3 A. The pricing of UNEs could be done in much the same fashion as the pricing for
4 other services; the level of contribution could be based on market conditions.
5 There is no sound economic basis for precluding the use of unbundled and inter-
6 connection prices to compensate for unrecovered past expenditures.
7

8 ***EVEN INTERMEDIATE SERVICES SOLD TO COMPETING PROVIDERS***
9 ***SHOULD NOT BE PRECLUDED FROM MAKING A CONTRIBUTION***
10 ***TOWARD COMMON COSTS***
11

12 Q. IF ONE ASSUMES THAT ONE OR MORE OF THE SERVICES IN THIS
13 PROCEEDING IS A MONOPOLY SERVICE, OR AN ESSENTIAL SERV-
14 ICE, SHOULD THAT SERVICE BE PRECLUDED FROM PROVIDING A
15 SUFFICIENT CONTRIBUTION TOWARD THE COMMON COSTS OF THE
16 LEC?
17

18 A. No, all services should be allowed to provide a sufficient contribution to the
19 common costs of the LEC.
20

21 First, it is likely that the very reason a service or service element is sought after
22 is precisely because it is produced most efficiently as a unique element in the

Before the
FEDERAL COMMUNICATIONS COMMISSION
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In the Matter of	)	
Staff's Analysis of the Use of	)	CCB/CPD 97-2
Computer Models for Estimating	)	
Forward-Looking Economic Costs	)	

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GTE's COMMENTS

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SUMMARY

In examining "forward-looking" cost models for purposes of universal service, unbundled network element ("UNE") pricing and access charges, the Commission has misplaced its effort. Rather than concentrating on how cost models can be employed effectively within their limited range of usefulness, the Commission mistakenly assumes that the currently available proxy cost models are capable of estimating the forward-looking cost of a market entrant. The Commission proposes to compound this error by ignoring the manner in which real-world competitive markets establish prices -- on the basis of the average actual cost of incumbents.

As a threshold matter, the 1996 Act gives the Commission no authority to establish prices for UNEs. In any case, it is time to face reality. Use of the cost models under consideration in the manner the Commission contemplates would result in a massive experiment putting at risk a great percentage of the revenues of the nation's incumbent LECs. Cost models have been used for a long time in the telecommunications industry for the limited purpose of estimating cost relationships, but here the Commission proposes to use a model for far more complex purposes, *i.e.*, to estimate cost levels, control prices and set universal service support. This means a new and unprecedented opportunity for error exists.

The faulty theory underlying this experiment would be that an ILEC's recovery of cost should be based on the guessed-at cost level of the firm represented in the model. This firm could not survive in the marketplace since it does not emulate the characteristic business decisions that real-world firms make in seeking to provide competitive service. Thus, unlike actual telecommunications firms like the ILECs,

AT&T, and MCI, the models do not grapple with the problem of how to invest in indivisible units of capacity so as to meet their customers' demand for service while minimizing cost over time. Instead, the models simply build a new network from scratch – something that would never be good business for any firm. These and other similarly unrealistic assumptions make the model not just theoretical but simply wrong.

And under the Commission's proposals, real-world ILECs would have their revenue levels controlled by reference to this badly mistaken idea of how an efficient business would operate rather than in relation to the actual costs borne by actual firms providing service.

To the extent the concept of a cost model has an appropriate role, it should be developed in realistic terms. This means the end result must bear a reasonable resemblance to the operations of a firm that could exist in the real-world. Nor can the Commission simply assume that an entrant will be more efficient than an ILEC, because an entrant faces the same optimization problems as the incumbent, and will be more efficient only if it better solves those fundamental business problems. In these comments, GTE suggests ways to approach the task.

The purpose of a cost estimate in this context should be to provide an accurate estimate of the price that would prevail in a competitive market. If it is set too low, it will have the same effect as any other price control that seeks to hold the price in a market below its equilibrium level: new firms will be discouraged from entering, and existing firms will be encouraged to exit or to reduce their investment levels. If the amount is too high, it will create an artificial incentive for firms to enter.

