between Case 1 and Case 2 in the LIUC model involves a percentage increase in the number of lines subscribing to local measured service. For each class of service each line has given usage characteristics defined in terms of calls and CCS usage per line by time of day. Recall also that class of service is delineated by tariff definitions such as flat-rate customers and measured usage customers, for instance. This distinction is important. The question to be posed is from where the additional lines are coming.

If subscribers to local measured service are new to the system, the number of lines for each class of service are unchanged except for the local measured service customers. The algorithm for computing additional investments in the line-link network termination equipment does not completely distinguish an increase in the number of lines from an increase in usage. The equation is of the form

If O+T-CCS $\leq C_1$

Then

line-link investment = C_2 * (# of lines)

Otherwise

line-link investment = C_2 * (# of lines) * C_1 * $\frac{\text{(O+T-CCS)}}{\text{line}}$

where C_2 and C_1 are constants depending on the line-link concentration ratio, and O+T-CCS is originating and terminating 100 call seconds per line. It can now be seen that if the number of lines subscribing to local measured service increases while the usage per line remains constant, the planning algorithm views this as an increase in total usage and would increase the investment in the line-link network termination equipment under certain circumstances.

Consider now a different scenario. Suppose the increase in the number of lines that are subscribing to local measured service came from flat-rate customers converting to measured service. In this case, the aggregate effect of the customer characteristics associated with the number of lines terminating at a switch is changing. Although the number of lines is not changing, the net effect on the originating and terminating CCS per line will change, as demand characteristics between these two classes of service are different. This is the same as a change in total originating and terminating usage in this algorithm. Again in this case, the net effect may be to change the investment in the line-link network termination equipment.

The conclusion drawn from these two scenarios is that the investment in line-link termination equipment is, under certain circumstances, sensitive to traffic. The question then becomes one of the time frame over which incremental costs are being measured. In the short run, the reconfiguration of the line-link network may not be undertaken, if it is already installed and in service. However, in the longer term, the reconfiguration of the switch may be necessary to provide adequate service at a minimum cost. Since the planning algorithm in MUSIC does not clearly distinguish between the number of lines and usage, and since the source of additional lines in the LIUC model is left unclear, the inescapable conclusion is that the LIUC model is incomplete. The line-link network termination investment is omitted simply as the result of an assumption that such costs are not sensitive to the amount of usage. This probably should not be the case.

Measurement Equipment

The incremental cost of measurement equipment is calculated by COE switch type. For 1-ESS (CC or SP) and 1A-ESS switches, the costs of measurement equipment depend on the number of calls and their duration or CCS usage. For 2-ESS switches, the costs of measurement equipment depend only on the number of calls, since the duration is measured at the originating office only. The 5X-Bar switch has both call-related and CCS-related costs for measurement equipment. As one might expect, the technology of measurement differs between the ESS switches and the 5X-Bar. The algorithms for computing the incremental costs of measurement equipment for a 1A-ESS switch are reviewed in this subsection.

The call-related costs for a 1A-ESS switch are modelled as a linear function of the number of originating local messages requiring automatic message accounting (AMA). These additional local AMA messages increase the use of the ESS processor. It should be noted that measurement is assumed to occur on both intraoffice and outgoing calls. The CCS usage-related investment requires additional message-register or word-storage capacity in the processor. The investment in additional message registers is a function of the number of local busy-hour AMA CCS usage. The outputs of the measurement equipment module are reported as incremental costs per busy hour or total minutes of use and incremental cost per busy hour or total messages.

Trunking Module

The trunking module of the LIUC model calculates the incremental costs of trunking plant attributable to increasing the use of local measured service. The number of trunks required to handle the interoffice traffic is calculated in the trunking module of MUSIC and is assumed to be a function of busy-hour, busy season usage. As in MUSIC, the LIUC model uses the needed trunk capacity to calculate the investment in trunking facilities and related circuit equipment. The calculation of additional investments is accomplished in several steps. First the additional investment in trunking circuit equipment is the product of the number of additional interoffice trunks times the investment in circuit equipment per trunk. Second, the investment in trunking facilities is calculated in a similar fashion as a function of the number of interoffice trunks. The investment in circuit equipment for trunking and trunking facilities is divided between call-related and CCS usage-related costs as a function the ratio of holding time to conversation time. The ratio of conversation time to holding time represents the portion of time that trunking facilities and related circuit equipment are tied up with a successful completion of a call. This fraction represents the portion of the investments in trunking that is related to the duration of the call or the CCS usage. The complement of this ratio is the portion of holding time not related to the duration of the call. This is the call-related portion or set-up portion of the investment in trunking facilities and related circuit equipment.

There are four outputs of the trunking module. The incremental trunking costs per busy-hour message or annual message are the sum of the incremental cost of trunking facilities and related circuit equipment. The incremental trunking cost per busy-hour conversation minute or total annual conversation minute is the sum of the incremental costs of trunking facilities and related circuit equipment.

Load Factor and Annual Cost Factor

Two factors in the LIUC model applied to many of the investments are the load factor and the annual cost factor. The load factor is used to inflate the cost of equipment puchased from a vendor to the total cost incurred by the telephone company to put the equipment in service. The annual cost factor, alluded to earlier,[8] is used to convert the investment in plant in service to annual cash flows to cover a number of expenses. Each of these factors is described below.

The load factor generally consists of a composite of three or four factors. One is the power-switching factor. This factor is the ratio of the investment in power facilities at a switching location to the dollars of investment in exchange central office equipment. This factor plus one yields a factor that increases an investment in switching equipment to account for power facilities. Another part of the load factor is the "telco factor." The telco factor is used to inflate the engineered, furnished, and installed cost charged by a vendor for equipment to account for expenses incurred by the telephone company in the installation of the investments. It should be emphasized that MUSIC and the LIUC model begin with the engineered, furnished, and installed cost charged by the vendor. The telco factor as part of the load factor adjusts this price to reflect resource commitments by the telephone company to the construction project. These costs include such things as initial engineering specifications and the costs of personnel for testing, quality control, maintenance, and administration. The "calibration factor" is used to adjust the telco factor so that specific special conditions at a location are recognized. Finally, the telephone plant index adjusts the vendors costs to the base year dollars of the study. It is an account by account price index. Thus, the load factor adjusts the engineered, furnished, and installed cost to reflect a number of considerations.

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[8]See footnote 5 infra.

The annual cost factor is a capital recovery factor and very much more. One portion of the annual cost factor converts investments in plant and equipment to cash flows to cover depreciation, cost of money, and income taxes. The depreciation portion is calculated using the average life of the plant. The cost of money portion is based on the current, rather than the embedded, cost of money. The income tax portion is a function of the return. In addition to the capital costs proportions of the annual cost factor, it is used to calculate annual cash flows associated with the following:

1. Maintenance
2. Interest during construction
3. Property and miscellaneous taxes
4. Direct administrative expense
5. Gross receipts tax
6. Land factor
7. Building factor
8. License contract fee

The factor for the license contract fee should be deleted when runs of the LIUC model are made in a postdivestiture setting. The land and building factors allow for income tax, maintenance, cost of money, ad valorem tax, administration, and gross receipts tax expenses associated with land and buildings in which the plant and equipment is housed or located. The maintenance portion, as well as most other expense portions, are calculated as the ratio of the previous year's expenses to the plant investment in that type of equipment. The use of the word "direct" with administrative expenses insures that many administrative expenses are assumed not to be marginal with respect to the design parameters of the network. All in all, the annual cost factor seeks to summarize a lot of cost incurrence with minimal information. It might be that the maintenance and land factors could be greatly improved through more direct modelling.

Comments and Critique

The LIUC model and MUSIC are two very interesting applications of planning and engineering simulation models to costing. The LIUC model, or its use by BOCs however, is deficient in several respects. First, the LIUC model, as well as MUSIC, does not explicitly seek to minimize costs. Secondly, the BOCs use the LIUC model to generate a point estimate of marginal costs. More complete information about marginal costs can be obtained from the model by using the confidence limits associated with the demand estimates for the various services. Finally, as previously noted, it is not clear that all switching costs are properly modelled in the LIUC model.

The baseline case in MUSIC is supposed to replicate the cost of the system, given the tariffs currently in effect. There is no optimization technique to insure a minimum cost is achieved in meeting the given demand with the planned configuration of equipment. Only to the extent that current construction programs and operating practices lead to minimum costs of service can it be said that the baseline case in MUSIC is a minimum cost. It should be noted that even if this is true in the baseline case of MUSIC, it is less certain when new customer characteristics are induced by the proposed tariff and MUSIC reconfigures the network to meet these demands. First, the algorithms do not test for excess capacity on the switch with, for instance, busy-hour blocking probabilities. Any excess capacity at a point in time is assumed to be needed to accommodate growth and is therefore only temporarily unneeded capacity. However, many of the algorithms rely on historical ratios to size various facets of the system. Thus it is questionable whether the proposed tariff case in MUSIC is a cost minimum. The LIUC model uses this case as its base case. Another run is used to calculate the marginal cost in the LIUC model. This marginal or incremental cost is based on extrapolations of historical data, current vendor prices, and planning considerations. One would feel more comfortable about the resulting incremental costs if the algorithms did a meaningful search for a cost minimum. Instead, one is left with the assumption that the telephone company is a cost minimizer and the model reflects this.

The second concern about the LIUC model is not the model itself, but the way in which it is used by the BOCs. MUSIC and the LIUC model provide the vehicle to generate upper and lower bounds. The estimated demands under the proposed tariff case are expected demands and have confidence limits associated with them. The confidence limits can be used to generate upper and lower bounds for the estimates of incremental costs. If the demand for the various classes of service is varied both independently and some of them together, within a range set by their respective confidence intervals, the contribution of each class of service to the overall variation in the estimates of marginal cost can be calculated. The BOCs in using the LIUC model do not estimate second- and third-order interactions between level of demands for the classes of service and the incremental costs. Clearly it would seem reasonable to hypothesize that an increase in demand (number of lines) by flat-rate customers (business and residential) may have some impact on the marginal costs of serving customers on local measured service. It could either raise or lower the marginal cost estimate for local measured service. It therefore seems reasonable to suggest that the main effects and second-order interactions between the level of demand for the classes of service and cost estimates be investigated.[9]

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[9]A fractional-factoral design to estimate the main and second-order interactions would seem to be a reasonable experiment. This would generate data to estimate the contribution of each class of service and their interaction to the variation in the marginal cost estimate. See Douglas C. Montgomery, Design and Analysis of Experiments, (New York: John Wiley and Sons, Inc., 1976).

The final comment on the LIUC model is to reiterate the reservations concerning the way it calculates the marginal costs of switching, particularly for the line-link network termination equipment. The exclusion of this equipment from the LIUC model seems to be the result of an assumption rather than an empirical fact or engineering consideration. Although capacity is acquired in lumps, it is clear that the originating and terminating CCS usage have some influence in the design of the line-link termination equipment. The LIUC model does not capture this causal relationship in its calculations although it should.

Marginal Cost Estimation for the C&P Telephone Company

Jeffrey H. Rohlfs of Shooshan & Jackson Inc. has estimated the marginal cost of telephone service for the Chesapeake and Potomac Telephone Company in Washington, D.C. His results will be briefly summarized, after which some criticisms are offered.

This study of marginal costs is based on seven separately estimated econometric equations. The dependent variable in each equation is the annual cost for a particular category of activities. That is, Rohlfs has implicitly disaggregated costs into several components and estimated a cost equation for each component. There are four separate expense equations and three capital investment equations. Each expense or construction cost is deflated by its own price index in order to express it in real terms. Expenses are deflated by the company's own wage rates, while separate Bell System telephone plant indices (TPIs) are used for each of the three investment variables. Each equation is estimated using time series data from about 1962 until 1983. The actual number of observations differs for each equation because of statistical considerations, such as correcting for serial correlation and the stability of the estimated relationship. Each equation is independent of the others; that is, no system-wide type of estimation is reported.

The first of the four expense equations explains maintenance and service connection (M&SC) expenses. These costs are those associated with the connection of new subscribers or the reconnection of old subscribers to the network. Rohlfs found three primary determinants of these expenses, each of which could be termed an output of the phone company. The most important type of explanatory variable was based on the concept of the inward movement of access lines or telephones. Inward movement is the total amount of connection activity, whether it is due to new lines or phones or whether it is due to network reconfigurations that result from customer relocation. Two inward movement measures were statistically significant in the M&SC equation. These were the current value of the inward movement of business phones and the lagged (1 year) value of inward movement of residential access lines multiplied by the fraction of all access lines that were not connected to the electronic switching system (ESS). In addition, the lagged value of the number of business lines was found to be significant. The final variable in this equation was a dummy variable for the year 1983 because AT&T began to take over some installation costs at that time. The results were used with other information to forecast 1984 marginal M&SC costs as the following:

Residential inward movement--$130 per installed access line

Business inward movement--$560 per installed telephone

Business access--$52 per year

Traffic expenses were explained in the second expense equation. These are mostly the salaries of operators; consequently the important determinants are the number of directory assistance calls and the number of operator-handled calls. Rohlfs chose a dynamic specification for this equation by entering the lagged value of the dependent variable on the right hand side of the equation. His reasoning is that traffic expenses do not immediately respond to changes in demand since the company cannot efficiently make continual changes in the number of operators. This type of specification is commonly used in econometrics and is called a Koyck distributed lag model.[10] Such a model has the advantage that it automatically provides both short-term and long-term estimates of marginal costs. The results show that the long-term marginal cost of a directory assistance call is about $.27, while that of an operator-assisted call is about $1.20.

Commercial and marketing expenses were explained as a response to technical progress that was measured using the fraction of lines connected to ESS as a proxy. Rohlfs did not use this equation in any estimate of marginal costs. The reason is that the prediction variable--fraction of ESS lines--cannot be priced in the same manner as access lines, for example.

The final expense equation was used to predict general office salaries, a large component of which is the Washington, D.C. allocation of C & P headquarters expenses. Rohlfs found that these costs are related to the total number of access lines and are therefore not fixed, as some observers have suggested. He concludes that these expenses are likely to be about $81 per access line.

The first capital cost equation predicted construction costs for central office and equipment, including land and buildings (COE). This category is dominated by the cost of switching machines. It was found to be related to two factors: the increase in the number of access lines connected to the ESS, and the number of central office Centrex lines. The sample period covered only the years from 1975 to 1983 because the relationship with ESS was not stable until the mid-1970s. Rohlfs' forecast of these costs was based partly on his empirical work and partly on the observation that the company had overconstructed in 1981 and 1982 and consequently has excess capacity, particularly in major business districts. He concludes that this cost category adds about $52 to the cost of a residential access line, about $130 to the cost of a Centrex line outside of major business districts, and that it adds no cost for Centrex within such districts.

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[10] L. M. Koyck, Distributed Lags and Investment Analysis, (Amsterdam: North Holland Publishing Company, 1954).

The next capital cost equation explained outside plant (OSP), which is mainly exchange loops. Rohlfs used the dynamic, lagged dependent variable specification in this case with two explanatory factors: the number of residential access lines as well as the year-to-year increase in these number of lines. The coefficient of the latter is multiplied by Rohlfs' estimate of the utility's real cost of capital (18 percent including taxes) in order to annualize the cost. No such adjustment is needed for the former since it is an annual cost as estimated. The conclusion is that residential access lines cost about $470 per year. The 1981/1982 overconstruction described above also is relevant to OSP. In Rohlfs' opinion, his equation estimates long-run marginal costs well, and on that basis he uses the estimated coefficients to develop his forecasts. This is inconsistent with his previous contention that overconstruction in major business districts results in zero marginal costs of Centrex. The inconsistency is not discussed or resolved in Rohlfs' report.

The final capital cost equation that Rohlfs attempted to estimate was for other construction, which consists mainly of computer hardware and software. No significant determinants were found, however, and he concludes that these are fixed costs.

Interestingly, local usage was examined as a potential determinant in all equations and was found to be insignificant in all cases. The reason is that the sum of local usage and toll usage per access line has remained approximately constant for the past 20 years. As a result, local usage and the number of access lines are highly collinear and hence statistically indistinguishable. The costs attributed to the gain in the number of access lines, then, partly reflect the corresponding increase in usage. Rohlfs does not report any attempt to disentangle these effects. There are several econometric techniques for doing so, which will not be discussed here.

The overall conclusions of the report are that 1984 forecasts of marginal costs are

Inward movement	
Residential	$130 per installed access line
Business	$560 per installed access line

Access line		
Residential	$600 per year	
Business Centrex	$130 per year	(major business district)
Business Centrex	$230 per year	(elsewhere)
Other business	$180 per year	(elsewhere)

Rohlfs concludes from these estimates that residential rates (the IRF rate), in particular, are much less than marginal costs, but he thinks that universal service is promoted thereby.

This study has been done competently and is presented in an understandable way. It has some drawbacks, however, that need discussion. The seven econometric models reported in the paper are only a few of those that were actually estimated. That is, Rohlfs explored his data extensively before selecting the models that he has deemed to be the best. Such an exercise is useful since it is a way of allowing the sample to yield ideas about the proper cost model specification. The results should not be interpreted, however, as a classical test of the hypothesis that a particular variable either does or does not belong in the cost equation. The models have been selected for presentation on the basis of having large t-statistics. It is incorrect, then, to point to their large size as evidence of statistical significance. The relationship uncovered in Rohlfs' sample may be an artifact of the sample itself and may not be an indication of an underlying, stable structural equation.

Rohlfs has deflated costs using company-specific input price indices. Input prices, themselves, are not used as explanatory variables, as would be the case in a conventional cost function. This type of cost specification implies that the underlying production process has a very restricted form. In particular, it implies that the production technology is, using the economist's jargon, of the fixed proportions variety. That is, the ratio of inputs to outputs is constant for all levels of output. Hence, if a particular output doubles, all of the inputs used to produce it must also double. In addition, if relative prices among the inputs change, the proportions of inputs to outputs remain the same. This type of assumption may be acceptable in an exercise to predict marginal costs in the near future, and therefore the error in Rohlfs' study may be slight. On the other hand, Rohlfs has estimated cost functions over a 20-year period that has witnessed a great deal of technical advance in the use of capital equipment, ESS being perhaps the most prominent example. It is highly unlikely that the same proportions of capital and labor, for example, are used today as were used 20 years ago. It seems likely that the marginal costs that are most influenced by labor expenses, such as maintenance and service connection expenses, are underestimated, while those influenced by capital costs are overestimated, if capital is relatively more productive today than in the past.

Rohlfs has estimated marginal capital costs in a novel way. Instead of relating total capital services from all accumulated capital to output, Rohlfs has related only the investment in each year to output. Since investment is the incremental change in the capital stock, he is able to estimate the incremental costs of various changes in demand directly. The idea is a good one and needs to be compared with the alternative, which is to develop measures of the replacement value of the entire capital stock using vintage data and capital acquisition price indices.

Finally, Rohlfs annualizes his marginal capital costs with a real cost of capital. In particular, he subtracts the inflation premium (as measured by the Bell System Telephone Price Indices) from the nominal cost of capital. This is the appropriate calculation, but it is one with which the reader may not be familar. It corresponds to the idea of "trending" the rate base. That is, in setting rates, this year's capital costs are multiplied by the real cost of capital. Next year, however, last year's investment is valued at its replacement cost and then multiplied by the real cost of capital. The result over the lifetime of the investment is to recover the full value of the investment. The pattern of payments differs from that of the ordinary rate base treatment, however. By using the real cost of capital, the consumers' payments remain constant in real terms, which is to say that they increase at the rate of inflation in nominal terms. This is in sharp contrast to the conventional treatment, which is front end loaded with much larger payments initially than at the end of the investment's lifetime, both in real and in nominal terms.

Rohlfs has presented seven statistically estimated cost functions that he has combined with projections of the cost of labor and construction to forecast the marginal cost of various aspects of telephone service. Four of the equations were used to develop marginal access cost for residential and business customers, one was used to estimate the marginal cost of a directory assistance call, and two were not used at all because the costs were essentially fixed, at least with respect to the services for which a customer may be charged.

The statistical techniques used by Rohlfs are straightforward and he incorporates the novel idea of predicting annual investment, instead of finding the cost of the entire capital stock. The study seems well designed and carried out, although it might be improved by estimating a less restrictive cost function that explicitly considers input prices, instead of embedding these as deflators of cost. Rohlfs' technique may be helpful to a commission in setting minimum prices for competitive services; however, it is not likely to help in any type of fully allocated cost study typically used in rate cases.

Fuss and Waverman Multi-Product Multi-Input Cost Functions

Melvyn Fuss and Leonard Waverman have written a paper regarding the estimation of multi-product cost functions, using data on the operations of Bell Canada from 1952 to 1975.[11] The paper has two important sections dealing with theoretical matters, as well as a report on an actual cost function estimated from the Bell Canada data. The principal contrast between the Fuss-Waverman (F-W) paper and the

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[11]Melvyn Fuss and Leonard Waverman, "Multi-product Multi-input Cost Functions for a Regulated Utility: The Case of Telecommunications in Canada," in Studies in Public Regulation, G. Fromm, ed. (Cambridge, Mass.: The MIT Press, 1982).

Rohlfs study is the level of cost aggregation. F-W is concerned with the telephone company's aggregate cost, while Rohlfs estimated separate equations for several components of cost. Rohlfs' approach is likely to provide good cost prediction in the short term, whereas the F-W study helps to improve our understanding of the long-run structure of costs. In particular, substitution possibilities between factors of production can be estimated using the F-W method, whereas the specification adopted by Rohlfs is inherently incapable of capturing such effects. Such a limitation is not likely to be important in the short term, however.

In the view of F-W, econometric cost analysis can be useful in the regulatory process, but one must understand the limitations of this technique. First, it is mainly helpful as a way of examining cost functions retrospectively. This kind of historic cost-causation analysis is useful for identifying cross-subsidization or cream skimming, and can also be used as a guide to setting future prices if technology does not change too rapidly. Prospective long-run incremental cost, however, in theory, is the appropriate concept for rate-making purposes and econometric cost analysis is valuable to the extent that it provides insight about such future costs.

