16 Application of Real Options Theory to TELRIC Models: Real Trouble or Red Herring

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Abstract - Since the inception of policy debates on opening local markets to competition, the incumbent local exchange carriers (ILECs) have argued against any costing methodology that would erode their monopoly level of revenue and profits. Real options issues were introduced to this debate at a time when the FCC was considering adopting TELRIC models to set rates for interconnection to the local exchange. The ILECs' goal was to use these real options issues to undermine the credibility of the TELRIC methodology, leaving the FCC with no choice but to rely on embedded costs.

Although the theoretical issues raised by real options are legitimate and intriguing, they do not apply to the case at hand. The competitors' use of the local network does not expose the ILECs to more risk than the typical customer. Customers of the ILECs have always had the option to use or not use the ILECs' network, and the ILECs have never imposed a premium for option values on those customers. Indeed, the customers that imposed the greatest risk on the ILECs - the Centrex customers - frequently paid the lowest rates.

An attempt to measure the upper bound of the option value effect also shows that the ILECs will be fully compensated for the use of their network when prices are set at the levels estimated by the TELRIC models. The risk to the ILECs of a failure to recover the costs of sunk investments is greatest for portions of the local loop plant. Yet, this plant is shown to exhibit very large economies of scale, and the ILECs' option to build a smaller-scale network is essentially valueless. The conditions that would render the real options theory as a killer critique of the use of the TELRIC models simply do not exist.

It is important to understand the policy context of this conference. The topic chosen – the application of real options theory to telecommunications pricing – has been the subject of recent filings at the FCC in its landmark proceeding to implement the Telecommunications Act of 1996.[1] In response to the Commission's proposal to use forward looking economic prices for unbundled network elements

(UNEs), the incumbent local exchange carriers (ILECs) sponsored an affidavit by Professor Jerry Hausman in which he argued that the use of "a TSLRIC calculation which ignores sunk costs for networks is systematically downward biased by a factor of at least 2, and the factor probably exceeds 3."[2] Although this argument was eventually rejected by the FCC in its order adopting TELRIC (total element long-run incremental cost), the debate has not ended.

The debate over the validity of TELRIC (and hence the importance of these challenges to TELRIC) can be traced to fundamental conflicts between the incumbent local exchange carriers and the competitive local exchange carriers (CLECs) over ratemaking policies that will have a profound influence on the telecommunications market. Specifically, the ILECs argue for full recovery of their embedded accounting costs, even if competitors succeed in capturing customers and market share. The CLECs insist that interconnection and UNE prices should not be saddled with make-whole costs reflecting accounting or embedded costs, but rather should be set at forward looking cost. In response to the CLECs' proposed use of forward looking costing methods and models, the ILECs launched a full-scale attack on the TELRIC models, designed to eliminate this significant challenge to their "right" to recover all of their embedded costs.[3] Thus, although the focus of the conference is on real options theory, at the root of the debate lie fundamental conflicts about the direction that public policy should be taking at this crossroads regarding competition in telecommunications markets. This calls for a more complete understanding of the policy context.

The ILEC position on how competition should affect pricing and costing policies is well illustrated by a paper of Monson and Rohlfs of Strategic Policy Research (SPR), released by the United States Telephone Association (USTA) in July 1993.[4] The paper entitled "The $20 Billion Impact of Local Competition in Telecommunications," claimed that competition threatened the ability of the ILECs to recover the "contribution" to universal service from the customers of services priced above cost – especially toll and access services. According to USTA, this "contribution is an integral part of the regulatory fabric that has maintained universal service through subsidized rates for rural areas and residential customers."[5] The thesis of the Monson and Rohlfs paper was that the policy goal of providing universal service was inextricably linked to the ILECs' ability to recover their embedded costs.[6] Furthermore, the size of the universal service subsidy did not need to be measured directly by estimating the costs of providing local telephone service to the subsidized customer groups (e.g., rural customers), but could be measured by the excess of rates over costs from the "contributing" services. In other words, according to USTA, there was a simple duality theorem: *All revenues collected from services priced above cost are used to subsidize the provision of services to beneficiary* *customer groups at rates below cost.* Therefore, any shortfall of contribution caused by competition would need to be made up by increases in universal service subsidies, lest these rates increase and universal service be threatened.

MCI opposed USTA's position, arguing that while local competition might threaten the ILECs' profits, it did not have to threaten universal service. MCI proposed that universal service subsidies be made explicit, and then the ILECs' rates could be driven to forward looking cost by competition, without sacrificing universal service. In MCI's view, the size of the universal service subsidy (both then and in the future) should be estimated directly, as the difference between the direct costs of providing service to targeted customer groups (e.g., rural customers) and the revenues received from those customers.[7] The size of the "contribution" from overpriced services was irrelevant to that measurement, in MCI's view, because these overcharges could be explained by many factors other than "contributions" to universal service, such as cross-subsidies to competitive services, inefficiencies, or excess profits.

To prove that universal service subsidies could be measured directly by looking at the costs of serving rural customers from the "bottom up," rather than from the "top down" (i.e., embedded costs), MCI commissioned Hatfield Associates Inc. (which was later renamed HAI) to construct a stylized model of the costs of providing local telephone service as a function of the density of population.[8] This model showed that the size of the subsidy to basic local telephone services from other services was $3.7 billion per year.[9]

The sizeable gap between the HAI model estimate and the SPR estimate – between $14 and $16 billion – received much attention at the time and to this day provides a powerful insight into the debate between the ILEC-sponsored and CLEC-sponsored economists on the issues of the validity of TELRIC and the relevance of real options theory to the pricing of UNEs. This is not a debate of abstract economic theory, but rather part of a major public policy dispute between warring corporations.

