11

The Forecasting Implications of Telecommunications Cost Models[1]

Timothy J. Tardiff
National Economic Research Associates

Abstract - The Federal Communications Commission and state regulators have relied on models of long-run forward looking costs when establishing prices for the services and facilities provided by incumbent local exchange carriers. These models produce results that are fundamentally complicated long-run forecasts: what constant price(s) can the incumbent charge for the output it produces that will just recover its expenses and allow it to earn a reasonable return on and of its capital investments. This paper discusses the underlying assumptions of these forecasts and identifies methods for properly representing their inherent uncertainty in the estimates produced by cost models.

The Federal Communications Commission and numerous state regulators have required the use of forward looking economic cost models to establish prices for network components that must be sold to the competitors of incumbent local exchange carriers (ILECs) and to establish the subsidy levels required for universal service.[2] While forecasting is typically associated with the demand, rather than the cost, side of a company's business operations, there are a number of implicit forecasting issues involved in proper cost calculations that are often either not recognized or ignored in practical applications.

When one looks at economic costs, in general, and those associated with assets with long lives, in particular, the essential role of forecasting becomes apparent. The economic definition of cost deals with the question of the expenditure of resources that will be incurred as the result of a decision to offer a product or service. Clearly, the answer to this question depends on how resources will be used in the future, i.e., a forecast is necessary. In the case of investments with short economic lives, such forecasts can be straightforward – what you recently paid for a quickly used-up resource is likely to apply in the near future. For assets with long lives, the forecasting becomes more complicated.

Consider the case of a telecommunications investment, such as a central office switch. Determining the economic cost of that asset is equivalent to a how a business determines whether it is economic to invest at all. In addition to the purchase price of the switch, the business must consider: 1) how long the switch will last (economic life), 2) the volume of products produced by the switch that will be sold (demand forecast), 3) the price at which switches will be sold, 4) how the purchase price of new switches will change in the future (economic depreciation), and 5) uncertainty in the "forecasts" just enumerated. A sound investment decision considers all of these factors, and so should a properly conducted cost study.

This paper elaborates on how forecasting impinges on the development of correct economic costs. Section 1 describes the typical approach to cost models and compares it to the conceptually equivalent approach to investment decisions. Section 2 identifies how the consideration of specific items subject to forecasting affects the development of correct costs. The last section concludes the paper.

1. TYPICAL COST MODELS AND INVESTMENT DECISION MODELS

Turning first to cost models, the analysis in models that have been recently adopted or are being considered by regulators consists of the following steps: 1) estimate the *investment* in new equipment necessary to serve a predetermined level of demand, 2) estimate the operating expenses required to operate the new equipment, and 3) convert these costs, which are forecasted to occur over the life of the investment, into annual (or monthly) costs.

A simplified view of this process can be represented by the following equation:[3]

PV asset = Value of Investment + PV (operating costs, life, discount rate)

In the equation above, PV denotes present value and the value of the investment accounts for tax considerations, i.e., depreciation is tax-deductible and equity earnings are taxed. Operating expenses are typically assumed to be constant over the life of the asset, so that their present value is determined by applying a present value formula found in spreadsheet software for a constant annuity over a period equal to the life of the project, discounted at a rate approved by the regulator.

The present value calculated above is then annualized, again applying standard financial formulas.[4] Note that the step of annualizing the present value of the investment creates a peculiar depreciation pattern that is quite different from any used in regulation, let alone the actual economic depreciation of telecommunications assets. Just like a personal financial transaction (e.g., a home loan), a constant annual amount implies that the investment is depreciating slowly at first (in the early years of a home loan, the payment is predominantly interest) and accelerates as the life of the investment unfolds (at the end of the home loan, the same payment represents mainly principal).