F-W acknowledges that several problems limit the usefulness of econometric cost estimation in the regulatory arena. For example, it is important that long-run incremental costs be measured in terms of changes in capacity, and not in terms of changes in output at less than capacity. The quality of the exchange network may be higher due to a need to accommodate long distance transmission. Such upgrading costs are properly part of the incremental costs of the long distance traffic. A second difficulty is the statistical problem of relying on historical outcomes to provide the samples to be analyzed. Such samples, particularly those collected over time for a single company, tend to have highly correlated sets of outputs (services) and inputs. This type of data tends to limit the precision with which marginal costs of individual services can be estimated. A third issue that needs recognition is that in most econometric studies capacity is valued at its replacement value. Regulation allows a return only on the historic cost of the used-and-useful plant and equipment. After a period of general inflation, replacement costs will exceed historic values, perhaps substantially. Consequently, prices based on econometrically estimated marginal costs are useful as a guide to efficiency but provide much less insight into actual rate-making.

The actual strength of this paper is in the two theoretical sections. In the first of these, F-W develops the implications and properties of a multi-product cost function for a firm that is not regulated or, if it is, the regulation is not effective. In the second theoretical section, the authors expand upon this discussion by examining effective rate-of-return regulation.

In the unregulated case, F-W discusses several important properties of multi-product cost functions. They point out that a notion of economies of scale can be developed if all outputs are increased by the same percentage. As an example, if all outputs are increased by 10 percent and the resulting costs increase by only 8 percent, the firm would possess decreasing costs or, equivalently, increasing returns to scale. Importantly, no similar scale measure can be constructed for any single product, at least as long as the multiple products share common costs. In the absence of common facilities, costs would be separable and conventional individual measures of scale economies could be used.

In addition to scale economies, F-W discusses economies of scope that exist when it is efficient to produce two or more products in the same firm, as opposed to organizing separate production processes. Fairly simple specifications of cost functions can be used to statistically test whether joint production lowers cost. F-W gives an example for which the test is based upon the coefficient of a variable measuring the interaction between two outputs in an ordinary regression model.

In the second theoretical section, F-W examines the multi-product cost function for a rate-of-return regulated utility. The effect of the regulation, theoretically, is to distort the firm's perception of input prices. In other words, the traditional Averch-Johnson overcapitalization hypothesis can be interpreted as the case of a regulated firm that is minimizing costs, except that that firm's perception of the price of capital is distorted downward by the regulation itself. Hence, the firm chooses relatively capital-intensive technologies because it perceives that capital is cheaper than its actual social cost. F-W shows how this idea can be incorporated into an econometric cost specification so as to consistently estimate the factor substitution effects. This is a novel and sophisticated approach that helps to improve our estimates of cost relationships, but that may be difficult to incorporate into regulatory practice.

The empirical section of the F-W study presents the author's estimates of a multi-product cost function using Bell Canada data. They incorporated three output measures in their analysis--local services, message toll services, and competitive services. The last of these is an aggregation of other toll services such as private line, TWX and data communications, directory advertising, and consulting. These services were produced with three inputs: materials, labor, and capital. The capital stock was measured as replacement cost in 1967 dollars. Each of six categories of capital (buildings, central office equipment, station equipment, outside plant, furniture and office equipment, and motor vehicles) was adjusted for the age distribution of investment and the price of each type of investment. This produces a real capital stock series, the price of which is typically measured as the rate of return requested by investors (including the depreciation rate) multiplied by the acquisition price of capital.

The statistical model estimated in F-W begins with the specification that cost is related to outputs and prices of inputs according to a particular algebraic relation that is called the translog functional form. From this, the authors derive several ancilliary equations, the purpose of which is to improve the efficiency of the estimation procedure. The actual statistical model consists of five simultaneous equations: the cost function, cost share equations for two factors (there are three inputs, but one equation must be omitted in the estimation procedure because the three factor shares necessarily add to unity, hence one is redundant), and two revenue share equations that incorporate demand elasticity information from a separate statistical analysis. The entire system of equations is jointly estimated using interative, three-stage, least squares, which is an asymptotically (large sample) efficient procedure. On the basis of the estimated demand elasticities, F-W concludes that local service (one of the three outputs) can be considered exogenous, while the remaining two outputs (message toll service and competitive services) were deemed endogenous. The distinction is important and is based upon the plausible rule that a profit-maximizing monopolist would not willingly be content to produce in an inelastic region of a demand curve.[12] Observing inelastic demand then, such as in the case of local exchange services, must be the result of regulatory action that has forced the monopoly to provide service beyond that which would have been provided by an unregulated monopolist. For such a service, F-W concludes that the ordinary profit maximizing conditions will not be met, and the level of service will be exogenous. In the case of elastic demands, however, it is reasonable to suppose the regulated monopolist is able to manipulate price so as to equate marginal revenue and marginal cost. These outputs, consequently, should be considered endogenous, that is, jointly determined with the cost function. For the two services with elastic demands, then, F-W must include equations to determine the unknown, endogenous outputs. Hence, the two revenue share equations were incorporated into the overall statistical model. If all three services had inelastic demands, only the cost function and factor share equations would require estimation. Since two outputs

[12]If demand is inelastic, marginal revenue is negative and thus is assuredly less than marginal cost. An unregulated monopolist would not choose to produce such an amount.

were endogenous, consistent estimation required the use of instrumental variables within the three-stage procedure. Hence, the statistical technique used in F-W is quite sophisticated, applications of which appear mainly in the econometric literature.

The statistical results reported by F-W are plausible, although often not statistically significant. They found that capital, labor, and materials were all substitutes for one another for Bell Canada. The com any apparently displayed decreasing returns to scale (that is, increasing costs) during all years of the sample. This is somewhat counterintuitive and although the point estimates indicate decreasing returns, a 95 percent confidence internal includes constant returns, so that the Bell Canada results are not statistically different from the constant returns case. Estimates of incremental or marginal costs of each of the three services indicate that marginal costs are increasing for local exchange service and decreasing for toll and competitive services. The marginal cost curves for toll and competitive services will also eventually start to rise according to the F-W estimates, although such a point is well beyond the observed points in the sample.

Overall, the Fuss and Waverman study is an excellent application of recent economic theory, as well as advanced econometric estimation procedures, to the telephone industry. The insights are suggestive of future research needs, but undoubtedly have not been developed to the point of being conclusive about such issues as scale economies and scope economies. This type of aggregate cost estimation exercise provides a good background for understanding the appropriate industrial structure of the telephone industry. It is less useful as a method for predicting next year's costs for rate-making purposes.

CHAPTER 8

SURVEY OF STATE COMMISSION POLICY REGARDING COST-OF-SERVICE STUDIES

In early 1984, a survey was undertaken by an NRRI research team to ascertain which cost of service methods were used in telephone rate making and how commissions used them in determining rates. A letter[1] was mailed to state public utility commissions requesting information on cost-of-service methods being used or under study by the commission. Nineteen states responded in one form or another. The states were the following:

1. Alabama
2. California
3. Colorado
4. Florida
5. Indiana
6. Kansas
7. Louisiana
8. Maine
9. Maryland
10. Missouri
11. Montana
12. New York
13. North Carolina
14. North Dakota
15. Ohio
16. Oklahoma
17. Texas
18. Washington
19. Wisconsin

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[1]A copy of the letter is in appendix C.

The level of response among these respondents varied considerably and presumably reflected their activities in the cost-of-service area. The purpose of this chapter is to summarize briefly the results of this survey.

This chapter is organized into two sections. The first section contains a summary on a state-by-state basis of commissions that do not prescribe a cost-of-service method or do not have explicit policies on the use of cost-of-service studies in rate-making proceedings. The second section summarizes briefly the policies of state commissions that either prescribe a particular cost-of-service method or have adopted explicit policies concerning their use in rate-making proceedings.

State Commissions Without a Policy Regarding Cost-of-Service Methods

Fourteen of the nineteen states responding to the survey letter responded by either sending a letter indicating the use of cost-of-service methods in their rate-making proceedings or forwarded testimony on cost-of-service studies that had been presented before the commission. Two states, Alabama and Louisiana, responded with letters indicating they did not prescribe a method nor use one in rate-making proceedings. The remaining eleven commissions, however, sent testimony concerning cost-of-service studies or gave some indication of which methods are presented. These responses are summarized below.

Colorado

The Public Utilities Commission of Colorado is currently modifying Embedded Direct Analysis for use in rate proceedings. This activity had not begun at the time of the survey. At that time a commission staff member indicated that the Colorado commission does not prescribe a cost-of-service method and that telephone companies have not submitted cost-of-service studies as a standard part of their rate case. He went on to say:

> In our last rate case with Mountain Bell, staff contracted with Walter Hinchman and Associates in Washington, D.C. to perform a cost-of-service study based, for the most part, on separations principles. This study was not accepted by the Commission for a number of reasons. At the present time, we are in Phase I of another rate case with Mountain Bell, and staff plans to do its own cost-of-service in this case. We hope to clean up a number of defects in the first study, and to have our study adopted in this case.

It appears that the Colorado staff is working to move the direction of telephone rate making from value-of-service principles toward cost-of-service. This effort, however, is in its embryonic stage.

Florida

The Florida Public Service Commission contracted with Associated Utility Services, Inc., located in Moorestown, N.J. to develop a cost-of-service manual for telephone services. This manual was used as the basis of a cost-of-service study for Southern Bell Company of Florida. The method in the manual is based on separations principles and is a full-costing method. To date, the Florida commission has not adopted the manual, and refinement of allocation methods is still underway.

Indiana

The Indiana Public Service Commission responded with a letter indicating that cost-of-service studies were not used in establishing rates for telephone services. The responding staff member did indicate that incremental cost studies are provided to support rate requests for support services subject to competition. In such cases a summary of the study was requested for commission files.

Maine

The Maine Public Utilities Commission provided testimony presented on behalf of New England Telephone and Telegraph Company in an unspecified rate case. The testimony presented the results and conclusions of an EDA study and its supporting analysis based on studies such as ECS and ECOST. The conclusions drawn from this study included the following:

> The results for the Company's major categories of service show that the Exchange, Private Line, Supplemental Services -Business, Inside Wire and Terminal categories all have shortfalls. Positive contributions are being generated by the State Toll, Supplemental Services -Residence, Other, and Interstate categories. These contributions partially offset the Common costs and shortfalls in other categories.[2]

As in other states, these conclusions are typical for EDA. The further disaggregation of service categories and analysis with ECS, ECOST, and other studies further disclosed that

> ...testimony shows that costs exceed revenues in the Residence, Business, Local Coin, and Local DA categories, indicating that a shortfall exists in all of the subgroups as well as in the Exchange category as a whole.
>
> The State Toll disaggregation results show that the Operator handled and State Toll DA subgroups have shortfalls, and that Direct Distance Dialed, 800 Service, and Outward WATS subgroups all providing positive contributions.[3]

The responding commission staff member indicated that no other cost studies are presented in support of telephone rates in commission proceedings. As noted, the results of the studies are typical for the Bell company composite method. The allocation of the NTS costs to the access category and the assignment of these costs to the exchange category as a whole is the underlying reason for these results.

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[2]Testimony of James J. Callahan, Jr., Manager, New England Telephone and Telegraph, State of Maine, pp. 3-4.

[3]Ibid., pp. 4-5.

Maryland

The Maryland Public Service Commission in a rate case[4] involving Chesapeake and Potomac Telephone Company ordered the commission staff to organize a manual to perform cost allocation of intrastate telephone services. At that time, the commission staff contracted with Bethesda Research Institute to assist the staff in development of the manual. This manual has been developed and submitted to the commission for review. As of March 1985 the commission had not adopted the manual.

Currently, the staff has contracted with Exeter Associates located in Bethesda, Maryland, to apply the manual in a current rate case involving Chesapeake and Potomac Telephone Company. The method in the manual is essentially a modified EDA. The method in the manual retains the access services category, but breaks it down into two subcategories: carrier and customer. The customer subcategory is further broken down into exchange, state toll, and state private line subcategories. The state toll subcategory of the customer portion includes message telephone service and WATS.[5]

New York

The New York Public Service Commission responded to the survey letter with a brief letter describing the use of cost-of-service studies in rate cases. The responding staff member indicated that a variety of costing methods is used depending on the particular company and service category being studied. Some of the studies are performed on an embedded cost basis and others on current or incremental costs. The New York commission, however, does not prescribe a specific costing method for these studies.

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[4]Order No. 66504. No other information was provided, but the order was issued in early 1984.

[5]Telephone conversation with Roland Wentworth, Director, Research and Economics, Maryland Public Service Commission, March 1, 1984.

North Carolina

The North Carolina Utilities Commission responded to the NRRI survey letter by sending a brief letter and Southern Bell Telephone Company's EDA executive overview. The responding staff member indicated that the North Carolina commission does not prescribe a cost-of-service method and that very little testimony has been submitted by telephone companies on cost-of-service studies.

North Dakota

The North Dakota Public Service Commission forwarded some EDA documentation in response to the survey letter. The accompanying letter states that testimony had never been submitted by telephone companies on cost-of-service methods.

Oklahoma

The Oklahoma Corporation Commission responded to the survey letter by sending testimony presented before the commission on cost-of-service studies by Southwestern Bell and General Telephone Company of the Southwest. The accompanying letter indicated that the commission does not prescribe cost-of-service methods. The Southwestern Bell testimony[6] presented the results of the Bell composite method of EDA, ECS, ECOST, and others. The General Telephone Company testimony[7] presented an avoidable-cost study for various categories of service.

Texas

The Public Utility Commission of Texas directed the commission staff to develop recommendations for cost-of-service methods for

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[6]Testimony of Russell H. Ewing, Cause No. 28002. Dated August 29, 1982.

[7]Testimony of Oscar C. Gomer, Cause No. 28229. Presented April 11, 1983.

telephone. The commission staff has agreed to explore the allocation methods proposed in chapter 9 of this report. This work is to begin in the summer of 1985.

Washington

The Washington Utilities and Transportation Commission responded by sending the commission's order in Cause No. U-82-4.[8] This order delineates seven criteria the commission used in setting rates. They were cost of service, value of service, impact on customers, balance between rates, uniformity, understandability, and revenue required.

Wisconsin

The Wisconsin Public Service Commission has recently undertaken a "stand-alone" cost study of various types of local dial switching equipment and all categories of expenses. Electronic offices studied included 1-ESS, 2-ESS, Digital, and a 1-ESS that provides a combination of toll and exchange services. These cost studies were used to generate stand-alone costs and incremental costs. The incremental costs of exchange switching were derived by subtracting the stand-alone costs of the toll switch from the stand-alone costs of a 1-ESS switch used to provide both toll and exchange services. Stand-alone costs were developed for the following service categories: private-line, local; private-line; toll; local service; toll service; and vertical services. The study is due to be released by the middle of March 1985.

State Commissions With a Policy Regarding Cost-of-Service Methods

Five states responding to the survey letter indicated that through a commission order or use of cost-of-service methods or both, the

[8]Cause Number U-82-4-1, Second Supplemental Order, Washington Utilities and Transportation Commission v. Continental Telephone Company of the Northwest, Inc., (August 1983).

commission had adopted a position concerning the use of cost-of-service methods in rate-making proceedings. Of these, only the Kansas Corporation Commission prescribes a particular method as being the proper method to perform cost studies. The California Public Utilities Commission requires that studies be performed by a particular set of methods, but has not adopted them as the proper method. Missouri and Montana have expressed a preference for marginal costs in certain circumstances. The Public Utilities Commission of Ohio has developed (with the help of NRRI) a costing method that it uses in rate-making proceedings. Each of these state commissions' responses to the survey is reviewed below.

California

The California Public Utilities Commission has directed that two types of cost studies be performed in support of rate requests filed before it. They are a "bottoms-up" study and "tops-down" study. It stated in Decision No. 84-06-111 that cost of service is only one of the relevant considerations in setting rates. It suggested that beyond setting rates to meet the revenue requirement for a service, that the fair distribution of any rate increases among customers was also important and often conflicted with setting rates at cost. The tops-down and bottoms-up studies are used to gauge the degree of cross-subsidy among services when setting rates.

The tops-down study refers to a study that begins with the total companies books and allocates these costs to categories of services. The Pacific Telephone and Telegraph Company uses EDA to do the tops-down study. The results of this study are compared to the bottoms-up study.

The bottoms-up cost study is a functional cost study. In other words, the costs of providing a service are studied piece by piece and the cost of each piece is aggregated to the level of the company as a whole. The bottoms-up study is performed for the following service categories: subscriber access, recurring and nonrecurring; customer-premise wiring; operator services; private line, recurring and non-recurring; local usage; and direct inward dialing. The bottoms-up costs include commercial and marketing expenses, taxes, and general and administrative expenses--both direct and indirect.

The commission requires both types of studies to ascertain the degree of and source of disrepancies between these two types of studies. These costs are used only indirectly in ratemaking. For instance, subscriber access costs have an intrastate subscriber plant factor applied to them before rates are set. The procedure is referred to as allocating the revenue requirement rather than costs. The revenue requirement for local exchange service is the residual after toll and all other revenue requirements have been allocated. A number of objectives other than setting rates equal to costs are used in this rate-setting process. These objectives relate primarily to the fairness of the resulting rates.

Kansas

The Kansas Corporation Commission in Docket No. 117,220-U adopted the fully distributed cost method developed by Richard Gabel. The method was reviewed in an earlier chapter and the details of this allocation of plant accounts are contained in appendix A. In this docket the commission felt that Gabel's study clearly showed that monopoly services in exchange and intrastate toll categories are subsidizing competitive items and services offered by Southwestern Bell Telephone Company of Kansas. The commission further noted that it was in these monopoly areas that the company sought to recover most of its revenue deficiency.

The commission's adoption of this method stemmed directly from its dissatisfaction with EDA. It stated:

> ...after considering Applicant's EDC study for the third successive time, it having been presented in Docket #103, 400-U, #107,330-U and in this docket (#110,941-U), that such study is inappropriate in studying cost service of the various service categories...[9]

This docket, #110,941-U, was the docket previous to docket 117,220-U, the docket in which the Gabel method was adopted. The order in docket #117,220-U went on to state that the adoption of the Gabel method did not prevent the Southwestern Bell from submitting other cost studies so long as they employ a full-costing method.

Missouri

On June 21, 1977, the Missouri Public Service Commission adopted a specific position regarding the types of cost-of-service methods appropriate for three categories of service. "Category one" services are those that are subject to substantial competition. The second category of services, "category two," is all those services that are classed as basic telephone service. The third category, "category three," is made up of the balance of all services provided by the telephone company. The following position was adopted for each of the three service categories:

> Category one services will be priced so as to generate the largest practical level of contribution from those services to joint and common costs and to basic services based on LRIA (long-run incremental analysis). A price shall not be approved by the commission which does not allow for some contribution to be made to the joint and common costs of the company.
>
> Category two services will be priced residually after taking into consideration any contribution to revenue requirement made by category one and category three services....

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[9]Docket 117 220-U, p. 75.

> Category three services will be priced using long-run incremental analysis as a foundation, and adjusting for social or economic factors related to the provision of receipt of those services...[10]

Thus, the Missouri commission has adopted a marginal cost standard for competitive and nonbasic services. With respect to the costing method appropriate for basic telephone service, the commission ordered:

> ...the embedded direct costs for all classes of service under category two. The relationships between those embedded direct costs shall serve as the basic relationship in pricing category two services under the residual technique.[11]

The commission went on to require several other studies to be performed in support of these two types of studies. The commission stated that its guidelines provide an appropriate response to the increase in competition and the need to maintain affordable basic services. It also pointed out that the particular services included in each of the categories may change over time as competitive pressures develop or subside.

Montana

The Montana Public Service Commission responded to the survey letter by forwarding a commission order[12] that addresses the allocation of nontraffic sensitive costs in determining the costs of access for interstate, state, and exchange services. The commission

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[10]Case No. 18,309, In the Matter of the Cost of Service Study of Southwestern Bell Company, Missouri Public Service Commission, June 21, 1977, pp. 3-4.

[11]Ibid., p. 4.

[12]Order No. 4991b, Docket No. 83.3.18, In the Matter of the Application of the Mountain States Telephone and Telegraph Company (Mountain Bell) For Authority to Increase Rates and Approval of Tariff Changes for Telecommunications Service, Montana Public Service Commission, December 30, 1983.

seemed to express a preference for marginal costs and used it as a benchmark throughout the order. The issues concerning the allocation of nontraffic sensitive costs by EDA and the J. W. Wilson and Associates method are briefly reviewed here.

The EDA study was presented on behalf of Mountain States Telephone and Telegraph Company. This cost-of-service study disclosed that state and interstate toll rates have been increasingly subsidizing the revenue requirement for access. The order notes that the EDA study leaves the common cost and access costs as separate line items. The common costs account for 6.4 percent of the total embedded cost and the access costs constitute 32.1 percent of the total EDA costs. The J. W. Wilson study was presented on behalf of the Montana Consumers Council. The allocation of nontraffic sensitive costs (access costs) to toll and exchange services was: 25 percent to interstate toll, 25 percent to state toll, and 50 percent to exchange services. The primary differences between these two studies are the allocation access and common cost categories.

The commission noted that it is unacceptable for usage rate elements to reflect any nontraffic sensitive costs. The commission went on to state:

> ...the distinction between access elements (if there is any) should be based on marginal or avoided costs--not an arbitrary 50 percent allocation factor--...it requires a functional access/usage cost study.[13]

The commission also noted that:

> to the extent EDA results in reflecting marginal usage-related access costs in non-traffic sensitive rate elements, it is unacceptable.[14]

It questions both of these studies on the grounds that neither purports to reflect marginal usage-related access costs.

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[13]Ibid., p. 34.

[14]Ibid., pp. 34-35.