For a market to be in equilibrium, the average price will reflect an average of the actual costs of the firms that supply that market. When a change in technology makes it possible to produce at a lower cost, this does not cause the average price in the industry to fall immediately to a level exactly equal to the new, low-cost technology, as the Commission has proposed. Instead, some firms will enter using the new technology, or some incumbents will begin to adopt it, as determined by each firm's attempt to minimize its costs. As more capacity incorporates the new technology, the average price will be driven down. At the end of this adoption process, the average price in the industry will reflect that of the new technology. Until this occurs, firms adopting lower-cost technology will establish prices at or just below the then-current average industry cost. They will thereby enjoy greater profits generated by their lower cost structure, and will not forego that opportunity by instantly setting their price equal to cost.

Even if all errors in estimation caused by inputs or engineering algorithms could be eliminated from the models -- which is unlikely -- they would still tend to underestimate forward-looking cost because they do not capture important aspects of the cost minimization problem facing any firm -- incumbent or entrant. None of the models capture the dynamic factors of: (i) growth in demand; (ii) changes in technology, or in input prices, or (iii) the presence of uncertainty. Nor do the models fully recognize the effect on cost of the fact that facilities come in indivisible units.

Thus, the results of cost models cannot be taken as standards of "efficiency" against which ILECs are measured because the models do not optimize anything.

Rather, the models follow simple rules of thumb in a world which is perfectly static, and without uncertainty.

For the sake of reality, the Commission must correct the many deficiencies of the models, verify model estimates against actual cost data, and explain and reconcile any differences. Only after this has been completed can cost models be used. But their use should be for a more narrow purpose than the Commission proposes. They should only be used to determine relative cost relationships.

These comments discuss the specific topics within the *Staff Analysis* and provide GTE's suggestions for improving the cost models under consideration. Clearly, a great deal of improvement is necessary. The recently introduced Hatfield Model Version 3.0 does not correct the many serious shortcomings of its predecessor. These shortcomings are detailed in two separate, attached papers and suggested corrections are discussed within these comments.

The most critical areas requiring improvement involve: (1) use of verifiable input prices; (2) fill factors in accord with industry norms; (3) placement of standard units of capacity in discrete increments, rather than all at once; (4) algorithms that result in approximately the same quantity of cable facilities as currently exist; (5) elimination of unrealistic support structure sharing assumptions; (6) use of market-determined cost for debt and equity; (7) use of depreciation schedules based upon economic lives; (8) use of realistic amounts of joint and common costs; (9) predicting expenses based upon statistical forecasting techniques; and (10) ensuring that estimated retail costs are consistent with avoided cost levels established by the states.

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In the Matter of Staff's Analysis of the Use of Computer Models for Estimating Forward-Looking Economic Costs	))))	CCB/CPD Docket No. 97-2

GTE's COMMENTS

GTE Service Corporation ("GTE"), on behalf of its affiliated domestic telephone operating companies, submits the following comments on the FCC Staff paper entitled "The Use of Computer Models for Estimating Forward-Looking Economic Costs" ("*Staff Analysis*").[1] GTE also provides input regarding the recently released revised versions of two proxy cost models under consideration by the Commission.[2]

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[1] Public Notice, Commission Staff Releases Analysis of Forward-Looking Economic Cost Proxy Models ("*Staff Analysis Notice*"), DA 97-56 (released January 9, 1997).

[2] Public Notice, Extension of Time Granted for Parties to Submit Comments in Response to Commission Staff's Analysis of Cost Proxy Models ("*Extension Notice*"), DA 97-239 (released January 31, 1997).