In contrast, the "text book" investment equations is:[5]

$$PV = -I_0 + \sum_{i=1}^{T} \frac{-I_i + (Rev_i - Op\ Cost_i)}{(1 + r)^i}$$

In the above equation, I denotes investment and r represents the (after-tax) discount rate. Comparing the cost model equation to the investment decision equation identifies a number of simplifying assumptions, which in turn impose powerful forecasting *assumptions* on the former. First, in general, investments can occur throughout the life of the project, while cost models typically assume that investment occurs up-front and that any subsequent investment occurs in replacing the asset after its life is over. Second, whether the investment is economic (PV > 0) depends on the revenue realized by the investment, and this revenue can vary over the life of the project. In contrast, the cost model implicitly produces a constant revenue over the life of the investment that makes the present value equal to zero. Third, the investment decision model allows operating costs to vary over time, while the cost model assumes that they are constant.

The revenue forecast implied by the cost model is especially stringent. Such models typically provide for facilities sufficient to accommodate a known level of demand. Therefore, the constant revenue outcome is fundamentally a forecast: the ILEC will be able to charge a single price over the life of the asset that will just allow it to recover its expenses, depreciate its plant, and earn a fair return on its investment. And this "forecast" is implicitly made independent of whatever is happening to the demand for the services produced by the investment — in particular, no consideration is given to factors such as how competition will affect demand, how changes in the prices of equipment will affect the market price for services produced by that equipment, and how the first two items might vary by geography, customer type, and service mix over the operations of the ILEC, and uncertainty in all three.

2. ACCOMMODATING ALTERNATIVE FORECASTS IN COST MODELS

The implicit forecasts of constant prices for both telecommunications equipment and the services produced by these investments defy expectations. In particular, at least for some types of equipment (mainly those based on electronics and computers, such as switches and fiber optic electronics), the expectation is for *decreasing*, not constant, prices. Similarly, there is a general expectation that the competition, which is the main backdrop in the development of the models in the first place, will drive the prices of services down.

Of course, it is important to recognize that the simple implicit forecasts have been adopted with good intentions: namely, to produce workable cost models that will provide prices that will start competition rolling. These models are already very complicated. In effect, the forward looking philosophy underlying these models calls for prices and quantities of numerous items that comprise a telecommunications network, based not on what can be observed outside, but instead on a hypothetical new company that serves demand by starting over with new equipment. Whether this task is doable in a reasonable time period is still an open question. In a sense, overlaying complicated price and demand forecasts on top of what is already there could make the whole enterprise impossible.

Fortunately, recent research as well as casual observation of other industries can produce results that 1) qualitatively explain the consequences of the implicit forecasts when they depart too much from reality and 2) suggest possible adjustments to the results produced by a typical cost study. Interestingly, while these emerging approaches tend to produce a series of prices that vary over the life of the project, they tend to focus on the prices for the first year. This focus makes sense in that the most immediate need is for prices that allow competition to get started. As that competition develops, alternatives to the products and services produced by the ILECs will emerge and the market, rather than regulators, will increasingly determine the relevant prices.[6]

2.1 Accommodating Non-constant Equipment and Output Prices

Hausman[7] and Krouse[8] have analyzed the impact of declining equipment prices on the costs and prices produced from a cost study. Turning first to declining prices for equipment, both Hausman and Krouse analyze the case of prices declining at a constant rate.[9] Mathematically, the effect of such a price pattern on the initial price is equivalent to increasing the discount rate by the rate of the price decrease.

Hausman provides the following equation that captures the effect of price changes.

$$PV = \int_0^\infty e^{-rt} \, (P e^{-\alpha t}) \, \frac{1 - e^{-\delta t}}{\delta} \, dt = \frac{P}{r + \alpha + \delta} \qquad (1)$$

The integral contains three terms: the first converts future cash flows to present value, at the discount rate, r; the second depicts the decline in the output price at a rate of α from the initial level, P; and the third represents economic depreciation of input prices, at a rate of δ.

The right-hand side expresses the relationship between the value of the investment and the output price for the initial period. For a given level of investment, this relation implies that the higher the rate of decline in output and asset prices (α and δ), the higher the initial price has to be to make the investment economic.