Ohio

The Public Utilities Commission of Ohio has been developing a cost-of-service method for use in rate cases for the past 5 years. The commission uses a fully allocated, embedded cost study to determine the revenue requirement for several categories of service. Typically, the categories of service are: (1) customer premises equipment; (2) interstate toll; (3) state toll; (4) interstate private-line and private line-like services; (5) state private line and private line-like services; and (6) local exchange service, which includes vertical services. The study is based on a cost-causation philosophy, but is restricted to the use of readily available and auditable accounting and engineering data.

In general, some plant investment is directly assigned to the service category that uses it or it is allocated according to current separations assignments. An exception to this is the allocation of plant investment for that equipment whose costs are typically classified as not sensitive to traffic. This nontraffic sensitive plant is often treated under a number of scenarios in which the allocation factors used to allocate it to the toll categories have been either subscriber plant factor, subscriber line usage, a 50 percent factor, and zero. The remainder of the nontraffic sensitive plant is directly assigned to the remaining categories once an allocation to the toll categories is made.

Expenses that cannot be directly assigned to a service category are usually related to the cost of owning, operating, managing, and maintaining the physical assets of the company as well as marketing the services that those assets can provide. It is presumed that these costs would then vary according to either the amount of equipment involved or the amount of service provided. The study uses plant investment as a measure of the amount of equipment involved in a service and it uses revenue requirements as a measure of the amount of service provided. Allocation factors based on these two measures are then used to allocate the unassignable expenses. Taxes are usually related to rate base, to revenues, or to wages, depending on the type of tax, and are allocated accordingly.

A special feature of this cost study is that it is implemented with an interactive computer program called ICAS (Interactive Cost Allocation System) that was designed to make it easy for an analyst to make changes in the cost study methods. This has made it possible to easily generate alternative studies based on different scenarios as mentioned above, and to adapt a cost study method to the study of different telephone companies—each with its unique ability to provide helpful data. In this regard, the study has been applied in various, but similar forms to Ohio Bell, Cincinnati Bell, a GTE company in Ohio, a United Telephone Company in Ohio, and the Lorain Telephone Company.

CHAPTER 9

A PROPOSAL FOR A FULLY DISTRIBUTED COSTING METHOD USING A PEAK-RESPONSIBILITY ALLOCATION OF COSTS

In this chapter, a fully distributed costing method for intrastate telephone services is outlined. For the most part, the costs of plant and equipment, plant-related expenses, and operator expenses are allocated to broad service categories according to the capacity-required criterion by using network planning criteria. This is accomplished by applying probability-weighted usage to develop allocation factors for the appropriate separations cost categories. The allocation of the subscriber loop is also outlined, but whether the allocation is guided by the capacity-required criterion or the beneficiality criterion is less clear than with network costs. It was noted in chapter 5 that the costs of rendering telephone service can be divided between network and customer-related costs. The subscriber loop, of course, falls under this latter category, which implies that the customer plans his own loop capacity. The coincident demands for a subscriber loop by incoming and outgoing callers and the resulting congestion are important cost-causative factors leading customers to install additional loops. To the extent that this decision process can be approximated, the allocation factor that results would be developed

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[1]A detailed cost manual for all categories of plant will be released as a separate volume. This will be followed by appropriate computer software to perform a cost study using this method.

according to the capacity-required criterion. Realization of this ideal, however, is unlikely because of the quantity and quality of information that must be made available to the cost analyst. As the ideal is compromised in the interest of feasibility and practicality, the beneficiality criterion may have to be used to develop allocation factors for the costs of the subcriber loop. It should be emphasized that the purpose of this chapter is not to present in detail the treatment of cost category for a telephone company. A detailed cost manual, which is forthcoming, will present the allocations of all the costs of a telephone company. Instead, the purpose here is to outline the development of probability-weighted usage factors for selected cost categories.

As noted, the separations cost categories are retained by this method. These cost categories are a division of the accounting costs recorded on the telephone company's books into supposedly homogeneous technological groupings. These costs are further divided according to dedicated use or shared usage. Dedicated plant, equipment, and associated expenses are directly assigned to the appropriate service categories. Shared plant and equipment, on the other hand, are allocated, when appropriate, among service categories according to the probability-weighted usage factors proposed in this chapter. The cost categories for telephone plant and equipment accounts are presented in column (1) of the tables in appendix A.

It should be noted that separations procedures are assumed to determine the accounting costs that are potentially includable in a state's jurisdictional revenue requirement for a telephone company. If a cost category in separation is allocated only between interstate and state toll, the residual cost from separations should become a direct assignment to state toll in a cost study for intrastate services. If, on the other hand, the cost is allocated between interstate toll and intrastate telephone services (both state toll and exchange), the probability-weighted usage factor is used to split the costs of intrastate services between state toll and exchange services. In both cases, the acceptance of the separations procedures enhances the ability to audit and verify the outcome of the allocations performed on state jurisdictional costs. If the entire separations procedures are reworked, as with EDA, a reconciliation must be performed. It should be noted that the assumption that separations are not reworked should not be construed in any way to be an endorsement of current separations practices. The approach outlined in this chapter is recommended as an appropriate method to determine state and federal jurisdictional costs.

This chapter is organized into four sections. In the first section, the conceptual basis for the probability-weighted usage allocation factor is explained. The second section contains examples of how these weighted usage factors would apply to network costs such as exchange trunk plant, local dial switching equipment, and operator services. In the third section, a proposed method for allocating the subscriber loop is presented. Finally, in the fourth section, the allocation of common costs is discussed.

Probability-Weighted Usage Allocation Factors

The probability-weighted usage factor is derived by combining hourly usage information for an item of plant with its associated probability that the plant item is used at full capacity during that hour. These probabilities are used for capacity planning by network planning engineers and reflect cost-causative phenomena. These hourly probability-weighted usages for each plant item are aggregated over all similar plant in a rate-making service area[2] and over all hours of a typical day. The resulting fraction of this aggregate measure that is attributable to a service is its probability-weighted usage divided by the total probability-weighted usage. This calculation involves several steps that are explained in detail below.

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[2]A rate-making service area is defined as a geographical area for which rates are being set and a cost-of-service study is supporting the proposed rates. This area could be the jurisdictional area in which the company operates or a specific city, county, or several county region.

The first step in calculating the probability-weighted usage factors is to sample the usage of various types of services for a given item of plant at a location and develop a usage profile on an hourly basis for a typical day.[3] A trunk connecting two central offices or a local dial switch at a central office would be examples of this plant and a location. Let U_{ijtc} be the usage of the i^{th} service on the j^{th} plant item in hour t by the c^{th} customer class.[4] Total hourly usage of this plant item in hour t is given by

$$\sum_{c=1}^{C} \sum_{i=1}^{N} U_{ijtc} = U_{jt}$$

These hourly usages U_{ijtc} and U_{jt} should be developed for a typical day for each plant item. For certain plant items, such as a local dial switch and the subscriber loop, which are two-way communications paths, both incoming and outgoing usage should be measured, since usage in both directions contributes to congestion and queuing in the system when this capacity is fully used.

The second step in developing the probability-weighted usage factor is to calculate for each hour the probability of a given hourly usage, U_{jt}, occurring on plant item j. This probability is given by

$$Pr\{U_{jt}\} = \frac{U_{jt}}{\sum_{t} U_{jt}}$$

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[3]Collecting hourly usage data for each service and compiling it in the manner prescribed would in all likelihood, require a new usage study. However, this is not known for certain, and existing data collection procedures might be found adequate for the purpose of this study.

[4]The customer class distinction is not easily made when measuring minutes of use on a trunk or some other piece of equipment in the network that is far removed from the customer. However, it does seem possible that functional relationships for subscriber-line use by a customer class could be used to predict usage of plant in the network by a class.

such that

$$\sum_t \Pr\{U_{jt}\} = 1$$

for all j. This probability is simply that fraction of total usage of the j^{th} plant item represented by the usage in hour t of a typical day.

In the third step, probability information used by planning engineers for sizing communications paths is introduced. One must calculate or obtain the probability that a call will not be completed during a given hour because this item of plant is used to full capacity or the probability that usage during that hour exceeds design specifications. These probabilities are calculated with the Erlang B formula (as explained below) and are called blocking probabilities for such plant as trunk groups. For equipment like senders, these probabilities are calculated with the Erlang C formula, which yields the probability that a delay longer than a given length will be experienced when making a call. Both the Erlang B and Erlang C formulas are used by network planners to determine the capacity of network plant and equipment as well as operator services to meet some quality of service critera.

To apply these formulas to capacity planning at points in a communication path, certain assumptions must be made. First, the arrival of calls at a point in the network is assumed to form a Poisson process. Second, service times are assumed to be negative expotentially distributed with a known mean hang-up rate. It is further assumed that any blocked calls disappear without effect on the network.[5] Under these assumptions the Erlang B formula is given by[6]

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[5]This amounts to an assumption that call attempts are independently and randomly distributed. This last assumption is somewhat controversial primarily because redials of blocked calls contribute to congestion. In this case, the Erlang B formula will underestimate the amount of blocking. For more discussion see Bell Laboratories, Engineering and Operations in the Bell System, (Indianapolis, IN: Bell Laboratories 1977), p. 483.

[6]Most of this discussion is drawn from Engineering and Operations in the Bell System.

$$B(n,a) = \frac{a^n/n!}{\sum_{k=o}^{n} (a^k/k!)}$$

where a is the traffic intensity in terms of offered load in Erlangs and n is the number of servers. Servers can be the number of trunks in a trunk group or the number of paths through a switch to connect a call.

Traffic intensity, a, is the mean number of arrivals per average holding time for an hour of a typical day. This offered load can be derived from the U_{ijtc} and expressed as offered load in Erlangs. Traffic, in terms of Erlangs, is the sum of the holding time of the paths divided by the period of measurement. By summing hourly usage over the services and customer classes

$$U_{jt} = \sum_i \sum_c U_{ijtc}$$

the holding time for plant item j is derived. Since U_{jt} is measured in minutes for an hour, the corresponding offered load in erlangs, A_{jt}, is given by[7]

$$A_{jt} = \frac{U_{jt}}{60}$$

A_{jt} is a dimensionless unit of traffic intensity expressed as the average number of calls underway.

Network planners set quality of service criteria by setting an upper bound for B(n,a)--the Erlang B formula. For instance, the probability that a call along a trunk group will be blocked is 1 percent or less.[8] Given this upper bound and the traffic intensity,

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[7]If U_{jt} had been expressed in hundred call seconds (CCS) the formula would be

$$A_{jt} = \frac{U_{jt}}{360}$$

[8]See Gordon Pearce, Telecommunications Switching, (New York: Plenum Press, 1981), p. 146, table 10.

A_{jt}, planners can determine the number of trunks necessary to meet this upper bound.

For the purpose of cost allocations, the Erlang B formula can be used to compute blocking probabilities for each hour of a typical day. Given the hourly traffic intensity and number of servers along a path, N_j, the blocking probability can be computed as

$$B\{N_j, A_{jt}\} = Pr\{B|A_{jt}\}$$

This probability, $Pr\{B|A_{jt}\}$, is interpreted as the probability that a call is blocked given the usage in hour t for plant item j. This conditional probability is the second probability necessary to compute the probability-weighted usage factor.

The Erlang C formula is used in a similar manner where delay can occur and queuing is the result. The Erlang C formula is given by

$$C(n,a) = \frac{\dfrac{a^n}{(n-1)!(n-a)}}{\displaystyle\sum_{j=o}^{n-1} \frac{a^j}{j!} + \frac{a^n}{(n-1)!\ (n-a)}}$$

where all terms are as defined previously. By using the hourly traffic intensity, A_{jt}, and the actual number of servers, N_j, a probability of delay (D>0) for each hour of the day, $Pr(D|A_{jt})$, can be calculated. This probability is interpreted as the probability of experiencing a delay greater than zero when using plant item j in hour t, given the usage at that hour.[9] As with the Erlang B formula, the Erlang C formula is an important piece of the probability-weighted usage factor.

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[9]Ibid., p. 146, table 10.

In the fourth step, Bayes formula[10] is applied to calculate the conditional probability that is used directly in computing the probability-weighted usage factor. Applying Bayes formula[11]

$$\Pr\{U_{jt}|B\} = \frac{\Pr\{B|A_{jt}\}\ \Pr\{U_{jt}\}}{\sum_{t}^{n} \Pr\{B|A_{jt}\}\ \Pr\{U_{jt}\}}$$

$\Pr\{U_{jt}|B\}$ can be interpreted as the probability that a blocked call on plant item j occurs to usage in hour t. In other words, it answers the question: given that a call is blocked on plant time j, what is the probability that it is the result of traffic in hour t. These conditional probabilities have the property that

$$\sum_{t} \Pr\ \{U_{jt}|B\} = 1 \qquad \text{for all } j.$$

In other words, the hourly probabilities for the j^{th} plant item summed, over the hours of the day equal unity. This is a convenient property for an allocation factor to have.

The relative value of $\Pr\{U_{jt}|B\}$ reflects the likelihood that hour t is a peak hour and usage in that hour may cause capacity to be added. Recall that $\Pr\{B|A_{jt}\}$, the blocking probability, is used by network planners to size communication paths given the expected traffic. A quality-of-service criterion is imposed that places an upper bound on the value of the blocking probability. When expected (average) traffic intensity during an hour causes this bound to be violated, network planners solve the Erlang B formula for the number of servers, N_j, that satisfies this quality-of-service constraint. Since both traffic and

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[10]See Alexander M. Mood, Franklin A. Graybill, and Duane C. Boes, An Introduction to the Theory of Statistics, 3rd ed. (New York: McGraw-Hill, 1974), p. 36.

[11]$\Pr\{U_{jt}\}$ is used here instead of $\Pr\{A_{jt}\}$. The U_{jt} and A_{jt} differ only by a constant that disappears when $\Pr\{A_{jt}\}$ is calculated (see above).

this blocking probability vary directly with each other, higher values of the $Pr\{U_{jt}|B\}$ are associated with both high traffic intensity and high blocking probabilities. Peak and off peak periods can be ascertained by analyzing the hourly values of the conditional probability $P\{U_{jt}|B\}$ directly.[12] Thus, the capacity-required criterion is satisfied by this condition probability and a cost-allocation scheme based on it would allocate costs according to cost causation.

If this conditional probability, $Pr\{U_{jt}|B\}$, applies to systemwide utilization of plant and equipment, the allocation of the cost of plant item j to service i rendered to customer class c would be straightforward. The cost of plant item j, C_j, would be allocated as follows:

$$\sum_{t} C_{ijtc} = C_j \sum_{t}^{n} U_{ijtc} \; Pr\{U_{jt}|B\}$$

where the left-hand side of this equation is the proportion of the cost of plant item j that is allocated to service i and customer class c. Unfortunately C_j is not necessarily unknown for specific plant items. For instance, if plant j is a trunk group between two central offices or an electronic switch in a central office, the local telephone company could not easily give the cost of these specific items of plant. Instead, accounting records are categorized according to type of switch or purpose of trunk group. This aggregated cost ($C=\sum C_j$) requires that the hourly utilization data for plant item j, U_{ijtc}, serve as the basis for the aggregation scheme to allocate the accounting costs.[13] Thus, the fifth step is needed to compute the probability-weighted usage factors, F_{ic}.

For each plant item j, there is an associated usage and probability. The product of these two items summed over all such plant items j yields the probability-weighted utilization of that plant by service i rendered to customer class c in hour t; that is

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[12]An analysis of variance of the hourly probabilities might be one such approach to ascertain the peak and off peak periods.

[13]The accounting costs to which these allocation factors will apply are the separations cost categories.

$$W_{itc} = \sum_j U_{ijtc} \Pr\{U_{jt}|B\}$$

The relative value of W_{jtc} varies with both $\Pr\{U_{jt}|B\}$ and U_{ijtc} reflecting peak and off-peak periods. Summing the W_{itc} over the hours of a typical day yields the daily probability-weighted utilization of service i by customer class c. The allocation factor for plant type j is given by

$$F_{ic} = \frac{\sum_t \sum_j U_{ijtc} \Pr\{U_{jt}|B\}}{\sum_i\sum_c\sum_t\sum_j U_{ijtc} \mathrm{Pt}\{U_{jt}|B\}} = \frac{\sum_t W_{itc}}{\sum_c\sum_i\sum_t W_{itc}}$$

such that

$$\sum_i\sum_c F_{ic} = 1$$

F_{ic} is the proportion of the cost of plant type j that is allocated to the i^{th} service used by customer class c.

This allocation factor assigns the costs of service according to a customer's class and service's contribution to a peak demand that causes capacity to be added. Recall that $\Pr\{U_{ijtc}|B\}$ are derived by using the Erlang B or C formulas in Bayes formula. The Erlang formulas are used by network planners to size specific parts of the network. Thus, the allocation factor satisfies the cost causation embodied in the criterion capacity required because it assigns costs to those services and customer classes that cause capacity to be added.

Applications of the Allocation of Costs with the Probability-Weighted Usage Factor to Three Cost Categories

In this section, three examples of how the probability-weighted usage factor can be applied to the allocation of telephone plant and expenses that are classified as network-related costs are presented. The allocation of exchange trunk plant that is jointly used for toll and exchange services is presented in the first subsection. The allocation of the cost of local dial switching equipment is presented in the second subsection. The issue of the nontraffic sensitivity of a portion of the local dial switching equipment is addressed once more in this subsection.[14] In the third subsection, the allocation of operators wages, account 624, is presented.

Exchange and Interexchange Outside Plant

The 240 series accounts,[15] in which the costs of outside plant are recorded, are categorized according to exchange and interexchange outside plant in the Bell Company's implementation of the separations procedures. The interexchange portion is broken down further into twenty categories of costs, while the exchange portion is split into fifteen categories. The interexchange plant is allocated between state toll and interstate toll by the separations procedures. Thus, the costs of interexchange trunk plant not assigned to the interstate jurisdiction by separations are directly assigned to state toll.[16] Exchange trunk plant, on the other hand, is allocated to all service categories. In this subsection, the probability-weighted usage factor is applied to cost category KCT-2, message exchange trunks that are used wholly or jointly for toll traffic and exchange message services.

Table 9-1 summaries the allocation of cost category KCT-2 by separations procedures, EDA, the J. W. Wilson method, and the Gabel method. Note that all three methods allocate these costs by relative

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[14]The nontraffic sensitivity of a portion of the local dial switch was previously discussed in chapter 7. The nontraffic sensitivity of the subscriber loop was discussed in chapter 5.

[15]The 240 series accounts refer to accounts 241, 242.1, 242.2, 242.3, 242.4, 243, and 244, which are combined for each cost category, a practice that corresponds to the BOC's input to BOCSIS, the program used by the Bell companies to perform separations.

[16]There are of course some direct assignments to interstate and state private line services.

number of exchange minutes of use as estimated for the entire demand cycle. This allocation factor has two problems from a cost-causation perspective. First, exchange trunk minutes of use fails to reflect the length of the trunk in miles. Thus, minute miles of use may be more appropriate as a basis for cost allocation. Second, minutes of use over the entire demand cycle fail to reflect potential shortages of trunking capacity during certain hours of the day. The probability-weighted usage factor will correct this problem.

TABLE 9-1

ALLOCATION OF MESSAGE EXCHANGE TRUNKS
BY SEPARATIONS AND THREE COST-OF-SERVICE METHODS

Method	Category KCT-2 Exchange Trunk Plant	
	Allocation Factor	Service Category
Separations	Relative number of exchange MOU that is interstate toll	IS[1]
EDA	Relative number of exchange MOU	IS, S,[2] E,[3] Offl[4]
J. W. Wilson	Relative number of exchange MOU with residual going to exchange	E, S, IS
Gabel	Relative MOU	E, ST

[1]IS stands for interstate toll services.
[2]S stands for intrastate toll services.
[3]E stands for exchange services.
[4]Offl stands for use by Bell system employees.
Source: Supra, footnotes 1, 3, and 4 from chapter 6 and NARUC-FCC <u>Separations Manual</u>

Whether exchange trunk minutes of use should be weighted by the length of the trunk in miles is largely a question of the net benefit to telephone customers resulting from the additional measuring effort. In other words, the benefit[17] accruing to the telephone subscribers from the improvement in cost allocation must outweigh the additional costs of measuring miles of exchange trunking along each route. This is an empirical question and is capable of being estimated. The implicit assumption in leaving exchange trunk minutes of use unweighted is that exchange trunking is roughly the same length throughout exchange service areas.

If this is the case, little resolution in the cost allocation would result from measuring the length of the trunk. Minutes of use of exchange trunking is provisionally adopted as an appropriate basis of a cost allocation, but with the suggestion that minute miles should be investigated as the basis for the probability-weighted usage factor.

The probability-weighted usage factor is asserted to reflect forces leading to the potential provision of additional capacity when congestion at a point in the network reaches some upper bound. Minutes of use of the exchange trunk converted to Erlangs are an appropriate measure of costs to be used in the Erlang B formula. The remainder of this subsection delineates the steps necessary to calculate the probability-weighted usage factor.

The first step in developing the probability-weighted usage factor for exchange trunk plant is to develop a hourly usage profile for a typical day for trunk group j. Usage of this plant jointly used by interstate toll, state toll, and exchange services (denoted by the index i) should be measured for each of these services on an hourly basis (denoted by the index t). Denote this usage by MOU_{ijt}.

These minutes of use are used directly to calculate the probability of a minute of use of exchange trunk group j in hour t. This probability is given by

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[17]As measured by an improvement in social welfare shown by the sum of producers' and consumers' surplus.

$$\Pr\{MOU_{jt}\} = \frac{\sum_i MOU_{ijt}}{\sum_t \sum_i MOU_{ijt}}$$

where MOU_{jt} is the aggregate minutes of use of all services on trunk group j in hour t. All other terms are as defined previously. This probability, along with the usage profile for each of the exchange trunk groups in the sample, are the first two pieces of information needed to calculate the probability-weighted usage factor.

