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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, NW, Room 222
Washington, DC 20554

RE: Ex Parte Presentation
CC Docket No. 96-98

Dear Mr. Caton:

Pursuant to the Commission staff's request, AT&T is submitting the attached response to the Reply Affidavit of Jerry A. Hausman that was appended to USTA's Reply Comments in this Docket. This response was prepared by Professors R. Glenn Hubbard and William H. Lehr of Columbia University.

Two copies of this Notice are being submitted to the Secretary of the FCC in accordance with Section 1.1206(a)(1) of the Commission's rules.

Sincerely,

Richard N. Clarke

Attachment

cc: J. Farrell
G. Rosston
G. Hubbard
W. Lehr

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CAPITAL RECOVERY ISSUES IN TSLRIC PRICING:

RESPONSE TO PROFESSOR JERRY A. HAUSMAN

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

R. Glenn Hubbard and William H. Lehr

Columbia University

July 18, 1996

I. Introduction and Summary

In his reply affidavit for this proceeding,[1] Professor Jerry Hausman argues that "TSLRIC should not be the price for interconnection elements for two reasons: (1) it ignores fixed and common costs, and (2) telecommunications are mostly sunk costs." Hausman justifies this second reason using three basic arguments:

(1) TSLRIC prices fail to compensate incumbent local-exchange carriers (ILECs) adequately for past investments;

(2) TSLRIC prices are a theoretical construct which are not realized anywhere and will not be realized in the imperfectly competitive local-exchange markets; and

(3) TSLRIC prices will result in inefficient investment and production decisions in the future, leading to insufficient facilities-based entry.

[1] See *Reply Affidavit of Jerry A. Hausman*, In the Matter of Implementation of Local Competition Provisions in the Telecommunications Act of 1996, CC-Docket No. 96-98, May 30, 1996.

As we explain below, each of Professor Hausman's arguments is incorrect. His first argument confounds two separate questions leading to unnecessary confusion and an erroneous conclusion. Because TSLRIC prices are forward-looking, they ignore past investments of ILECs *by definition*. This is as it should be because, in competitive markets, only costs that are efficient on a forward-looking basis can be recovered in prices. To the extent that one can show that the ILECs should be awarded additional revenues as part of a "regulatory compact," these revenues should be treated analogously to the need to fund universal service. TSLRIC pricing of interconnection components is designed to induce efficient, competitively-neutral, non-discriminatory investment decisions, not to effect rent transfers or subsidies which are more efficiently and appropriately handled via a separate, competitively neutral mechanism (*e.g.*, a lump sum addition to the subscriber line charge). If these cross-subsidies and transfers are permitted to continue in the future by embedding them in component pricing, then local-exchange competition will not succeed and the Telecommunications Act of 1996 will have failed. While we do not accept Professor Hausman's implicit contention that such a "regulatory compact" did in fact exist, or that the ILECs failed to adequately recover costs that were due them, we do not wish to debate these matters here. This argument and the counterarguments against it are made more forcefully elsewhere.[2]

[2] See, for example, *Reply Comments of AT&T Corporation*, In the Matter of Implementation of the Local Competition Provisions in the Telecommunications Act of 1996, CC-Docket No. 96-98, May 30, 1996, and June 3, 1996. As noted therein, the courts generally affirmed no obligation to include in the rate base all actual costs for investments which were prudent when made.

Hausman's second argument is that TSLRIC prices are inappropriate because they are a theoretical construct[3] and because local-exchange markets are not likely to become competitive. Professor Hausman argues that "highly imperfect competition is the expected outcome" (page 10) in a whole collection of network industries such as banking, airlines, and telecommunications. The presence of network "externalities" (page 10) accentuates the market power which accrues to an established incumbent and makes it all the more important that potential entrants be guaranteed efficient, nondiscriminatory, competitively neutral interconnection rights if competition is to survive. Not surprisingly, the industries mentioned by Hausman were at one time heavily regulated (in part to address interconnection and market power issues). Rather than refuting the logic of TSLRIC pricing, the fact that local-exchange markets are not competitive today offers a powerful inducement for its adoption. Moreover, the threat of market power associated with the ILECs' position as dominant incumbents makes it important to include an array of additional regulatory policies in order to facilitate effective competition (*e.g.*, imputation rules to protect against predatory pricing, promoting total service resale and reciprocal termination agreements).[4]

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[3] Hausman states: "To attempt to impose a theoretical ideal through regulation on a real world situation in which the ideal cannot occur because of technology leads to inefficient outcomes" (see *Reply Affidavit of Jerry A. Hausman*, note 1, *supra*, page 10).