Thus, according to the formula, when input and/or output prices are declining, the constant demand and price assumptions lead to an understatement of the initial period price by a factor of[10]

$$\frac{r}{r + \alpha + \delta}$$

For example, if the discount rate is 10 percent and the combined rate of decline in output and input prices is 5 percent annually, the correct price for the first period would be 50 percent higher than that produced by the typical cost model; alternatively, the cost model result is only two-thirds of the correct result.

Krouse discusses the relationship between prices in the initial and subsequent periods when the input price declines at a constant rate. The basic result is that the rate of change in the output price from one year to the next is the same as the rate of change in the input price.[11] The intuition behind this result is straightforward. Under competitive conditions, the decline in input price will be reflected in a decline in the output price. A firm expecting such a price decline would have to charge a higher price early on in anticipation of the decline in revenue that is expected to occur later. Although the present value of revenues recovers investments and operating costs in both the constant output price and declining price cases, a firm facing competition does not have the luxury of charging prices that are inconsistent with competitive conditions. At a constant price, it will recover too little in the early years because competition will drive prices down so that it cannot fully recover its cost from the declining revenues in the later years.

2.2 Accommodating Uncertainty

Both the standard cost model and the alternative case of declining prices assume certain forecasts. Of course, the transitions being experienced by the industry – towards more competition, industries converging, and technology advancing –

have made any long-term forecast of demand and/or cost characteristics problematic. One need look no further than how local competition is developing to see how hazardous such forecasting can be. When the Telecommunications Act was passed a little over three years ago, the then chairman of AT&T announced his expectation that his company would capture a significant share of the local market through a combination of its own facilities plus resale of ILEC services and network components. The current chairman is also predicting a large share, but through a different means – the upgraded facilities of the cable television firms it has already acquired or is in the process of adding. Clearly, to the extent that AT&T succeeds in its current strategy, it will likely result in a very different pattern of demand levels and prices for ILEC services and facilities than AT&T's initial strategy would have produced.

Recently, there has been increasing interest in "real options," which is essentially the conceptual basis for derivative investments in the stock markets. Two aspects of this approach have been suggested for telecommunications applications.[12] First, real options theory recognizes the inherent uncertainty facing many investment decisions and considers the value of alternative courses of action, such as delaying the initial investment, pulling out in the future if demand conditions do not materialize, and so forth. Such a view is the polar opposite of that assumed by recent cost models: the firm for which costs are needed is assumed to make all of the investments needed to serve a certain predetermined demand level up-front, with facilities available at certain input prices in return for a constant price that is supposed to recover these investments over a long period. Because options theory teaches that costs can be lower when uncertainty is accommodated, the very long-run perspective assumed in cost models may, in fact, increase costs, rather than provide the basis for efficient prices.

Therefore, the converse of the cost-reducing effect of keeping one's options open is the possibility that the cost estimates produced by a model that assumes certain demand and prices can understate the correct economic costs by a substantial amount. Hausman has identified four sources of uncertainty that produce higher costs: 1) uncertainty in demand, 2) output price uncertainty, 3) input price uncertainty, and 4) discount rate uncertainty.[13] Using an approach similar to the Black-Scholes option pricing model, Hausman concludes that the price determined in equation 1 above must be increased by a multiple, which in turn is determined by the amount of economic uncertainty in question.[14]

Hausman offers some indication of the amount by which economic uncertainty increases costs. He reports that previous calculations by MacDonald and Seigel[15] and Dixit and Pindyck,[16] where neither output nor input prices are expected to decline, has resulted in a markup factor of approximately two. Focusing on telecommunications, where such price decreases are anticipated, he estimates that the markup is larger – on the order of three.