Before hourly blocking probabilities for trunk group j can be computed, two preliminary steps must be completed. First, the hourly rate of utilization for trunk group j must be converted to Erlangs. Second, the number of equivalent circuits for trunk group j must be obtained. Exchange trunk minutes of use MOU_{jt} are converted to Erlangs by dividing by the 60 minutes in an hour. Denote this by A_{jt}, which is given by

$$A_{jt} = \frac{MOU_{jt}}{60}$$

This measure of traffic intensity in hour t is used directly in the Erlang B formula. The number of equivalent circuits for trunk group j is a measure of capacity along that trunk group in that it measures the number of servers on trunk group j. Denote this by N_j. The blocking probability for hour t on exchange trunk group j given the usage in hour t is

$$\Pr\{B|MOU_{jt}\} = \frac{A_{jt}^{N_j}/N_j!}{\sum_{k=o}^{N_j} \left(A_{jt}^{k}/K!\right)}$$

This blocking probability for trunk group j in hour t is combined with the probability of an hourly demand occuring on trunk group j; that is, $Pr\{MOU_{jt}\}$. This calculation yields

$$Pr\{MOU_{jt}|B\} = \frac{Pr\{B|MOU_{jt}\}\ Pr\{MOU_{jt}\}}{\sum_{t} Pr\{B|MOU_{jt}\}\ Pr\{MOU_{jt}\}}$$

This conditional probability is interpreted as the probability that a blocked call on exchange trunk group j occurs to usage in hour t. As pointed out in the previous section, this conditional probability has the property that

$$\sum_{t} Pr\{MOU_{jt}|B\} = 1$$

The probability-weighted usage factor can now be constructed for cost category KCT-2.

The probability-weighted minutes of use for service i on trunk group j in hour t is

$$Pr\{MOU_{jt}|B\}\ MOU_{ijt}$$

where the i services on trunk group j are interstate toll, state toll, and exchange services. Aggregating these probability-weighted usages over all trunk groups (summing over j) in cost category KCT-2 and over all hours of the day (summing over t) yields the total probability-weighted exchange minutes of use associated with service i, W_i

$$W_i = \sum_{t} \sum_{j} Pr\{MOU_{jt}|B\}\ MOU_{ijt}$$

Using this probability-weighted usage, the allocation factor for exchange trunk cost category KCT-2 can be calculated.

If interstate usage is excluded, the probability-weighted usage factor is applied only to the costs not allocated to the federal jurisdiction by separations. In this case the allocation factor can be computed as

$$F_i = \frac{W_i}{W_s + W_e}$$

where W_s is the probability-weighted state toll usage, W_e is the probability-weighted exchange usage, and i is an index of state toll (s) or exchange (e) usages. If only the probability-weighted usage factors (F_i) are available where i includes interstate toll services, the factors applicable to the state jurisdictional cost are

$$F_i' = \frac{F_i}{F_s + F_e}$$

where F_s is the allocation factor for state toll, F_e is the factor for exchange service, and the index i is for state toll (s) and exchange services (e). This probability-weighted usage factor, F_i, is used to allocate the residual costs in category KCT-2 after separations has allocated a portion of these costs to the federal jurisdiction. The allocation factor F_i determines the split of these remaining costs between state toll and exchange services.

Local Dial Switching Equipment

In this subsection, the allocation of the costs of local dial switching equipment is presented. The application of the probability-weighted usage factor to these costs is complicated because there are two physical limits on the local dial switch and both relate to different usage measures. The first limit is related to the amount of traffic that the switching matrix can carry.[18] In this case, the Erlang B formula is used to determine the appropriate capacity. The other limit relates to the number of calls simultaneously attempted at a switching location. The Erlang C formula is used to determine, for instance, the number of registers necessary to meet the quality of service criterion. The investment in the local dial switch is contained in separations cost category 6, the allocation of which, by separations procedures, EDA, the J. W. Wilson method, and the Gabel method, is summarized in table 9-2. All of these methods apply a nontraffic sensitive factor to the local dial switching equipment investment to divide each of the cost categories into a traffic sensitive and nontraffic sensitive portion. The traffic sensitive portion is allocated by weighted dial equipment minutes of use. These allocation practices ignore the planning considerations inherent in the probability-weighted usage factor. However, several issues are raised by existing practices. First, is it appropriate to partition the costs of the local dial switch into traffic sensitive and nontraffic sensitive portion, and, if it is appropriate, is the nontraffic sensitive factor an appropriate way of so partitioning them? Second, if dial equipment minutes of use is the proper measure of usage and the Erlang B formula depicts cost-causative phenomena, is a weighting for toll use appropriate and, if so, what is the weight? This discussion of existing practices, however, assumes that the question of which Erlang formula and usage measure is appropriate has been resolved.

Upon the initiation of a telephone call, certain equipment on the local dial switch is tied up while the caller is connected to the called party and then, once the call is connected, the equipment is released and made available to serve other customers. The determination of the capacity of this equipment is dependent on the

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[18]This problem is complicated by newer digital switches (4-ESS) that are essentially nonblocking. In other words, the cost of the matrix is determined by the number of lines or ports, which is only indirectly related to the volume of traffic.

THE ALLOCATION OF LOCAL DIAL SWITCHING EQUIPMENT BY SEPARATIONS AND THREE COST-OF-SERVICE METHODS

(1)	(2) Separations	(3) EDA		(4) J.W. Wilson		(5) Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Category 6 includes all local dial switching equipment not included in other categories. Each sub-category is divided between nontraffic sensitive and traffic sensitive by the NTS Factor for each type of equipment.							
Category 6A - Panel - One or more central office units group.	Nontraffic Sensitive equipment-subscriber plant factor		Nontraffic Sensitive	Nontraffic Sensitive		Nontraffic Sensitive	
		Other	Direct Assignment (DR)				
		SR	Direct Assignment of Res. TT inv. (Spec. Study #9).	E,ST,IST Centrex	Availability Allocator	ST,E	Subscriber Plant Factor
Category 6B1 - No. 1 Cross-bar - One or more central office units served by the same common originating market group.		SB	Direct Assignment of Bus. TT inv. (Spec. Study #9). Direct Assignment of CTX Fixed BC (Spec. Study #6). Distributive Assignment to VB based on theoretical qty. of CTX-CO intercom lines.				
Category 6B2 - No. 5 Cross-bar - One or more central office units served by the same marker group.		ST,IST,AL	CO access line quantities.				
Category 6C1 - Step-by-Step - (0-5,000 working lines) - One or more central office units served by the same marker group.		Offl.	Offl. portion of AL based on Offl. portion of total subscriber lines less WATS, TWX, CTX,-CO lines and PBX-CTX-CU trunks. Offl. portion of CTX-CO based on Offl. portion of totl. CTX-CO lines & PBX/CTX-CU trunks.				
Category 6C2 - Step-by-Step (Over 5,000 working lines) - One or more central office units having a common distributing frame.	Traffic Sensitive - weighted DFM	Other	Traffic Sensitive Direct Assignment of Res.	Traffic Sensitive		Nontraffic Sensitive	
		SB	Direct Assignments of Res.	E,ST	Peak Adjusted	ST, E	Dial Equipment
			TT & CCF inv. (Spec. Studies #9 & 10)	IST Centrex	Message, Minute Miles	V	Minute of Use
Category 6E - Electronic - One or more central office units served by the same central control.		SB	Direct Assignments of Bus. TT. & CCF inv. (Spec. Studies #9 & 10). Direct Assignments of CTS Fixed BC (Spec. Study #6). CTX-CO usage inv. assigned based on DEMs.				
		ST,IST	Based on Weighted DEMs.				
		E	Based on DEMs.				

number of simultaneously originating calls and the average time necessary to complete the connection of the call once dialed. Thus, for instance, in determining the number of registers on a local dial switch that are necessary to meet quality of service criteria, the average number of originating calls multiplied by the average dialing time per calls (weighted for number of digits, toll or local) is stated in terms of Erlangs and used in the Erlang C formula.[19] This is the estimate of how many of the calls will be simultaneous. A shortage of registers relative to the number of simultaneously originating calls can lead to inordinate delay. In such circumstances, an increase in the capacity of registers and similar equipment used only momentarily in completing the connection may be necessary. Therefore, the duration of the call does not influence the size of this capacity.

Once the call is connected, only the path through the switching matrix and associated equipment is tied up for the duration of the call. The Erlang B formula and average holding time of each call measured in Erlangs is used to determine the size of the switching matrix that is necessary to meet quality-of-service criteria. The frequency of calls is also important for correctly sizing this capacity. Longer holding times as well as more frequent calls on a switch act to utilize it more fully. The average number of arrivals per average holding times capture this phenomenon in the Erlang B formula.

It would appear that the arrival rate of calls to the switching matrix is the output of the queuing system that characterizes the registers. It might best be characterized as a tandem queue with either function being the bottleneck. In fact, frequency of calls at a given central office as compared to their duration will vary considerably from one time period (possibly an hour) to the next. In this case it would be difficult to capture cost causation in a meaningful way.

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[19] J. Gordon Pearce, Telecommunications Switching, (New York: Plenum Press, 1981).

A solution might be to further segregate category 6 costs for each subcategory, 6A through 6E, according to equipment used for the duration of the call and that equipment used only momentarily. The equipment used only momentarily would be allocated by the probability-weighted number of attempts (originating and terminating calls or incoming or outgoing calls) for each hour using the Erlang C formula and the relative number of attempts. The equipment used for the entire duration of the call would be allocated by the probability-weighted usage for each hour, the Erlang B formula, and the relative usage of the matrix. This approach, while optimal, does require that new cost categories be developed for this category.[20] Cost allocation procedures for the local dial switching should move in this direction. In lieu of creating new cost categories, however, a second best solution would be to accommodate the allocation of these costs within the existing set of cost categories for the local dial switch.

The practice of apportioning the cost of local dial switching equipment into traffic sensitive and nontraffic sensitive costs was proposed in the Ozark Plan that was implemented by the FCC on January 1, 1971.[21] The nontraffic sensitive portion is determined by applying a nontraffic sensitive factor to the aggregate booked cost of local dial switching equipment. The costs of the line-link network termination equipment constitute a major portion of the nontraffic sensitive costs. As previously noted in chapter 7, the costs of this equipment are a function of the line-link concentration ratio, the number of lines, and the originating and terminating CCS per line. The costs of the line-link network termination equipment are not included in the calculation of incremental costs in the LIUC model. Instead

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[20]Alternatively, switches with shorter than average holding times (or holding times "much" shorter than average) might be assumed to be "attempt limited," and allocated using the Erlang C formula, while switches with longer than average holding times might be allocated using the Erlang B formula. Such a rule could, with some adjustments, be made to give reasonable results in most instances, but the rule is inherently arbitrary, so some errors in application are inevitable.

[21]Richard Gabel "Development of Separations Principles in Telephone Industry," Draft of revision for the Office of Telecommunications Policy, (August 25, 1975).

the costs of this equipment are considered a function of the number of lines terminating at the switch. It follows that since the subscriber loop is considered to be nontraffic sensitive the costs of this equipment are likewise nontraffic sensitive.

As also previously noted in chapter 7 it is not clear that the line-link network termination equipment is insensitive to traffic since the planning model does consider originating and terminating CCS in sizing this capacity. It was concluded in that discussion that the investment in the line-link network should be included in the incremental cost of switching. The question raised now is whether the partitioning of the costs of the local dial switching equipment into a nontraffic sensitive portion is appropriate.

The February 1971 Separations Manual defines nontraffic sensitive costs as "the cost of those items of equipment used jointly for both exchange and toll services, the quantities of which are determined as a function of the number of subscriber lines terminated and which in no way are a function of the busy hour or total volumes of attempts, calls, or messages offered to or switched by the office, together with a share of common equipment items..." (Emphasis added.)[22] The telling phrase in this definition is the "which in no way are a function of the busy hour or total volumes"[23] of various usage measures. This assertion essentially ignores the effect congestion has of blocking calls incoming to the office from either the trunk-side connection or switching within the central office. The functional relationship between these costs and the coincident demands for the switching paths is either direct or indirect.

The question of whether demand for switching capacity is direct or indirect is a function of whether the capacity is a function of the number of lines or traffic on the customer lines. This relates to the distinction made earlier between network costs and customer-related

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[22]NARUC-FCC Cooperative Committee on Communications, Separations Manual, Washington, D.C.: NARUC, February 1971, par. 24.82, pp. 34 and 35.

[23]Ibid., par. 24.82, p. 35.

costs. The decisions about the capacity underlying network costs are made by the telephone company planning engineers. With customer-related costs, the capacity decision regarding the number of lines is made by the subscribers; the telephone company simply responds to their demands. In both cases, the decision maker reacts to the experienced or perceived congestion on the relevant part of this capacity. Thus, if the functional relationship is direct, congestion on what is labeled as the "nontraffic sensitive" portions of the local dial switch directly leads the telephone company to increased capacity to switch calls that previously would have been blocked. If indirect subscribers who react to the congestion install additional loops, this in turn leads to additional investment in this portion of the switch, as well as the traffic sensitive portion.

This question of the direct or indirect effect of congestion is an empirical one, although it is probably not easily answered. However, the classification of the costs as "in no way sensitive" to the busy-hour or total volume of usage seems difficult to justify. Furthermore, the authors are totally unaware of any studies supporting the claim that these costs are indeed nontraffic sensitive. Thus, the partitioning of the local dial switch into traffic sensitive and nontraffic sensitive portions is not retained for the full costing method outlined in this chapter.

Weighted local dial equipment minutes of use as the activity measure appropriate to the allocated traffic sensitive portion of the cost of local dial switching equipment was instituted in the Ozark Plan. The weight was designed to reflect the differences in average costs per minute of toll use as compared to the average cost per exchange minutes of use.[24] The weight for purposes of separations has a value of 1.5 and this value is calculated as a nationwide average for all types of local dial switching equipment. In 1970, the range for the ratio of average costs was from 1.3 to 2.5. The 1.3 was for central offices where less than half of the office traffic was internal

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[24]Richard Gabel "Development of Separations Principles in the Telephone Industry" draft revision, 1976, chap. 6, p. 33.

and with more than five thousand ESS or No. 5 crossbar lines. The 2.3 was for step-by-step offices with fewer than five hundred lines.[25] The value of 1.5 is calculated as a weighted average of such values for each company in each area. The weight on the ratios is the relative amount of investment in local dial switching equipment at each office.

The appropriateness of using 1.5 as the weight for dial equipment minutes of use is an empirical question. The procedures for determining the ratio of average costs for toll and exchange in 1970 produced substantial variation in value of the ratio. This ratio is dependent upon both the relative amounts of each switching technology used in offices in a service area and the number of lines connected to the office. Given that it is 14 years since the Ozark Plan was implemented, the value of 1.5 is an historical artifact that may no longer reflect the mix of switching technologies or service area size and density. Furthermore, since it is a nationwide average, the weight of 1.5 would fail to reflect legitimate regional differences in costs of service. This last point is a particular problem for cost studies of a telephone company rendering service within a jurisdictional service area within a state.

For purposes of the method presented here, it is proposed that new weights be developed for each type of switching equipment in a telephone company's jurisdictional service area. The ratio of the average cost of toll service to the average cost of exchange service for each type of switch equipment (Category 6A through 6E) at each central office would be a weight for dial equipment minutes of use at the respective office. Let DEM_{ijtl} be the dial equipment minutes of use by service i in hour t on type equipment j at location l. Let R_{ijl} be the ratio of the average toll to exchange costs for equipment type j at location l for service i. Weighted dial equipment minutes of use by service i in hour t on equipment j at location l is given by

$$R_{ijl}\ DEM_{ijtl}$$

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[25]Ibid., chap. 6, p. 33.

where R_{ijl} = 1 when i denotes exchange service; otherwise, it is the ratio of toll to exchange costs. This weighted usage is used in developing the probability-weighted usage factor. It differs from the weighted dial equipment minute of use currently used in separation in two ways. First, this weighted usage better reflects regional differences in technologies used by telephone companies and in service area size and density: second, it reflects the changes in the relative mix of switching technologies.

The probability-weighted usage factor is developed by using unweighted dial equipment minutes of use in the Erlang B formula; that is, DEM_{ijtl} is used. First, this usage is summed over all services (i) to get the hourly usage on equipment type j at location l. In the second step, the probability of a given hourly demand occurring in hour t on equipment type j at location l is computed. It is given by

$$Pr\{DEM_{jtl}\} = \frac{DEM_{jtl}}{\sum_{t} DEM_{jtl}}$$

where

$$DEMjtl = \sum_{i} DEM_{ijtl}$$

This probability is used directly in Bayes' formula to calculate the probabilities to be used as weights, as shown below.

In the third step, the Erlang B formula (for blocked calls that are lost) is used to calculate hourly blocking probabilities for local dial switching equipment type j at location l. The hourly traffic volume, DEM_{jtl}, is converted to Erlangs by the following operation

$$A_{jtl} = \frac{DEM_{jtl}}{60}$$

where A_{jtl} is the traffic volume in Erlangs that is handled by local dial switching equipment type j at location l in hour t.

The number of paths through the switching matrix of local dial switching equipment type j at location l is denoted by N_{jl}. The blocking probability for this local dial switch in hour t is given by

$$Pr\{B|DEM_{jtl}\} = \frac{A_{jtl}^{N_{jl}} / N_{jl}!}{\sum_{k=1}^{N_{jl}} (A_{jtl}^{K}/K!)}$$

This hourly blocking probability for local dial switching equipment type j at loction l is combined in Bayes formula with its associated probability of an hourly demand occurring on this switch. The calculation yields

$$Pr\{DEM_{jtl}|B\} = \frac{Pr\{B|DEM_{jtl}\}\ Pr\{DEM_{jtl}\}}{\sum_{t} Pr\{B|DEM_{jtl}\}\ Pr\{DEM_{jtl}\}}$$

This conditional probability is interpreted as the probability that a blocked call on the local dial switch of type j at location l occurs to usage in hour t. Again this probability has the property that

$$\sum_{t} Pr\{DEM_{jtl}|B\} = 1$$

The probability-weighted usage factor for local dial switching equipment can now be developed.

Recall that the hourly dial equipment minutes of use for service i on local dial switching equipment type j at location l is already weighted to reflect the relative cost of servicing toll versus exchange. This is given by $R_{ijl}DEM_{ijtl}$, where $R_{ijl} = 1$ when i denotes exchange service. The probability-weighted minutes of use for service i on local dial switching equipment type j at location l in hour t is given by

$$Pr\{DEM_{jtl}|B\}\ R_{ijl}DEM_{ijtl}$$

Aggregating these probability-weighted usages over all locations l (summing over l) and hours t (summing over t) yields the total probability-weighted dial equipment minutes of use by service i of local dial switching equipment type j; that is

$$W_{ij} = \sum_{t} \sum_{l} Pr\{DEM_{jtl}|B\}\ R_{ijl}DEM_{ijtl}$$

where i is exchange, intrastate toll, and interstate toll service and j is cost category 6A, 6B1, 6B2, 6C1, 6C2, and 6E. Using this probability-weighted usage, the allocation factor for local dial switching equipment type j can be calculated.

If separations continue to be done by the current methods, interstate usage is excluded. In this case, the probability-weighted usage factor is applied only to those costs left to the state jurisdiction after separations is performed. In this case the allocation factor, F_{ij}, is computed as

$$F_{ij} = \frac{W_{ij}}{W_{sj} + W_{ej}}$$

where W_{sj} is the probability-weighted usage for state toll service and W_{ej} is the probability-weighted usage for exchange service. This probability-weighted usage factor, F_{ij}, is used to allocate the residual cost in category 6 for each of the j subcategories after separations has allocated a portion of these costs to the federal jurisdiction. The allocation factor, F_{ij}, determines the split of these costs remaining in the jth subcategory of category 6 costs between state toll and exchange services.

Account 624 - Operators' Wages

The probability-weighted usage factor is appropriate for the allocation of account 624, operators' wages expenses. Operations planners use the Erlang C formula to determine the number of operators needed to provide adequate operator-assisted services at various times of the day, week, and year.[26] This procedure is called "forcing" by the Bell operating companies, because it is the procedure used for determining the size of the work force. The primary criterion for service quality used in determining an adequate operator work force is the probability of experiencing a delay of more than T seconds. This short-run planning criterion allows the wage expense for operator services to be attributed to traffic and services most likely to use these services during the hours of a typical day. A probability-weighted usage factor for these expenses is developed in this subsection.

The current treatment of operator expenses by separations is presented in table 9-3. The cost categories in this table are retained for the costing method presented in this subsection. The expenses recovered in account 624 are broken down into the five major cost categories: private branch exchange, teletypewriter exchange, network administration, number service record work, and all other. Private branch exchange is further divided into subcategories for private line and all other PBX operator services. Number service record work is divided into three subcategories for directory assistance, intercept, and credit card calling services. The allocation of the private line subcategory for PBX and the credit card calling service for number record service is moot since separations is not redone by the cost allocation method presented here. For both private line PBX and credit card calling services, the residual costs left to the state

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[26]A similar procedure is used to determine the capacity of operator facilities for long-term planning purposes. This will be useful for allocating investment in operator position switchboards recorded in account 221.

TABLE 9-3

THE ALLOCATION OF ACCOUNT 624, OPERATORS' WAGES BY SEPARATIONS

Cost Category		Allocation Factor
1. Private Branch Exchange		
Private Line	-	Number of interstate and state private lines served
All Other	-	Relative number of subscriber line MOU
2. Teletypewriter Exchange	-	Relative number of state and interstate TWX traffic units or weighted standard work seconds
3. Network Administration	-	On the basis of the apportionment of COE in Categories 1 through 7
4. Number Service Record Work		
Directory Assistance	-	Weighted standard work seconds generated by the directory assistance offices
Intercept	-	Weighted standard work seconds generated by the intercept offices
Credit Card Calling Service	-	Relative number of credit card messages
5. All Other	-	Relative number of weighted standard work seconds at each exchange or group of exchanges

Source: NARUC-FCC Separations Manual

jurisdiction are simply direct assignments to state private line and state toll services, respectively. The allocation procedure used in separations for network administration costs is extended to the intrastate jurisdiction by the allocation method proposed in this subsection. Thus, the costs of the network administration are allocated according to the allocation of cost categories one through seven for central office equipment. The probability-weighted usage factor is applied to the cost remaining in account 624.

