SECTION E
Essential Tools of Regulation

Regulators must establish standards and guidelines to support, and help justify, the decisions they make. The better the standards and guidelines, and the more informed the regulator is, the more effective regulation will be. This Section reviews the essential tools of regulation – cost analysis, the overall information needs of regulators and the development of statistical indicators.

If there is a holy grail in regulation, it is cost. It is the proposed standard for judging most pricing and competition issues. Cost-based pricing frequently is pronounced as the solution for a range of regulatory issues. William Melody reviews the key concepts and methods of network cost analysis, observing that cost is not the end of the problem, but rather the entry to point to a complex field of analysis that offers as many traps and dead ends as it does solutions. Fred Bigham summarizes the experience of the Canadian Radio-television and Telecommunication Commission (CRTC) in applying cost analysis as party of its price regulation of Bell Canada over the past 20 years. Martin Cave discusses cost modeling employed by OFTEL in its regulation of BT. Both the Bigham and Cave chapters document that cost is no panacea, nor is it a tool for the unwary. But it can be fashioned to guide regulatory decisions in a number of important areas.

Michael Minges describes and illustrates the value of statistical indicators as a toll for judging the absolute and relative performance of PTOs. Indicators developed at ITU and OECD in particular are being used increasingly in both international policy discussions and national regulation. William Wigglesworth looks at the role of information in facilitating the regulatory process, including the information needs of regulators and the need for regulators to have the effective power to get the information required. Many potential regulatory problems can be averted by the publication of information, and sometimes simply by gathering it.

Chapter 17

Network Cost Analysis: Concepts and Methods

William H. Melody

1.0 Introduction

The recommended solution to many problems in telecom management and regulation is that cost should be the standard for judging reasonable levels of prices and profitability. Maximum prices for basic residential services should be based on cost. Minimum prices for competitive services of a PTO should cover their costs. The solution to most interconnection problems is that interconnect charges should be based on costs. Indeed "cost-based pricing" is recited with such frequency and conviction, particularly by economists, as the correct answer to most telecom and other public utility regulatory problems, one is tempted to conclude the regulation of telecom prices should be a straightforward and non-controversial issue.

In fact, cost is the most important standard for addressing most regulatory issues. But adopting the principle of cost as an important standard for regulation is not the solution to any problem. Rather it is the entry point to a complex and controversial field of analysis. There are many different cost theories, concepts, definitions, interpretations, methods of measurement and data sources. The most appropriate approach to cost analysis depends upon the problem being addressed and the purpose of the costing exercise. All approaches to costing require judgement in implementation, have limits to their ranges of usefulness in application, and require a careful interpretation of the meaning, significance and limitations of cost study results. Cost analysis can be an extremely useful tool for telecom managers and regulators. It is a tool to guide and facilitate judgement in decision-making, not a substitute for judgement.

The most significant disagreements in cost analysis are really about the purposes for costing and the definition of the costing problems, although these disagreements are often presented as debates over the intrinsic merits of particular cost theories, concepts and methods. The practical difficulty is that cost analysis, as a serviceable tool for decision-making, can offer a wide variety of approaches, concepts, methods and interpretations for every conceivable problem involving the use of economic resources. This means that whenever there are serious disagreements, all parties to the dispute can find some approach to costing that will get results that support their preconceived or vested interest views. As a result, regulators are sometimes presented with cost "justifications" for all of the different contending views, and the theoretical ideal of "cost-based pricing" far too often becomes perverted to "price-based costing". For regulators and policymakers it is important to select and adapt the most appropriate approach, or approaches to cost analysis which will facilitate effective resolution of the problem at hand and the ongoing implementation of policy and regulatory objectives. Thus, they will need access to independent cost analysis and regulatory staff members who are experienced and informed on all aspects of costing. This chapter provides an overview of some of the main cost approaches, concepts and applications in telecom, with particular reference to the needs of regulation.

2.0 Professional Approaches to Cost Analysis

There are three quite fundamentally different approaches to cost analysis which can be associated with different professions. Accounting is principally concerned with the recording, classification and interpretation of actual, incurred costs. Engineering is directed to examining the costs of alternative ways of performing specified tasks, such as finding the least cost way of adding a specified amount of capacity to a telecom network. Economics is concerned with the most efficient way of allocating society's limited economic resources among different possible uses. In a sense these approaches are complementary. Economics can help decide what quantity of output to produce by comparing the cost estimates of producing at different possible output levels. Engineering can provide the estimates of the minimum cost for producing each possible output level being considered in the economic analysis. Accounting can measure what the output that is actually produced really cost.

Knowing accounting costs can help improve the forecasts that are necessary in estimating economic and engineering costs. Knowing a range of engineering costs is necessary for economic costs to be estimated. But since each profession approaches cost analysis by making very different sets of assumptions, in most cases the cost estimates of the different approaches cannot be directly compared. Thus it is important to understand the strengths and limitations of the different approaches. One is not intrinsically better than the others. They address different problems. The difficulty in practice is that far too often particular cost approaches, concepts and methods are proposed to solve problems that lie totally outside the limits of their applicability. This is one reason why the different professions have such difficulty communicating with one another and appreciating the limitations of their own approaches or the contributions of the other professions.

2.1 Accounting

Accounting is concerned with the development of an accurate record of the actual costs incurred by a firm, or any other organisation. It addresses issues of cost valuation, classification, accuracy, consistency and independent verifiability. It establishes rules for classifying expenditures as investments or expenses, and how investments in long lived assets will be allocated over their useful lives. Costs are normally recorded at the exchange value, in monetary terms, of arm's length transactions. If the market or revenue producing value of assets has changed significantly over time, it considers the best way to recognise this in the accounting records. A major purpose of the exercise is to obtain the best estimates possible of the actual costs of the firm during a specified time period, e.g. a year.

In estimating the actual costs incurred by a firm during a particular year, accounting must make certain assumptions. One important assumption is that the firm is a going concern, i.e., it will continue to operate and be able to use the productive assets in which it has invested. The current accounting record of the firm reflects all the decisions that affect the current year's costs, some of which were made in past years and some this year. It assumes the firm will continue to use its productive assets to produce output and revenue in future years, and therefore a portion of the investment cost of switches, cables, etc. can be allocated to future years. In this manner accounting attempts to capture a picture of the firm's financial health as it produces goods and services over time. The accounting record of the most recent year is the most current picture of the actual cost and revenue performance of an ongoing enterprise. The focus of accounting is the historical record that bears on the actual cost and revenue performance in the current period, under the assumption that the firm is a viable, ongoing organisation. If firms are just starting in business, or going out of business, there are special accounting rules to deal with those special circumstances.

There are two types of accounting that are of primary interest here. Corporate financial accounting measures the annual profitability of the company. It is presented in the form of financial statements, principally income statements and balance sheets, in independently audited annual reports. Profitable companies have retained earnings to reinvest and their profits provide a basis for attracting additional funds for investment. Obviously decisions to undertake new investments consider a wide range of market, technological and other information in addition to the financial statements. But the benchmark guideline as to how the firm is doing in its ongoing activities is its most recent financial performance, as measured in its financial statements.

Management accounting attempts to refine the basic information that goes into the financial accounts to make it useful for the more detailed management of the company. It develops cost and revenue information for the company's different lines of business and the different product and service categories it supplies. It develops cost responsibility centres to facilitate ongoing cost control, and standard unit cost measurements against which the ongoing performance of the different activities of the company can be assessed. These range from large units such as corporate divisions or major service classifications to smaller ones such as the maintenance cost of residential customer lines or data modems. Applications of new information and communication technologies and services over the past 20 years have made possible more sophisticated and detailed applications of management accounting at much reduced cost. In the most sophisticated applications of some companies, every professional employee is a cost or profit centre.

Management accounting is especially important in competitive markets. Firms need to know precisely those services, functions and activities where they are making profit and those where they are not. This detailed profitability information can signal where new investment can be profitably committed, and what products, services, activities or functions should be cut back, reorganised or phased out. This information is essential to understanding the firm's detailed structure of efficiency and profitability – for cost control, pricing and the allocation of the firm's resources. Some companies establish trading units within the company that engage in arm's-length trading relations not only with other firms, but also with other trading units within the same firm.

Although understanding actual experience is fundamentally important to judging a firm's actual performance, and in most cases a very important indicator of probable future performance, it is not a sufficient standard for making new investment, pricing and other decisions relating to future markets. Financial analysts and investors consider such information necessary and important, but not sufficient. However the detailed analysis of actual experience provides a good foundation for forecasting financial statements, product line profitability and standard unit costs expected in future years. These forecasts incorporate management estimates of the impact on the company of possible changes in costs, demands, and market development. For capital intensive firms with relatively long-lived assets, such as PTO's, the great majority of next year's costs have been committed by management decisions already taken. Projections of accounting data for future years are a normal part of financial and management analysis. The projections can then be compared with the actual data as time passes, and explanations sought for any significant differences between forecasted and actual results.

For most of the history of public utility regulation, accounting data for the regulated firm, as recorded in special industry uniform accounting systems, has been used by regulators as the major source of information in regulating PTO's and other public utilities. Financial statements have provided the main data source for calculating the most current "test year" rate of return on investment. Management accounting systems have provided the main data source for cost of service measurements for different PTO services to the limited extent they have been employed by PTO managers and regulators.