2.3 Use of Long-Term Contracts

There appears to be widespread agreement that economic uncertainty increases costs, although there is considerable controversy over how large the impact is and what adjustments to the prices produced by cost models, if any, are needed. For example, the FCC has acknowledged the existence of risk and its cost-increasing effects, but has suggested that ILECs can employ long-term contracts to mitigate such risks.[17] When a buyer agrees to purchase output for the duration of the economic life of an asset, the seller's uncertainty is eliminated. In this case, the prices and costs produced by a typical cost model allow the seller to recover its economic costs, i.e., the mark-up factor discussed in the previous section would be 1.0.[18]

The solutions discussed in this and the preceding sections – a markup with no contract versus no markup with a full-term contract – define the extremes of a range defined by the length of the contract on the one hand, and the size of the markup on the other. Intermediate points on this range can be defined by assigning smaller markups to successively longer contract durations. For example, Hausman[19] has proposed a linear sliding scale over the range from the maximum markup (no contractual commitment) to no markup (contract duration equal to economic life).

The notion that contract commitments are accompanied by lower prices when assets are expected to decrease in the future is illustrated by the difference between lease rates and outright purchase prices for items such as computers. The monthly payments for a loan covering the purchase price of a computer are substantially lower than the monthly rate for a short-term lease.

2.4 Adjusting Standard Parameters in Cost Models

The preceding sections indicate that with the exception of long-term contracts for the life of the asset in question, current cost models will tend to understate economic costs in the presence of economic uncertainty. This finding suggests directional qualitative adjustments to standard parameters in cost models, particularly rates of return, depreciation lives and levels of spare capacity.[20] For example, the amount of spare capacity can be set to provide for efficient response to growth and spatial changes in demand, depreciation lives can be adjusted to reflect the impact of declining input prices on the required initial output price, and rates of return can be adjusted to reflect increased business risks.

Apart from these qualitative and probably ad hoc adjustments to model parameters, there is also the issue that any analysis in support of a particular quantitative adjustment is likely to be of a complexity similar to an analysis to quantify the factors in the more rigorous approached described above.

3. CONCLUSION

The long-run cost models that have gained prominence since the Telecommunications Act was passed have implicit long-run forecasts built into them. Both input and output prices are assumed to remain constant over the study period encompassed by the model and the ILEC is assumed to serve a pre-determined level of certain demand. Given the changes wrought by advancing technology and increasing competition, these implicit assumptions are at best heroic and most likely unrealistic.

Modifying these assumptions to more realistically match market conditions tends to increase the costs and prices produced by these models, especially in the early years. Declining prices for inputs and outputs impose a similar declining pattern on the economic costs of the ILEC. Even without uncertainty, declining costs imply that the ILEC must charged higher prices in early years in anticipation of prices and revenues being forced down by competition and technological progress in later years. Uncertainty in economic conditions causes an additional increase in economic costs, with estimates two to three times as high as the costs produced by typical cost models.

Perhaps more fundamentally, the long-run focus of the cost models and the need for firms to respond with flexibility to the technological change and growing competition that characterizes the telecommunications industry are mismatched. The long-run forecast is an attempt to *emulate* competition by anticipating the outcome of competitive processes. In contrast, in competitive markets, it is the often unpredictable actions of firms meeting the demands of consumers, and not attempts to predict the outcomes of this process, that determine what services will be offered and at what price. Establishing regulated prices that have a reasonable prospect of getting the *competitive process* moving would seem to be a better use of regulatory resources than attempts to forecast precisely the outcome of that process.

NOTES

[1] This paper was presented at the 1999 International Communications Forecasting Conference, Denver, Colorado, June 17, 1999.

[2] One interpretation of universal service is ensuring that any household that wants service is able to afford it. Historically and continuing under the terms of the 1996 Telecommunications Act, affordability has been ensured by limiting the price charged for basic telephone service. The universal service programs that are currently being designed and implemented pursuant to the 1996 Act will establish funding levels based on a comparison of a benchmark rate with the forward looking cost of basic service.