The procedures used to allocate the remaining cost categories of account 624 are similar to one another. The treatment of each category differs in that usage data used in allocating the cost is specific to the particular service provided. Thus, for PBX-all other, the usage data needed to develop the probability-weighted usage factor are the minutes of use of operator services for PBX by time of day. Similarly, the usage data for directory assistance services are the minutes of use by time of day for work at directory assistance offices. Usage data for intercept and teletypewriter exchange services are defined similarly. Due to this commonality of treatment for this expense account, the allocation of only one of the five cost categories is covered in this subsection.

Intercept services pertain to the routing of a call to an operator or to a recorder-announcer answering device when it is placed to a disconnected, reused, or nonexisting telephone number. It is the operator's duty to give information to customers and operators regarding changed numbers, disconnected numbers, no such number, and so forth. The primary measurements for efficiency of an intercept office or any other operator service office are the speed with which the customer is answered and how rapidly the customer is served once he or she has been answered. The parameters of the service efficiency are, in part, the total number of operator positions available (manned or unmanned), the number of operator positions manned by an operator at a point in time, and the arrival rate of calls. The quality of service criterion is stated in terms of experiencing a delay of more than T seconds in receiving intercept services. Offered traffic to the intercept offices on an hourly basis, stated in terms of minutes of use, is the basis for the allocation of operators' wages for intercept services. This minutes of use for offered load is converted to Erlangs and used directly in the modified Erlang C formula. The probability-weighted usage factor is now developed for intercept services.

Most information needed to calculate the probability-weighted usage factor can be provided by the Force Administration Data System (FADS) that is used by the Bell operating companies. The delay in answering a call for or diverted to operator services, the actual work time per call, counts of calls, and total work volume usage as well as operator team size are provided by FADS.[27] For the remainder of this subsection, it is assumed that the information necessary to perform the calculation is derived or obtained from FADS.

The minutes of use of intercept services by service i at intercept office j in hour t is denoted by MOU_{ijt}. These hourly minutes of use are used to calculate probability of a minute of use of intercept office j occurring in hour t. It is given by

$$Pr\{MOU_{jt}\} = \frac{\sum_{i} MOU_{ijt}}{\sum_{t}\sum_{i} MOU_{ijt}}$$

where MOU_{jt} is the aggregate minutes of use of all services at intercept office j in hour t. This probability along with the usage profile for a typical day at intercept office j completes the first two steps.

Before hourly probabilities of experiencing a delay of more than T seconds at intercept office j can be computed, some preliminary steps must be completed. First, the Erlang C formula must be modified to calculate the probability of a delay of more than T seconds rather than the probability of a delay more than zero seconds. The modified Erlang C formula is given by

$$P\ \{D>T\} = C(n,a)e^{-(n-a)\mu t}$$

where C(n,a) is the Erlang C formula, μ is the number of calls per average holding time, and T is the quality of service criterion for delay in answering the call. Two terms in this modified Erlang C formula deserve further comment. The rate of calls, μ, is the average number of calls counted in any given hour. It is the mean rate of arrivals from the Poisson distributed that is assumed to characterize the probability distribution that describes the arrival process. The

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[27]Bell Laboratories, Engineering and Operations in the Bell System, p. 492.

quality of service criterion, T, is set by the Bell operating companies. As of 1977, the delay in receiving an answer by an operator was set at 2 to 6 seconds depending on the type of service and equipment.[28] By setting the value of T, the modified Erlang C[29] is solved to obtain the operator work force needed to meet the service standards in the short run and is also solved for the size of the switchboard needed at a particular office.[30] Thus, the value for T affects both the amount of investment in switchboard capacity and the level of operators' wage expenses. Regulators could set T or at least review the grade-of-service criteria used by telephone companies as one method of regulating investment and expenses.

Before hourly probabilities of delay for intercept office j can be computed, two preliminary steps must be completed. First, the hourly usage for intercept office j must be converted to Erlangs. Second, the size of the operator work force at intercept office j for each hour of a typical day must be obtained.

Minutes of use of intercept services at intercept office j in hour t are converted to Erlangs by dividing by the 60 minutes in an hour. Denote this usage A_{jt} which is given by

$$A_{jt} = \frac{MOU_{jt}}{60}$$

This measure of traffic intensity in hour t is used directly in the modified Erlang C formula. The number of operators on duty at intercept office j in hour t is the measure of the number of servers, N_{jt}, in the modified Erlang C formula. The probability of a delay greater than T seconds at intercept office j in hour t is given by

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[28]Known as the "objective speed of answer." Bell Laboratories, Engineering and Operations, p. 513.

[29]Further modifications are done to the Erlang C formula to account for other problems in meeting the assumptions of the model. Ibid., p. 513.

[30]This last observation indicates that the probability-weighted usage factor can be used to allocate the costs of these investments.

$$\Pr\{(Dj>T)|MOU_{jt}\} = \frac{\dfrac{A_{jt}^{N_{jt}} \; e^{-(N_{jt}-A_{jt})\mu T}}{(N_{jt}-1)!(N_{jt}-A_{jt})}}{\displaystyle\sum_{k=0}^{N_{jt}-1} \frac{A_{jt}^{k}}{k!} + \frac{A_{jt}^{N_{jt}}}{(N_{jt}-1)!(N_{jt}-A_{jt})}}$$

where D_j is the delay in answering a call at intercept office j and all other terms are defined as previously discussed.

This probability of a delay at office j is combined with the previously calculated probability of an hourly demand occurring at intercept office j, $\Pr\{MOU_{jt}\}$, in Bayes' formula to yield

$$Pf\{MOU_{jt}|D_j>T\} = \frac{\Pr\{D_j>T|MOU_{jt}\}\Pr\{MOU_{jt}\}}{\sum_t \Pr\{D_j>T|MOU_{jt}\}\Pr\{MOU_{jt}\}}$$

This conditional probability is interpreted as the probability that a delay greater than T seconds experienced at intercept office j occurs to intercept usage at that office in hour t. As noted previously, this conditional probability has the property that

$$\sum_t \Pr\{MOU_{jt}|D_j>T\} = 1$$

The probability-weighted usage factor can now be constructed for the operators' wage expense included in the intercept services subcategory.

The probability-weighted minutes of use for service i at intercept office j in hour t is given by

$$\Pr\{MOU_{jt}|D_j>T\}MOU_{ijt}$$

where the i services at intercept office j are interstate toll, state toll, and exchange services. Aggregating these probability-weighted usages over all intercept offices (summing over j) in the cost subcategory for intercept services and over all hours of the day (summing over t) yields the total probability-weighted minutes of use of intercept services by service i, W_i

$$W_i = \sum_t \sum_j Pr\{MOU_{jt} | D_j > T\} \, MOU_{ijt}$$

Using this probability-weighted usage, the allocation factor for the cost subcategory of operators' wage expenses for intercept services can be calculated.

Since the results separations is accepted as state jurisdictional costs, interstate usage is excluded from the calculation of the usage factor. The probability-weighted usage factor is applied only to those costs left to the state jurisdiction after separations is performed. The allocation factor is computed as

$$F_i = \frac{W_i}{W_s + W_e}$$

where W_s is the probability-weighted usage for state toll intercept services, W_e is the probability-weighted usage for intercept services arising from exchange usage, and i is an index of state toll (s) or exchange (e) usages. This probability-weighted usage factor, F_i is used to allocate the residual costs in the cost subcategory of account 624 for intercept services after a portion of these costs have been allocated to the federal jurisdiction by separations. The allocation factor, F_i, determines the split of these remaining costs between state toll and exchange services.

The number of paths through the switching matrix of local dial switching equipment type j at location l is denoted by N_{jl}. The blocking probability for this local dial switch in hour t is given by

$$\Pr\{B|DEM_{jtl}\} = \frac{A_{jtl}^{N_{jl}} / N_{jl}!}{\sum_{k=1}^{N_{jl}} (A_{jtl}^{K}/K!)}$$

This hourly blocking probability for local dial switching equipment type j at location l is combined in Bayes formula with its associated probability of an hourly demand occurring on this switch. The calculation yields

$$\Pr\{DEM_{jtl}|B\} = \frac{\Pr\{B|DEM_{jtl}\}\Pr\{DEM_{jtl}\}}{\sum_t \Pr\{B|DEM_{jtl}\}\Pr\{DEM_{jtl}\}}$$

This conditional probability is interpreted as the probability that a blocked call on the local dial switch of type j at location l occurs to usage in hour t. Again this probability has the property that

$$\sum_t \Pr\{DEM_{jtl}|B\} = 1$$

The probability-weighted usage factor for local dial switching equipment can not be developed.

Recall that the hourly dial equipment minutes of use for service i on local dial switching equipment type j at location l is already weighted to reflect the relative cost of servicing toll versus exchange. This is geven by $R_{ijl}DEM_{ijtl}$, where $R_{ijl} = 1$ when i denotes exchange service. The probability-weighted minutes of use for service i on local dial switching equipment type j at location l in hour t is given by

$$\Pr\{DEM_{jtl}|B\}\ R_{ijl}DEM_{ijtl}$$

Aggregating these probability-weighted usages over all locations l (summing over l) and hours t (summing over t) yields the total probability-weighted dial equipment minutes of use by service i of local dial switching equipment type j; that is

$$W_{ij} = \sum_t \sum_l \Pr\{DEM_{jtl} | B\} R_{ijl} DEM_{ijtl}$$

where i is exchange, intrastate toll, and interstate toll service and j is cost category 6A, 6B1, 6B2, 6C1, 6C2, and 6E. Using this probability-weighted usage, the allocation factor for local dial switching equipment type j can be calculated.

If separations continue to be done by the current methods, interstate usage is excluded. In this case, the probability-weighted usage factor is applied only to those costs left to the state jurisdiction after separations is performed. In this case the allocation factor, F_{ij}, is computed as

$$F_{ij} = \frac{W_{ij}}{W_{sj} + W_{ej}}$$

where W_{sj} is the probability-weighted usage for state toll service and W_{ej} is the probability-weighted usage for exchange service. This probability-weighted usage factor, F_{ij}, is used to allocate the residual cost in category 6 for each of the j subcategories after separations has allocated a portion of these costs to the federal jurisdiction. The allocation factor, F_{ij}, determines the split of these costs remaining in the jth subcategory of category 6 costs between state toll and exchange services.

The Allocation of the Subscriber Loop

In this section, a probability-weighted usage factor to allocate the costs of the subscribers loop is presented. The goal of the cost allocation for this plant is to reflect the underlying cost-causative forces that lead a subscriber to install additional loops between his premises and the central office. As discussed in chapter 7, these cost-causative forces relate to the congestion experienced on the subscriber loop, both internal and external. The impractical mechanism of the Vickery auction discussed in that chapter is not available in the real world, nor is it likely to be implemented in the future. In lieu of these auctions, an allocation scheme that improves existing cost allocation practices is proposed. Current pricing and cost allocation practices do not provide any conduct to signal to the subscriber about the extent of external congestion experienced on his or her loop. EDA, by allocating the entire cost of loops to the access service category, assumes that the loop is installed to provide the capability to place outgoing calls only. Subscriber line use (SLU) as a measure of traffic for loops is only a measure of outgoing usage. Consequently, allocations of loop costs using factors based on SLU reflect only outgoing usage. In both cases the contribution of incoming calls to congestion on a loop is ignored. When the costs allocated by these current cost allocation practices are translated into prices, the result is a lump-sum payment for the entire cost of the loop accompanied by terminology like "customer access line charge" and "basic subscription fee." By not accounting for the contribution of incoming calls to congestion, inefficient price signals are emitted to subscribers, leading them to make incorrect decisions about loop capacity and about their use of the loop.

The cost allocation for loop costs suggested in this section provides a basis for a more efficient set of prices. Two types of externalities have been identified for telephone services in this report. The first externality is associated with a customer's initial subscription to telephone service. This externality is the external benefit accruing to all telephone subscribers by having another subscriber line hooked up to the network. Their ability to receive calls from and place calls to this new subscriber is the benefit. In order to provide efficient price signals to potential subscribers and make them take this external benefit into consideration, theory indicated that the hook-up fee for this initial subscription should be set below the marginal cost of the loop and the remaining portion recovered through usage prices.

The second type of externality is an external cost associated with the congestion incoming callers experience on a subscriber's loops. This external cost, in theory, is the value of the waiting time people incur when placing calls to subscribers over their sometimes congested loops. As discussed in chapter 7, an efficient price for additional loops is below the marginal cost of the loop, with the balance collected through usage prices. Incoming calls can be used as a proxy for these external costs. In both cases, the presence of these externalities argues that the loop be priced below its marginal costs. Initial subscription is encouraged and the external benefits accrue to existing subscribers. Furthermore, the external congestion is something a potential subscriber would not necessarily consider in the absence of the price signal. Subscription to additional loop is facilitated because the customer with the sometimes congested loop has only to consider his or her own internal congestion. All other subscribers benefit when congestion is relieved by additional loops.

If a cost allocation scheme for the loop is to mimic these efficient prices, it must allocate the cost of the loop according to incoming and outgoing calls and account for the potential for blocked calls. The portion allocated to incoming calls provides a basis for pricing out this cost according to use on a time of day basis. The remaining portion is the access portion and provides the basis for a lump-sum subscription fee. Before turning to the development of the probability-weighted usage factor for the subscriber loop, the cost categorization procedures for loop costs need to be discussed.

The costs of loops are assigned to separations category 1.3 for outside plant or Division of Revenues (DR), category KCS, Exchange Subscriber Loops-Message Telephone Service including WATS access lines. Current procedures assign the costs in category KCS among message telephone service, interstate and intrastate private line nonbroadband services, and ENFIA Central Office Connecting Facilities (COCF), and by average cost per loop regardless of service carried on the loop or the customer's classification. Costs assigned to the private line and ENFIA COCF subcategories of KCS are obtained by multiplying the average loop cost by the loop count for those services. The residual costs for KCS are assigned to the message telephone services subcategory. Several questions can be raised about the cost categorization procedure used in the separations and the Divison of Revenues procedures.

An assumption embodied in this procedure is that the cost of a loop is the same no matter which type of service it provides, which type of customer, or the typical location of customer. Loop costs may vary considerably among private line, ENFIA COCF, and message telephone service categories and vary considerably within each subcategory. Within service subcategory loops providing message telephone service to a typical business customer may exhibit considerable variation in costs along several dimensions when compared to a typical residential customer--in particular, the length of the loop. Furthermore, since the message telephone service subcategory is the residual category, any cost variations not properly modelled for the private line or ENFIA COCF subcategories affect the costs assigned to the message telephone service. A study of loop costs and the identification of customer class by service and usage characteristics would resolve many questions regarding these categorization procedures. Particular research questions are:

1. Does an average loop cost for private line, ENFIA COCF, and message telephone services properly model the cost of providing loops for these services?

2. Do loop costs vary significantly among appropriately designated customer classes for the message telephone service subcategory?

3. What is the magnitude of error introduced by relegating the message telephone service category to the residual category?

Resolution of these research questions will go a long way toward rectifying any possible inequities in the existing procedures for allocating loop costs among service categories.

The allocation of loop costs proposed in this subsection maintains a customer class distinction throughout the exposition. Appropriately designed customer classes are identified primarily by usage characteristics. Most likely hours of congestion, total volume of use, relative volumes of incoming and outgoing usage, number of loops connecting the central office, and other usage or size characteristics are a few such characteristics that would define cost causation factors for a customer class. The customer class distinction is maintained for the allocation factors proposed in this section and it is assumed that separate cost subcategories exist for each customer class. These costs are assigned to these subcategories by loop counts and loop costs to each customer class and are allocated to each of the possible service categories.

The first step in developing the probability-weighted usage factor is to take a sample by customer class of incoming and outgoing calls by service and hour of the day on the subscriber's loops. This sample will allow a usage profile for a typical customer in a customer class to be developed for incoming and outgoing usage. The following six measures of subscriber line use should be sampled:

1. Outgoing intrastate interLATA toll
2. Incoming intrastate interLATA toll
3. Outgoing intrastate intraLATA toll
4. Incoming intrastate intraLATA toll
5. Outgoing exchange
6. Incoming exchange

The term "usage" as used in this context refers to outgoing attempts in terms of holding time for both successful and unsuccessful attempts and duration of calls for successfully completed calls. Incoming usage refers only to the duration of the call in terms of holding time for successfully connected calls. It is assumed that the number of incoming blocked calls lost cannot be counted with current technology. Of course, if it can be measured, this information should be incorporated into the measure of incoming usage developed by this sample. This usage information is incorporated into the allocation scheme in three ways as explained below.

Let $OSLU_{itc}$ denote subscriber line minutes of use attributable to a typical customer in customer class c using service i in hour t. Similarly, let $ISLU_{itc}$ denote incoming subscriber line minutes of use attributable to service i in hour t for a call to a typical customer in customer class c. The total usage relevant to the blocking that occurs during hour t on the subscriber loop of the typical customer in class c is given by

$$TSLU_{tc} = \sum_{i} (OSLU_{itc} + ISLU_{itc})$$

$TSLU_{tc}$ is the total use of a subscriber's loop that may lead to congestion in hour t and is the information necessary to develop the probability weights for hourly usage of service i by typical customer in class c.

The second step in constructing the probability-weighted usage factor is to calculate the probability of an hourly usage occurring on the loop of a typical customer in customer class c. It is given by

$$Pr\{TSLU_{tc}\} = \frac{TSLU_{tc}}{\sum_{t} TSLU_{tc}}$$

This probability is used in conjunction with a blocking probability to yield the probability weights.

Before progressing, the question of the appropriate queuing model for blocking on a subscriber loop must be raised. The Erlang B formula is used in the probability weights developed in this subsection. Recall that for this queuing model it is assumed that arrivals are Poisson distributed, holding times are (negative) exponentially distributed, and blocked calls leave the system without effect. The Erlang B formula approximates blocking probabilities for plant and equipment related to systemwide measures of usage rather than usage related to customer-specific plant like the loop. A relevant research question regarding the appropriate queuing model is whether the assumptions of the Erlang B model fit the circumstances of the subscriber loop. In particular, are holding times exponentially distributed and do blocked calls leave the system without effect? Such research questions, however, are merely raised in this report; answering them would go beyond its scope. For the purpose at hand, it is assumed that the Erlang B model provides an adequate approximation of the blocking probabilities on a subscriber loop for both single or multiple loop customers.

In order to calculate hourly blocking probabilities with the Erlang B formula, total hourly usage for each customer class must be converted to Erlangs. If total hourly usage is in terms of minutes of use, the equivalent measure in Erlangs is given by

$$A_{tc} = \frac{TSLU_{tc}}{60}$$

This measure of total usage is used directly in the Erlang B formula to calculate the hourly blocking probability for a subscriber loop used by a typical customer in class c. Given the number of loops serving a typical customer in class c, N_c, the blocking probability is calculated as

$$Pr\{B|TSLU_{tc}\} = \frac{A_{tc}^{N_c}/N_c!}{\sum_{k=o}^{N_c} (A^k/K!)}$$

This blocking probability is combined in Bayes formula with the probability of an hourly demand occurring in hour t to yield the probability weight. It is given by

$$\Pr\{TSLU_{tc}|B\} = \frac{\Pr\{B|TSLU_{tc}\}\ \Pr\{TSLU_{tc}\}}{\sum_t \Pr\{B|TSLU_{tc}\}\ \Pr\{TSLU_{tc}\}}$$

This conditional probability is the probability that the typical customer experiences congestion in hour t given that a call is blocked on the loop.

The probability-weighted usage for service i used by customer class c is computed for both incoming and outgoing calls. Both of these probability-weighted usages are used to develop an allocation factor that assigns an appropriate portion of the cost of the loop to incoming calls that occur during hours in which congestion is likely to be experienced. The probability weighted usages are given by

$$IW_{ic} = \Pr\{TSLU_{tc}|B\} ISLU_{itc}$$

for incoming usage of service i by a typical customer in class c, and

$$OW_{ic} = \sum_t \Pr\{TSLU_{tc}|B\}\ OSLU_{itc}$$

for outgoing usage of service i by a typical customer class c. The index i for services denotes interstate toll, intrastate interLATA toll, and intrastate interLATA local exchange service. These probability-weighted usages are used to develop allocation factors for the subscriber loop of a typical customer in class c.

The probability-weighted usage factor allocates the cost of a subscriber loop between incoming and outgoing usage by service i for each customer class. The allocation factor for incoming usage of service i is given by

$$IF_{ic} = \frac{\sum_t IW_{itc}}{\sum_i \sum_t (IW_{ic} + OW_{itc})}$$

where the index i does not include interstate toll usage, incoming or outgoing, because separations is not redone. The allocation factor for outgoing usage of service i is given by

$$OF_{ic} = \frac{\sum_{t} OW_{itc}}{\sum_{i}\sum_{t} (IW_{itc} + OW_{itc})}$$

where, again, the index i excludes interstate toll usage. These allocation factors for incoming and outgoing usage of service i by customer class c have the following property:

$$\sum_{i} (IF_{ic} + OF_{ic}) = 1 \quad \text{for all } c$$

Conclusion

In this chapter, a proposal for cost allocation factors based on blocking probabilities was outlined. Network costs are allocated in accordance to a peak-responsibility approach to full costing of telephone plant, equipment, and expenses. The costs of subscriber loops attributable to a customer class are divided between incoming and outgoing calls during periods of typical day in which congestion of the loop is likely. The incoming call portion of the loop is the usage-related investment, while the outgoing portion is the access portion of the loop. The probability-weighted usage factors proposed in this chapter can be applied to either accounting costs or marginal costs. It is not claimed that these allocation factors constitute a definitive method, but only an improvement in existing costing methods. In the near future, a manual incorporating these probability-weighted usage factors will be produced by The National Regulatory Research Institute.