[4] Throughout his reply affidavit, Hausman makes reference to industry comparisons which do not fit the circumstances of local-exchange markets and are of little relevance to the present proceedings. Occasionally, his examples seem to refute the very point he is trying to make. For example, Hausman claims: "no airline is required by Congress to charge the same amount for a 200 mile flight as for a 2000 mile flight (rate averaging)" (see *Reply Affidavit of Jerry A. Hausman*, note 1, *supra*, page 10). We and AT&T agree that historical regulations have distorted the pricing of retail telephone services; however, this has nothing to do with the appropriateness of TSLRIC for the pricing of unbundled network elements and for estimating the avoided cost.

Hausman's third argument is the most complex and, if it were true, the most relevant for the present proceedings; we devote the bulk of our comments to its refutation. Briefly, the essence of Hausman's argument is that TSLRIC-based prices will lead to inefficient investment decisions because they fail to take account of (1) *expected* economic depreciation (which exceeds allowed depreciation because of expected technical progress), and (2) the risk associated with *unforeseen* changes in final product demand and prices, capital goods prices, and interest rates. The former point is incorrect, as we explain below. To explain the effects of the latter effect, Hausman provides a simplified and highly stylized example based on contemporary investment theory. Most of the examples and empirical research he cites are designed to show the validity of this theory and its applicability in the modern analysis of efficient investment behavior. Hausman's principal error, though, is to redefine TSLRIC incorrectly to create a straw man, which he can then discredit with highly stylized examples of a complex theory and unsupported and unexplained references to his own empirical estimates.

In Hausman's notation, he implicitly argues that TSLRIC is equivalent to setting component prices equal to $P^T = rI + C$, where r is the ILEC's risk-adjusted cost of capital, I is the total investment cost, and C are the operating costs. Hausman argues that even in a world of certainty, prices would need to be higher than P^T to compensate firms for expected economic depreciation and declines in the price of the capital goods. In such a world, the correct pricing rule would be to set price higher than implied by Hausman's (incorrect) definition of TSLRIC. (In the first part of his reply affidavit, Professor Hausman also conveniently assumes that $C = 0$, which has the effect of enlarging on a percentage basis his estimate of the potential understatement of TSLRIC costs.)

Hausman then notes that we do not live in a world of certainty. There may be unforeseen changes in technical progress or factor prices (in addition to the anticipated changes noted above),

and perhaps more important, unanticipated changes in firm demand (both because of uncertainty in aggregate demand, and, because of competition, uncertainty in the firm's future market share). By itself, this uncertainty does nothing to change his earlier analysis (since Hausman and others typically assume firms are risk-neutral investors). However, if one assumes that the total incremental cost of investing in local-exchange plant is irreversible and could be postponed, then there is an "option value" associated with "waiting to invest." In such cases, there may be an added "opportunity cost" to investing today which should be taken into account when a firm makes its investment decision.

There are a number of problems with Hausman's application of modern investment theory to critique TSLRIC. First, Hausman has assumed a definition for TSLRIC which is incorrect; as a result, he falsely accuses TSLRIC of failing to account for expected depreciation and possible declines in investment goods prices. He sets up a theoretical straw man by choosing to redefine TSLRIC so that is excludes costs which are clearly included in the TSLRIC concept. He then proceeds to show how failure to include these costs (which actually are included) leads to a gross underestimation of costs. The actual correction is an empirical issue which Hausman addresses by referring to largely unsupported and unexplained examples. On closer inspection, we show how these examples help to refute, rather than support Professor Hausman's arguments. As an empirical matter, we conclude that there is no basis of support for the doubling (or, in some cases, more than doubling) of the appropriate user cost of capital as suggested by Hausman. If any adjustments to conventional derivations and estimates of the cost of capital are required to address the issues raised by Hausman, such adjustments would be modest

II. The Logic of TSLRIC

In elementary economics courses, students learn that there are two types of costs in the short run: variable costs, which change with the level of production, and fixed costs, which do not. Economic efficiency requires that prices be set equal to marginal costs so that only consumers who value consumption at least as much as what it costs society to satisfy their demand will actually purchase the good or service. Business school students learn further that profit-maximizing firms should ignore fixed costs in the short run since they are irreversible or sunk. In the long run, all costs are variable and reversible because firms can revisit their decision to continue operating in the industry (*i.e.*, firms could enter or exit the industry). Whether a cost is variable, fixed, or sunk depends on the horizon. In the simplest decision-making framework, a firm chooses whether to enter or exit an industry at a single point in time, which divides the world neatly and unambiguously into the long run (before deciding whether to enter) and the short run (after the firm has decided). The efficient entry decision is for the firm to enter only if the expected future price (post-entry) is greater than the post-entry average variable costs which will be incurred plus the post-entry fixed costs which will be sunk once the firm has entered. The "$P = MC$" rule still applies as long as one understands that P now refers to the expected future price and MC to the long-run incremental cost.