2.2 Engineering

In contrast to accounting, which is primarily concerned with the actual experienced costs arising from management decisions already taken, both engineering and economic costing are primarily concerned with management decisions that have not yet been taken. The engineering analysis examines alternative possible ways of producing something with a view to finding the best way, e.g., the minimum cost way of expanding capacity. This could range from assessing the costs of adding transmission capacity by cable, radio microwave or satellite; dimensioning, and maybe designing the functional capabilities, quality and capacity of a new switching machine at minimum cost; or developing algorithms for network traffic management which will maximise use of existing capacity, thereby minimising costs. In essence, engineering cost analysis assesses different ways of meeting a specified objective with a view to finding the least cost, or optimal cost way.

Most major engineering cost analysis must address the problems of comparing alternatives that are not easily compared. For example a new fibre cable may expand transmission capacity by 20,000 circuits and have an expected useful life of 30 years, but it is inflexible as it must remain in the ground where it is placed. If its capacity is actually going to be used at a high level of efficiency, significant additional investment may be needed to feed additional traffic into the ends of the fibre cable. A satellite might provide 10,000 circuits for ten years which could connect any of the company's earth stations and permit regular reallocations of circuit capacity to where it is needed. It may have a lower investment cost, but a higher annual cost per unit of capacity. It may require earth station expansion costs in later years and have higher maintenance costs per unit and a higher risk of circuit failure. And there may be a half dozen additional options to be evaluated. In the analysis, assumptions must be made about when funds will have to be committed in present and future periods and how these should be compared, the extent to which the capacity created is likely to be used over its life, related investments likely to take place elsewhere in the network in present and future periods, improvements in technology that might take place in the future, and other factors. In a telecom network, which is characterised by many interdependent parts, engineering cost analysis rarely seeks the absolute minimum cost solution to individual capacity expansion decisions. Rather it seeks a solution that will contribute to minimising costs for overall network development over time while providing enough flexibility to cope with possible future uncertainties, including changes in demand and technology.

At the completion of the engineering cost analysis, a decision whether to invest in a specific expansion plan will be made. If a decision to invest is taken, the engineering estimates of the cost of that expansion plan are recorded and later compared with the actual experienced accounting costs of the plan, as a basis for improving future engineering estimates. Sometimes experience demonstrates that the assumptions of the engineering analysis were unrealistic, or demand or technology developed in unforeseen ways, and the most efficient investment choice was not selected. This generally leads to changes in the assumptions of the engineering cost analysis for future studies.

Normally the analysis of investment options and the making of investment decisions is a prerogative of management. Although telecom and other public utility regulators often have the power to review investment decisions, only under the most extreme circumstances have regulators intervened in the decision-making process of management. Rather PTO and utility management have been asked to provide only a general justification that the investment program it has developed is a reasonable one. Other investment options that were considered, and the engineering cost analyses associated with them are not part of the justification. However, under rate of return regulation based on accounting information, utility investments in facilities that were not "used and useful" in the supply of public utility services could be deducted from the investment base on which the utility was allowed to earn a rate of return. The prices for utility services were to cover only the costs of investments used and useful in providing service.

Traditionally regulators have been much more concerned about the real world efficiency of the investments actually made by public utilities than the basis by which utility management made their investment decisions, or the alternative investment possibilities management rejected. Indeed, this has been the traditional dividing line between the prerogatives of management and the limits of regulatory power and responsibility. Management evaluates the alternatives and makes the investment decisions. Regulators do not interfere with PTO management decisions, but hold the PTO accountable based on its record of actual performance in the marketplace.

2.3 Economics

The economic approach to costing is principally concerned with the optimal allocation of economic resources in society. The economic theory is addressed to explaining the conditions under which this optimal resource allocation can be achieved in a market system. The overall structure of market prices for goods and services will determine the choices consumers make as to what they would prefer to buy, and the choices suppliers make as to what they would prefer to supply. The objective is to find the particular structure of prices that will provide the maximum satisfaction of consumer demand in society from the limited, scarce economic resources in society.

As this is a fairly large societal problem, the economic theory must make some fairly large assumptions. Some of the most significant are the following,

1. conditions in society are frozen at a moment in time so that nothing can change except what the theory specifically chooses to allow to change. Thus the economy is closed and the analysis is static. It does not permit time to pass;

2. everyone has perfect knowledge, i.e., perfect information, not only about his or her own demand or cost conditions, but also about everyone else's. This enables everyone to make perfectly informed rational choices;

3. there is a satisfactory distribution of income in society so that all the individuals have sufficient resources for their needs to be expressed as legitimate consumer demand, i.e., supported by an ability to buy in a marketplace.

As all potential suppliers of goods and services have perfect information about the most efficient way to produce any particular quantity of all possible goods and services, they do not have to confront the problems of engineering cost analysis which attempt to determine the most efficient way of supplying specified quantities of output. Similarly with perfect information of both demand and supply conditions, in a static market in which time does not pass, there is no need for accounting analysis of actual experienced costs, or for comparisons between forecasted and actual costs. The economic theory is only addressed to comparisons of alternative possible output levels and prices at a moment in time and the conditions for selecting an optimal arrangement.

The economic theory demonstrates that the optimal arrangements of supply and demand in this artificial economy can only be achieved by examining all the possibilities for making changes in the production of all possible goods and services, to see if more consumer demand can be satisfied. If a consumer would be willing to pay a price for something that is equal to, or greater than, the additional cost of producing one more unit of some good or service, i.e., the marginal cost of that specific unit, then it should be produced. From a societal perspective its production would increase consumer satisfaction, and therefore society's economic resources would be allocated with improved efficiency. All possible marginal changes in the production of all possible goods and services must be examined until the structure of output in the economy maximises the consumer demand that could be satisfied.

The theory then demonstrates that this optimal arrangement for society can occur only under conditions of perfect competition, a market structure where no firm produces a significant portion of the output in any market. The entry or exit of any firm in any market would have no impact on market conditions. Firms could exercise no influence over the market price, but could only change the quantity of their outputs so as to maximise profit at the prevailing market price. This would be determined by the aggregate supply and demand conditions created by a multitude of individually insignificant consumers and suppliers. If a firm supplying a good or service in any market had enough market power to influence the market price, then this "distorted" price signal would result in consumers making different, non-optimal choices. This is illustrated in Figure 1. Overall market supply (SS) and demand (DD) conditions determine the market price (P_M) and quantity produced (Q_M). The competitive firm accepts the market price and increases its production to the point where the marginal cost (MC) of its last unit produced (Q_F) equals the market price. At this output level the firm's profits are maximised. But since there is perfect competition, profits are restricted to a rate of return equal to the firm's cost of capital, which is considered part of its total economic cost.

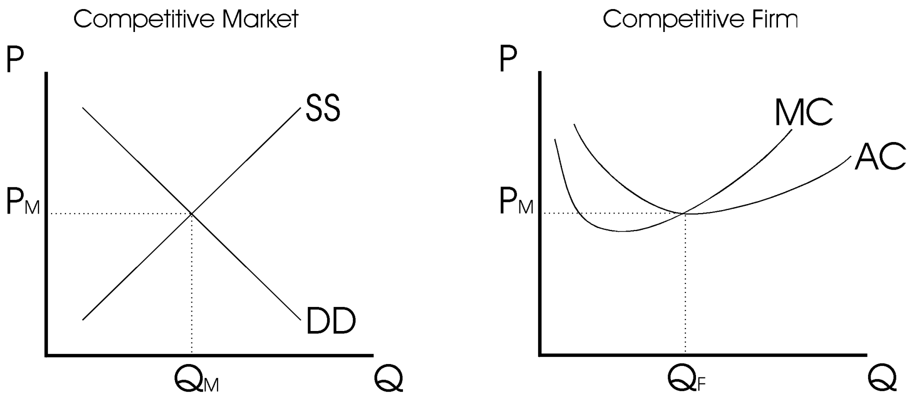

Figure 1 **– Theoretical perfectly competitive markets**

Each marginal cost is calculated by taking the difference between the cost of the most efficient way of producing one level of output, say X, and the most efficient way of producing a marginally different level of output, X+1. There will be a different marginal cost for each unit of output a firm considers it might add to its production. After examining all the different marginal costs associated with all possible production quantities or output levels, the optimal output level can be selected. But the competitive firm does not set its price equal to the marginal cost of the last unit to be produced. It does not set its price at all. Rather it can only select its level of output. Given the price, the firm will maximise profit by producing up to the output level where the marginal cost of its expanded production has increased to the point where it matches the market price. The marginal cost of the last unit of production of all competitors is the same and is equal to the market price. In the theory it is not necessary for a firm to undertake any cost studies. Not only are all costs known by assumption, but one need only observe the market price to identify the marginal cost of the last unit of production for all competitors.

Problems arise with the theory under conditions of extensive and continuing economics of scale where a single firm can produce enough output for the whole market at declining unit costs. Competition is no longer the optimal market structure as the end result of competition will be monopoly. There is no competitive market price that can determine the firm's production level, and the marginal cost of additional production will remain always below the firm's average cost over the entire range of possible production. This is illustrated in Figure 2, and in the past often has been claimed to be illustrative of the conditions of public utility natural monopolies, including telecom.

If a profit maximising price (P_1) is set by a natural monopoly, monopoly profits will be realised. If the price (P_2) is set equal to average cost (AC), total costs will be covered, but consumers willing to pay a price equal to the marginal cost (MC) of additional production will be denied service. If price (P_3) is set equal to MC, the conditions of optimal efficiency are satisfied but the firm will not recover its total costs. It will suffer losses, not be capable of reinvestment and eventually be forced into bankruptcy, and then there will be no production at all. Recommended solutions to this problem have ranged from public ownership with government subsidies to permit optimal marginal cost pricing, to average cost pricing, to a range of systems for adding differential price mark ups to a variety of marginal cost estimates so that total costs would be recovered from a structure of optimal differential or discriminatory prices.