The Telecommunications Act of 1996 included two major provisions that moved forward looking cost models to the forefront. First, the Act required that universal service subsidies be converted from an implicit to an explicit mechanism. This meant that the size of the required subsidy had to be determined directly – rather than using the USTA/SPR "duality" approach, which measured the $20 billion contribution from above-cost services. Second, the Act required the ILECs to provide access to network elements on an unbundled basis at cost-based prices "determined without reference to a rate-of-return or other rate-based proceeding."[10] The passage of the Act and its implementation at the FCC and the state commissions caused the potential new entrants into the local market (especially MCI and AT&T) to launch major efforts to turn the initial stylized HAI model into a highly sophisticated engineering-economic cost model of local telephone networks.[11]

The latest version of the HAI model includes sophisticated engineering algorithms that compute the amount of telephone plant required to serve customers in all parts of the continental United States. The inputs on customer locations, telephone line counts, and numerous geographical factors are highly detailed and disaggregated, and enable the model to estimate costs separately for each Census Block. Because the model contains separate modules for each category of telephone plant, it yields cost estimates for each network element as well as the cost of the bundle of services encompassed by the FCC's definition of the basic universal service.

Two features of the HAI model are particularly noteworthy. First, the model is completely open to inspection and dissection by outside parties. It is written in Microsoft Excel and all of the data and algorithms are provided to the public on a CD-ROM. Second, many of the model's formulas and inputs can be varied to test sensitivities. For example, the cost of copper wire or the fill factors (the percent of telephone cables actually in use) can be varied at the will of the user. This stands in marked contrast to the "black box" cost models provided by the ILECs in the past (both those based on embedded and incremental cost). Among the major differences between the TELRIC models and the traditional ILEC-sponsored models are:

- TELRIC models are open and transparent
- TELRIC models can be tested for sensitivities to hundreds of inputs and assumptions.
- Consistent TELRIC models can be used for all ILECs.
- TELRIC models develop costs for each major element of the network from the ground up, which minimizes the complex and controversial allocations necessary when using embedded costs.

Clearly, the use of costing methods outside the control of the ILECs was a major change to historic practice and created a significant threat to the ILECs at a crucial juncture in the history of regulation.

Recently, the FCC adopted a model "platform" that it plans to use to size the universal service fund for the large ILECs beginning in January 2000.[12] The model is a synthesis of three models, including the HAI model. It shares much of the HAI approach to modeling described above, differing primarily in the methods used for "clustering" customers into local serving areas and to calculate distribution plant requirements. Because the FCC model platform is still being tested and has not been on stage for long, one must surmise that it will receive much of the same criticism that the ILECs leveled at the HAI model over the past five years. Thus, the debate between the ILEC-sponsored critics and the TELRIC proponents will undoubtedly be repeated as the FCC synthesis model moves into the limelight.

The HAI model has been vigorously, and unceasingly, attacked since its first incarnation in 1994. USTA and SPR claimed that the first HAI model's assumption that the telephone plant was built from scratch on a "greenfield" was only appropriate for costing telephone service in Kuwait or Bosnia.[13] The ILEC attack has focused on the theme that HAI models a "fantasy" network. Soon after the passage of the Telecommunications Act, and the interexchange carries' proposal to use the model as the basis for pricing the unbundled network element as well as for universal service, USTA sponsored an attack that focused on the claim that the model failed to account for growth in demand, but instead assumed that the ILEC "invests at a single point in time to serve instantaneously the entire market."[14] Jerry Hausman's FCC filing on real options theory returns to the same theme, claiming "the HAI model assumes a 'start from scratch' world where technology has never changed, no uncertainty exists, and no firm ever made an investment without correctly predicting how technology would change."[15]

It is beyond the scope of this paper to address all of the attacks on the TELRIC models made over the last several years. Nevertheless, it is important to put this debate in perspective. All models by their nature involve simplification; the alternative is the construction of a parallel universe. So the question is not whether the assumptions of the model are correct (indeed all simplifying assumptions are technically "incorrect"), but whether use of the model creates substantial irremediable error, which some other feasible alternative does not.[16]

What the ILECs really want is for the TELRIC modeling process to be discredited, so that the FCC would be forced to rely on some embedded cost basis for setting rates paid by the CLECs.[17] In the ongoing universal service debates, USTA recently filed a new plan at the FCC based on embedded cost.[18] USTA estimates the size of the universal service subsidy as the amount necessary to replace the intra-company implicit subsidies included in interstate access charges. According to USTA, "cost models can properly be used for non-rural carriers to implement the distribution of high cost funds, but should not be used to size the fund itself. Rather, the fund should be sized based on the need to support universal service and on the need to replace other sources of support."[19] USTA cites SPR's 1993 estimate of the $20 billion support contributed from access and toll services, noting the estimate was recently updated to nearly $24 billion annually. Interestingly, in this age of rapidly declining prices in telecommunications services, the cost of universal service is higher than ever before. Old habits die hard.