In the real world, decisions occur continuously. Firms may decide to invest, disinvest, or wait to make a decision at a later time, or to reverse wholly or partially an earlier decision (*e.g.*, by selling off assets). Information is continuously arriving and firms revise their dynamic investment strategies. In this more general framework, the "$P = MC$" rule must be applied by interpreting P as

the expected average present value price of output and MC as the "Total Service Long Run Incremental Cost," or TSLRIC.[5]

The TSLRIC includes all costs which are relevant to the firm when it decides whether to invest in additional capacity (*i.e.*, enter). It is forward-looking by construction because it ignores all costs which may have been incurred in the past and are now sunk. It includes all future costs which result from the decision to enter irrespective of whether they are fixed or variable, or whether they will be sunk following the firm's decision. Because the future is uncertain, the TSLRIC must and does account for uncertainty with respect to technological progress, factor prices, firm demand, and interest rates.

To the extent some of the costs incurred will be sunk, new information arrives continuously, and it is possible to postpone the investment decision until some of the future uncertainty is resolved, there is an option value associated with "waiting to invest," in postponing incurring the sunk investment component. The value of this option should be included in the TSLRIC. The unwieldy acronym "TSLRIC" was created in order to make sure that all relevant, forward-looking incremental costs would be included. Because Professor Hausman conveniently redefines TSLRIC to exclude costs which are clearly included when a proper definition is used, Hausman presents himself with a theoretical straw man which he then attempts to cut down via recourse to contemporary investment theory.[6]

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[5] For a more extensive discussion, see *Reply Affidavit of William Baumol, Janusz Ordover, and Robert D. Willig*, In the Matter of Implementation of the Local Competition Provisions in the Telecommunications Act of 1996, CC-Docket No. 96-98, May 30, 1996, Appendix D.

[6] Hausman states on page 4 that "[p]roponents of a TSLRIC price for network elements are attempting to establish a single price over a long period of time." This is not true. TSLRIC is a conceptual basis for estimating forward-looking efficient prices on an ongoing basis. The Hatfield model operates very much in this spirit. For example, if technological progress occurs, it would be

The acronym "TSLRIC" emerged expressly to deter such simplistic interpretations of the appropriate incremental cost concept to use. It is obvious that Professor Hausman's definition of TSLRIC as equal to just "$rI + C$" is not applicable to the world of telecommunications, which faces significant recurring capital investments which must be recovered for a firm to be financially viable. Thus, Professor Hausman's theoretical criticism of TSLRIC only applies to incorrectly estimated TSLRICs.

Hausman claims that TSLRIC fails to include sufficient allowances for depreciation, and therefore understates efficient prices even in a world of certainty. In order to estimate TSLRIC, one must perform a discounted cash flow analysis of the future costs associated with the decision to invest. This is exactly what the Hatfield model is designed to do.[7] One-time costs associated with the acquisition of capital goods are amortized over the economic life of the asset using the user cost of capital (see below), which requires accounting for both expected capital good price changes and economic depreciation. These effects and the option effect discussed above are incorporated in TSLRIC calculations, and are reflected in the service lives and discount rates used. Perhaps recognizing the invalidity of his claim that, as a theoretical model, TSLRIC neglects these costs, Hausman then attacks the Hatfield model for using parameter estimates based on historical regulatory proceedings, implicitly arguing that the service lives assumed were too long and the discount rates were too low. If true, this would underestimate true incremental costs. However,

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tracked in the ongoing updating and periodic review of TSLRIC as estimated by the Hatfield model. The Hatfield estimates could then be used to support decisions made by regulators in their periodic review of prices.

[7] For a description of the Hatfield model, see *Reply Comments of AT&T Corporation*, In the Matter of Implementation of the Local Competition Provisions in the Telecommunications Act of 1996, CC-Docket No. 96-98, May 30, 1996, Appendix D.

Hausman provides no evidence that these parameters are biased in the direction he claims, as we describe in section IV. Moreover, attacking specific parameter estimates is not equivalent to attacking a methodology. It is possible to reestimate the Hatfield model using alternative assumptions regarding economic lives and discount rates.