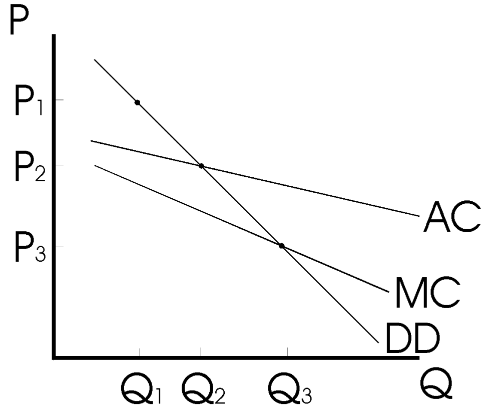

Figure 2 **– Theoretical natural monopoly market**

However now that telecom markets are presumed to be potentially competitive, then the theoretical marginal costs of PTOs must be presumed to increase to their average costs at efficient levels of production. As there are no independently determined market prices in the telecom services sector, according to the theory, if PTOs set their prices equal to marginal costs of the last units of production planned for each service provided, these prices should be at or above the PTOs average costs.

The difficulty with attempting to implement the cost concepts used in the economic theory of efficient resource allocation is that they are artificial constructions, constrained by the heroic assumptions of a very specialised and limited theory, with only a very indirect relation to real world problems. It is unrealistic for firms to plan around marginal, i.e., single unit changes in output, so larger changes, i.e., increments, must be used. The size of the output increment can vary from relatively small to the total output of the firm, where the incremental cost per unit of output becomes the firm’s average cost. Incremental costs will vary significantly with the size of the output increment selected. In every case the incremental costs are calculated by comparing the estimated costs of producing most efficiently at two different potential output levels. Obviously the firm can only actually produce at one of them.

Thus, the calculation of any incremental cost depends entirely on the estimated cost of an alternative output level that the firm will not produce. There can of course be many of them. Although these incremental costs may be of value to management in helping to formulate its judgements on the firm's planned production levels, these incremental costs have no necessary relation to the forecasted or actual costs of producing any particular output level. Thus there can be an enormous number of incremental costs. They are all subjectively determined and none of them can be compared with any measure of actual cost. One can never know whether one's estimate of incremental cost was correct, or how good the estimate was. As a result, in any contested situation, e.g., an interconnection negotiation, or a debate over reasonable consumer or competitive service prices, all parties can estimate incremental costs that support their particular interest. Thus, the usefulness of the concepts of marginal or incremental cost from economic theory as guidelines for accountable management, or for regulatory authorities, is extremely limited. Even the theoretical average cost concept has no necessary relation to the actual average cost of a firm operating in real markets.

The economic theory also assumes away the most fundamental issues that have affected PTO costs in recent years. The telecom reform movement has been addressed primarily to improving the efficiency performance of national PTOs toward the standard of world's best practice. Corporatisation, privatisation and competition policies have been directed to that purpose. The RPI-X method for regulating prices is directed to that purpose. The enormous cost improvements that have been achieved in many PTOs are all steps that bring them closer to world's best practice. Ironically, in economics these improvements have been labelled "X efficiency", which is separate from and outside the theory of resource allocation efficiency. The economic theory assumes the PTO has perfect knowledge of, and is capable of instantly implementing world's best practice costs for every possible output level, and the only problem is selecting the output level at which it will produce.

In most developing countries, the PTOs have serious problems in attempting to achieve operating efficiency standards, have long waiting lists of potential subscribers who cannot be served and an overwhelming need for investment capital and new skills. The theory cannot help. In all telecom markets, new technologies are changing the actual cost structures of PTOs, competitors, VAS suppliers and other operators every few years, as these firms seek to cultivate potential new consumer demands. The economic theory assumes away the issues that characterise dynamic competitive markets, including technological change and new market demands. Although the theory supports competition as the preferred market structure, it does so not on the grounds upon which telecom competition is actually taking place, i.e., improved operating efficiency, changing consumer demands and new technologies, but rather on the narrow technical grounds of static resource allocation in a closed economy. J. M. Keynes summarised the limitations of the theory a long time ago as follows:

> Our criticism of the accepted classical theory of economics has consisted not so much in finding logical flaws in its analysis as in pointing out that its tacit assumptions are seldom or never satisfied, with the result that it can not solve the economic problems of the actual world (1936, p. 378).

A theory that assumes perfect knowledge and only allows the price and quantity of goods and services to vary can have only limited applicability to real world problems. Nevertheless some important concepts and ideas have been drawn from the theory. First, prices for particular goods and services should cover the costs their production imposes on society, i.e., the idea of cost causation and attribution. Second, a competitive market system is likely to bring about a more efficient allocation of economic resources than other market arrangements. It increases the choices and opportunities of both suppliers and consumers in seeking improved production arrangements and increased consumer satisfaction. Third, in making resource allocation decisions, optimal decisions comparing alternative output possibilities can only be made by looking at the incremental conditions, i.e., the costs that would be added or subtracted by specific incremental changes in output.

Despite the extreme limitations of the economic theory of cost, it has had some beneficial effects on ways of thinking about costs, and as a basis for critiquing the weaknesses and limitations of cost analyses in accounting, management and engineering. The concept of opportunity cost, i.e., evaluating the cost of producing something in terms of the best alternative use of the resources, can be adapted for useful application in a number of practical applications in both accounting and engineering cost analysis. The emphasis on cost variability and incremental cost relationships has helped promote deeper examinations of cost characteristics than accounting and engineering analyses traditionally have provided. The emphasis on consumer demand as a factor that influences costs in many of its applications is another important contribution.

Equally important for regulators today is the fact that the terminology of economic theory, and in particular "incremental cost", has been widely adopted to describe a mind-boggling array of different cost concepts and methods that are being introduced into the field of telecom regulation. It is as if use of the term "incremental cost" as a label is sufficient to justify any cost study and to allow a claim to be made that efficient resource allocation in telecom, if not the whole economy, will be promoted if it is accepted. In fact, few of these "incremental cost" studies even attempt to measure the static "output increments" of economic theory, which is probably just as well given the limitations of the theory and the dynamic efficiency considerations that are driving the telecom reform process. In reality, nearly all incremental cost studies use the accounting classifications of expenses and facility investments and then attempt to apply incremental analysis in selecting, assigning and allocating costs.

For the most part, studies of telco incremental costs have been submitted to regulatory authorities by telcos or large business users to justify low or reduced prices for potentially competitive business services. The particular incremental analyses being applied calculate costs that are almost always lower, and sometimes significantly lower than the actual average costs of supplying the services. This raises issues of whether such prices are anti-competitive and/or whether some of the costs of these special services are being cross-subsidised by the monopoly basic telephone service. The only way to find out is to undertake a detailed examination of the cost methodology and data sources used to calculate the costs of the different services.

To summarise, both the economic theory of cost and engineering cost analysis can help management make its best judgements about the firm's production and output levels by facilitating comparisons among alternative possibilities before decisions are taken. Accounting cost analysis can assess the experienced actual cost of decisions after they are taken and provide a foundation for forecasting future costs. Each approach to costing can contribute to an improved understanding of costs and facilitate improved decision-making by telco management and telecom regulators.

3.0 Concepts in Cost Analysis

Cost analysis in telecom is directed toward understanding the more detailed cost relationships in a firm's operations. It attempts to identify cost characteristics which will facilitate pricing, investment and other resource allocation decisions by the firm. It attempts to estimate the costs of particular services and provide a foundation for cost-based pricing. Without detailed cost analysis there can be no cost-based pricing.

The basic principle behind all cost analysis is to identify the causal relations between the output of particular activities or services and the costs necessary to generate that output. Since telecom provides many different services over the same physical network, the identification of cost causality can be complex, as it is in other major industries characterised by multi-product and multi-service operations. Thus direct assignments of costs-to-service categories are often not possible and studies of special cost relationships are necessary to provide a basis for cost allocation across the services that are causing the costs to be incurred.

In the conduct of cost studies, a wide variety of concepts and methods are employed. Some of the concepts commonly used in telecom cost analysis are briefly reviewed here in light of the experience of regulatory agencies which have attempted to apply them to estimate costs as a foundation for judging the reasonableness of prices.

3.1 Actual, Forecast, Hypothetical

The discussion earlier in this chapter distinguished among,

1. the focus of accounting on *actual* costs, which can provide a basis for forecasting future costs;

2. the focus of engineering on *forecasted* costs under different possible expansion plans;

3. the focus of economic theory on an array of *hypothetical* forecasted cost differences, i.e., marginal or incremental costs.

It is important to distinguish the particular type of cost analysis being undertaken. Actual costs require a critical examination of the methods for assignment and allocation of the recorded costs. Forecasted costs require a critical analysis of the basis for forecasting, the incentives of the forecaster, and the significance and consequence of forecasting errors. Hypothetical costs require a critical examination of the assumptions underlying the calculations and their relevance to the problem at hand, the incentives of the party doing the calculations and the significance and consequence of errors. In telecom cost analysis, all cost studies employ assignments and allocations as well as assumptions. However, the results of studies of actual costs are likely to be more sensitive to the criteria adopted for cost allocation. Engineering costs will be more sensitive to the forecasting parameters. Hypothetical incremental cost study results will be more sensitive to the assumptions underlying the hypothetical calculations.