BACKGROUND

In accord with the Telecommunications Act of 1996 ("1996 Act"), the Commission has undertaken proceedings dealing with local competition,[3] universal service,[4] and access charge reform.[5] In each of these, the Commission has examined the use of cost models as a regulatory tool to estimate the forward-looking economic costs of providing telecommunications services. In the instant proceeding, the Commission seeks comment on issues relating to the design and use of forward-looking cost models, and specifically the items discussed in the *Staff Analysis*. The Commission noted that the record gathered in response to the *Staff Analysis* "may at a future date be associated with the official record" of the proceedings undertaken as part of implementation of the 1996 Act, *i.e.*, *D.96-98, D.96-45, D.96-262.*[6]

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[3] Implementation of the Local Competition Provisions of the Telecommunications Act of 1996, CC Docket No. 96-98 ("*D.96-98*"), First Report and Order, 11 FCC Rcd 15499 (1996) (*Local Competition Order*), Order on Reconsideration, CC Docket No. 96-98, 11 FCC Rcd 13042 (1996) (*Local Competition Reconsideration Order*), *petition for review pending and partial stay granted, sub nom.* Iowa Utilities Board et. al v. FCC, No. 96-3321 and consolidated cases (8th Cir., Oct. 15, 1996), *partial stay lifted in part*, Iowa Utilities Board et. al v. FCC, No. 96-3321 and consolidated cases (8th Cir. Nov. 1, 1996).

[4] Federal-State Joint Board on Universal Service, Recommended Decision, CC Docket No. 96-45 ("*D.96-45*"), FCC 96-93 (released November 8, 1996) ("*D.96-45 Recommended Decision*").

[5] Access Charge Reform, Notice of Proposed Rulemaking, CC Docket No. 96-262 ("*D.96-262*"), FCC 96-488 (released December 24, 1996).

[6] *Staff Analysis Notice* at 1. The Staff also asks for comment on the use of models to estimate costs for other purposes, such as for unbundled network elements. *Id.* at ¶ 11.

Additionally, two cost models have recently been submitted for possible use by the Commission, the Benchmark Cost Proxy Model ("BCPM") and the Hatfield Associates Model Version 3.0 ("Hatfield 3").[7] The Commission has requested that parties focus their efforts on evaluating the new models to determine "whether, and to what extent, the new models: (1) meet the criteria set forth in the Staff Analysis; (2) improve on potential shortcomings of the prior versions of the models."[8]

INTRODUCTION

As a threshold matter, GTE does not believe that the use of cost models, such as the proxy cost models discussed in the *Staff Analysis*, by the Commission for establishing average price levels is consistent with the 1996 Act. For example, the 1996 Act makes clear that prices for unbundled network elements must be based on the actual costs of the incumbent Local Exchange Carrier ("ILEC"), and not on "proxy costs" resulting from models based on unrealistic hypothetical networks.[9] *See* 47 U.S.C. § 252(d)(1). While cost models are appropriate for some purposes -- such as generating information about relative cost relationships across geographic areas -- they cannot and should not be used to establish specific price levels. Moreover, the risk

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[7] The BCPM was developed based on the Benchmark Cost Model Version 2 ("BCM2") and the Cost Proxy Model ("CPM"). The new Hatfield model is sponsored by AT&T and MCI.

[8] *Extension Notice* at 2.

[9] The recently released "Economic Report of the President, Transmitted to the Congress, February 1997" recognizes at 204-205 that "recovery of costs legitimately incurred pursuant to regulatory obligations" is warranted. Those are actual costs, not hypothetical costs produced by a model of a network that does not exist.

attendant on implementing a cost proxy model in *D.96-45* affecting a very high percentage of the revenues of ILECs would be so serious, the Commission must not take such a step without the most thorough examination and validation.[10]

With this significant limitation in mind, and to the extent possible in the limited time available,[11] GTE shares the results of its review of the new cost models, compares the known changes with previous cost models, and provides suggestions for improvements that the Commission should incorporate into any cost model that may ultimately be adopted for any purpose.