Hausman uses historical data for declines in switch prices from $200 per access line in 1987 to $80 today to demonstrate the importance of including expected changes in capital goods prices. This is misleading on three counts. First, even if one agrees with Hausman's assessment of parameter estimates based on historical rate proceedings, the TSLRIC estimates would still reflect a partial accounting for economic depreciation. Second, TSLRIC is supposed to be based on forward-looking costs. The 1987 price is only interesting in so far as subsequent price declines were unforeseen (which is not obvious) and it may assist in estimating further price declines which should be reflected in the choice of the discount rate and expected economic life for switch assets (which may end up being the same as those used in the Hatfield model). Third, Hausman focuses on the decline in switch prices, which reflect a much smaller share of total plant in service than is contributed by loop facilities. Because the much more significant nonrecurring costs of loop facilities has declined quite slowly or may even have increased, it is not surprising that Hausman chose to focus on switch prices.[8]

III. Irreversible Investment Under Uncertainty

[8] See *Reply Affidavit of Lee L. Selwyn and Patricia D. Kravtin*, submitted as Appendix C of *Reply Comments of AT&T Corporation*, In the Matter of Implementation of the Local Competition Provisions in the Telecommunications Act of 1996, CC-Docket No. 96-98, May 30, 1996.

Hausman begins his analytical treatment of the effect of sunk cost and irreversibility on efficient pricing with a mischaracterization of the role of the user cost of capital in the determination of TSLRIC. Absent taxes, the familiar user cost of capital in the neoclassical model is given by:[9]

$$User\ cost\ of\ capital = P_k(r + \delta - \Pi^e_k) \tag{1}$$

where P_k is the relative price of the capital good purchased, r is the risk-adjusted discount rate,[10] δ is the exponential rate of expected depreciation, and Π^e_k is the expected exponential rate of change in the relative price of the capital good. Equation (1) has a simple interpretation: the user cost of capital is the financial cost of investing funds in a project plus the depreciation of the value of the capital good. Hence Hausman's characterization of the user cost of capital implicit in TSLRIC is not correct in so far as he claims that it fails to account for expected changes in prices. Note that while it follows that expectations of falling capital goods prices make straight-line depreciation calculations inappropriate, Hausman's suggestion that depreciation expenses should therefore be higher in all years is incorrect. If capital goods prices are expected to decline (with no change in useful lives), depreciation should be higher in the early years of the life of a capital good and lower

[9] The original derivation of the user cost of capital in the neoclassical model of investment appears in Dale W. Jorgenson, "Capital Theory and Investment Behavior," *American Economic Review* 53 (May 1963), pages 247-255; for a review of the literature since then, see Kevin A. Hassett and R. Glenn Hubbard, "Tax Policy and Investment," Mimeograph, Columbia University, 1996.

[10] The conventional approach to determining the risk-adjusted discount rate is to apply the Capital Asset Pricing Model (CAPM). The discount rate in the CAPM is the sum of the risk-free return and the product of beta and the equity risk premium.

in the later years.[11] In addition, Hausman provides no evidence that the prices of capital goods purchased by the ILECs are expected to fall at increasing rates in the future. Indeed, any such evidence would appear inconsistent with the very modest productivity rates that the ILECs' have forecast in the Commission's current price cap proceeding (CC Docket No. 94-1).

The basic neoclassical model has some limiting features, as the research to which Hausman refers suggests. In particular, it assumes that firms cannot delay investing in a particular project (they must undertake the investment or lose the opportunity). Further, it assumes that investment projects are reversible: that is, the capital can be resold in efficient secondary markets. A recent line of inquiry has criticized these assumptions, stressing that firms do often have the option to delay — and, in the presence of certain forms of uncertainty, that option is a valuable one.[12] The second area of emphasis is that investment is irreversible: that is, once a capital good is committed to a project it has no resale value.[13] With demand uncertainty and irreversibility, the user cost of

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[11] This point has long been recognized in this context; see, for example, Michael Crew and Paul Kleindorfer, "Economic Depreciation and the Regulated Firm Under Competition and Technological Change," *Journal of Regulatory Economics* 4 (March 1992).

[12] In addition to the option value of delay for ILECs' investments Hausman notes (on page 2) that the Telecommunications Act of 1996 gives the CLECs the right, though not the obligation, to use ILECs' capacity investment — thereby granting them an option. While this is true, it is also more generally true that the ILECs also gave their traditional local-exchange customers such "options." Hence as long as prior TSLRIC calculations incorporated adequate capital recovery, substantial additional changes are not warranted.

In contrast to Hausman's unsubstantiated assertion that such options are a one-way bet in favor of the ILECs, should equipment prices increase in the future, TSLRIC would rise and ILECs may increase prices for unbundled elements in the future. Hence there is no one-way bet in favor of the CLEC.