[3] Some models create a "revenue requirement" (a time series of annual depreciation and return on investment) corresponding to the initial investment, and then take the present value of that "cash flow." It turns out that this calculation is equivalent to the purchase price of the investment, reduced by the tax benefit of depreciation deductions. See Tardiff, Timothy J. and Miles O. Bidwell, Jr.. May 10, 1990. "Evaluating a Public Utility's Investments: Cash Flow vs. Revenue Requirement," *Public Utilities Fortnightly*.

[4] Some cost studies utilize an equivalent approach where annual capital factors, which account for depreciation, return, and taxes over the life of the investment, convert the investment to an annual equivalent and then add the annual operating costs to this amount.

[5] The cash flows in the equation are after-tax, i.e., annual revenues and expenses are reduced by the income tax rate and the tax-deductibility of depreciation is included as a positive cash flow. For simplicity, these effects are not explicitly depicted.

[6] One of the ironies of the debates that accompany the development of cost models is that some parties view the ILEC's facilities as having at least in part natural monopoly characteristics, and as a result, call upon the regulator to produce models that emulate the results of competition. As the previous discussion indicates, such a task could be virtually impossible because of the sheer complexity of the forecasts needed to model the workings of competition. Consequently, a process that produces reasonable starting prices and lets competition do the rest has considerable appeal.

[7] Hausman, Jerry A. 1997. "Valuing the Effect of Regulation on New Services in Telecommunications." *Brookings Papers on Economic Activity Microeconomics*, M.R. Baily, P.C. Reiss, and C. Winston, eds., pp. 1-38.

[8] Krouse, Clement G. 1999. "LRIC Pricing, Dynamically Competitive Markets and Incentives to Invest." Department of Economics, University of California, unpublished manuscript.

[9] Hausman also considers the impact of constantly declining prices for the output produced by the investment. The result is symmetrical and additive. That is, if output prices are decreasing in addition to the amount indicated by the decline in equipment price, the effect of first period price is equivalent to an additional increase in the discount rate.

[10] Hausman's formulation assumes an indefinite life for the investment. Krouse produces an equivalent result when investment lives are finite.

[11] Krouse also considers the case in which investment and operating costs decline at different rates. He concludes that the rate of decline in the output price is a weighted average of the different input costs' rates of decrease.

[12] The October 1998 conference on real options held at the Columbia Institute for Tele-Information, from which this volume was drawn, is one example.

[13] Hausman suggests that the effect of uncertainty on economic cost applies mainly to sunk assets; other investments can be redeployed in the face demand uncertainty. For example, while some of the plant needed to provide access lines to customers in a certain area cannot be reused if the expected demand fails to materialize, switching facilities are more fungible between areas.

[14] Hausman credits Dixit and Pindyck for the formula that produces the markup. Dixit A. and R. Pindyck. 1994. *Investment Under Uncertainty*, Princeton, NJ: Princeton University Press, pp. 279-80 and p. 369.

[15] MacDonald, Robert and Daniel Siegel. 1986. "The Value of Waiting to Invest," *Quarterly Journal of Economics*, Vol. 101, pp. 707-728.

[16] Dixit and Pindyck, op. cit., p. 153.

[17] Federal Communications Commission, *Implementation of the Local Competition Provisions of the Telecommunications Act of 1996*, CC Docket No. 96-98, *Interconnection between Local Exchange Carriers and Commercial Mobile Radio Service Providers*, CC Docket No. 95-185, August 8, 1996, p. 687. Although the FCC correctly concluded that term contracts mitigate risk, it did not require competitors to enter such contracts as a condition for receiving low prices.

[18] With a long-term contract, the seller does not need to respond to a decline in output price generated by input price decreases and competition because the buyer has committed to purchase at the pre-determined price. Therefore, the pattern of prices over the life of the contract is not a crucial detail from an economic perspective.

[19] Testimony of Jerry A. Hausman before the California Public Utilities Commission, on behalf of Pacific Bell, April 8, 1998.

[20] Emmerson, Richard D. 1999. "Cost Models: Comporting with Principles," in this volume. Emmerson characterizes such adjustments as "crude but useful."