3.2 Fixed, Variable, Incremental

One of the first distinctions made in cost analysis is the division of a firm's total costs between fixed and variable costs. Once investment has been made in the physical infrastructure of a telecom network, costs have been committed to the creation of capacity that will last for many years and can provide communication for many different services. Whether or not the capacity is used, the costs of creating the capacity have been incurred. They are fixed. They were variable before the investment was undertaken, but fixed after it was committed. The variable costs are those that are directly related to the production of services on the network, e.g., costs which increase as the volume of output increases. The idea of incremental cost (although not the same concept as defined in economic theory) can be applied to recognise that the rate of variation of the variable cost may change as output increases. For example, if there is considerable excess capacity, the variable cost per unit of output may be quite low, but as the volume of output increases toward capacity, it may be much higher. Incremental cost estimates would identify the variability of particular cost elements over a specified increase in output.

The extent of cost variability varies depending upon the circumstances and the particular problem under analysis. Economic theory distinguishes between a short run planning horizon when capacity is fixed and therefore not part of variable cost, and a long run planning horizon when all costs are variable, i.e., the firm's investment decisions in capacity are still flexible; the capacity can be varied as the investment decisions have not yet been taken. The variability of the planning horizon can be dictated by market conditions or can be determined by the firm's management, depending upon the circumstances. In economic theory a short run planning horizon will be characterised by fixed and variable costs. In a long run planning horizon, all costs are variable.

In reality, of course, a firm's costs do not fall neatly into fixed and variable categories. Fixed costs often have a degree of variability and some variable costs may be only semi-variable. Moreover costs may be fixed with regard to one measure and variable with regard to another. For example, transmission or switching capacity may be fixed over time, i.e., for many years into the future, but variable across different services, i.e., it can be easily transferred from one service to another. In addition, fixed, variable and incremental costs are generally analysed in terms of some measure of the output units they contribute to providing, e.g. lines, circuits, calls, minutes, bandwidth, etc. Some costs may be fixed with respect to some measures of output, e.g. calls and variable with respect to others, e.g. lines. Most cost analysis develops a variety of average cost per unit measures to apply in the cost estimation process, e.g. average fixed, average variable, average incremental, average total cost, etc. It is important that these unit costs be representative of the activities they are attempting to measure and they not be applied outside their limited range of applicability and relevance.

3.3 Direct, Indirect, Overhead

Costs are often classified between direct and indirect costs, especially in estimating the costs of particular services or activities of the firm. Direct costs are associated specifically and solely with a particular service and can be directly assigned to that service. Indirect costs are those that have a causal relation to an activity or service, but the relation is indirect and must be studied to determine what the specific relationship is. Indirect costs usually must be allocated. For example, the costs of data modems and international telephone operators can be directly assigned to the data services and international telephone services respectively. However, transmission system maintenance costs are related to transmission systems, which provide the capacity for both data services and international telephone services. The provision of each service requires transmission capacity, which in turn requires maintenance. Maintenance is an indirect cost of each category of services.

If total costs are divided between direct and indirect costs, there may be some costs where even an indirect cost relation cannot be readily identified. These are generally called overhead costs. They are considered to be necessary and legitimate costs of supplying all services collectively, but not assignable or allocable to any services in particular. The company president's office is often cited as an example. Although some company presidents may be disturbed to learn they make no identifiable contribution to any revenue-producing service, the logic is that if a basis for allocation on a cost causation basis cannot be found, a cost allocation cannot be made. Additional responsibilities for generating revenue may be distributed across the different service categories to ensure company profitability targets are met, but it is important to distinguish between cost causation and additional revenue generating responsibilities that are not based on cost causation.

Direct and indirect costs may be either fixed or variable. Overhead costs are normally fixed, since if they varied with output, a causal basis for allocation to services should be evident. They are normally a very small proportion of a firm's total cost.

3.4 Common and Joint Costs

There are two concepts of common cost that arise in the theory and practice of cost analysis. In economic theory the difference between the marginal cost of the last unit of production and the average cost per unit is the common cost per unit. But marginal cost is less than average cost only under conditions where internal economies of scale for a single firm extend for the entire market, as illustrated in Figure 2 above. Competition can not exist. If competition can exist, internal economies of scale will be exhausted and there will be no theoretical common costs. Marginal cost per unit will be at least equal to average cost per unit. But given the artificial nature of the theory, it is very rare that cost studies attempt to apply the theory. So this issue seldom arises in real world cost studies.

The more widely understood use of the term "common costs" comes from accounting and management cost analysis and refers to the cost of something that is shared among different activities or services. For example, transmission costs are common to all the services that use and share transmission capacity. The degree of use by any particular service can and does vary from time to time. In telecom networks, there is a very high proportion of common costs, but most of these costs are fungible, i.e., highly substitutable, with other services. The core component of all services is communication signals of many different services being transmitted over a common telecom network. Because of the high degree of substitutability of network capacity among the different services, the same unit cost calculations are generally applicable for all the services sharing the common facilities or activities.

If conditions of joint production or joint supply exist, then the production of one service *requires* that another be produced at the same time, usually in a relatively fixed proportion. These services are perfectly not at all substitutable. In telecom there are joint costs among different time periods. The creation of capacity to meet demand at the peak period automatically creates the same capacity for off-peak periods. Peak capacity and off-peak capacity are not substitutable. Thus the cost of usage at peak periods is relatively high because that usage causes further investment in additional capacity to be undertaken.

The cost of usage during off-peak periods is relatively low because it uses capacity that would otherwise go unused. Cost studies applying the cost causation principle recognise this in the cost assignments and allocations.

However difficulties can arise if demand patterns are changing. Many years ago when AT&T introduced its low off-peak prices for long distance calling after eight PM in the evening, it stimulated so much usage that a number of local exchanges experienced peak demands between eight and nine PM. At the present time, the rapid growth in Internet usage is shifting peak/off-peak relations in some local exchanges in the US, and the growth of international traffic and global networks increasingly allows peak demands in one region to be met using off-peak capacity in other regions. Thus, the significance of joint costs may be declining. In telecom, cost causation must be examined in its dynamic context.

3.5 Cost Causation and Information Sources

In an industry with complex cost relationships, such as telecom, the quality of the cost analysis that can be done is heavily dependent upon the information sources. In the real world, cost causation is often a function of how hard one wishes to look and how much detailed information is available. If information systems are designed in advance to isolate detailed information, then more direct assignments of costs can be made and fewer allocations are required. Allocations in turn will have a stronger and more precise foundation, as will forecasts used in making engineering and economic estimates.

In telecom, the complexity and arbitrary allocations that have characterised some cost studies have arisen, in significant part, because detailed information systems were not used and the incentive of the telco to identify cost causation was very weak. For example, when AT&T and the Bell System operating companies first began doing cost of service studies for the US state and federal regulatory commissions in the 1960s and 1970s, more than 20 percent of costs were categorised as unallocable overhead. After a decade of critical analysis by regulatory commission staff members and intervenors in regulatory proceedings, and some improvements in the telco information systems, the unallocable overhead was reduced to about two percent of total costs.

Careful attention should be given to the design of the detailed information systems which will enable the highest quality cost studies possible. This will head off many debates over cost study methodology, cost allocation methods and the adequacy of particular information. If cost-based pricing is to be the key standard for implementing competition policy, it is essential that the cost estimates be as accurate as possible.

4.0 Network Cost Characteristics

Cost trends in the telecom industry have been reviewed in Chapter 9. Certain key characteristics of telecom network costs are examined here with respect to their influence on the application of different cost concepts to telecom network services. Whereas in some industries there is a direct relationship between the incurrence of costs and the supply of particular goods and services, in the telecom industry the relationship is often complex, requiring a more sophisticated analysis to identify the particular services causing and benefiting from the incurrence of costs.

4.1 Interdependence of Network Components

The very nature of a network is that its components are interdependent. Each component is dependent on the others in order to function effectively, whether it is different types of transmission equipment, switching machines, local exchange systems or terminal devices. Thus the requirements of one part of the network often impose costs on another part. This is especially evident when the network is upgraded and more advanced services introduced. For example, the introduction of long distance calling required a very costly upgrading of the local exchange facilities, including the local switching capability, the quality of local cable and wire, the size of local telephone poles and the technical sophistication of the telephone. Later, when automated direct distance dialling was introduced for long distance calls, the major investment required was a very costly improvement in local switching capabilities. If one is examining cost causation on a telecom network, it is apparent that any particular service may impose costs across many segments of the telecom network.

Of particular importance is the cost of the local exchange facility system. As all services must originate and terminate in a communication terminal somewhere, and a major portion of the cost of all services is in the origination and termination of the communication signals, it is not surprising that a major portion of costs for all services is in the local exchange. In the early days of telephony, the local exchange was synonymous with local telephone service. There were no other services. But over time the local exchange has become the most important multi-purpose component of nearly all telecom services. Its costs are common to the increasing variety of sophisticated telecom services now being provided over the local network. The requirements of local telephone service have not determined the design, investment or cost structure of the local exchange for a very long time.

This raises important issues for cost analysis. Many telcos have tended to retain the now obsolete view that the local exchange and all its costs are associated entirely with local telephone service. Under this view long distance and other more recently added services are simply additions to the core local exchange network. If long distance services are assigned only the transmission costs of their communication, a majority of the costs these services impose on the telecom network are not being identified with the service that is causing them. If all, or even a majority of local exchange costs are assigned to local telephone service, the costs of this basic unsophisticated service will be greatly overstated and continuously driven up by the local exchange improvements required to provide the more sophisticated services being added to the network. Many telcos continue to use the old simplistic cost analysis that assigns local exchange costs to local telephone service, thereby concluding that long distance, international and new business services are earning high rates of profit and are subsidising basic local telephone service. This view has provided the cost evidence for the “rate rebalancing” programs implemented in some countries.