[13] For reviews of models in this line of inquiry see Avinash Dixit and Robert S. Pindyck, *Investment Under Uncertainty*, Princeton: Princeton University Press, 1994; and R. Glenn Hubbard, "Investment Under Uncertainty: Keeping One's Options Open," *Journal of Economic Literature* 32 (December 1994), pages 1816-1832.

capital is augmented by an additional term, raising the value relative to the neoclassical benchmark under certainty.

In the example of Robert McDonald and Daniel Siegel considered by Hausman,[14] the value of a project, V, evolves according to a geometric Brownian motion with drift:

$$dV = \alpha V dt + \sigma V dz, \tag{2}$$

where dt is a time increment, dz is the increment of the Wiener process, and α and σ are constants. The stochastic process for V describes the arrival of new information over time and is consistent with an uncertain future value of V.

The analytical advantage of this setup is clear from the perspective of Hausman's argument. The investment opportunity considered by the firm is a call option with no expiration date; that is, the firm has the right, though not the obligation, to undertake the project at a pre-specified cost of I. At the same time, this simple setup — on which Hausman relies — has some drawbacks in describing typical investment projects. It assumes that the cost of investment is always I and *infinite* delay is possible, a suspect assumption for telecommunications markets. Also, if there are variable costs, the process for V may not be geometric Brownian motion even if that for the output price is. Finally, if the firm had competitors (Hausman's example derives from the case of a monopoly firm), the process for V may even be more complicated. We return to these concerns below.

In the conventional neoclassical criterion, the threshold value, V^*, is given by $V = I$; the firm invests up to the point at which the cost of investment just equals its value to the firm. The

[14] See Robert McDonald and Daniel Siegel, "The Value of Waiting to Invest," *Quarterly Journal of Economics* 101 (November 1986), pages 707-723.

solution to the McDonald-Siegel problem yields a threshold value, V^*, for the project at which the firm should invest:

$$V = [\beta_1/(\beta_1 - 1)]I \tag{3}$$

The basic intuitive point is this: Irreversibility and the possibility of delay generate a range of inaction (not present in the neoclassical model) in which $V > I$, yet the firm does not invest.[15] (This is because in the solution $\beta_1 > 1$, $[\beta_1/(\beta_1 - 1)] > 1$ and $V > I$.) The value of foreclosing the option to delay must be included in the cost of capital, thereby raising the hurdle rate for irreversible investment under uncertainty. This value arises from an asymmetry: delay — waiting for new information — engenders small costs (because the firm is assumed to be able to make the investment later) and potentially large benefits (because costly errors may be avoided).

What are the implications of uncertainty and irreversibility on the threshold output for price for investment? This question pierces the generality in the process described by equation (2) by specifying a source of fluctuations in value — price uncertainty. Suppose that the proposed project produces a physical flow of one unit of output each period in perpetuity. The price depends on the inverse demand function $P = YD(1)$, where D is a measure of nonstochastic flow demand and Y is a stochastic shift variable. In the simplest case, with no variable costs of operating the project, one can write a process for P reminiscent of the geometric Brownian motion used earlier to study V:

$$dP = \alpha P dt + \sigma P dz \tag{4}$$

[15] It is important to note that this line of research excludes from consideration strategic motivations in capacity investment — for example, strategic advantages accorded to first movers. Dixit and Pindyck agree that such concerns limit and may reverse the option value of waiting to invest, implying the firm may actually want to invest early, not late (see Avinash Dixit and Robert S. Pindyck, note 13, *supra*).

In this case, the solution for the threshold price at which investment should occur, P^*, equals $[\beta_1/(\beta_1 - 1)]$ times the Marshallian price.[16] Again, there is a range of inaction in which price exceeds long-run incremental cost with no response of investment or entry.

How large is the wedge between traditional net present value investment criterion and that in Hausman's example? Without going into algebraic detail, we can indicate some channels. First, as uncertainty about future returns (measured by σ) rises, the wedge $[\beta_1/(\beta_1 - 1)]$ also rises. Second, all else being equal, an increase in the discount rate, r, increases the wedge. Third, for a given discount rate, r, an increase in the trend value growth α increases the wedge. In the new solution, the user cost of capital rises by an amount equal to $P_k(\frac{1}{2}\beta_1\sigma^2)$.

Under parameter values given by Dixit and Pindyck,[17] Hausman conjectures that $[\beta_1/(\beta_1 - 1)] = 2$, so that $V = 2I$. He then concludes that

> "[a] TSLRIC calculation which ignores the sunk cost feature of telecommunications network investments would thus be off by a factor of two. Using parameters for ILEC and taking into account the decrease in capital prices due to technological progress (which Dixit and Pindyck assume to be equal to zero in their calculation), I calculate the value of $m[\beta_1/(\beta_1 - 1)]$ to be around 3.2-3.4."[18]

Hausman offers no justification for his application of the basic McDonald-Siegel problem to the telecommunications case under consideration, nor does he offer any justification for the parameter values he assumes. The major problems with Hausman's calculations fall into two

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[16] See Avinash Dixit and Robert Pindyck, note 13, *supra*, Chapter 6; and R. Glenn Hubbard, note 13, *supra*, page 1823.