The purpose of presenting this historical overview to the policy issues at the heart of the debate in the conference is to emphasize that the goal of the attacks on TELRIC is to destroy, not to improve, the TELRIC models, and by doing so, force the FCC and the state commissions to rely only on embedded cost-based prices. Taken in this context, the test that the models must pass is not whether they are always "right" or whether they are even capable of solving all of the economic riddles posed by their opponents, but rather whether the models are reasonably accurate and provide a fair regulatory tool, *in comparison* to the embedded cost approach. The opponents of the models are clearly trying to show that the TELRIC models fail to meet a reasonableness standard. How else can one interpret Professor Hausman's attempt to claim that the TELRIC prices are biased downward by a factor of 2 or 3?

1. CAPITAL RECOVERY ISSUES IN TELRIC MODELS

Critics of the TELRIC models raise two issues concerning the models' treatment of capital recovery costs. First, they claim that the assumption of constant capital goods prices is at variance with an expected large decline in the price of switches and other electronic equipment over time.[20] Second, they argue that there is a substantial option value that should be included in the TELRIC-based prices paid by the CLECs. Each of these arguments is examined here in turn.

There are several reasons why the potential for declining capital goods prices should not undermine our confidence or reliance on the models. Three of these are stated briefly (and then discussed more fully below):

1. The most important network element, from the standpoint of both universal service and CLEC competition, is the loop. The loop is the most essential of all ILEC facilities and also accounts for about one-half of the typical ILEC's rate base. It is highly unlikely that the capitalized value of the loop plant is falling over time, and thus the critics' argument concerning the declining value of the ILECs' plant neglects a large portion of the plant, whose value is constant or even increasing.
2. It is difficult to postulate future changes in switch prices from historical trends. Moreover, the ILECs themselves have argued that productivity improvements in local telephony will not continue at historic levels.[21]

3. TELRIC models can be adjusted for accelerated depreciation, just as they are adjusted for hundreds of other variables. Plausible estimates of declines in capital goods prices would have a very small effect on TELRIC-based price.

The first point is that the unbundled network element that matters the most is the loop. The ILECs currently provide 168 million subscriber lines, while the CLECs provide only 5.6 million.[22] For the vast majority of customers, CLECs will be unable to duplicate the loop plant any time soon, so the only way they can offer service to the public at large is by leasing unbundled loops. This makes unbundled loops, and associated elements such as collocation, the linchpin of the Telecommunications Act of 1996. This point is realized by the industry and policymakers, and consequently the model developers and regulatory agencies have focused the greatest attention on the loop.

Rather than depreciating rapidly over time, much of the investment associated with loop plant – such as poles and conduit – retains a substantial percentage of its economic value over long periods of time.[23] Indeed, much of the supporting structure may actually increase in value over time, to the extent that replacement costs are highly labor-intensive and the costs of installation are much higher after an area is fully developed. Even the copper loop, which at one time was viewed as plummeting in value because fiber was considered a superior alternative, has recently become more attractive as a medium for carrying xDSL signals. With respect to loop plant, then, the depreciation concerns raised by the opponents of TELRIC are much ado about nothing.

With respect to the second point, Hausman cites the example of an AT&T Class 5 Central Office Switch to demonstrate a rapid decline in capital goods prices. He claims the price of the switch has fallen from about $200 per line in 1989 to $80 per line today.[24] Could this trend, if accurately measured, continue? There is some evidence that it will not,[25] and it is useful to explain why large declines in prices are unlikely to continue. As Professor Hausman points out, the Central Office switch includes a switch block and a computer. The price of chips used in the computer has declined rapidly in the past ten years, which is reflected in lower switch prices. The prices of other components, as well as of software that is capitalized in the purchase price, have not declined at similar rates. The price of labor used to engineer, furnish, and install the switch has likely increased over time. This implies that as chips become a smaller proportion of the total cost of the switch, even continued declines in chip prices would not cause as large a percentage drop in switch prices as they have in the past.

What have the ILECs said about the significance of the decline in capital goods prices on their overall costs? USTA has recently filed comments on access charges at the FCC in which they argue that the productivity improvements of the recent past will not be achievable in the future.[26] Central to their argument is that past productivity gains have been achieved by reductions in employment and a "dramatic operational restructuring," which cannot be replicated in the future. Further, USTA's expert economist claims that a longer-term downward trend in productivity has already begun, and that without future declines in employment, productivity improvements will be even smaller.[27] USTA's arguments on productivity, and the notable lack of any recognition of a "dramatic" decline in capital goods prices, is in stark conflict with the position taken by their experts critiquing TELRIC.

The final, and most important, point to make about the depreciation issue is that the TELRIC models *can be adjusted for accelerated depreciation,* just as they are adjusted for thousands of other variables.

Although the model has not yet been modified to allow for accelerated depreciation, the author has conducted several runs of the model to estimate the impact of different depreciation rates on estimated UNE costs.[28] Table 1 shows the sensitivities of the cost of "basic universal service" to reductions in the projected lives of three categories of equipment: digital switching, computers, and digital circuit equipment for New York Telephone (the reporting area for Bell Atlantic in the State of New York). It is evident that even large reductions in depreciation lives do not cause large-scale increases in the total costs of the UNEs or of local exchange service. For example, even if the service lives of *all three major categories* of electronic equipment were cut in half, the cost of universal service (the loop, the switch port, and local usage) would increase by only 11percent: from $13.66/month to $15.14/month.[29] This extreme example, where all of the electronic equipment in the ILECs' network is assumed to be worthless in half its normal lifetime – as opposed to being worth less, as the critics posit – demonstrates how the rhetoric of the ILEC advocates goes beyond any reasonable interpretation of the reality of modern telecommunications networks.