Whether such a subsidy exists or not in any country depends on a more detailed and sophisticated analysis of local exchange costs, which are common to all network services, to identify the factors causing their incurrence. To date, most PTOs and LECs have shown a distinct lack of interest in knowing the real characteristics of cost causation in the local exchange. With competition now coming into the picture, the incentive to find out will increase. Such information is needed by both PTO management and regulators. It will directly affect judgements about reasonable prices for monopoly local telephone services, as well as cost-based pricing for interconnection to the local exchange by competitors.

Cost causation on the local exchange is especially important in the new era of upgrading the telecom network for future information society services. A major portion of the investment in the information superhighway is in the local exchange. Perhaps the greatest single investment component being considered by many telcos is replacing the current copper wire to the home, which is already more than adequate for local telephone service, with a fibre cable that will provide an enormous increase in capacity so as to accommodate future interactive video and other information services.

If the traditional monopoly telco approach to assessing the increased costs of the new upgraded local exchanges is applied, then the vast majority of these upgrading costs will be allocated to consumers of local telephone service in the form of increased access and/or usage charges. Yet if one examines the causes of cost incurrence in upgrading the technical capabilities of the local exchange, clearly the requirements of local telephone service are not one of them. Local telephone service is rapidly becoming a by-product on a local exchange telecom system designed entirely for other more sophisticated and more costly services. The incremental cost of adding local telephone service to a local exchange network designed for long distance telephone and information services is extremely low and declining in significance with each passing year. Yet local telephone service still provides the majority of telco revenues. Clearly, if cost is to be a guideline for establishing prices for the increasing variety of different services that use the local exchange, i.e., almost all of them, then a detailed analysis of cost causation in the common local exchange will be essential both for telecom managers and regulators. The sooner this challenge is taken up, the better.

4.2 Economies of Network Expansion

Telecom networks are being expanded to a larger portion of the population in nearly all countries, both developed and developing. This includes not only the expansion of basic voice telephone service to meet national universal service objectives, but also expansion of new service networks to provide access to information services, the Internet and other VAS. The development of different network services in different countries is at different stages of diffusion across the potential user population. In examining the costs of network expansion for any service, it is important to recognise that communication network capacity and costs do not expand uniformly, or in linear fashion, especially for interactive services such as voice telephone, fax, e-mail, etc. This can be demonstrated by the following illustration.

In all interactive networks, calling opportunities are determined by the combination of subscribers who can initiate calls, and subscribers who can receive calls. A ten percent penetration rate of households, or of the potential market for a new interactive service such as e-mail, will permit only one percent (10% x 10%) of the potential network calling opportunities, as 90 percent of the participants can call neither one another, nor the ten percent who are connected to the network. At 50 percent penetration, 25 percent of the potential calling opportunities are possible. At 90 percent penetration, 81 percent of the potential calling opportunities are possible. As the network is extended, the expanding (i.e., incremental) calling opportunities increase at a rate more than twice as fast as the network expansion rate. This is illustrated in Table 1. For every one percent increase in network coverage, there will be an increase in calling opportunities greater than two percent. At early stages of network development, when the penetration or diffusion rate is low, the calling opportunity multiplier will be even higher.

		Change With Growth		
Household or Market **Coverage (%)**	Calling Opportunities **(% of Total)**	Household or Market Coverage **(% Increase)**	Calling Opportunities **(% Increase)**	Calling Opportunity **Multiplier**
10	1	–	–	–
20	4	100	300	3.0
30	9	50	125	2.5
40	16	33	78	2.3
50	25	25	56	2.3
60	36	20	44	2.2
70	49	17	36	2.2
50	64	14	31	2.1
90	81	12	27	2.1
100	100	11	23	2.1

Table 1 **– Economies of network expansion**

This is enormously significant for assessing network capacity, incremental costs, growth rates and potential benefits. If customer calling opportunities are used as an indicator of network size, capacity, or potential output, then there are significant network economies in adding customers to the network. If those being added to the network have similar calling characteristics to those already on the network, in a representative situation the additional, or "incremental" cost per additional customer calling opportunity is less than half the average cost. Therefore, twice the average cost per connection could be incurred to extend the network to new customers without increasing the average cost per calling opportunity. Twice the average customer cost would bring twice the average calling opportunity benefit for the network as a whole. Moreover the benefits of the expansion are primarily realised by those already on the network who now can call the new participants on the expanded network. The new participants who contact the established participants will receive the same benefit per subscriber, but a much smaller aggregate benefit. The majority of the new revenues generated on the network as a result of the additional subscribers will be identified with those who were previously part of the network.

This has great significance in analysing the costs of network extension to achieve universal service. The unit costs of network extensions can be more than twice the PTO average costs per customer before high cost subsidies need to be considered at all. The incremental revenue benefits to the PTO will be much greater than the charges billed to the additional subscribers, as there will be increased calling by those already on the network to the new subscribers. When this is combined with the fact that rural and remote area subscribers generally use the network at a higher than average level and incur even higher charges due to the much greater proportion of long distance use, several times the average customer extension cost can be justified on a cost recovery, if not profitable basis, when a network wide analysis is undertaken. Indeed this has been demonstrated in a number of countries, perhaps most notably in Alaska, and helps explain why universal service need not be a significant subsidy issue in most countries.

This analysis also has significance for the design of rate structures, most particularly the use of customer access charges. Customer access charges can be a barrier to customer connections to the network, although this may stimulate usage by those already on the network because of lower usage charges. If there are no access charges, the network will have more customers join, and experience more rapid network diffusion. Usage charges may be higher, but with declining unit costs as a result of this more rapid diffusion, this will not necessarily be so. Whether the service is universal telephone service, Internet service or other new VAS services, customer access charges that restrict network diffusion are economically inefficient. Network incremental costs should be estimated as a reference point for judging the reasonableness of consumer access charges, the achievement of universal service objectives and the significance of any universal service obligation (USO) subsidies.

It should perhaps be noted that the significant economies of scale in network development are economies of the network, not of any individual telco. They are internal to the network and the market, but external to any particular firm. Achievement of these network economies depends heavily on effective interconnection among the competitive and cooperative suppliers of network services. It illustrates the significant economies and benefits to be achieved from seamless national and global telecom networks

5.0 Cost of Service Applications in Telecom Regulation

Over the past 30 years there have been an enormous variety of cost of service studies submitted to telecom regulators as proposed guidelines for evaluating the reasonableness of maximum or minimum prices charged to consumers, or in more recent years interconnect prices to be charged to competitors. Most of this activity has been in the US and Canada. The newer telecom regulators in other countries have been, are being, or will be required to undertake detailed examinations into PTO costs for providing different monopoly, competitive and interconnect services.

The cost studies submitted to regulators have employed all the approaches and concepts summarised above, often mixed and matched so as to justify the particular interest of the telco, competitor or industry user group putting forward the cost study. As a rule, the telcos normally undertake the initial study and then intervening parties and regulatory commission staff experts make what they believe are appropriate adjustments to it. Occasionally independent studies are undertaken by regulatory commission staff experts or others, but often the cost and delay in obtaining the necessary detailed information from the telco has rendered this approach ineffective or unfeasible.

For the most part, all studies have relied very heavily on analyses of actual costs from the firm's accounting and management information records. If accounting and management cost principles are employed, there is generally an evidentiary basis for the assignment, allocation or exclusion of each element of actual costs in the cost of service calculations. The study methodology and data sources used normally permit both a replication of the study and a review of each step in its development.

Engineering cost analyses have been used only occasionally, but in two different ways. First, to study the nature of cost causation by examining the records of the engineering cost analyses that were used for designing and dimensioning facility investments, particularly with respect to the local exchange. This information was then used to assign or allocate the actual costs of these investments, or the forecasted cost of future investments. Second, engineering costs have been used to forecast the costs of additions of advanced technology facilities that the telco expects to undertake in the near term future. In telecom, these forecasted costs are normally lower than the actual accounting costs for the same capacity because of improving technology, and generally are used to calculate lower costs for competitive services, but not monopoly services.

Because the economic theory of marginal cost is such an artificial theoretical construct, attempts to measure it in a real world situation are rare. Rather the ideas from the theory are used to influence the selection, valuation, assignment, allocation or exclusion of actual or forecasted costs for particular services. In practice, incremental costs usually have meant the application of a cost methodology for arriving at cost estimates that are lower than the actual costs for potentially competitive services. Certain cost elements (e.g. some fixed or common costs) may be excluded entirely; other cost elements may be assigned a lower value (e.g. a future cost estimate); or the service under examination may be assumed to be in a privileged position on the network (i.e., use idle capacity, or always be able to use facilities at full capacity). However, now that competitive interconnection prices are to be cost-based, new interpretations of incremental cost are being tested by the RBOCs and PTOs. This Section illustrates the main approaches to cost of service analysis that are being used or considered by telecom regulators.

5.1 Rate of Return on Investment

The most frequently used methodology for estimating the costs of the major categories of telco services has distributed the actual costs from the accounting and management information systems across the different services for the most recent test year. As revenues are readily identified by service category from billing records, income and rate of return calculations can be made for each service category. This kind of study is most generally referred to as a rate of return on investment or fully distributed cost study. It attempts to assign or allocate all the actual costs across all of the services.

The results of the first comprehensive cost of service study done by AT&T for the FCC are summarised in Table 2. Although the FCC standard for a reasonable overall rate of return for Bell System interstate services at the time was 7.5 percent, which was also the rate actual earned in 1964, the monopoly public telephone services earned 10 percent and 10.1 percent, while the potentially competitive services earned significantly less than AT&T's cost of capital. These study results indicated that the prices for the monopoly services should be reduced and the potentially competitive services should be reassessed so they could earn higher rates of return through price increases or restructuring. AT&T then pointed out the limitations of fully distributed cost studies (i.e., historical costs with arbitrary allocations), and argued that the appropriate cost standard for judging competitive services was incremental cost. It submitted a new cost study showing that the potentially competitive service revenues were covering their incremental costs, and suggested the monopoly telephone services be priced so as to recover AT&T's residual revenue needs so it would earn its allowed overall rate of return on investment.