[17] See Avinash Dixit and Robert S. Pindyck, note 13, *supra*, page 153.

[18] See *Reply Affidavit of Jerry A. Hausman*, note 1, *supra*, page 6.

categories, relating to the inapplicability of his simple example to pricing in local-exchange markets and the false characterization of all local-exchange investments as irreversible.

In the following three subsections, we justify our critique of Hausman by examining his application of the theory more closely. We first review the theory Hausman cites and show how his choice of examples and parameter assumptions bias his estimates in favor of amplifying his claim that TSLRIC understates true investment costs. We then show how a slightly different analytical model — one which may more accurately reflect the threat of future competition — dramatically reduces Hausman's estimate. The essence of this model is to question the reasonableness of assuming with Hausman that local-exchange investments by the ILEC might be postponed indefinitely. Finally, we argue that Hausman's characterization of all ILEC investment as irreversible is inappropriate and grossly overstates whatever effect irreversibility may have on estimates of TSLRIC.

A. Problems with Hausman's Application of Irreversibility and Uncertainty

In order to take Hausman's example seriously, one would first have to believe that the assumed parameter values are reasonable. The example cited above assumes that there are no variable (operating) costs and that the standard deviation of the annual rate of return on local-exchange investments is 20 percent. Surely, some justification of these assumptions (taken from an abstract general example from Dixit and Pindyck) is necessary.

Second, as Hausman notes,[19] in the presence of variable costs, C, the investment criterion implied by the new view is:

[19] See *Reply Affidavit of Jerry A. Hausman*, note 1, *supra*, page 8.

$$P = mrI + C, \tag{4}$$

where $m = [\beta_I/(\beta_I - 1)]$.[20] The ratio of this price to the Marshallian (neoclassical) price of "$rI + C$" is:

$$Ratio\ of\ Prices = (mrI + C)/(rI + C) = 1 + [(m - 1)rI]/(rI + C). \tag{5}$$

Hence the size of the operating costs is important for determining the wedge implied by Hausman's calculations. If $m = 2$ — as in Hausman's example — and operating costs are twice as large as capital costs — a more realistic assumption for LECs — the ratio of the prices falls from 2 down to 1.33. Obviously, one could experiment further with parameter values and so produce a range of price ratios in this example

In some respects, the wedge between the investment criteria in the neoclassical model and Hausman's example is likely to be at its upper bound in geometric Brownian motion examples in which delay can be arbitrarily long. While Hausman's example has virtually no relevance for analyzing local-exchange investments, Dixit and Pindyck offer a more germane example which allows for the possibility that the value of the investment, V, will decline discontinuously at some random time in the future. Intuitively, one can think of this as applying to the case where the incumbent local-exchange monopolist has a window of opportunity before other competitors enter and reduce profits and V. Analytically, Hausman's example would be augmented by the possibility of a downward Poisson jump, which would require modification of equation (2) as follows:

$$V = \alpha V dt + \sigma V dz - V dq, \tag{6}$$

[20] The example assumes that, in Equation (1), $P_k = 1$, $\delta = 0$, and $\Pi^e_k = 0$.

where dq, an increment of a Poisson process with a mean arrival rate λ, is independent of dz. When the "jump" occurs, q declines with probability one by some fraction θ (between zero and one). Intuitively, while V fluctuates (with geometric Brownian motion), over each interval (dt), there is a probability (λdt) that is will drop a fraction of the original value ($1 - \theta$) and continue fluctuating (with geometric Brownian motion) until the next event occurs. In this case, holding other parameters constant, the option value of delay falls relative to the pure geometric motion example. Using Hausman's calculation as a benchmark, even a 20 percent chance of a loss of economic profits reduces the value of m from 2 to 1.33.[21] While one can obviously design many versions of this experiment, one point is clear: The example used by Hausman is quite special and overstates the effect of uncertainty and irreversibility on the user cost of capital and the efficient price.

B. Problems with Hausman's Example in a Competitive Setting

Hausman's example refers to the problem of a monopolist deciding to invest. For researchers and practitioners interested in empirical applications to telecommunications, however, the lessons of recent investment models would be more compelling if couched in an industry equilibrium. This is because — as a result of market forces and the Telecommunications Act of 1996 — incumbents and potential entrants are engaged in a competitive struggle. The concept of irreversibility is also perhaps more appropriately analyzed at the industry level because the liquidity of most assets in place is surely greater within than outside the industry.