Table 1. Depreciation Scenarios

Scenario	Total Loop (Unit Cost)	% Change	End Office Switching Line Port	% Change	End Office Switching Non-Line Port	% Change	Total Switched Network Elements (w/o Public)	% Change
	per month		per month		per minute		per month	
HAI Model Default Inputs	9.34		0.98		0.00173		13.66	
One Half Depreciation Life								
Digital Switching	9.24	-1.1%	1.17	19.4%	0.00206	19.1%	14.22	4.1%
Computers	9.38	0.4%	0.98	0.0%	0.00174	0.6%	13.76	0.7%
Digital Circuit Equip.	10.02	7.3%	0.99	1.0%	0.00175	1.2%	14.49	6.1%
All three categories	9.97	6.7%	1.18	20.4%	0.00208	20.2%	15.14	10.8%

2. OPTION VALUES AND TELRIC

Hausman argues that "competitive firms use a 'hurdle rate' for investments far beyond their estimated cost of capital."[30] He cites Summers' survey of firms to back up his claim that hurdle rates "exceed the cost of capital by a factor of between 2 and 10."[31] A closer examination of Summers' evidence shows, however, that it does not back up Hausman's claim, and that Summers' survey is consistent with conventional capital asset pricing model (CAPM) cost of capital estimates, as well as with the cost of capital used by the FCC.

The mean hurdle rate of 17percent reported by Summers can be compared to the CAPM cost of capital.[32] The CAPM cost of capital for a company of average risk (beta equals one) is simply the risk-free rate plus the equity premium. The real riskless rate has averaged 1.0 percent for the last sixty years. The equity risk premium for large companies such as those surveyed by Summers has averaged 7.4 percent, for a total average real return of 8.4 percent.[33] To compare this real return to Summers' nominal hurdle rate, it is necessary to adjust for inflation. The expected inflation at the time of the Summers' survey can be estimated by taking the ten-year government bond rate in 1985, which was 10.62 percent, and subtracting the average real return on such bonds of 2 percent, to yield expected inflation of

8.6 percent (which coincidentally was the approximate inflation rate over the decade prior to 1985).[34] Subtracting 8.6 percent from Summers' mean nominal hurdle rate of 17 percent gives a real hurdle rate of 8.4 percent, *which is identical to the CAPM cost of capital* for a firm of average risk.

This real hurdle rate of 8.4 percent is somewhat below the 11.25 percent rate of return currently prescribed by the FCC.[35] With current expectations of inflation running around 2.0 percent, the nominal hurdle rate consistent with Summers would be approximately 10.4 percent.[36] Interestingly, recent estimates of the ILECs' cost of equity using the CAPM model also yield estimates in the range of 9.96 to 10.22 percent.[37]

The literature on option values is relatively new and it cannot be proven that CAPM or other conventional cost of capital estimates always capture these effects. Nevertheless, there is little evidence to suggest that required rates of return deviate significantly from CAPM estimates.[38] For example, in U.S. industries generally, Caballero and Pindyck find that doubling industry-wide uncertainty raises the required rate of return on new capital by about 20 percent.[39]

Although the author does not agree that the ILECs' cost of capital is understated by the traditional measurements relied on by the FCC, an upper bound to the potential effect of uncertainty on the costs estimated by the TELRIC model has been estimated here by running the HAI model with a 15 percent cost of equity. The basis for this estimate is the recent filing of the ILECs at the FCC, which discusses the marketplace uncertainties faced by the ILECs as the major reason for their claim that their cost of capital has increased significantly to a range of 13.95 percent to 14.15 percent, from the 11.25 percent rate of return set in 1991.[40] It is an interesting coincidence that the increase proposed by the ILECs is close to the 20 percent suggested by Caballero and Pindyck for the impact of a doubling of uncertainty. Changing this input yields an increase in the average TELRIC cost for basic exchange service by 8 percent compared to the default run of 11.9 percent cost of equity – an upper bound well below the one suggested by Hausman.[41]

The final factor to consider is whether the CLECs' use of the network exposes the ILEC to more risk than the typical customer. ILEC customers have always had the option to use or not use the ILECs' network. The uncertainty in demand faced by the ILECs can be ascribed to a number of factors, including: Centrex (which is discussed in greater detail below), demand for second lines, substitution of different forms of access (special vs. switched) that require different mixtures of facilities, and competition. For many years the ILECs have argued that competition (of one form another) has been a major factor causing substantial financial risk. Thus, there is no reason to believe, *a priori*, that the risk to the ILECs from leasing UNEs is different than these other risks. Indeed, it is reasonable to presume that the CLECs' use of UNEs will reduce ILECs' risk, because it means that a loss of customers to a competitor will not result in a lower utilization of the network.

Regulators are unlikely to have the information available to quantify the differences in uncertainty across different users of the ILECs' network. Perhaps this explains the apparent goal of the ILECs to sow doubt and confusion on this issue. Faced with an inability to scope out the size of a problem, the regulator could reject a methodology (i.e., TELRIC) that is perceived to be highly sensitive to factors that are difficult to quantify. This concern can be dispelled by analyzing the possible impact of the CLEC demand for UNEs on the ILECs' investment costs.