Service classification	**Rate of return (%)**
Message toll telephone	10.0
Wide area telephone service (WATS)	10.1
Teletypewriter exchange service (TWX)	2.9
Telephone private line	4.7
Telegraph private line	1.4
Telpak	0.3
Other (mostly video transmission)	1.1
Total all services	**7.5**

Table 2 – **Rate of return on net interstate investment, Bell System, by principal service categories, year ended 31 August 1964.**

Source: AT&T Exhibit 81, Attachment A, p. 4, FCC Docket 14650, as cited in W.S. Bolter (1978)

The FCC has required AT&T to submit periodic cost of service studies calculating the rates of return being earned on four broad classes of interstate long distance telecom services during most of the period it considered AT&T a dominant carrier. Some US state regulatory agencies require the BOCs and other LECs to file cost of service studies calculating rates of return for major service categories periodically, or as part of rate increase or restructuring applications. However, many states employ other cost standards as well.

5.2 Embedded Direct Analysis

In the 1970s when many US state regulatory authorities began requiring the Bell Operating Companies (BOCs) to file rate of return cost of service studies, the BOCs introduced a new kind of cost of service study, Embedded Direct Analysis (EDA). This study methodology used the same accounting and management information of the company's actual costs (i.e., "embedded" in the accounts), but only assigned these cost elements to services that could be directly associated with the different service categories. Common local exchange costs that did not vary directly with usage (i.e., access costs) and common management and overhead costs (i.e., common costs) were not allocated to services. Revenues for each service category were then compared with their respective direct costs. The BOCs argued all services should contribute revenues greater than their direct costs, but the proportionate contributions of revenue above direct costs to cover the access and common costs should be decided by company management.

An illustration of EDA study results is provided in Figure 3 for services provided by Pacific Northwest Bell for the state of Oregon for 1979. Direct costs assigned to the different service classifications represented about 57 percent of total costs. Ratios of revenues to direct cost are calculated for each service and illustrated on the chart. For example, local exchange service contributed revenues that were 2.26 times its direct cost, interstate long distance service 2.46 times its direct cost and state leased lines. 0.78 times its direct costs. The company's total costs, including its cost of capital were 1.75 times the sum of the direct costs of all the services.

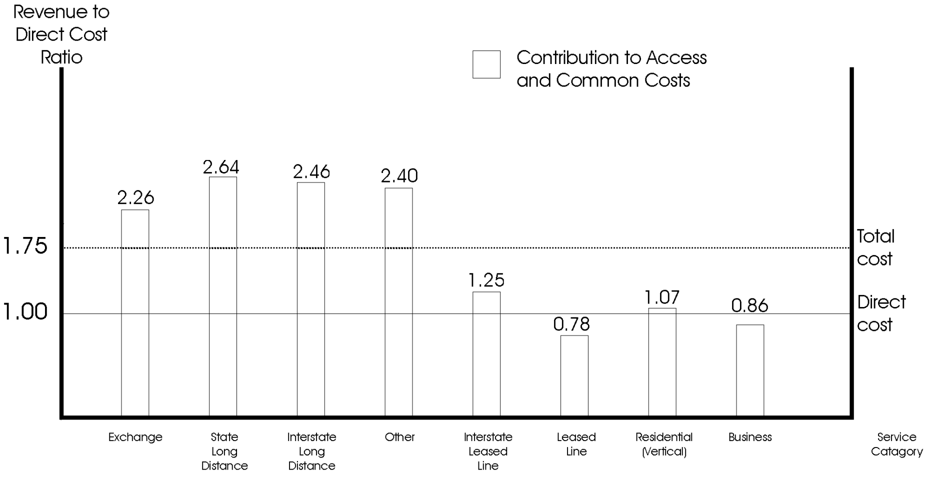

Figure 3 **– AT&T operating company comparison: EDA, Oregon, 1979**

Residential and business vertical services were primarily special terminal equipment and enhanced service components that the BOCs argued should not be expected to contribute revenues significantly in excess of their direct costs because they were not really network services. The other services were all network services, with leased line services being subject to potential competition.

Although the EDA cost study methodology and results were not adopted by regulatory agencies as standards for judging reasonableness, the studies did contribute to an understanding of telco cost characteristics. The direct cost standard may have been a weak standard for judging the reasonableness of prices for different service classifications, but it was a clear and unambiguous standard that avoided traditional disputes over cost allocation and used the same accounting and management actual cost information that the BOCs claimed as appropriate for judging the reasonableness of their overall profit levels. Certain decisions could be taken on the basis of this information. Other decisions would require a more sophisticated analysis of cost causation of the exchange access and common costs.

The EDA cost study methodology fell out of favour with the BOCs with the divestiture of AT&T in 1984, and the lack of success of the BOCs in getting state regulatory authorities to accept these studies. Although several more recent BOC cost study methodologies trace their heritage to the EDA, each of the now separate RBOCs and their respective operating companies has followed its own independent course in developing cost justifications for the reasonableness of its pricing proposals to the state regulators in the areas it serves.

5.3 Criteria for Sharing Local Exchange Benefits and Costs

In any telecom network cost study the most challenging problem is identifying cost causation on the local exchange. Although some local exchange costs can be directly assigned to particular services and other costs directly allocated to services on the basis of usage, most local exchange costs, e.g., the subscriber loop network and a major portion of local switching, are considered by telcos to be the core of the access network for all services. Many telcos argue that these access costs should be assigned in total to local exchange telephone service for historical reasons or because this is the largest core service. Others recognise that access costs are common multi-service costs, but claim they are not attributable to any particular services as demonstrated for example in the EDA studies discussed above.

Yet, the telecom local exchange is neither the first nor the last multi-service facility that has required detailed cost analysis of the cost causation of the different services provided over it. The principle of economic cost causation requires that a cost allocation method be developed that will reflect the extent to which each of the services being provided over the common facilities causes the common costs to be what they are. In attempting to achieve this objective, economic theory can help. The opportunity cost, i.e., the cost of the best alternative means of supply of the different services, can provide a good indicator of cost causation. This can be illustrated in the following simple illustration. If the cost of providing a specified quantity of two services, A and B, on a common multi-service facility is $25, while the cost of providing each service independently is $10 for A and $20 for B, then clearly the cost of independent, or stand-alone supply tells us which service is the primary cause of the common cost, and the primary beneficiary of common supply. It is in service B's interest to enter into the common supply arrangement as long as service A would accept more than $5 of the common cost. But it is not in service A's interest to enter the common supply arrangement unless service B would accept more than $15 of the common cost.

An equal sharing of common costs at $12.50 each would provide a $7.50 benefit to B and a $2.50 penalty to A for participation in the common supply option. Obviously, if consumers of service A had a choice, they would not participate in the common multi-service supply arrangement, but would prefer to be supplied independently. But in the telecom local exchange, the different services have no choice. The common supply option has been chosen by telco management under conditions of monopoly supply. The negotiation over the appropriate cost sharing method, i.e., the selection of the cost allocation rule for sharing the benefits of common supply, is coming after the fact.

Illustrations where there is recognition of the opportunity cost of independent supply in other areas can be found in the costing of:

1. highways, which are primarily designed for heavy trucks, not cars;

2. water distribution mains, where the large capacity is designed for fire protection, not household use;

3. multiple purpose river dams which are sometimes constructed for electricity generation, navigation, flood control, recreation and/or irrigation; and

4. multi-product firms competing in markets where efficient competitors are, or can supply each product independently. In highly competitive markets, competition ensures no service is asked to bear more than the cost of independent supply, i.e., its most efficient stand alone costs.

Some telecom regulatory agencies are now undertaking serious analyses of cost causation on the local exchange. As competition increases others will find it necessary to do so.

This approach to local exchange cost analysis is illustrated by an independent study of Michigan Bell for the year 1985 undertaken for the Michigan Research Divestiture Board (Gabel, D. 1991). This study examined the data from the engineering design and dimensioning studies used to plan the local exchange facility investment program, so as to identify the cost causality of the major services for the actual common local exchange costs. Special engineering requirements and functional capabilities for long distance services, high speed data, video services and other enhanced services were identified and associated with those services. Using the engineering design information, the stand alone costs for each major class of service were calculated, based upon the requirements of each class of service. These stand alone costs were then compared with the revenues for each class of service to obtain an indication of the benefits to each service from being supplied on a common multi-service local exchange. For comparison, the ratios of service revenues to average embedded costs and incremental costs also were calculated. The results of the study are summarised in Table 3.

Source Category	Stand-alone revenue (USD m)	Stand-alone revenue (USD m)	Revenue/ Stand-alone cost ratio	Revenue/ Embedded cost ratio	Incremental Revenue/ incremental cost ratio
Local	981	1,179	0.832	2.173	3.662
Long Distance	863	1,506	0.573	1.932	1.871
Leased Line	180	245	0.801	0.936	0.824
Other					0.877

Table 3 **– Michigan Bell Telephone Company: revenue/cost ratios, 1995**

Source: Gabel D., (1991), "An application of stand-alone costs to the telecommunications industry", *Telecommunications Policy,* February, 75-84.

The study results show that in Michigan all categories of service were benefiting from supply on the same common local exchange, but the extent of benefit varied among services. By common supply, rather than stand alone supply, local services provided revenues that were 83 percent of their stand-alone costs, leased line services provided revenue that were 80 percent of their stand alone costs, and long distance services provided revenues that were 57 percent of their stand alone costs. The study concludes that if there were to be a proportionate sharing of benefits among the services, then local exchange service prices would need to be reduced and long distance service prices increased. The comparative study results indicated that revenues from the leased line and "Other" service categories were covering neither their incremental nor their embedded costs.