APPENDIX A

THE ALLOCATION OF PLANT AND EQUIPMENT, INCOME, AND REVENUE ACCOUNTS BY SEPARATIONS EMBEDDED DIRECT ANALYSIS, THE J. W. WILSON METHOD, AND THE GABEL METHOD

This appendix contains several tables that delineate the allocation methods employed by separations procedures and three cost-of-service methods reviewed in this report. The tables contain abbreviations for the service categories. The key to the abbreviations is

E - Exchange services
ST - State toll services
IST - Interstate toll services
SPL - State private line services
ISPL - Interstate private line services
AL - Access line category
C - Common
Other - Yellow pages and leased facilities
V - Verticals
CENTREX - CENTREX services
SR - Supplemental services - residence
SB - Supplemental services - business
Offl - Official use by BOC
TER - Terminal equipment - residence
TESB - Terminal equipment - simple business
TECB - Terminal equipment - complex business
TEB - Terminal equipment - Business
IWSB - Inside wire - simple business
IWCB - Inside wire - complex business

TABLE A-1

THE ALLOCATION OF ACCOUNT 221, CATEGORY 1 - MANUAL TELEPHONE SWITCHING EQUIPMENT, BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Category 1A Separate long distance (LD) switchboards. This category includes outward, through, inward, and any other long distance positions in separate lines, and, at locations where outward long distance positions are in a separate line, any associated inward and through positions that are in the same line with local manual positions.	Traffic units at each switchboard.	E, ST, IST	Relative proportion of total traffic units.	E, ST, IST	Traffic Units	Not Mentioned	
		Offl.	Official proportion of total Orig. + Term. Busy Hour Calls.				
Category 1B Combined LD and Dial Service Assistance (DSA) switchboards. These include all such switchboards at which all of the originating long distance traffic is handled to completion, i.e., ticketed and timed, whether located in single office or multi-office exchanges. Also included are switchboards having segregated long distance and DSA positions in the same line.	Traffic units at each switchboard.	E, ST, IST	Relative proportion of total traffic units.	E, ST, IST	Traffic Units	E, ST	Traffic Units
		Offl.	Official proportion of total Orig. + Term. Busy Hour Calls.			Offl.	Ratio of Busy Hour CCS
Category 1D, 3CL Manual Type	Not mentioned	E, ST, IST	Relative proportion of total traffic units.	Same as EDA		Not Mentioned	
		Offl.	Official proportion of total Orig. + Term. Busy Hour Calls.				
Category 1F 100 A Traffic Service Positions (TSP) and related equipment (non-electronic only).	Traffic units at each traffic service position location.	E, ST, IST	Relative proportion of total traffic units.	Same as EDA		Not Mentioned	
		Offl.	Official proportion of total Orig. + Term. Busy Hour Calls.				

TABLE A-1--Continued

THE ALLOCATION OF ACCOUNT 221, CATEGORY 1 - MANUAL TELEPHONE SWITCHING EQUIPMENT, BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Category 1G Separate Centralized Rate and Route Board installations	Traffic units at each board.	E, ST, IST Offl.	Relative proportion of total traffic units. Official proportion of total Orig. + Term. Busy Hour Calls.	Same as EDA		E, ST Offl.	Traffic Units Ratio of Busy Hour CCS
Category 1H 100-B Traffic Service Positions (TSPS) and related equipment (electronic only)	Traffic units at each traffic service position location.	E, ST, IST Offl.	Relative proportion of total traffic units. Official proportion of total Orig. + Term. Busy Hour Calls.	E, ST, IST	Traffic Units	Not Mentioned	
Category 1K Switchboards at all attended pay stations handling LDI traffic to completion.	Included in "Message Telephone Station Equipment" and apportioned on the Subscriber Plant Factor.	Not mentioned		Not Mentioned		Not Mentioned	
Category 1N Service observing boards (Separate long distance service observing boards, joint exchange and long distance service observing boards and separate exchange service observing boards).	The long distance portion of each service observing switchboard is apportioned to interstate on the basis of the relative number of long distance minutes of use associated with long distance messages originating in the offices observed. (The long distance portion of joint exchange and long distance service observing boards is determined on the basis of the relative number of service observing work time values.)	E, ST, IST Offl.	Relative proportion of service observing work time values. Official portion of total Orig. + Term. Busy Hour Calls.	E, ST, IST	Traffic Units	E, ST, Offl.	Traffic Units Ratio of Busy Hour CCS

TABLE A-1--Continued

THE ALLOCATION OF ACCOUNT 221, CATEGORY 1 - MANUAL TELEPHONE SWITCHING EQUIPMENT, BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Category 1P Separate Directory Assistance boards or Automatic Call Director (ACD) Systems used for Directory Assistance service as well as the Directory Assistance portion of a joint auxiliary board or ACD System.	Traffic units at each Directory Assistance Board.	E, ST, IST	Relative proportion of total traffic units.	E, ST, IST	Traffic Units	E, ST	Traffic Units
		Offl.	Official portion of total Orig. + Term. Busy Hour Calls.			Offl.	Ratio of Busy Hour CCS
Category 1Q Separate Intercepting boards or Automatic Call Director Systems used for Intercept service as well as the Intercept portion of a joint auxiliary board or ACD System.	Subscriber Line Use Factor for the study area.	AL	Direct Assmt. of total CAT IQ investment (less official).	E, ST, IST	Traffic Units	E, ST	Traffic Units
		Offl.	Official portion of total Orig. + Term. Busy Hour Calls.			Offl.	Ratio of Busy Hour CCS
1P, 1Q and/or 1G Joint Use Swbds.	Included in above categories	AL	Direct Assignment (Intercept)	E, ST, IST	Weighted Traffic Units for Categories IP, IQ, & IG	Not Mentioned	
		E, ST, IST	Relative proportion of total traffic units (DA, Rate & Route)				
		Offl.	Official portion of total Orig. + Term. Busy Hour Calls				
Category 1X3 Segregated official Company PBX's	Included in "Message Telephone Station Equipment" and apportioned on the Subscriber Plant Factor.		Not mentioned				

TABLE A-2

THE ALLOCATION OF ACCOUNT 221, CATEGORY 2 - DIAL TANDEM SWITCHING EQUIPMENT, BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Category 2A Long haul dial tandem switching equipment.	Minutes of use at each location.	IST	Direct Assignment (DR)	Not Allocated		E, ST	Relative Minutes of Use
		E	Direct Assignment (Spec. Study #4)				
		ST	DR CAT total less direct assignments (residual)				
		Offl.	Official portion of total Orig. + Term. Busy Hour CCS.				
Category 2B Short haul dial tandem switching equipment.	Number of Tandem connections.	IST	Direct Assignment (DR)				
		E	Direct Assignment (Spec. Study #4)	Direct to Exchange		E, ST	Analysis of Traffic at each Location
		ST	DR CAT total less direct assignments (residual)				
		Offl.	Official portion of total Orig. + Term. Busy Hour CCS.				
Category 2C Common switching and control equipment used for message through switched exchange traffic and/or through switched plus terminal exchange traffic.	No Assignment to interstate.	E	Direct Assignment (DR)	E, IST	Same as EDA	Not Mentioned	
		Offl.	Official portion of total Orig. + Term. Busy Hour CCS.				
Category 2D Trunk relay equipment and other identifiable equipment other than that classified as Category 2C used wholly for through message exchange switching.	No Assignment to interstate.	E	Direct Assignment (DR) (Complement of Offl.)	E, IST	Same as EDA	Not Mentioned	
		Offl.	Official portion of total Orig. + Term. Busy Hour CCS.				
Category 2H through SW (HILO)	Not mentioned	E	Direct Assignment (DR)	Not Allocated		Not Mentioned	
		Offl.	Official portion of total Orig. + Term. Busy Hour CCS.				

TABLE A-3

THE ALLOCATION OF ACCOUNT 221, CATEGORY 3 - INTERTOLL DIAL SWITCHING EQUIPMENT, BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Category 3A No. 4 crossbar and/or electronic tandem type switching equipment used primarily for the trunk-to-trunk interconnection of long distance message circuits with each other. Such equipment may also interconnect long distance message circuits with local or tandem central	Message minutes of use	E	Direct Assigment (DR) (Spec. Study #4)	E, ST, IST	Same as EDA	E, ST	Relative Traffic Usage
		IST	Direct Assignment (DR)				
		ST	DR CAT total less direct assigments (residual)				
		Offl.	Official portion of total Orig. + Term. Busy Hour CCS.				
Category 3B1 Intertoll dial switching facilities that handle some interstate message traffic.	Message minutes of use.	Categories 3B1 and B2 treated as one category					Categories 3B1, 3B2, 3B3, & 3B4 are treated as one category
		E	Direct Assignment (Spec. Study #4)				
		IST	Direct Assignment (DR)				
		ST	DR CAT total less direct assignments (residual)			ST	Direct Assignment
Category 3B2 Intertoll dial switching facilities that handle only interstate message traffic or intrastate private line services.	No assignment to interstate	SPL	Direct Assignment from State Separations	E, ST, IST	Conversation Minutes		
		Offl.	Official portion of total Orig. + Term. Busy Hour CCS.				
Category 3B3 CAMA selector equipment in step-by-step offices.	Message minutes of use.	IST	Direct Assignment (DR)	E, ST, IST	Traffic Units		
		ST	DR CAT total less direct assignment to IST (residual)				
Category 3B4 Trunk terminating and access group controller equipment which handle interstate private line services.	Assigned directly to interstate consistent with the tariffs covering the switching function.	ISPL	Direct Assignment (DR)	ISPL	Direct Assignment		

TABLE A-3--Continued

THE ALLOCATION OF ACCOUNT 221, CATEGORY 3 - INTERTOLL DIAL SWITCHING EQUIPMENT, BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Category 3C Common switching and control equipment that is used to handle appreciable amounts through switched message-type traffic and/or through plus terminal switched private line traffic.							
Applicable to message services	Through-switched minutes of use.	IST, ISPL	Direct Assignment (DR)	IST, ISPL, T, SPL	Message through Conversation Minutes	ST, SPL	Relative Distribution of Traffic
Applicable to private line services.	Assigned directly to interstate consistent with the tariffs covering the switching function.	ST	DR CAT total less direct assignments (residual)				
		SPL	Direct Assignment (Special Study)			Offl.	Relative Busy Hour CCS
Category 3D Long Distance Message Telephone Concentrators.	Assignment on basis of trunks.	Not mentioned.		Not Mentioned		Not Mentioned	
Category 3E Long Distance message telephone rate quoting systems COE (RQS)	Assigned on the basis of interstate requests.	IST	Direct Assignment (DR)	ST, IST	Same as EDA	Not Mentioned	
		ST	DR CAT total less direct assignment to IST				
Category 3H, Intertoll TK Terminal (HILO)	Not mentioned	ST	3H, DR CAT Direct Assmt. 3H1, DR CAT TOT Less direct assignment to IST 3H2, DR CAT Direct assmt.	ST, IST	Same as EDA	Not mentioned	
		SPL	3H, DR CAT Direct 3H2, DR CAT Total Less Direct Assignment to ST 3H3, DR CAT Total Less Direct Assignment to ISPL				
		IST	3H, DR CAT Direct Assmt. 3H1, DR CAT Direct Assmt.				
		ISPL	3H, DR CAT Direct Assmt. 3H3, DR CAT Direct Assmt. 3H4, DR CAT Direct Assmt. 3H5, DR CAT Direct Assmt.				

TABLE A-3--Continued

THE ALLOCATION OF ACCOUNT 221, CATEGORY 3 - INTERTOLL DIAL SWITCHING EQUIPMENT, BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Category 3Z1 Applicable only at CCIs Signal Transfer Points - Includes equipment dedicated to the CCIS function, e.g., CCIS Terminal Group Frame, STP alarm and display, Signal Distributor, etc., and the portion of the Electronic Translator Equipment that is allocated to the CCIS function, e.g., the stored program contol, etc., of the ETS. The allocation of the ETS that is not allocated to the CCIS function is assigned Category 3A. The allocation between Categories 3A and 3Z1 is based on the relative minutes of use of the CCIS function to the total minutes of use of the ETS.	CCIS Minutes of Use		3Z1 and 3Z2 Treated as One Category	IST, ST	Categories BZ1 and BZ2 treated as one category	Not Mentioned	
		IST	Direct Assignment (DR)				
		ST	DR CAT total less direct assignment to IST (residual)				
Category 3Z2 Applicable only at CCIS user offices - Includes equipment at a user office required solely for CCIS purpose, e.g., co-outpulser link frame, outpulser link controller frame, CCIC terminal group frame, etc.	CCIS Minutes of use.		See Above		See Above	Not Mentioned	

TABLE A-4

THE ALLOCATION OF ACCOUNT 221, CATEGORY 4 - AUTOMATIC MESSAGE RECORDING EQUIPMENT, BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Category 4A Automatic message recording equipment used for the duration of a call that handles only interstate traffic.	Assigned directly to interstate.	IST	Direct Assignment (DR)	IST	Direct Assignment	Interstate not Allocated	
Category 4B General automatic message recording equipment, used only momentarily, which handles some interstate traffic.			Categories 4B1 and 4B2 are directly assigned to IST and ISPL for EDA.	Categories 4B1 and 4B2 are treated are as one category		SPL	Direct Assignment
Category 4B1 Applicable to message services.	Messages recorded at each location.	Other IST, ISPL E, ST, SPL	Direct Assignment (DR) Direct Assignment (DR) Quantity of messages automatically recorded	E, ST SPL, IST ISPL	Messages Automatically recorded	E, ST	Weighted Number of recorded messages Weights are are .5 for exchange and 1 for toll
Category 4B2 Applicable to private line services.	Assigned directly to interstate on a basis consistent with the tariffs covering the private line service.						
Category 4C Automatic message recording equipment handling no interstate traffic.	No assignment to interstate.		Total Inv. in DR CAT less ST assignment (residual) Direct Assignment - Special Study.	ST	Direct Assignment	Not Mentioned	

TABLE A-5

THE ALLOCATION OF ACCOUNT 221, CATEGORY 5 - OTHER TOLL DIAL SWITCHING EQUIPMENT, BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Category 5A Includes all toll dial switching equipment provided and used for operator or customer-dialed charge traffic except equipment included in Categories 2, 3, 4, 5B, 6 and 7.	Minutes of use at each location.	IST ST	Direct Assignment (DR) DR CAT total less direct assignment to IST (residual)	IST, ST	Same as EDA	Categories 5A and 5B are treated as one Category ST, SPL	Relative Minutes of use at each location
Category 5B General Foreign Area Translator equipment used in the completion of message and private line traffic originating at or switching through Step-by-Step and No. 5 Crossbar Offices. Those installations associated with tandem systems in DR Categories 2A and 2B (Dial Tandem Switching Equipment) and 7 (Special Service Switching Equipment) are excluded from this Category.		Categories 5B1 and 5B2 are treated as one category and the interstate portion of each is directly assigned to IST		IST, ST	Categories 5B1 and 5B2 are treated as a single category Same as EDA		
Category 5B1 Applicable to Message Service.	Relative number of messages telephone state and interstate numbering plan areas served.	IST ST	Direct Assignment (DR) DR CAT total less direct assignment to IST (residual)				
Category 5B2 Applicable to Private Line Services (Includes Foreign Area Translator equipment at any No. 5 Crossbar office (other than those included in Category 7) used to provide Selective Routing Arrangements to permit interconnection of CCSA network trunks and access lines with off network services).	Assigned directly consistent with tariff covering the CCSA system.						

TABLE A-6

THE ALLOCATION OF ACCOUNT 221, CATEGORY 6 - LOCAL DIAL SWITCHING EQUIPMENT, BY FOUR COST-OF-SERVICE METHODS

	Separations	EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Category 6 includes all local dial switching equipment not included in other categories. Each subcategory is divided between nontraffic sensitive and traffic sensitive by the NTS Factor for each type of equipment.							
Category 6A - Panel - One or more central office units group.	Non-traffic sensitive equipment-subsriber plant factor		Nontraffic Sensitive		Nontraffic Sensitive	Nontraffic Sensitive	
		Other	Direct Assignment (DR)				
		SR	Direct Assignment of Res. TT inv. (Spec. Study #9).	E,ST,IST Centrex	Demand Availability Allocator	ST,E	Subscriber Plant Factor
Category 6B1 - No. 1 Crossbar - One or more central office units served by the same common originating market group.		SB	Direct Assignment of Bus. TT inv. (Spec. Study #9). Direct Assignment of CTX Fixed BC (Spec. Study #6). Distributive Assignment to VB based on theoretical qty. of CTX-CO intercom lines.				
Category 6B2 - No. 5 Crossbar - One or more central office units served by the same marker group.		ST,IST,AL	CO access line quantities.				
Category 6C1 - Step-by-Step - (0-5,000 working lines) - One or more central office units served by the same marker group.		Offl.	Offl. portion of AL based on Offl. portion of tot. subscriber lines less WATS, TWX, CTX,-CO lines and PBX-CTX-CU trunks. Offl. portion of CTX-Co based on Offl. portion of totl. CTX-CO lines & PBX/CTX-CU trunks.				
Category 6C2 - Step-by-Step (Over 5000 working lines) - One or more central office units having a common distributing frame.	Traffic Sensitive - weighted DEM						
Category 6E - Electronic - One or more central office units served by the same central control.		Offl.	Offl. portion of E, ST and IST usage based on Offl. portion of MB O & T BH CCS. Offl. portion of total CTX-CO Lns. and PBX /CTX-CU Trks. in service.				

TABLE A-7

THE ALLOCATION OF ACCOUNT 221, CATEGORY 7 - SPECIAL SERVICES SWITCHING EQUIPMENT, BY FOUR COST-OF-SERVICE METHODS

	Separations	EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Category 7B1 Dial Switching Equipment used exclusively for interstate switched private line services, i.e., CCSA services.	Assigned directly to interstate consistent with the tariffs covering the switching function.	Categories 7B1 and 7B2 are treated as one category ISPL, SPL,	Direct Assignment (DR)	SPL, ST, IST, ISPL	Categories 7B1 and 7B2 are treated as one category Same as EDA	Interstate is not Allocated Other PL	Minutes of Use
Category 7B2 Switching systems used exclusively for private line services Note: Category 7B2 also includes switching systems that serve WATS access lines in addition to the above mentioned services and No. 5 crossbar switching systems which are owned jointly with Long Lines.	Minutes of use and/or assigned	Other, ST, IST	Distributed based on Minutes of use directly				
Category 7D Switchboards used exclusively for private line services.	Relative number of state and interstate private lines served at each location.	Not mentioned.		Not Mentioned		SPL	Directly Assigned
Category 7E Control units for an Electronic Switching System (ESS) located in Central offices, which are used to control switch units or other equipment of the same system housed at the customer's; premises, (e.g., No. 101 ESS control unit).	Subscriber Plant Factor.	SB	Direct Assignment (DR)	Other	Direct Assignment	V	Direct Assignment
Category 7F Four wire crossbar switching equipment as well as associated trunk relay equipment used for wideband message services.	Minutes of use at each location.	IST ST	Direct Assignment (DR) DR CAT total less direct assigment to IST	Same as EDA		ST	Direct Assignment
Category 7H, Transaction Network	Not mentioned	E	Direct Assignment (DR)	ame as EDA		Not Mentioned	

TABLE A-8

THE ALLOCATION OF ACCOUNT 221, CATEGORY 8 - CIRCUIT EQUIPMENT, BY FOUR COST-OF-SERVICE METHODS

	Separations	EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Category 8C Interexchange circuit equipment used to provide special communications services at certain missile sites. The circuit equipment included in this group comprises only that equipment associated with circuits between the missile control center and the individual missle locations that are (1) furnished to the Government under special contractual arrangements, i.e., no filed tariffs, and (2) do not interconnect with any other services terminating in the missile control center.	No assignment to interstate.	Other	Direct Assignment (DR)	Not Allocated Allocator not Mentioned		E, SPL	Consistent with treatment of corresponding revenues
Category 8D Location Case File interexchange circuit equipment, i.e., equipment included in Parts 1.2, 1.3 and 1.4	Book Cost of Location Case File interexchange circuit equipment used for Long Lines broadband private line service are assigned directly to Private Line Interstate. The remainder of Category 8D is apportioned between Message Interstate and Private Line Interstate using the factors described in Section DR 94.15.	IST ISPL	Direct Assignment (DR) Direct Assignment (DR)	IST, ISPL	Same as EDA	Interstate not Allocated	
Category 8EA1 Private Line Interstate Broadband Circuit Equipment	Assigned directly to Private Line Interstate		Categories 8EA1, 8EA2, and 8EB are treated as a single category for EDA.		Categories 8EA1, 8EA2, and 8EB are		Categories 8EA1, 8EA2, and 8EB are

TABLE A-8--Continued

THE ALLOCATION OF ACCOUNT 221, CATEGORY 8 - CIRCUIT EQUIPMENT, BY FOUR COST-OF-SERVICE METHODS

Categories	Separations Basis of Apportionment to Interstate	EDA Service Category(ies)	EDA Assignment Method	J. W. Wilson Service Category(ies)	J. W. Wilson Assignment Method	Gabel Service Category(ies)	Gabel Assignment Method
Category 8EA2 Private Line Interstate Boroadband Circuit Equipment - Non Dr. (Includes educational TV provided under OTC - FCC tariffs.	No assignment to interstate.	ISPL	Direct Assignment (DR)		treated as a single category		treated as a single category
		SPL	DR CAT total less direct assignment to ISPL.	ISPL, SPL	Same as EDA	SPL	Direct Assignment
Category 8EB Private Line Intrastate Broadband circuit equipment.	No assignment to interstate.						
Category 8FA Private Line Interstate circuit equipment for wideband interexchange services.	Assigned directly to Private Line Interstate.		Categories 8FA, 8FB, and 8FH are treated as a single category for EDA.		Categories 8FA, 8FB, and 8FH are treated as a single category		Categories 8FA, 8FB, and 8FH treated as a single category
Cateogry 8FB Private Line Intrastate circuit equipment for Wideband interexchange services.	No assignment to interstate	ST	Direct Assignment (DR)				
		IST	Direct Assignment (DR)	SPL, ISPL	Same as EDA	ST, SPL	Direct Assignment
		SPL	Direct Assignment (DR) plus Nonofficial portion of state DDS investment.				
Category 8FE Wideband message circuit equipment i.e., DATAPHONE message circuit equipment.	DATAPHONE Message Minute Miles	ISPL	Direct Assignment (DR) plus Nonofficial portion of interstate DDS investment.				
Category 8FH Wideband message circuit equipment, i.e., PICTUREPHONE* message circuit equipment.	PICTUREPHONE Message Minute Miles.	Offl.	Official portion of intra-state and interstate DDS Stations.				
Category 8G Interexchange circuit equipment not assigned to Categories 8C, 8D, 8E, 8F and 8K. This category is divided into basic and special circuit equipment.							
Basic Circuit Equipment is that equipment that performs functions necessary to operate channels suitable for voice transmission (telephone grade circuits)			Basic and Special Circuit Equipment are not treated Separately for EDA		Basic and Special Circuit Equipment are not treated Separately		Basic and Special Circuit Equipment are not treated Separately