The first step in this analysis is to look at the major elements of a local exchange network and consider what investments are sunk. The ILEC network has three major components: the local loop, the local switch, and interoffice transport.[42] Of these, only the local loop involves substantial sunk costs. Switching has become more modular over the last several years. Capacity can be added by installing additional line cards, switching modules, and in some cases, processor capacity. Relatively large variations in demand can be accommodated by installing or removing these different components, which can then be reinstalled at other locations. The capacity of interoffice transport facilities, which consist mainly of fiber optic links between wire centers, can be easily augmented or reduced (a rare occurrence) by substituting for the electronics at each end of the fiber.

The local loop portion of the network includes both significant sunk and non-sunk costs. Sunk costs include structure costs (poles, conduits), trenching, serving area interface construction costs, and the costs of placing the cable (copper or fiber) on the structure. Non-sunk costs include the electronics installed at the serving area interface (such as digital loop carrier equipment) and terminating equipment at the central office (e.g., fiber terminating equipment, distribution frames).

The next step in the analysis is to attempt to measure the ILECs' exposure to the risk that the CLECs will use loops for only a short period of time, after which the plant is "stranded." Making the best possible case for the ILEC side of this argument, one could measure the ILECs' exposure to this risk as the difference between the investment cost to serve 100 percent of the market versus the investment cost of serving something less than 100 percent of the market, i.e., the situation where the ILEC does not stand ready to offer UNEs to the CLECs.[43] It is then possible to answer the question of whether the ILECs will receive adequate compensation for this risk when UNEs are priced at TELRIC.

The analysis is based on the conservative assumption that the CLECs' use of UNEs would strand 10 percent of the existing number of subscriber loops. Since the ILECs' plant would be stranded only if the decline in CLEC demand is not offset by the growth in the market, this analysis allows for far greater than 10 percent market penetration by the CLECs using UNEs. To estimate the investment cost of different sized loop networks, the HAI Model 5.0a for New York Telephone was run at three levels of demand: 100 percent, 90 percent and 10 percent of current demand. Table 2 shows the results, which demonstrate significant economies of scale in the production of subscriber loops: a change in demand from 90 percent to 100 percent of the existing market requires only a 4 percent increase in investment, while the per-unit cost of serving 10 percent of the market is 5.7 times higher than the per-unit cost of serving 100 percent of the market. The presence of such large economies of scale implies that the ILECs should have a strong incentive, absent any anticompetitive strategy, to lease capacity at prices well below the CLECs' cost of constructing their own loops.

Table 2. Investment Costs by Quantity Demanded

	100 percent	90 percent	10 percent
Copper feeder cable (u/g)	274,272,241	251,740,976	55,826,874
Copper feeder cable (buried)	32,487,105	30,009,074	7,771,892
Copper feeder cable (aerial)	36,175,145	33,404,872	8,620,244
Fiber feeder cable (u/g)	24,349,087	24,119,864	23,157,448
Fiber feeder cable (buried)	63,996,012	63,246,234	55,849,239
Fiber feeder cable (aerial)	35,048,947	34,611,657	30,610,292
Feeder conduit	33,613,018	33,276,368	30,916,862
Feeder manholes	150,538,172	150,571,749	150,717,899
Copper feeder u/g placement	436,932,943	436,972,541	437,218,243
Fiber feeder u/g placement	454,238,241	454,136,879	452,549,981
Copper feeder buried placement	12,741,689	12,746,758	12,760,470
Fiber feeder buried placement	61,859,281	61,715,172	59,185,419
Feeder pole inv	50,028,698	49,943,163	48,345,673
Distribution cable (u/g)	17,216,717	15,891,511	3,879,548
Distribution cable (buried)	640,778,401	588,524,892	133,358,001
Distribution cable (aerial)	353,290,848	325,453,835	75,707,322
Distribution conduit	4,388,020	4,233,079	2,432,575
Distribution conduit placement	190,237,578	185,450,195	110,507,589
Distribution buried placement	645,979,763	616,998,556	306,282,915
Distribution poles	212,452,228	203,186,086	102,863,175
TOTAL	3,730,624,135	3,576,233,460	2,108,561,663
Per Unit Cost	37,306,241	39,735,927	210,856,166

To determine the return necessary to compensate the ILEC for making investments, it is necessary to consider the choices it faces prior to making irrevocable commitments. The ILEC has two choices. Either it can invest to have the capacity to serve 100 percent of the market, or it can invest to have the capacity to serve 90 percent of the market, maintaining the option to make an investment in the future period to serve the additional 10 percent of the market. An investment to serve 100 percent of the market involves no real option calculation, because management has no flexibility (or interest) in adding to the capacity or withdrawing that capacity in the future.[44] An investment in the first period to serve 90 percent of the market gives the ILEC the option to add to its plant in the second period, and that option must be valued.