PTOs in many countries have begun programs of prematurely replacing local exchange facilities with upgraded facilities to supply new enhanced and VAS services. At the same time depreciation charges on local facilities have been increased significantly to reflect increased market risks and technical requirements of competitive services. The easiest solution for telcos is simply to apply these increased local exchange costs to the local exchange telephone service, where the PTOs will retain significant monopoly power for a considerable period of time. If telecom regulators are to be in a position to provide effective regulation of maximum prices for local telephone service, they will have to pay serious attention to identifying cost causality on the local exchange. This will be the most significant future issue for the application of cost-based pricing in telecom.

5.4 Long-Run Incremental Cost (LRIC)

According to economic theory, the production of firms should be expanded until the marginal cost of the last unit of output equals the market price. As the firm must already have invested in capacity in order to produce output, and its cost relationships are determined by the principle of diminishing returns, as variable resources are added to fixed resources, the firm's planning horizon is the short run. The theoretical concept of resource allocation efficiency addresses the problem of efficient short run output decisions, not efficient long run investment decisions. However, economists have attempted to adapt the ideas of the theory to investment decisions by assuming a long term planning horizon where all costs are variable, i.e., there have been no commitments of resources at all.

As investments establish increases in output capacity that are in units both much greater than one, and in varying sizes, the concept of incremental cost has been adopted in practice, instead of the marginal cost concept of economic theory. The concept of long-run incremental cost (LRIC) has been developed as one with more relevance to real world decision-making, although it lacks the theoretical precision to permit any claims about optimising resource allocation even under the artificial conditions assumed by the theory. In practice LRIC is a general umbrella concept that covers a wide variety of concepts and methods of cost analysis. In defining any particular LRIC, decisions must be made with regard to a number of important parameters.

The first issue is defining the output increment. A decision must be made with respect to the specific volume of output that will be assumed to be added to a specifically defined core or base level of output. In some cases the output increment is defined as the forecasted growth in output of a particular service, or of the telco as a whole, over a future period of one year, three years, or some other specified period. The base output level to which the output increment will be assumed to be added could be zero (as implied by the theory), or the actual output levels of the core service, the entire firm, or some other specified level. As there is an almost infinite number of output increments that could be selected, it is extremely important to define carefully the particular costing problem being studied, as well as the precise output increment being measured and its relevance to the problem under examination.

Second, the data source(s) must be selected. In most cases the accounting and management information records provide the basic information source, although sometimes accounting and management information forecasts, engineering forecasts or other economic forecasts are used. It is not unusual for some data to be selected from all these sources, as well as others, for particular parts of the incremental cost study. The incremental cost approach permits the selection or omission of data from any source. This provides the freedom and flexibility to seek the best data possible, but it also means the selection process is highly judgmental and vulnerable to biased selections so as to achieve desired results. It means that if incremental cost calculations are to be useful, there must be a strong justification for the particular data sources selected.

Third, the time period for which incremental costs are being measured must be defined. In most cases incremental cost methods deliberately exclude accounting and management data relating to investments in all past periods except the most recent year or two. For some studies, current costs are estimated by using the actual costs of recent investments in the most current technologies, and then assuming the entire telecom system has been constructed with these newer technologies. This can create a situation where current costs per unit are significantly lower than accounting book costs per unit, but whether it does or not will depend almost entirely on the depreciation practices being applied to the book assets and the assumed depreciation practices for the more current assets. Technological improvements often mean that book costs of certain assets, e.g., old switching machines or transmissions systems, are higher than the current costs of new technologies. But a detailed examination of depreciation sometimes reveals that the old technology assets are almost fully depreciated and have a net book cost close to zero. Moreover, if continued technological improvements are expected in the future, it will be necessary to assume a very rapid rate of depreciation of the investment cost of the new technology, thereby raising its current cost.

If forecasts of future investments in new technologies are used instead of the most recent current investments, the depreciation/obsolescence assumptions remain just as important to the calculations. In this area also, the justification of judgements with respect to the forecasted investment cost data selected, the pace of technological improvement in future periods, and the depreciation/obsolescence assumptions will be important determinants of the cost estimates and the validity of the study results.

Finally, there is the matter of selecting the elements of cost, e.g., maintenance, marketing, administration, R&D, etc., that will be included in the incremental cost study and the cost valuations that will be assigned to each element or group of elements. Under the incremental cost approach, cost elements may be included or excluded and the cost valuations may be drawn from any source. In practice, the cost elements considered for inclusion are normally those listed in the accounting and management records. The cost valuations assigned are normally based on judgements of future costs and estimates of cost variability. In this process, the investment and expense assignment and allocation methods used are similar to those employed in the cost study methods described above.

5.4.1 TELRIC

A recent example of LRIC is provided by the US FCC in its first Order implementing the US *Telecommunications Act of 1996* that opens local exchange services to competition.

(FCC 1996). For this purpose the FCC has introduced a new concept of LRIC that it calls Total Element Long-Run Incremental Cost (TELRIC).

> The Commission has concluded that the prices that new entrants pay for interconnection and unbundled elements should be based on the local telephone company's Total Element Long-Run Incremental Cost (TELRIC) of providing a particular network element, plus a reasonable share of forward-looking joint and common costs. States (regulatory agencies) will determine, among other things, the appropriate risk-adjusted cost of capital and depreciation rates.

The Act provides for three paths of entry to the local telecom market – the construction of new networks; the use of unbundled elements of the incumbent LEC's network; and resale of telecom services. The FCC concluded:

> The incumbent LECs have economies of density, connectivity, and scale; traditionally, these have been viewed as creating a natural monopoly...the local competition provisions of the Act require that these economies be shared with entrants. We believe they should be shared in a way that permits the incumbent LECs to maintain operating efficiency to further fair competition, and to enable the entrants to share the economic benefits of that efficiency in the form of cost-based prices.

The FCC Order concludes that the new Act requires LECs to provide interconnection, as well as non-discriminatory access, to the local exchange network or to network elements on an unbundled basis. This must be supplied to any requesting telecom carrier, at any technically feasible point in the local exchange network, at reasonable prices. The Order identifies a minimum set of five technically feasible points at which the LECs must provide interconnection, and a minimum set of ten unbundled network elements to which the LECs must provide access. It also notes that state regulators may require LECs to provide additional network elements on an unbundled basis.

Determining cost-based prices for network interconnection, and for access to network elements, at every technically feasible point, will require cost analysis of the local exchange at a level of detail far greater than has ever been attempted before by any telecom regulatory agency. For competitors who wish to enter the market by reselling telecom services, the FCC adopts an "avoidable cost" interpretation of incremental cost. "State commissions shall determine wholesale rates on the basis of retail rates charged to subscribers for the telecom service requested, excluding the portion thereof attributable to any marketing, billing, collection, and other costs that will be avoided by the local exchange carrier."

The FCC Order emphasises that the TELRIC cost methodology, which will have to be implemented by the state regulators, must be forward-looking, and that embedded accounting book costs should not be used. The TELRIC of an unbundled element has three components, the operating expenses, depreciation cost and the risk-adjusted cost of capital. Yet depreciation costs are accounting allocations of books costs, and are not normally used in forecasting economic costs. Calculations must be made on the most efficient technology available, but the study must assume the incumbent LEC's existing wire centre locations. "The forward-looking costs directly attributable to local loops, for example, shall include not only the cost of the installed copper wire and telephone poles but also the cost of payroll and other back office operations relating to the line technicians, in addition to other attributable costs." Thus, the physical structure of the local exchange apparently must be assumed to remain as it is. But the cost of it must reflect forward-looking costs, not accounting book costs.

As the Order refers by number and descriptive titles to the specific classifications of assets and expenses used in the accounting records, as well as specific criteria for assignments and allocations of costs, it would appear the FCC has adopted an approach where a traditional accounting cost methodology is applied to forward-looking valuations of all the network components. The FCC does not specify what this forward-looking period should be, but the Order emphasises that the "long run" to be used shall be a period long enough that all costs are treated as variable and avoidable. The increment to be studied "shall be the entire quantity of the network element provided," and the cost study shall include assignments or allocations of all costs, including overhead costs, to the greatest extent possible. In this regard the FCC states:

> Common costs also include costs incurred by the firm's operations as a whole, that are common to all services and elements (e.g., salaries of executives involved in overseeing all activities of the business) ... Given these common costs, setting the price of each discrete network element based solely on the forward-looking incremental costs directly attributable to the production of individual elements will not recover the total forward-looking costs of operating the wholesale network. Because forward-looking common costs are consistent with our forward-looking, economic cost paradigm, a reasonable measure of such costs shall be included in the prices for interconnection and access to network elements.

It is apparent that the concept of common cost that has been adopted is from accounting, not economic theory, but the values of the common costs to be allocated must be forward looking estimates, not actual amounts. The FCC provides advice on reasonable and unreasonable methods for allocating forward-looking common costs to network elements. For example, it approves percentage mark-ups over directly attributable costs, as well as relatively low mark-ups "to certain critical network elements, such as the local loop and co-location, that are most difficult for entrants to replicate promptly (i.e., bottleneck facilities)". It specifically rejects allocating common costs "in inverse proportion to the sensitivity of demand for various network elements and services", and concludes application of the Efficient Component Pricing Rule (ECPR) would be improper because "the existing retail prices that would be used to compute incremental opportunity costs under ECPR are not cost-based."