TABLE A-8 --Continued

THE ALLOCATION OF ACCOUNT 221, CATEGORY 8 - CIRCUIT EQUIPMENT,
BY FOUR COST-OF-SERVICE METHODS

Categories	Separations Basis of Apportionment to Interstate	EDA Service Category(ies)	EDA Assignment Method	J. W. Wilson Service Category(ies)	J. W. Wilson Assignment Method	Gabel Service Category(ies)	Gabel Assignment Method
Special Service Circuit Equipment is that equipment peculiar to and used only for Teletypewriter grade Private line services.							
Classes of Circuits Interstate message	Assigned Directly to message interstate.	SPL	Residual service category Equiv. Ckt. Miles Assigned State Message.			Interstate not Allocated	
Intrastate Message	No assignment.	IST	Equiv. Ckt. Miles Assigned				
Jointly used message, i.e., message circuits which handle both inter-state and intrastate messages	Message-minute-miles		Interstate Message.	ST, SPL, IST, ISPL	Same as EDA	ST	Equivalent Circuit Miles
		Other	Equiv. Ckt. Miles Rented to Others.				
		ISPL	Tot. Interexchange inv. Assigned ISPL (DR)			SPL	Equivalent Circuit Miles
Private Line Tele-typewriter	"Private Line tele-typewriter" revenue producing equivalent telephone circuit miles.	Offl.	Official portion of total Orig. + Term. Busy Hour CCS.				
Other Private Line	"Other private line" revenue producing equivalent telephone circuit miles.						
Basic Circuit Equipment Con. Long Lines Order and Alarm	Apportioned between Message Interstate and Private Line Interstate using the factors described in Section DR94.15.	See Above			See Above		See Above
Rented (circuits rented to others)	No assignment.	See Above			See Above		See Above
Private Line Services other than wideband and broadband.							
Special Service Circuit Equipment used only for teletypewriter grade private line services.	Assigned on basis of analysis						

TABLE A-8--Continued

THE ALLOCATION OF ACCOUNT 221, CATEGORY 8 - CIRCUIT EQUIPMENT, BY FOUR COST-OF-SERVICE METHODS

Categories	Separations Basis of Apportionment to Interstate	EDA Service Category(ies)	EDA Assignment Method	J. W. Wilson Service Category(ies)	J. W. Wilson Assignment Method	Gabel Service Category(ies)	Gabel Assignment Method
Other Special Service Circuit Equipment used only for all other private line services, excluding private line wideband and broadband services.	Assigned on basis of analysis.						
Category 8J IX Radio End Links	Not Mentioned	SB Offl.	Direct Assignment (DR) Official minutes of use	Other	Direct Assignment	Not Mentioned	
Category 8KA1 Broadband circuit equipment used on local channels associated with private line interstate broadband services. Also includes similar circuit equipment on video pairs used for local channels on private line interstate wideband (Category 8FA)	Assigned directly to Private Line Interstate.	ISPL	Direct Assignment (DR)	ISPL	Direct Assignment	Interstate not Allocated	
Category 8KA2 Broadband circuit equipment used on local channels associated with private line interstate broadband services - Non DR. (Includes educational TV provided under OTC-FCC Tariffs).	No assignment to interstate.	Not mentioned.		Not Mentioned		Not Mentioned	
Category 8KB Broadband circuit equipment used on local channels associated with private line intrastate broadband services. Also includes similar circuit equipment on video pairs used for local channels on private line intrastate wideband services (Category 8FB).	No assignment to interstate.	SPL	Direct Assignment (DR)	SPL	Direct Assignment	SPL	Direct Assignment

TABLE A-8 --Continued

THE ALLOCATION OF ACCOUNT 221, CATEGORY 8 - CIRCUIT EQUIPMENT
BY FOUR COST-OF-SERVICE METHODS

Categories	Separations Basis of Apportionment to Interstate	EDA Service Category(ies)	EDA Assignment Method	J. W. Wilson Service Category(ies)	J. W. Wilson Assignment Method	Gabel Service Category(ies)	Gabel Assignment Method
Category 8KCT-1 Other ex-exchange circuit equipment associated with message exchange trunks used wholly for exchange traffic.	No assignment to interstate.	E	DR CAT total less Toll and Official	E, ST	Direct Assignment	E Offl.	Direct Assignment ratio of Busy-Hour CCS
		ST	DR CAT total, multiplied by ENFIA-ST ratio.				
		IST	DR CAT total, multiplied by ENFIA-IS ratio.				
		Offl.	Based on Offl. Orig. + Term. BH CCS.	E, ST, IST	Same as EDA		
Category 8KCT-2 Other exchange circuit equipment associated with message exchange trunks used wholly or in part for toll traffic. Also includes other exchange circuit equipment associated with the exchange trunk portion of WATS access lines.	Exchange trunk minutes of use.	E	Total less IST and ST				
		ST	State Toll Usage				
		IST	Direct Assignment (DR)				
		Offl.	Minutes of use.				
Category 8KCT-4 Other exchange circuit equipment associated with the exchange trunk portion of outside plant used for interstate private line local channels.	Assigned directly to Private Line Interstate	ISPL	Direct Assignment (DR)	ISPL	Direct Assignment	Interstate not Allocated	
Category 8KCT-5 Other exchange circuit equipment associated with the exchange trunk portion of outside plant used for intrastate private line local channels.	No assignment to interstate.	SPL	Direct Assignment + Trunk portion of off-prem. ext. and Foreign C.O. Lines.	SPL	Direct Assignment	SPL	Direct Assignment
Category 8KCT-7, ENFIA & OCC Facilities	Not mentioned	ST	Trunk portion of ENFIA-State	SPL,	Same as EDA	Not Mentioned	
		SPL	Trunk portion of OCC-State	IST,			
		IST	Trunk portion of ENFIA-Interstate	ISPL			
		ISPL	Trunk portion of OCC-Interstate				

TABLE A-8--Continued

THE ALLOCATION OF ACCOUNT 221, CATEGORY 8 - CIRCUIT EQUIPMENT, BY FOUR COST-OF-SERVICE METHODS

	Separations	EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Category 8KCS Other exchange circuit equipment used on exchange subscriber loops.							
Classes of Working Loops							
Message Telephone (Including WATS).	Subscriber Plant Factor.	AL, ST SPL, SB,	Investment associated with "designed" loops	E, ST, IST,	Access Portion Allocated by	E, V	Based on the Distribution
Interstate Private Line	Assigned directly to Private Line Interstate	Other, IST, ISPL, Offl.	distributed in proportion to count of "designed loops" (optional)	Centrex	Demand Availability		of Working Loops
Intrastate Private Line	No assignment to interstate.		Remaining investment distributed in proportion to total loops.	ST, SPL, IST, ISPL	Direct Assignment	ST	Subscriber Plant Factor
Category 8KD Circuit equipment used to provide local channels (trunk and loop) for wideband message data service, i.e., DATA-PHONE 50. Also includes circuit equipment used to remove the 4 wire crossbar data switch from the 2 wire local switch unit.	DATAPHONE 50 Wideband Minutes of Use	SB	Direct Assignment (DR)		Not Allocated and Allocator not Mentioned	Not Mentioned	
Category 8KE Circuit equipment used to provide local channels (trunk ad loop) for wideband message data service, i.e., PICTUREPHONE.	PICTUREPHONE Wideband Minutes of Use.	SB	Direct Assignment (DR)		Not Allocated and Allocator not Mentioned	Not Mentioned	
8KF, Wideband Local Channels - PICTUREPHONE Meeting Service	Not mentioned	SB	Direct Assignment (DR)	Other	Direct Assignment	Not Mentioned	
8KJ, Exch. Radio End Links	Not mentioned	SB	Direct Assignment (DR)	Other	Direct Assignment	Not Mentioned	

TABLE A-9

THE ALLOCATION OF THE 240 SERIES ACCOUNTS BY FOUR COST-OF-SERVICE METHODS

	Separations	EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
			Exchange Outside Plant				
Category KA Exchange Outside Plant - Broadband for Interstate Private Line	Directly assigned to interstate	ISPL	Direct Assignment (DR)	ISPL	Direct Assignment	Not Mentioned	
Category KB Exchange Outside Plant - Broadband for State Private Line	Directly assigned to State	SPL	Direct Assignment (DR)	ISP	Direct Assignment	Not Mentioned	
Category KD Local channels (trunk and loop portions) for wideband message data services	Allocated to message interstate on traffic factor of the per centage LDI of wide-band minutes of use	SB	Direct Assignment (DR)		Allocated by COE Data phone COE category 8KD	Not Mentioned	
Category KE Wideband Loc. Channels - PICTUREPHONE	Not mentioned	SB	Direct Assignment (DR)		Allocated by COE Picture phone COE category 8KE	Not Mentioned	
Category KF PICTUREPHONE Meeting Service	Not mentioned	SB	Direct Assignment (DR)	Other	Allocated by COE category 8KF	Not Mentioned	
Cateory KJ Exchange Radio End Links	Not mentioned	SB	Direct Assignment (DR)	Other	Allocated by COE category 8KJ	Not Mentioned	
Category KCT-1 Message Exchange Trunk	Apportioned to ENFIA Interstate on basis of Interstate ENFIA ratio	ST IST E Offl.	Total, multiplied by ENFIA-ST ratio. Total, multiplied by ENFIA-IS ratio. Total less Toll & Official Offl. portion of E inv. based on Offl. portion of tot. Orig. + Term. Busy Hour CCS.	E, IST	Allocated by COE category 8KCT-1	E Offl.	Direct Assignment Ratio of Busy-Hour CCS
Category KCT-2 Msg. exch. trunks used wholly or in part for toll traffic and exch. trunk portion of WATS access lines	Allocated to interstate by applying the the percentage of LDI of exchange trunk MOU	IST E, ST Offl.	Direct Assignment (DR) Based on KCT-2 Trk. Mins. of Use Based on Offl. portion of tot. Orig. + Term. Busy Hour CCS.	E, ST	Allocated by COE category 8KCT-2	E, ST Offl.	Relative Minutes of Use Ratio of Busy-Hour CCS

TABLE A-9--Continued

THE ALLOCATION OF THE 240 SERIES ACCOUNTS BY FOUR COST-OF-SERVICE METHODS

Subaccount	Separations: Basis of Apportionment to Interstate	Separations: Service Category	EDA: Assignment Method	J. W. Wilson: Service Category	J. W. Wilson: Assignment Method	Gabel: Service Category	Gabel: Assignment Method
Category KCT-4 Exchange Outside Plant Used for Interstate private line local channels	Direct assignment to interstate, average unit costs times number of circuits	ISPL	Direct Assignment (DR)	ISPL	Direct Assignment	Interstate not Allocated	
Category KCT-5 Exchange Outside Plant Used for State Private line local channels	Direct assignment to state, average unit costs times number of circuits	SPL	Direct Assignment + Total portion of off-prem. ext. & Foreign C.O. Lines.	SPL	Direct Assignment	SPL	Direct Assignment
Category KCT-7 Exchange Outside Plant used for ENFIA & COC Facilities	Direct assignment to interstate, average unit cost times number of circuits	ST SPL IST ISPL	Trunk portion of ENFIA-State Trunk portion of OCC-State Trunk portion of ENFIA-Interstate Trunk portion of OCC-Interstate	SPL, IST, ISPL	Allocated by COE category 8KCT-7	Not Mentioned	
Category KCS Exchange Subscriber Loops							
Message Telephone (including WATS)	Subscriber plant factor	AL, ST, IST	Based on Loop quantities. ST and IST are the costs of WATS access lines.		Divided into Access portion and Direct portion	E, ST,	Intrastate Sub-scriber Plant Factor is used to determine ST portion
Interstate Private Line nonbroadband services	Assigned directly to Private Line Interstate	Other, ISPL, SPL	Direct Assignments, plus PL-like services.	E,ST, IST, Centrex	Access portion Allocated by Demand Avail-ability	SPL	Number of working loops
State Private Line nonbroadband services	No assignment	SB	CTX-CO assignment based on equivalent CTX-CO intercom. loop.			V	Centrex-CU Number of working loops
ENFIA COCF	Directly assigned to interstate	Offl.	Offl. portion of AL based on Offl. portion of total sub-scriber lines. Offl. portion of CTX-CO based on Offl. portion of CTX lines and trunks.	ST,SPL, IST, ISPL	Direct portion Allocated by COE category 8KCS ST and IST are the costs of WATS access lines	Offl.	Direct Assignment
		(Optional) All	Based on Special Study #20				

TABLE A-9--Continued

THE ALLOCATION OF THE 240 SERIES ACCOUNTS BY FOUR COST-OF-SERVICE METHODS

Categories	Separations: Basis of Apportionment to Interstate	EDA: Service Category(ies)	EDA: Assignment Method	J. W. Wilson: Service Category(ies)	J. W. Wilson: Assignment Method	Gabel: Service Category(ies)	Gabel: Assignment Method
Category C: Plant used to furnish internal communications at certain U.S. government missile complexes, etc.	No assignment	Other		Other	Allocated by Special Construction COE category 8C	Not Mentioned	Direct Assignment (DR)
Category D3.1: Broadband facilities used for Long Line service.	Assigned directly to Interstate Private Line		Categories D3.1 and D3.2 are treated as a single category		Categories D3.1 and D3.2 are treated as a single category	Not Mentioned	
Category D3.2: Other than Broadband facilities used for Long Lines Private Line Service	Apportioned files between private line interstate and message interstate by Long Lines provided factors.	IST ISPL	Direct Assignment (DR) Direct Assignment (DR)	IST, ISPL	Allocated by Location Case File CMTS COE category 8D	Not Mentioned	
Category E: Broadband facilities used for IXC portion of AC Broadband Private Line services.			Categories EA1, EA2, and EB are not treated separately for EDA		Categories EA1, EA2, and EB are treated as a single category	Not Mentioned	
Category EA1: Interstate Private Line	Assigned directly to Interstate Private Line	ISPL SPL	Direct Assignment (DR) DR CAT total less direct assignment to ISPL	ISPL	Direct Assignment		
Category EA2: Interstate Private Line - non-DR (i.e., Educational TV provided under OTC-FCC tariffs)	Not assigned						
Category EB: State Private Line	Not assigned.						

TABLE A-9--Continued

THE ALLOCATION OF THE 240 SERIES ACCOUNTS BY FOUR COST-OF-SERVICE METHODS

Categories	Separations: Basis of Apportionment to Interstate	EDA: Service Category(ies)	EDA: Assignment Method	J. W. Wilson: Service Category(ies)	J. W. Wilson: Assignment Method	Gabel: Service Category(ies)	Gabel: Assignment Method
Category FA: Book costs of wideband circuit facilities used for interstate private line channels	Assigned private line interstate		Categories FA, FB, FC, FD, FE, and FH are not treated separately for EDA		Categories FA, FB, FC, FD, FE, and FH are treated as a single category	Not Mentioned	
Category FB: Book costs of wideband circuit facilities used for state private line channels	Assigned to state	IST	Direct Assignment (DR)	SPL, ISPL	Allocated by Interexchange Wideband Circuit Equipment COE category 8F		
		ST	Total less direct assignments less DDS investment.				
Category FC: Book costs of wideband circuit facilities used for state message channels	Assigned message interstate	SPL	Direct Assignment (DR) plus Nonofficial portion of state DDS investment.				
		ISPL	Direct Assignment (DR) plus Nonofficial portion of interstate DDC investment.				
Category FD: Book costs of wideband circuit facilities used for state messages	Assigned to state	Offl.	Based on Offl. portion of total DDS stations.				
Category FE: Book cost of Wideband circuit facilities used Jointly for Message Service	Proportion of Long distance Interstate Wideband Minutes of Use						
Category FH: Book cost of wideband circuit facilities used Jointly for Picturephone	Proportion of Long distance Interstate Picturephone Minutes of use						
Category J: IX Radio End Links	Not Mentioned	SB	Direct Assignment (DR)	Other	Allocated by COE category 8J	Not Mentioned	
		Offl.	Official minutes of use.				
Category G: Other Interexchange Outside Plant							
Interstate (IS) State Message	Directly assigned Interstate Directly assigned Intrastate	ST	Based on Equiv. Ckt. Miles assigned State Message.	ST, SPL,	Same as EDA	ST, SPL	Allocated by Equipment Circuit Rules. When Plant is used jointly for interstate and
		IST	Based on Equiv. Ckt. Miles assigned Interstate Message.				
		SPL	Based on Equiv. Ckt. Miles				

TABLE A-9--Continued

THE ALLOCATION OF THE 240 SERIES ACCOUNTS BY FOUR COST-OF-SERVICE METHODS

Categories	Separations: Basis of Apportionment to Interstate	EDA: Service Category(ies)	EDA: Assignment Method	J.W. Wilson: Service Category(ies)	J.W. Wilson: Assignment Method	Gabel: Service Category(ies)	Gabel: Assignment Method
Jointly Used Message	Apportioned state, interstate on basis of ratio of long distance interstate joint message minutes miles to total joint message minute miles.	 ISPL Other Offl.	assigned SPL (DR). Based on Equiv. Ckt. Miles assigned ISP1 (DR). Based on Equiv. Ckt. Miles Rented to Others. Based on Offl. portion of total Orig. + Term. Busy Hour CCS.				state toll message service, the interstate and state allocation is based on message minute rules.
IS Private Line	Directly assigned IS						
State Private Line	Directly assigned State						
Long-Line Order and Alarm	Apportioned between PL IS and MSG IS on following ratio: Long Lines and location case file book costs assigned message interstate/total Long Lines and location case files BC						
Rented to Others	No assignment						

TABLE A-10

THE ALLOCATION OF ACCOUNTS 211 AND 212, LAND AND BUILDINGS, BY FOUR COST-OF-SERVICE METHODS

Land and Buildings		EDA	J. W. Wilson	Gabel
Categories	Basis of Apportionment to Interstate	Assignment Method	Assignment Method	Assignment Method
Category 1 Operating Room and Central Office Equipment Space	Weighted COE book costs	By assignment of operating space - operators wages	By investment in manual COE	By assignment of Manual switchboard, dial switching, and circuit equipment
Category 2 Operators Quarters	Traffic Units	Traffic Units	By assignment of operators wages	Traffic Units
Category 3 General Traffic Supervision Space	Expense in Account 621	Expense in Account 621	Expense in Account 621	Expense in Account 621
Category 4 Commercial Office Space	Expense in Account 640, 643, 644 and 645	Expense in Account 640, 643, 644 and 645	Expense in Account 640, 643, 644 and 645	Expense in Account 640, 643, 644 and 645
Category 5 Space Used by Long Lines Department of AT&T Co. (other than operating rooms, operators' quarters, and COE space)	Assigned directly to Interstate (apportioned between message and private line interstate as discussed in Section (DR94.15)	Not Mentioned	Not Mentioned	Not Mentioned
Category 6 Revenue Accounting Space	Revenue Accounting Expenses included in Accounts 662-01, 02, and 03	Revenue Accounting Expenses included in Accounts 662-01, 02, and 03	Revenue Accounting Expenses included in Accounts 662-01, 02, and 03	Revenue Accounting Expenses included in Accounts 662-01, 02, and 03
Category 7 Garages, Storerooms, Warehouses, and Pole Yards	Book costs of Station Equipment and Outside Plant in Service and Material and Supplies	Book costs of Station Equipment and Outside Plant in Service and Material and Supplies	Book costs of Station Equipment and Outside Plant in Service and Material and Supplies	Book costs of Station Equipment and Outside Plant in Service and Material and Supplies
Category 8 Space rented to Others	No apportionment to interstate	Direct to Other	Not Mentioned	By assignment of Rent Revenues
Category 9 General Office Space	Expenses in Accounts 661-665 (except expenses in Accounts 662-01, 02, and 03 assigned Revenue Accounting), 668, 669, 675, 677	Direct to Common	By land and buildings investment	By wage expense for maintenance, traffic, and commercial and marketing

TABLE A-10 --*Continued*

THE ALLOCATION OF ACCOUNTS 211 AND 212, LAND AND BUILDINGS,
BY FOUR COST-OF-SERVICE METHODS

Land and Buildings		EDA	J. W. Wilson	Gabel
Categories	Basis of Apportionment to Interstate	Assignment Method	Assignment Method	Assignment Method
Category 10 Antenna Supporting Structures	Book costs of Antenna and Waveguide Supported	Direct to Interstate	Direct to Interstate	Direct to Interstate
Category 11 Substantial Space used and reserved for Long Lines COE	Assigned directly to Interstate (message, private line split based on DR94.15)	Direct to Interstate	Direct to Interstate	Direct to Interstate