Using the formula from Trigeorgis,[45] the value of the option to invest more in period 2 can be calculated as:

$$C = \frac{pC^{+} + (1-p)C^{-}}{1+r}$$

where C^{+} equals the value of the option if demand materializes in period 2 and C^{-} equals the value of the option if demand does not materialize in period 2. As shown in Table 2, however, the cost of the incremental investment in period 2 is 5.7 times the TELRIC cost of serving 100 percent of the market. At that per-unit cost, the incremental investment would have a negative NPV, unless for some bizarre reason the regulator allowed the ILEC to set a UNE price 5.7 times higher than its retail rates and then CLECs actually purchased the UNEs at that price – both of which are remote possibilities. Therefore, under either possible market condition, the incremental investment is not worth making. This means C^{+} and C^{-} are zero and the value of the option is zero.

Having shown that managerial flexibility is not a factor in the investment decision, it is possible to compare the cost of the investment in 100 percent versus 90 percent of market capacity to determine whether TELRIC will compensate the ILEC for making the additional investment in the first period.

If one considers the ILEC's *a priori* choice of whether to sink the investment necessary to serve this demand, the expected revenue from this investment will be a function of the probability that the CLEC uses the capacity over the life of the plant. If probable revenue (net of variable cost) equals or exceeds the cost of building the extra capacity, the ILEC will be better off building the capacity. This is expressed as:

$$\sum_{i} P_{TEL} * Q_i \lambda_i \geq (I_{100\%} - I_{90\%})$$

where PTEL is the TELRIC price (net of variable cost), Q is quantity demanded, l is the probability of demand, and I_x percent is the cost of building capacity to satisfy a demand equal to x percent of the existing market.

The analysis above indicates that the incremental investment per unit for the last 10 percent of the loops is approximately 40 percent of the average investment per loop for the entirety of the loop plant (precisely 11.1 percent additional loops are built for an additional 4.1 percent of investment, which yields a ratio of 36.9 percent). This allows the simplification of the equation above to:

$$\lambda_i \geq 0.4$$

This implies that the ILEC would build capacity to serve the CLEC at TELRIC prices, if it anticipates a 40 percent or greater probability (each year, adjusted to yield the present discounted value) that the CLEC will use the capacity over its lifetime.

This appears to be an easy condition to satisfy for a number of reasons. First, the CLECs are unlikely to build loop plant in most areas, because they will be unable to realize economies of scale equal to those of the ILECs. Second, any decline in demand by CLECs for loop UNEs may well be offset by growth in the overall demand for telephone service (e.g., second residential lines), in which case, the loop plant will not be "stranded." Third, the ILECs' tolerance for the risk of abandoned loop plant appears to be very high, based on their revealed preferences. Let history be our guide.

Over the past several decades, the ILECs have served other large customers who expose them to significant risks of decreased utilization of loop plant. Centrex has been a major competitive offering of the ILECs for decades and the ILECs have built vast amounts of additional loop plant (often concentrated in small geographic areas) to provide customers with the option to buy Centrex. Centrex service requires a dedicated loop for each station at a customer's premises. The competitive alternative to Centrex, which is a PBX at the customer premise, requires a loop only to trunk traffic between the PBX and the central office. Each individual station is linked to the PBX with inside wire and then shares the PBX trunks (i.e., the local loops) with all of the other stations at the customer premises. The ratio of the loops needed for Centrex compared to a PBX is approximately 10 to 1. Thus, the Centrex customer receives the option value of the investment made in the additional nine loops needed to provide the service. Yet the ILECs have traditionally priced Centrex service aggressively, well below the TELRIC-based rates considered as a usable proxy by the FCC in its 1996 interconnection order. The ILECs have revealed their tolerance for risk in the many Centrex tariffs filed over the past twenty years.[46] It appears that their tolerance for risk adjusts depending on the case that needs to be made to the regulator.

3. CONCLUSION

The real options issue is simply the latest in a series of arguments raised by the ILECs in an attempt to forestall competition for large segments of the local exchange market. The thesis that the ILECs are not being compensated for use of the network by the ILECs is a thinly veiled attempt to destroy any costing method or pricing rule that would deviate from guaranteeing the ILECs full recovery of embedded costs. The ILECs have, and will summon, a host of equity arguments to support their case for full recovery of embedded cost. They undoubtedly will have their day in court to argue equity, but this attempt to cloak equity in the garb of efficiency should not be given any credibility in the public policy arena.

The best way to encourage CLECs to use UNEs for a long period of time and thereby reduce the ILECs' risk of stranded plant is for the ILECs to provide high-quality service at a low price. Cooperation on the ordering, testing, and provisioning of UNEs is essential to the commercial success of the CLECs and the willingness of the CLECs to continue to use the UNEs over the long run. Thus, the greatest danger of adopting the ILEC view of the real options theory is that it will lead to greater stranded plant. That this will be accompanied by a slower introduction of competition may be in the ILECs' interests, but it is not in the public interest.

NOTES

1. Telecommunications Act of 1996, Pub. L. No. 104-104, 110 Stat. 56 (1996), amending the Communications Act of 1934, 47 U.S.C. §§ 151 et. seq.; and "Joint Board on Universal Service" and "Forward-Looking Mechanism for High-Cost Support for Non-Rural LECs," Further Notice of Proposed Rulemaking, CC Docket Nos. 96-45 and 97-160 (May 28, 1999).