To see the need for this distinction, suppose that investment is completely irreversible and firms expect an industry-wide expansion of demand. A given firm recognizes the qualitative

[21] See Dixit and Pindyck, note 13, *supra*, page 173

implications of the favorable demand shift for the industry prices, and would like to increase its capital stock. Of course, the firm understands that other firms will not increase irreversible investment by as much as a monopolist. By contrast, an unfavorable shift in industry demand has a larger effect relative to the monopoly case. Given the assumption (as in Hausman) of complete irreversibility, all firms suffer because exit is not possible. There is, then, an asymmetry in the competitive response to uncertainty because the firm understands that an idiosyncratic demand shift does not imply similar fortunes for other firms, hence the firm behaves like a monopolist.

With regard to Hausman's example, the "option value" argument becomes more tenuous. Intuitively, there is some price $\underline{P}$, above which entry occurs. Hence any one firm views the price process as described by geometric Brownian motion — as in the Hausman example — as long as $P < \underline{P}$; the price cannot go higher without triggering entry and a price decline.

There are important differences between the cases of monopoly and competitive equilibrium. First, while the monopolist's view of the price process is not affected by potential entry (at least in the example), the competitor's view is. An opposing second effect arises because the monopolist has an option value of waiting, while the competitive firms do not (in competitive equilibrium, the option value is zero).[22] To summarize, while the investment models emphasized by Hausman offer useful insights into determinants of investment, one must be careful to match the design of such models to the particular industry equilibrium being studied.

[22] It is still the case in this example that the threshold price for entry is above the usual Marshallian level. In Section III C that follows, however, we take issue with the claim that the ILEC's investments are largely irreversible.

C. Problems with Characterization of all Local-Exchange Investments as Irreversible

Hausman's estimates of higher hurdle rates and prices for LECs require both that investment be irreversible *and* that demand and prices fluctuate significantly. Indeed, Hausman assumes incorrectly that all of the costs associated with local-exchange investments are sunk. This is not true. As already noted, there are significant recurring variable and fixed operating costs. These costs would be avoidable if the firm subsequently decided to exit the industry. More important, while some of the plant investment may not be usable in another application, this is not true of all of the investment. For example, much of the switch and switching center investment is clearly not irreversible. Switches can be moved to new locations and the end-office real estate can be sold. Rights of way, conduit, and even excess wire-line facilities, which may face reduced demand for ordinary telephone lines, may be sold for other uses (such as delivery of video to the home via technologies such as ADSL).[23] To the extent that investments in local plant are reversible, they do not need to recover the opportunity cost associated with the option to wait to invest (*i.e.*, $m = 1$). Hausman's model assumes that the entire investment, I, is irreversible. Because the ILEC could

[23] Hausman does not raise another depreciation issue arising from lumpy investments. Because of the discrete nature of many local-exchange investments, it is likely to be efficient to live with underutilization of an asset for a period of time, thereby having capacity to exploit growing demand and realize economies of scale. Conventional regulatory depreciation policy, then, forces current customers to pay for a portion of the capacity put in place to serve future customers. When regulation permitted a local-exchange monopoly and controlled lines of business of the local-exchange firm, current and future customers had significant overlap, so that conventional depreciation policy may have created few distortions. However, as local-exchange firms invest for future lines of business, this cross-subsidy made possible by depreciation policy is inefficient. Hence costs of capacity put in place for future services should not be included in the costs of unbundled elements for local-exchange service. TSLRIC-based pricing would, for example exclude such costs.

always sell its plant to another firm, a portion of this investment is clearly recoverable. Indeed, at times, ILECs even sell entire exchanges.[24] Finally, evidence about ILEC depreciation suggests that most of the capital stock invested prior to 1990 will soon be replaced.[25]

Using the logic of option values of investment, Hausman argues that a TSLRIC-based calculation gives something free to entrants — the option — while forcing the ILEC to bear the cost of the option. Again, the premise of this argument is incorrect. The firm should use the correctly calculated TSLRIC as a hurdle rate when deciding whether to expand capacity. Presumably, this is what the ILECs did when they installed their current stock of plant and equipment. Indeed, most of the ILECs' plant and equipment was installed after 1990, a period in which it is implausible that the ILECs failed to anticipate more competitive local-exchange markets over the economic life of the plant and equipment.[26]

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[24] For example, the Iowa Commission recently approved the sale by US West of all of the physical assets associated with twenty-three exchanges. See *Order Granting Motion to Strike, Approving Settlement Approving Discontinuance, Approving Transfer of Certificates, and Terminating Docket*, Docket No. SPU-96-3, State of Iowa, Department of Commerce, Utilities Board, May 30, 1996.