TABLE A-11

THE ALLOCATION OF MISCELLANEOUS PLANT ACCOUNTS BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
100.1 Telephone Plant In Service	Apportioned as corresponding sub-accounts 201-277	All	The assignment method of the subaccounts of 100.1 are detailed in Part 2 of this Section.	All	Apportioned according to corresponding subaccounts 201-277	All	Apportioned according to corresponding subaccounts 201-277
100.2 Telephone Plant Under Construction	As Account 100.1	All	Account 100.2 is assigned to 100.1 subaccounts based upon DR data; each subaccount is then assigned to EDA service categories based upon the corresponding 100.1 subaccounts.	All	Apportioned according to the corresponding plant accounts 201-277 where construction is underway		Excluded from Rate Base for study state
100.3 Property Held For Future Use	As Account 100.1	All	Acct. 100.3 is assigned to 100.1 subaccounts based upon DR data, each subaccount is then assigned to EDA service categories based upon the corresponding 100.1 subaccounts.	All	Apportioned according to Land account 211	All	Apportioned as plant inservice for each class of plant
100.4 Telephone Plant Acquisition Adjustment	As Account 100.1	All	Acct. 100.4 is assigned to 100.1 subaccounts based upon DR data, each subaccount is then assigned to EDA service categories based upon the corresponding 100.1 subaccounts.		Apportioned as Accounts 276 and 277	Not Mentioned	
101 Investment in Affiliated Companies	Not used in Separations	C	Direct Assignment	All	Apportioned as Account 100.1	Not Mentioned	
122 Materials and Supplies	As Account 100.1	All	Acct. 122 is assigned to 100.1 subaccounts; each subaccount is then assigned to EDA service categories based upon the corresponding 100.1 subaccount.	All	Account 122 is divided in half. One half is Allocated as 100.1. One half is allocated as total wages and salaries.	All	Apportioned according to Outside Plant in Service and Station Equipment
171 Depreciation Reserve	Account 171 sub-accounts are apportioned according to the corresponding plant subaccount	All	Acct. 171 is assigned to the corresponding investment sub-accounts based upon MA16 data. Each subaccount is then assigned to EDA service categories based the distribution of its corresponding investment subaccount.	All	Apportioned according to the corresponding plant account	All	Apportioned according to the corresponding plant account

TABLE A-11--Continued

THE ALLOCATION OF MISCELLANEOUS PLANT ACCOUNTS
BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
172 Amortization	Apportioned according to corresponding plant subaccount.	All	This count is divided into four categories: Organization, Franchise, Pat. Rights, and Land. The Land portion is assigned based on Acct. 211, Land. The others are directly assigned to Common.	All	Apportioned according to the corresponding plant account	All	Apportioned according to the corresponding plant account
176 Accumulated Deferred Income Tax	Apportioned according to the corresponding plant subaccount.	All	Acct. 176 is assigned to the corresponding investment subaccounts based upon DR data. Each subaccount is then assigned to EDA service categories bassed upon the distribution of its corresponding investment subaccount.	All	Apportioned according to gross investment less accumulated depreciation	All	Apportioned according to gross investment less accumulated depreciation
113 Cash Working Capital 114 115	Not mentioned	Not Mentioned.		Not Mentioned		Not Mentioned	

TABLE A-11--Continued

THE ALLOCATION OF MISCELLANEOUS PLANT ACCOUNTS BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
261 Furniture and Office Equipment							
261.01 Storeroom Furn. and Office Equipment	Wage portion of maintenance, traffic commercial, and revenue accounting expenses	All	Based on Account 232, Station Connections				Subaccounts 261.01 and 261.02 are treated as a single subaccount
261.02 Other Furniture and Office Equip.	Wage portion of maintenance, traffic commercial, and revenue accounting expenses	All	Based on the Salaries of furniture users.	All	Based on gross plant investment excluding Account 261 and subaccount 264.06	All	Based on Allocation of employee wage portion for maintenance, traffic, commercial, marketing, and revenue accounting expenses
261.03 Computer and AMA Systems	Work functions performed	All	Based on Total Accounting Expense			All	Based on Allocation of employee wage portion of maintenance, traffic, commercial, and the wage portion of maintenance expenses associated with general office space
264 Motor Vehicles & Other Work Equip.	Subaccounts not utilized, apportioned according to the assignment of outside plant, station equipment, materials and supplies, combined.	All	This account is assigned to vehicle groups based on DR studies. Each group is assigned to EDA Service Categories based on use. (See FT4 documentation).	All	Subaccounts 264.01, 264.02, 264.04, 264.05 are based on Allocation of Outside Plant plus Station Equipment	All	Account 264 is treated as a single account Allocated according to investments in station equipment, outside plant, and material and supplies
264.01 Motor Vehicles		All	Same as above.				
264.02 Garage & Motor Vehicle Shop Equip.		All	Same as above.				
264.03 Special Tools & Work Equipment		AL, E, ST, SPL, SB, Other, IST, ISPL	Based on OSP investment.	All	Subaccount 264.03 is Based on Allocation of Outside Plant		

TABLE A-11--Continued

THE ALLOCATION OF MISCELLANEOUS PLANT ACCOUNTS
BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
264.04 Other Shop Equip.		All	Based on Total OSP and Station Investment				
264.05 Other Tools and Work Equipment		All	Based on Total OSP and Station Investment				
264.06 Storeroom Work Equipment		AL, ST, SPL, SS-Res., SS-Bus., Other, IST, ISPL	Based on Group 1 and 8 Vehicles in Acct. 264.01.	All	Based on gross plant investment excluding Account 261 and sub-account 264.06		
201 Organization 202 Franchise 203 Patent Rights	201, 202, and 203 are excluded from settlement studies under DR procedures	C C C	Direct Assignment Direct Assignment Direct Assignment	Not Mentioned		All	Accounts 201, 202, and 205 are allocated according to Plant in Service
276 Plant Acquired	276 is apportioned according to the corresponding account it is to be assigned	C	Direct Assignment (DR)	Not Mentioned		Not Mentioned	
277 Plant Sold (CR)	Not used in separations	C	Direct Assignment (DR)	Not Mentioned		Not Mentioned	

TABLE A-12

THE ALLOCATION OF THE 500 SERIES ACCOUNTS, REVENUES, BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Account 500 - Subscriber Station Revenues	Divided into non-wideband and wide-band services. Non-wideband is assigned directly to the exchange operation. Wideband message services apportioned as follows: (1) Local message revenues are assigned to the exchange operation; (2) Other wide-band message service revenues are apportioned on basis of relative number of minutes of use.	ST, SPL, E, SB	Assigned based on source of revenue adjusted by booked to billed ratio using special study data	SPL, E, CENTREX, TER, TEB, IWSB, Other	Mobile service charges are directly assigned according to source of revenue	SPL, E, V, Other	Subscriber message charges are assigned to E. Subscriber monthly charges are assigned according to source of revenues using special studies. Subscriber non-recurring charges are assigned based on the number of connections.
Account 501 - Public Telephone	Directly assigned to Exchange	E	Assigned based on source of revenue	E	Direct assignment	E	Direct assignment
Account 503 - Service Stations	Directly assigned to Exchange	E, TER, TESB	Assigned based on source of revenues and special studies	E, TER, TEB	Assigned based on source of revenues and special	E	Direct assignment
Account 504 - Local Private Line Services	Broadcast transmission services are assigned to interstate. Others are assigned to exchange.	ISPL, SPL, TECB, IWCB	Assigned based on revenues and special studies	ISPL, SPL, TEB	Same as EDA	SPL, V	Customer premises equipment charge, assigned to V. All other revenues assigned to SPL.
Account 506 - Other Local Service Revenue	No apportionment to interstate	E	Assigned based on source of revenues	E	Direct Assignment	E	Direct Assignment

TABLE A-12 --Continued

THE ALLOCATION OF THE 500 SERIES ACCOUNTS, REVENUES, BY FOUR COST-OF-SERVICE METHODS

Separations: Categories	Separations: Basis of Apportionment to Interstate	EDA: Service Category(ies)	EDA: Assignment Method	J. W. Wilson: Service Category(ies)	J. W. Wilson: Assignment Method	Gabel: Service Category(ies)	Gabel: Assignment Method
Account 510 - Message Toll	Revenue from telephone and miscellaneous services are apportioned according to source of revenues. Wideband message service revenues are apportioned as follows: (1) revenues from messages between points in different locations are apportioned by source and (2) revenue from station terminal monthly charges are apportioned by minutes of use.	ST, IST	Assigned based on source of revenues	ST, IST	Assigned based on source of revenues	ST	
Account 511 - Wide Area Telephone Service	Apportioned to ST and IST using special studies and toll settlements.	ST, IST, TECB, IWSB, IWCB	Assigned based on source of revenues and special studies	ISPL, SPL, TEB	Same as EDA	PL, V	Station apparatus charge assigned to V. All other revenues assigned to ST.
Account 512 - Toll Private Line	Apportioned to SPL and ISPL using special studies and toll settlements	SPL, ISPL, TECB, IWCB	Assigned based on source of revenues and special studies	SPL, ISPL, TEB	Same as EDA	SPL, V	Station apparatus charges assigned to V. All other revenues assigned to SPL.
Account 516 - Other Toll Revenues	Apportioned to ST and IST based on special studies	ST, IST, SPL, ISPL	Assigned based on source of revenues	IST, ISPL	Direct Assignment	E	Direct Assignment
Account 521 - Telegraph Commissions	No assignment to interstate	Other	Assigned based on source of revenues	Other	Direct Assignment	E	Direct Assignment
Account 523 - Directory Advertising	No assignment to interstate	Other, ST, IST	Assigned based on MA20 subaccount detail.	E	Direct Assignment	E	Direct Assignment

TABLE A-12--Continued

THE ALLOCATION OF THE 500 SERIES ACCOUNTS, REVENUES, BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Account 524 - Rent Revenues	Apportioned according to the corresponding plant and equipment accounts	Other, ISPL	Assigned based on revenues. Part of the assignment to "other" is reversed out and allocated to all service categories based on related revenues	All	Land and buildings allocated by corresponding investments. Rents related to private line services are assigned to ISPL. The remaining revenues are allocated based on gross plant in service	E, V	Directly assigned to E except TWX services, which are assigned to V.
Account 525 - General Services & Licenses	Apportioned according to source of revenues	Other	Assigned based on source of revenues		Not mentioned		Not mentioned
Account 526 - Other Operating Revenues	Apportioned according to special studies	E, ST, SSB, IST, Other	Operator services allocated by traffic units and a special study. All others allocated by revenues	All	Same as EDA	E, V	Directly assigned to E except revenues from design line phones and offsetting expenses (account 675) that are assigned to V.
Account 530 - Uncollectable Revenues	Apportioned according to special studies	All	Assigned based on source of revenues	All	Same as EDA	All	According to DR procedures
Account 304 - Investment Credits - Net	Amount associated with account 232 - Station Connections is apportioned by separation of 232. Amount associated with all other plant accounts are apportioned on basis of Telephone Plant In Service - Account 100.1 excluding Account 232.	All	Assigned based on distribution of Net Investment Base (sum of 100.1, 100.2, 100.3, 100.4, 101 and 122, less accounts 171, 172, and 176)		Same as EDA	All	Assigned based on net taxable income.

TABLE A-13

THE ALLOCATION OF THE 300 AND 400 ACCOUNTS, INCOME, BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Account 306 - Federal Income Taxes - Operating	Net income taxes are apportioned according to the distribution of net taxable income	All	Assigned based on distribution of Net Investment Base (sum of 100.1, 100.2, 100.3, 100.4, and 122 less accounts 171, 172, and 176)	All	No allocator mentioned	All	Assigned based on net taxable income
Account 307 - Other Operating Taxes							
01 Property Taxes	Based on Account 100.1	All	Assigned based on account 100.1	All	Assigned based on total plant in service	All	Assigned based on distribution of investment
02 State & Local Income	Not Mentioned	All	Assigned based on Net Investment Base (sum of accounts 100.1, 100.2, 100.3, 100.4, 101, and 122, less accounts 171, 172, and 176)	All	No allocator mentioned	All	Assigned based on net taxable income
03 Gross Receipts Tax	Based on the separation of the receipts, earnings, or income on which taxes are based	All	Assigned based upon the revenue that is subject to Gross Receipts Tax	E, ST, TER, TEB, IWS, Other	Assigned based on total operating revenues less interstate revenues	All	Assigned based on Plant in Service
04 Capital Stock Taxes	Based on Account 100.1	All	Assigned based on distribution of Net Investment Base (sum of accounts 100.1, 100.2, 100.3, 100.4, 101, and 122, less accounts 171, 172, and 176)	All	No allocator mentioned		Not mentioned
05 Social Security Taxes	Based on separation of wage portion of maintenance, traffic, commercial and revenue accounting expense	All	Assigned based on traffic, commercial and accounting, maintenance and general office wages	All	Assigned based on total wages and salaries	All	Assigned based on wages and salaries

TABLE A-13--Continued

THE ALLOCATION OF THE 300 AND 400 ACCOUNTS, INCOME, BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
06 Other Taxes	Based on Account 100.1	C	Assigned based on source of taxes	All	No allocator mentioned	All	Assigned based on Plant in Service
Account 308 - Federal Income Taxes - Deferred	Based on separation of related plant and equipment	All	Assigned based on distribution of Net Investment Base (sum of accounts 100.1, 100.2, 100.3, 100.4, 101, and 122, less accounts 171, 172, and 176)	All	No allocator mentioned	All	Assigned based on net taxable income
Account 309 - Income Credit From Prior Deferrals of F.I.T.	Based on separations of related plant and equipment	All	Assigned based on distribution of Net Investment Base	All	No allocator mentioned	All	Assigned based on net taxable income
Account 312 - Dividend Income	Not mentioned	C	Direct Assignment	All	Assigned based on total Net Investment Base	All	Assigned based on Plant in Service
Account 313 - Interest Income							
01 Interest Earned	Not mentioned	C	Direct Assignment	All	Assigned based on total Net Investment Base	All	Assigned based on plant in service
02 Interest Charged to Construction	Based on Telephone Plant Under Construction account 100.2	All	Allocated based on related plant and equipment	All	Assigned based on long-term plant under construction (Account 100.1-02)	All	Assigned based on plant under construction (Account 100.2)
Account 314 - Income From Linking and Other Funds	Not mentioned	C	Direct Assignment	All	Assigned based on total Net Investment Base	All	Assigned based on plant in service
Account 315 - Income from Miscellaneous Physical Property	Not mentioned	C	Direct Assignment	All	Assigned based on total Net Investment Base	All	Assigned based on plant in service

TABLE A-13-- Continued

THE ALLOCATION OF THE 300 AND 400 ACCOUNTS, INCOME, BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Account 316 - Miscellaneous Income	All miscellaneous income amounts are apportioned on the basis of the nature of the items			All	Assigned based on total Net Investment Base	All	Assigned based on plant in service
09 - Other		C	Direct Assignment				
50, 52, 59, 60, 62 Revenue From Sales		Other	Direct Assignment				
Account 323 - Miscellaneous Income Charges	Based on the apportionment of general expenses	C	Direct Assignment	All	Assigned based on total Net Investment Base	Not mentioned	
Account 326 - Federal Income Taxes - Non Operating	Apportioned in same manner as Account 306-Federal Income Tax-Operating (distribution of net taxable income)	C	Direct Assignment	Not mentioned		Not considered	
Account 327 - Other Nonoperating Taxes	Apportioned in same manner as Account 307 - Other Operating Taxes	C	Direct Assignment	All	Assigned based on Net Investment Base	Not mentioned	
Account 335 - Interest on Funded Debt	Not mentioned	All	Assigned based on Net Investment base	Not mentioned		All	Assigned based on net plant investment (Plant in Service Depreciation Reserve)
Account 336 - Other Interest Deductions	Not mentioned	C, All	Interest deductions not related to capital obligations are directly assigned to common. All others assigned based on Net Investment Base	Account 336-29 assigned to all categories based on total operating revenues. Other subaccounts are not mentioned.		All	Assigned based on net plant investment

TABLE A-13--Continued

THE ALLOCATION OF THE 300 AND 400 ACCOUNTS, INCOME, BY FOUR COST-OF-SERVICE METHODS

Separations		EDA		J. W. Wilson		Gabel	
Categories	Basis of Apportionment to Interstate	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method	Service Category(ies)	Assignment Method
Account 338 - Amortization of Discount on Long Term Debt	Not mentioned	All	Assigned based on Net Investment Base	Not mentioned		All	Assigned based on net plant investment
Account 339 - Release of Premium on Long Term Debt	Not mentioned	All	Assigned based on Net Investment Base	Not mentioned		All	Assigned based on net plant investment
Account 340 - Other Fixed Charges	Not mentioned	All	Assigned based on Net Investment Base	Not mentioned		Not mentioned	
Account 360 - Extraordinary Income Credits	Apportioned in a manner consistent with nature of the items.	C	Direct Assignment	All	Assigned based on total operating revenues	All	Assigned based on net taxable income
Account 365 - Delayed Income Credits	Apportioned in a manner consistent with the nature of the items	C	Direct Assignemnt	All	Assigned based on total operating revenues	All	Assigned based on net taxable income
Account 370 - Extraordinary Income Charges	Apportioned in a manner consistent with the nature of the items	C	Direct Assignment	All	Assigned based on total operating revenues	All	Assigned based on net taxable income
Account 375 - Delayed Income Charges	Apportioned in a manner consistent with the nature of the items	C	Direct Assignment			All	Assigned based on net taxable income
Account 380 - Income Tax Affect on Extraordinary and Delayed Items	Not mentioned	C	Direct Assignment	All	Assigned based on total operating revenues	All	Assigned based on net taxable income
Account 402 - Miscellaneous Credits to Retained Earnings	Apportioned in a manner consistent with the nature of the items	Not mentioned		Not mentioned		Not mentioned	
Account 413 - Miscellaneous Debits to Retained Earnings	Apportioned in a manner consistent with the nature of the items	Not mentioned		Not mentioned		Not mentioned	

APPENDIX B

CONFIDENTIALITY AGREEMENT WITH
SOUTHWESTERN BELL

The National Regulatory Research Institute

The Ohio State University

2130 Neil Avenue
Columbus, Ohio 43210
614/422-9404

October 29, 1984

Mr. Keith E. Davis
Attorney
Southwestern Bell
308 South Akard
Post Office Box 22552
Dallas, Texas 75262

Dear Mr. Davis:

I have requested that Southwestern Bell provide me a certain document for the purpose of my completing a study for the National Regulatory Research Institute (NRRI) and the National Association of Regulatory Utility Commissioners, and the report is to be distributed openly to all interested parties at the NRRI's regular publication prices. The document I have requested is the MUSIC User's Manual, section 10.0, Levelized Incremental Unit Cost Feature. Southwestern Bell has advised me that it considers this document to be proprietary and confidential and that it is not to be disclosed outside Southwestern Bell absent an agreement of confidentiality being entered into by the party to whom disclosure is made. Subject to such an agreement, Southwestern Bell is willing to release this document to me for the limited purpose of completing the aforementioned study.

Additional terms of that agreement are as follows:

1. The document shall be treated by me as constituting trade secrets, confidential or privileged commercial and financial information, and shall neither be used nor disclosed except for the purposes of my aforementioned study. The methodology will not be disclosed in sufficient detail to allow anyone to replicate, to duplicate, or to otherwise improperly acquire the Levelized Incremental Unit Cost Feature. The program and other details described or contained in this document will not be disclosed by me.

2. All confidential information produced by Southwestern Bell pursuant to this agreement shall not be used or disclosed except for purposes of my study.

3. I may take such limited notes regarding this confidential information produced by Southwestern Bell as may be necessary in connection with my study when required solely for the uses and purposes of my study. Such notes shall be treated the same as the confidential information produced by Southwestern Bell from which the notes were taken.

4. I shall neither use nor disclose the confidential information for purposes of business or competition, or any other purpose other than the purposes of preparation of my study and shall use my best efforts to keep the confidential information secure and in accordance with the purposes and intent of this agreement. To this end, persons having custody of any confidential information shall keep the documents under lock or otherwise properly secured during all times when the documents are not being reviewed.

5. Upon completion of the preparation of my study, all of the confidential information produced by Southwestern Bell and furnished under the terms of this agreement shall be returned to Southwestern Bell. The limited notes, derived from the confidential information produced by Southwestern Bell, may stay in my possession, but such notes will continue to be treated as confidential information and shall be kept under lock or otherwise properly secured during all times when the documents are not in use. These limited notes will be used only to document the discussion and conclusions and to help answer inquiries about the study. None of the information contained in these notes would be disclosed without Southwestern Bell's written permission. If at some time in the future it is determined that the limited notes derived from the confidential information are no longer needed, such notes will be returned to Southwestern Bell.

I fully understand and agree to comply with and be bound by the foregoing terms and conditions.

W. W. Pollard

Mr. William Pollard

29 Oct 84

Date

APPENDIX C

SURVEY LETTER

The National Regulatory Research Institute

OSU

The Ohio State University

2130 Neil Avenue
Columbus, Ohio 43210
614/422-9404

January 23, 1983

Dear

The purpose of this letter is to request your help in a survey of cost-of-service methods for telephone service that The National Regulatory Research Institute is conducting. The NRRI is developing a cost manual for intrastate telephone service as part of the program of research and technical assistance to NARUC member commissions for which NARUC established and funds the NRRI.

The survey serves two purposes. First, state commissions will be informed of telephone cost-of-service methods that are currently used or proposed in other states. Second, the survey will provide direction to the NRRI research team that is developing the cost-of-service method to be included in the proposed manual.

You can help the Institute in its survey by providing testimony on the format and method of telephone cost-of-service studies submitted before your commission. If your commission prescribes a cost-of-service method to be used by telephone companies under your jurisdiction, we would like a copy of the manual or documentation of this method. If your commission does not prescribe a method, testimony submitted by the telephone companies that explains their cost-of-service format and method would meet our needs. BOC's, independent telephone companies, and REA telephone companies are included in this survey.

It is also necessary to explain what we don't want. We do not want actual cost-of-service studies, nor do we want any information on CPE cost studies. We wish to keep the volume of material we receive from a commission responding to this request to the minimum necessary to accomplish our goal.

We would like you response to this request as soon as possible. We have set a tentative deadline of February 27, 1984. Your prompt attention to this matter will help ensure completion of this survey in a timely fashion. If you have any questions about the survey or information desired, feel free to call me at (614) 422-9404.

Sincerely,

William Pollard
Senior Research Associate

WP:jh

Established by the National Association of Regulatory Utility Commissioners at The Ohio State University

APPENDIX D

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