2. J. Hausman, "Reply Affidavit of Professor Jerry A. Hausman," Before the Federal Communications Commission, CC Docket No. 96-98 (May 29, 1996), 1. It is difficult to sort out what Professor Hausman is referring to when he states that a "TSLRIC calculation" is biased by a factor of at least 2 and probably in excess of 3. Is he referring to the results of a TSLRIC model, or to some component in the model? The FCC's rejection of Hausman's thesis seemed to interpret his claim as referring to the "forward looking methodologies" per se (see FCC Order p. 688). This also comports with my recollection of the way in which the debate was conducted at the time. It is possible, however, that Professor Hausman's statement was misinterpreted. In a later filed affidavit, he seems to have clarified his position that the bias only refers to the sunk portion of the investment (see Testimony of Jerry Hausman, April 7, 1998, before the California PSC).

[3] Although the thrust of Jerry Hausman's remarks at this conference and in his affidavits was not to defend embedded cost pricing by the ILECs, it strains credulity to believe that the goal of his attack on TELRIC costing is not part of an overall effort mounted by the ILECs to secure this result. In his first affidavit submitted in the Interconnection proceeding at the FCC, Professor Hausman states that "Numerous regulatory distortions and other economic factors weigh strongly against applying long-run incremental pricing to interconnection and network elements." (Affidavit of Professor Jerry A. Hausman, FCC CC Docket No. 96-98, filed on May 16, 1996). Further, the actual comments filed by USTA to which Professor Hausman's affidavit on real options was attached, call specifically for the recovery of embedded costs and vehemently reject the use of TSLRIC to set prices, stating that "TSLRIC-plus should still not be used as a rigid pricing formula" (see Reply Comments of United States Telephone Association, FCC CC Docket No. 96-98, filed on May 30, 1996, at 19). Further discussion of this point can be found later in this paper.

[4] Monson. C. and J. Rohlfs. July 16, 1993. *The $20 Billion Impact of Local Competition in Telecommunications*, Strategic Policy Research, Inc.

[5] USTA Press Release. July 1993. "Potential Impact of Competition on Residential and Rural Telephone Service," at 1.

[6] The term "embedded" is an odd appellation, because its usual connotation is that the ILECs would recover the net book value of their investments *plus* their recorded operating expenses. There is nothing embedded about expenses that reflect day-to-day operational decisions by the ILECs. These expenses are not fixed costs, and there is even less legitimacy to the ILECs' argument that their rates should be set prospectively to compensate them for these costs.

[7] "Defining and Funding Basic Universal Service: A Proposal of MCI Communications Corporation," July 1994.

[8] Hatfield Associates, Inc. July 1994. *The Cost of Basic Universal Service.*

[9] The $3.7 billion subsidy is estimated by subtracting the total cost of serving residential customers nationwide from total basic local revenues collected from these customers. This calculation yields a measure of the subsidy going to local service from other services (e.g., toll, access). There is an additional flow of subsidy going from low-cost to high-cost residential customers, which is not included in the $3.7 billlion figure. The total of both types of subsidies is approximately $6.4 billion, according to this version of the Hatfield model.

[10] Section 252(d)(1).

[11] Parallel to, and at times in conjunction with, the Hatfield modeling efforts, several of the ILECs developed the Benchmark Cost Proxy Model. Although this model yielded different results than Hatfield, these differences can be traced almost entirely to different input assumptions. Structurally these models were quite similar, and indeed the ILECs' participation in the BCPM process helped enhance the credibility of the TELRIC modeling efforts.

[12] Fifth Report and Order, CC Docket No. 96-45 and CC Docket No. 97-160, Adopted October 22, 1998.

[13] This leads to an interesting possibility, that according to USTA, the only way to get low-priced telephone service is to move to Kuwait or Bosnia.

[14] Taylor, William E. October 16, 1996. *Not the Real McCoy: A Compendium of Problems with the Hatfield Model*, National Economic Research Associates, Inc. Prepared for United States Telephone Association, Ex Parte Filing at the FCC, CC Docket No. 96-45.

[15] Hausman, Reply Affidavit, p. 18.

[16] The ILECs' criticism of the TELRIC modeling process is at odds with their own use of LRIC models in numerous cases in the past.

[17] In his first-round affidavit at the FCC, Professor Hausman supported the use of proxy rates in place of TSLRIC-based rates. He states "measurement of costs, no matter how defined, is in my experience labor intensive, time consuming, and contentious. The NPRM raises the possibility of using proxy

variables to set rates (p. 134). The idea provides significant potential benefits because transactions costs are likely to be much lower if the Commission provides a safe harbor that both parties know is acceptable." He goes on to propose the use of current access rates for interconnection charges. These rates are based on embedded costs (see Hausman, Affidavit, p.17). Similarly, the USTA filing to which the Hausman affidavit on real options was attached states that "It would be an administrative nightmare – indeed an impossibility – for the Commission itself to attempt to calculate reasonable TSLRICs for network elements" (USTA Reply comments, at 26).

18 United States Telephone Association, Ex Parte Notice, CC Docket Nos. 96-45 and 96-262, September, 18, 1998.

19 Id.

20 Hausman, Reply Affidavit, at 4, argues that the assumption of constant prices for capital goods is "extremely inaccurate."

21 See CC Docket Nos. 96-262, 94-1, 97-250, RM 9210, Comments of The United States Telephone Association, October 26, 1998.

22 FCC. May 1999. "Preliminary Statistics of Communications Common Carriers, and New Paradigm Resources Group." *1999 CLEC Report*, 10th ed.