[25] See *Reply Affidavit of Lee L. Selwyn and Patricia D. Kravtin*, note 8, *supra*.

[26] See *Reply Affidavit of Lee L. Selwyn and Patricia D. Kravtin*, note 8, *supra*. Two other conclusions of the study by Selwyn and Kravtin (quoted from pages 3 and 4) undermine Hausman's argument:

- ILEC efforts to expand the market for additional residential lines and other discretionary services required the ILECs to design and construct for more extensive feeder and distribution infrastructure (and expand far greater aggregate capital investments) than otherwise would have been required to provision basic local-exchange service and appear to overwhelm simple growth in basic local exchange line demand as a principal investment driver.
- ILEC strategic positioning in the market for advanced and broadband digital services has resulted in the ILECs significantly increasing feeder facilities relative to those actually required to meet demand for basic local-exchange lines and other POTS services, and provides a far better explanation of capacity expansion than simple POTS demand growth.

Finally, the suggestion that few of the costs considered in TSLRIC are sunk may at first seem at variance with the argument that there are significant entry barriers in local-exchange services. After all, if there are no sunk costs, then shouldn't the markets be contestable? The answer to this is no, and the apparent confusion stems from confusing TSLRIC with the cost standard which would be used by an incumbent monopolist formulating entry-deterring pricing strategies. For a monopolist ILEC anticipating a price war, the horizon is much shorter than for the decision to enter, exit, or invest in additional network capacity. Within this shorter "price war" horizon, many of the ILEC's costs will be properly construed as unavoidable and hence sunk. This assessment of the ILEC's strategic options (in the absence of regulatory controls) would be known to both the ILEC and the entrant. The entrant, however, would face a significant asymmetry of information (leading to a higher discount rate) and greater demand uncertainty. Also, the entrant will need to invest in significant one-time retail-related expenses which are not an issue for the ILEC, and in any case, would be excluded from the computation of the TSLRICs for unbundled network elements. This fundamental asymmetry implies that the entrant would perceive entry (followed by a potentially prolonged price war with the ILEC) as involving high sunk costs (over the duration of the price war) and could be effectively deterred from entering.

IV. Implications for Regulatory Policy Toward Capital Recovery

Our analysis demonstrates that Professor Hausman's strong claims about effects of capital goods price declines and option value of delay on the user cost of capital and efficient prices are overstated. Conventional derivations of the user cost of capital already treat the former through accelerated depreciation, not higher capital recovery allowances in all future periods. While Hausman's option value arguments have merit in the example (unrelated to telecommunications)

that he poses, they do not imply the need for large increases in capital recovery parameters used to calculate TSLRIC prices.

Our analysis suggests no need to change existing procedures used in the regulatory process to determine required rates of return and the user cost of capital. Indeed, in offering guidance to state regulatory commissions, the Commission can suggest that state commission staff turn to financial markets for analytical rigor. As suggested by the logic of the CAPM described earlier, to the extent that the transition to competition raises the nondiversifiable risk borne by LECs' shareholders, the required rate of return on LECs' equity rises.[27] However, Wall Street telecommunications analysts will subsume the effects described by Hausman in their expectations of and discounting of LECs' future earnings. Estimates by these analysts form the basis for discounted cash flow estimates of the cost of equity capital that have typically been relied on by Commissions.[28] Thus, current Commission practices already address Professor Hausman's substantive concerns.

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[27] Because the literature on option values in investment decisions is relatively new, there is little empirical evidence to suggest that required rates of return incorporating option values differ significantly from required rates of return predicted by the CAPM. Indeed, Vivek Ghosal and Prakash Loungani find little effect of price uncertainty on industry investment except for industries with almost no concentration. Ricardo Caballero and Robert Pindyck estimate for U.S. industries generally "that a doubling of industry-wide uncertainty raises the required rate of return on new capital by about 20 percent." See Vivek Ghosal and Prakash Loungani, "Product Market Competition and the Impact of Price Uncertainty on Investment: Some Evidence from U.S. Manaufacturing Industries," *Journal of Industrial Economics* (June 1996), pages 217-228; and Ricardo Caballero and Robert S. Pindyck, "Uncertainty, Investment, and Industry Evolution," Discussion Paper, Massachusetts Institute of Technology, September 1995.

[28] See the Commission's *Order* on CC Docket No. 89-624, or Appendix D of AT&T's *Comments* in CC Docket No. 94-1, filed May 9, 1994 for a brief description of how a discounted cash flow calculation is performed for the LECs.