The FCC TELRIC is a specially designed cost methodology that draws on economic, accounting and engineering approaches to cost analysis. Economics provides the concept of a fully costed, forward-looking increment in service. However, in practice the increment is not an output increment from economic theory, but rather the various elements that make up the local exchange network. Accounting provides the asset and expense information classification system, but not the cost valuations to be associated with them. The cost assignment and allocation methodology is drawn directly from accounting and management cost analysis. In a sense, TELRIC is a traditional fully distributed cost methodology, but it is distributing forward-looking costs, not the actual cost from the accounting and management records.

It would appear that TELRIC does not involve forecasts of an LEC's actual costs in a specific future period, or forecasts of what each unbundled network element is estimated to cost in a future period. Rather, use of the term "forward-looking" seems to refer to a current revaluation of network element costs, as those elements now exist in the actual network. The primary reason for selecting forward-looking rather than actual costs is because new competitors entering the market should incur costs only from their forward-looking decisions, and should not be required to pay costs arising from the past decisions. If an LEC has historical costs on its books for investments in older technologies that are higher than the current costs of new technologies, the FCC (interpreting the new Act) has concluded the LEC should not be permitted to pass on these obsolescence costs to competitors.

This raises questions about the effectiveness of past and current depreciation practices. Proper depreciation should have reduced the net book costs of assets on the books to the level of the most efficient current technologies so that, in theory, accounting and forward-looking costs should be the same. If net book costs have not been reduced sufficiently, the LEC may not be able to recover its actual costs. The LECs have appealed the FCC decision to the Courts on the ground, among others, that the TELRIC methodology denies them an opportunity to recover their actual costs, thereby confiscating their property. However, the LECs also have increased their depreciation rates substantially over the past 15 years. In practice, this may not be an issue, but it will not be possible to tell until the forward-looking costs, including forward-looking depreciation, are estimated. Moreover, when comparing hypothetical forward-looking cost estimates (that must include depreciation costs calculated on assumptions about future technological improvements), with actual accounting costs, it may not be possible to conclude that either one is "right". This problem will arise with respect to other costs as well, as it will be difficult to evaluate the validity of subjective forward-looking cost valuations, or make meaningful comparisons with actual costs.

Engineering cost analysis may provide a basis for estimating forward-looking costs for the elements that make up the existing local exchange network. Presumably the engineers would not be asked to design and dimension the most efficient local exchange possible based on the most current information about consumer demand, competition requirements and alternative technological possibilities. This makes the forward-looking estimation process much easier. But even estimating forward looking cost valuations for the existing network elements raises some fundamental issues that have enormous implications. For example, in most highly populated areas today, if a new local exchange were being constructed where there was none before, the most efficient local loop structure would be dominated by fibre cable to the home and mobile radio in higher cost areas, with a minimum use of copper and coaxial cable. However, because the LECs have inherited local exchanges that have been built up over the years using copper and coaxial cables, it is more efficient to phase in new fibre cable and mobile radio systems gradually rather than replace existing copper and coaxial cables.

The actual local loop facilities structure is dominated by copper and coaxial cables. The expansion plan of the LEC for future years will reflect a different structure of local loop technologies. A hypothetical revaluation of the existing elements in local exchange networks will reflect yet a different structure. How should these technologies be weighted in the forward looking cost estimates? The weights selected will significantly affect both total cost and network element cost structures. The assumptions adopted for the TELRIC cost calculations cannot help but bias the cost structure of different network elements.

The method selected for determining the cost valuations for the different technologies also will be extremely important. In most circumstances the LECs will not be replacing copper wire loop connections to the home at all for the foreseeable future, and when they do replace these loops, it is not likely to be with copper wire. The forward-looking TELRIC for most local loops could be viewed as including little or no cost for past investments (i.e., embedded costs) in existing local loop copper wire, especially since the cost of residential loop connections does not vary with usage of the loop. This forward-looking view would lead to very low TELRIC estimates. On the other hand, if it is assumed that all existing local network elements would have to be replaced in a proper long run analysis, the forward-looking costs of installing copper wire loops at the current price of copper and current wage rates will be much higher than the book costs of the actual installations. The FCC does not specify how it expects the state regulators to resolve such issues.

At this stage it is unclear what effects the interdependence of network elements will have on the costing of different network elements, and what effects the TELRIC costing methodology will have on LEC investment priorities and programs. Inasmuch as investments in most network elements create benefits across the whole network, incentives for sub-optimal investment and opportunistic behaviour may be created both for LECs and competitors, as each seeks to maximise its overall network benefits while minimising its costs. The value of access to any particular network element will depend on the whole network of which the network element is an interdependent part, not the TELRIC of the network element.

Whether the TELRIC methodology will be able to capture the more complex forms of cost causation on the local exchange that were identified in the Michigan Bell study described above is questionable. Since the focus of TELRIC is on local network facility and functional elements that will be made available to competitors, it is likely to capture those network upgrading costs directly associated with particular network elements. Upgrading costs associated with overall network design and capability that have been incurred to meet the needs of special services are likely to be treated as common costs and allocated across all services. Thus, it may understate rate element costs and overstate the LECs local telephone service costs. TELRIC is designed to ensure access to the local exchange for competitors. It does not address costing of customer services.

These are illustrations of some of the difficult issues that the state regulators will have to address as they attempt to implement TELRIC. Thus, one can expect a diversity of TELRIC interpretations, which in turn will affect the competitive opportunities arising in the different states. TELRIC will be vigorously debated in the US for some time.

6.0 Conclusion

This overview of cost theories, concepts, methods, data sources and interpretations has demonstrated that costs do not provide the answers to telecom regulatory problems. They provide tools for managers and regulators that can be guides to informed judgements.

Cost analysis can be fashioned to support almost any preconceived conclusion, and therefore provide apparent "justification" for any price or proposed price change. Both telecom managers and regulators must develop and apply the specific cost concepts, methods, data sources and interpretations that will address the specific problems they face and inform the specific decisions they must make. These may be drawn from accounting, economies or engineering. As we have seen from the US FCC's recent adoption of a new cost concept, TELRIC, real world cost studies draw on the ideas, concepts, methods and data sources of all three professions. This is usually necessary to shape the cost analysis to the objectives of the regulator and the policy being implemented. No theory, concept or methodology of cost analysis can claim intrinsic superiority over others on all issues of cost analysis, and regulators should resist attempts by the professions, and their clients, to take over the essential judgements about the roles of cost in regulation.

In a regulatory environment cost studies are undertaken to help make decisions on matters where there are contending interests. This can lead to cost manipulation, uncertainty and endless debate. If a regulatory agency adopts cost-based pricing, but then fails to establish the specific cost methodologies it will use for specific purposes, it is inviting an endless debate on all the issues reviewed in this chapter and more. The FCC vacillated over its approach to costing for 20 years, thereby allowing AT&T to use the cost debate as a vehicle for imposing costs and delay on potential competitors, creating a major barrier to entry and rendering the FCC ineffective in implementing its own competition policy.

Regulators must establish cost methodologies which are designed to meet their specific needs, that are not too costly to implement on a continuing basis, and that provide for the maximum extent of accountability for the necessary judgements that must be made in implementing them. Regulators must not allow themselves to be placed in a position where they simply must choose between the judgements of competing telco operators or other vested interests about hypothetical cost valuations, when the sole purpose for making these judgements is to influence the regulator, and there can be no accountability for the judgements. In addition, consistency of application of cost study methodology is extremely important. This helps reduce uncertainty, cost manipulation and unnecessary debate. If all parties know that a specific cost study methodology, using particular data sources, has been adopted by the telecom regulator for a defined set of purposes, the industry can adapt to the known ground rules. This will help direct competition to the marketplace rather than to manipulating costs in the regulatory process.

The most significant telecom cost issue for the future will be identifying cost causation on the continuously upgraded local exchange network. The majority of costs for all network services always has been in the local exchange, and that will continue. The Michigan Bell study has demonstrated a method of analysis that goes much further than previous studies in identifying cost causation by different classes of service. Telecom regulators will need to build further on this approach and possibly others directed to the same objective. The FCC TELRIC methodology will go part way in identifying cost causation for directly assignable costs relating to specific local exchange network elements. But a major portion of network upgrading costs are common to the whole network and will be shared across all services, including basic local telephone service which requires none of them. However as TELRIC has yet to be implemented, further exploration of this matter can be expected by the US state regulators as they attempt to implement TELRIC.

In developing cost methodologies, regulators will need to recognise the dual objectives of the cost study information, i.e., to protect consumers and to promote competition. Although in many cases promoting competition is the most effective way of protecting consumers, it is not likely to protect consumers of basic local telephone service for a long time. In the past, many telecom regulators have had to confront the issue of anti-competitive cross-subsidies by PTOs, where higher prices for monopoly services subsidised lower prices for competitive services. In the future, telecom regulators may have to address the issue of pro-competitive cross-subsidies, where higher prices for monopoly services subsidise lower prices for interconnect services used by competitors.

The FCC TELRIC methodology is fashioned to facilitate the implementation of a pro-competitive policy for local exchange interconnection and network access for LEC competitors, not a policy of consumer protection for basic local telephone service. This is understandable as the FCC's jurisdiction over price and service regulation is limited to interstate services. The TELRIC methodology requires extremely detailed network element cost studies to facilitate the competition policy objectives of the *Telecommunications Act of 1996*. The consumer protection objectives rest with the state regulators, who must also implement the pro-competitive TELRIC studies. They will have the challenge of attempting to shape the implementation of TELRIC so that it satisfies both competition policy and consumer protection objectives. Telecom regulators in other countries should follow these developments closely as they will be taking up this challenge over the next decade.