23 Digital Loop Carrier equipment is the only electronic component of the subscriber loop plant, and even in a forward looking network, this equipment accounts for less than 15 percent of the total investment in the loop plant. For example, for Bell Atlantic in the State of New York, DLC costs (inclusive of the site costs) are 14.9 percent of total loop costs. Excluding the site costs, which has not been done here, would lower this percentage.

24 Hausman, Reply Affidavit, p. 4.

25 Northern Business Information. January 1996. *The U.S. Central Office Equipment Market*, Northern Business Information.

26 CC Docket Nos. 96-262, 94-1, 97-250, RM 9210, Comments of The United States Telephone Association, October 26, 1998.

27 Gollop, Frank. October 22, 1998. "Attachment D to Comments of USTA," *Technical Report: Replication and Update of the X-Factor Constructed Under the FCC Rules*. Gollop, Frank. November 5, 1998. "Attachment D to USTA Reply Comments," *Sensitivity Analysis of the FCC X-Factor to Changes in Economic Variables*.

28 For a given expected useful life, accelerating depreciation will not change the total depreciation, but will shift the recovery schedule to earlier years. The example given in this paper of the increased costs resulting from shorter depreciation lives is a rough estimate of this effect during the early life of the equipment. Later in its life, depreciation expenses would be lower and the TELRIC prices would have to be reduced to account for the lower value of the equipment and the lower depreciation expenses.

29 It might seem odd that loop costs fall as a result of a decrease in the life of digital switches. The reason for this is that the model spreads some categories of common cost to the elements in proportion to their annual capital costs. Hence, the increase in digital switching costs causes a decline in the *relative* costs of loops and a decreased assessment of common costs to the loop.

30 Hausman, Reply Affidavit. p. 1.

31 Id. ftn. 10. The reference cited by Hausman is: Lawrence Summers, "Investment Incentives and the Discounting of Depreciation Allowances." 1987. *The Effects of Taxation on Capital Accumulation*, Martin Feldstein, ed. Chicago: University of Chicago Press.

32 This discussion was originally presented in "Depreciation and Capital Recovery Issues: A Response to Professor Hausman," Kenneth C. Baseman, Fredrick R. Warren-Boulton, and Susan Woodward, filed at the FCC in CC Docket 96-98 on July 24, 1996.

[33] See, Ibbotson Associates, *Stocks Bonds Bills and Inflation,* 1995 Yearbook, Table B-1 at 157.

[34] *Economic Report of the President,* 1993, Table B-69 at 428.

[35] The cost of equity component of the 11.25 percent cost of capital is approximately 14.0 percent, because the debt comprises approximately 43 percent of their capital and the cost of debt according to FCC methods is 7.35 percent.

[36] A measure of inflation expectations is the differential between the yield on 10-year treasury bonds and 10-year inflation adjusted treasury bonds, which is currently running at 2.0 percent (*Wall Street Journal,* 6/24/99).

[37] AT&T. March 16, 1999. *Affidavit of Bradford Cornell and John I. Hirshleifer,* FCC CC Docket 98-166.

[38] Another paper finds that price uncertainty does not affect investment in any but the most unconcentrated markets. See Goshal, Vivek and Prakash Loungani. June 1996. "Product Market Competition and the Impact of Price Uncertainty on Investment: Some Evidence from U.S. Manufacturing Industries," *Journal of Industrial Economics.*

[39] Caballero, Ricardo and Robert S. Pindyck. September 1995. "Uncertainty, Investment, and Industry Evolution," Discussion Paper, M.I.T.

[40] Comments of Dr. Randall S. Billingsley CFA, FCC CC Docket 98-166, Filed on behalf of USTA et al., March 16, 1999.

[41] The default run of the HAI model uses a cost of equity of 11.9 percent and a cost of debt of 7.7 percent, for a weighted average cost of capital of 10.0 percent, well below the current prescribed rate of return of 11.25 percent.

[42] The FCC has identified four other network elements: network interface, signaling network, operations support systems, and directory assistance and/or operator services. These account for a very small portion of the total costs of the ILECs.

[43] This test is not appropriate for measuring the short-term static efficiency benefits of requiring the ILECs to offer loop facilities at TELRIC, because the loop investments have already been made, and the return needed to maintain and operate the plant will be much lower than what it would earn at TELRIC prices.

[44] Clearly, there are other strategic considerations that the ILEC faces that will give it flexibility in the future. But for purposes of the analysis of whether prices set at TELRIC are compensatory, it is reasonable to assume that these considerations are not significant when comparing the choice between investing to serve 100 percent versus 90 percent of the market. The strategic benefit of retarding entry is explicitly excluded here because the regulator, in setting compensatory prices for UNEs, would not set prices that compensate the ILEC for foregoing entry deterring behavior.

[45] Trigeorgis, Lenos. 1996. *Real Options, Managerial Flexibility and Strategy in Resource Allocation.* Cambridge Massachusetts: The MIT Press, at 348.

[46] Another aspect of Centrex service is also instructive for the UNE debate. Centrex tariffs generally offer a lower price if the customer is willing to commit to a term of service (usually three years). This is one way of introducing the option value into the pricing process, and should be considered as an option for UNE prices. Of course, this does not mean that the month-to-month tariffs should be raised above current TELRIC estimates (just as the month-to-month Centrex tariffs were still low compared to TELRIC or other retail rates for identical network elements), but rather that discounts should be offered to CLECs that are willing to absorb more of the risk than the typical ILEC customer.