Unless otherwise noted, these Comments apply to the cost models regardless of whether the models are being considered for universal service, access charge reform, or local competition. However, because the *D.96-45* proceeding has actually proposed to use a proxy cost model to calculate the amount of universal service support and that proceeding is subject to a statutory deadline of May 8, 1997, GTE will discuss the use

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[10] The *Recommended Decision* proposes to use a cost proxy that has yet to be developed, much less proven to provide a reasonable estimate of the cost of offering universal service.

[11] The new version of the BCPM became available on February 7. The Hatfield 3 model became available on February 8. GTE cannot predict what amount of time is needed to thoroughly evaluate the new models. It has been GTE's experience in numerous state arbitration proceedings that prior versions of documentation, if any, have failed to provide a complete picture of the inner workings of the models, and that the review process is a laborious and complex task. Further, there will be little opportunity for the discovery and cross-examination processes used in state forums that have proven extremely useful in the past in evaluating earlier versions of proxy models prior to the May, 1997 statutory date the Commission seeks to meet. *See, e.g.*, GTE's *D.96-98* Comments, Opposition and Comments of GTE ("GTE's *D.96-98* Opposition"), October 31, 1996, Attachments B through F.

of a proxy model primarily in that context and will suggest specific ways the models can be improved for use in estimating universal service costs.

Section I of these comments explains how competitive markets determine prices, the limitations of cost models, and the appropriate criteria for evaluating the models. This Section generally corresponds to paragraphs 1-16 of the *Staff Analysis*. Section II discusses the model structure and input requirements of the cost models, and corresponds to paragraphs 17-73 of the *Staff Analysis*.

Two independent reports that critique the Hatfield Model Version 2.2.2 ("Hatfield 2.2.2") and Hatfield 3 models are attached to these Comments -- Attachments A and B, respectively. The first report was prepared by National Economic Research Associates ("NERA") and primarily analyzes Hatfield 2.2.2. The second was prepared by INDETEC International ("INDETEC") and analyzes the recently released Hatfield 3. Both these reports confirm that the Hatfield model is fundamentally flawed, and thus, should not be used to determine universal service support payments, access charges, or prices for unbundled network elements.

DISCUSSION

I. COST MODELS DO NOT CORRECTLY ESTIMATE A MARKET-DETERMINED PRICE LEVEL.

Sub-sections A through D contain a discussion of how a competitive market functions, and explains that a market-determined price does not instantaneously equal the cost experienced by a firm that adopts new technology. Sub-sections E through H consider the use of simulation models, such as cost proxy models, and explain why such models -- used by themselves -- are ill-suited to achieving the goals of the

1996 Act. Sub-section I discusses the limited usefulness of a proxy cost model in the context of universal service. These sub-sections respond, in large part, to paragraphs 1-9 of the *Staff Analysis*. Sub-sections J-M respond to the specific issues raised in paragraphs 10-16 of the *Staff Analysis*.

A. The Goal Of The Commission Should Be To Establish Market-Based Prices.

In all of the aforementioned proceedings -- universal service, interstate access charge reform, and local competition -- the goal of the Commission (and, in the case of local competition, the goal of the State commissions) should be to adopt policies that will produce an outcome as close as possible to the one a competitive market would produce. This means that prices should be as close to competitive market levels as possible. Wherever it can, the Commission should rely on market forces to accomplish this goal; where it is necessary to regulate, the goal should still be to replicate the market outcome. Therefore, when the Commission uses a cost estimate to determine a price, that cost estimate must be evaluated by how well it approximates the price that would be set in the marketplace.

In the particular context of a universal service plan, the price the Commission is seeking to estimate is the price a competitive market would set for basic local exchange service. This price would then be compared to the price the universal service provider is required to charge by regulatory agencies to achieve public policy goals. If the price set by regulators is lower than the market price, the difference is an estimate of the cost

of universal service imposed on the carrier, and hence also an estimate of the amount of explicit support required by the 1996 Act.[12]

The estimate of the market price must be as accurate as possible, because it will serve as the price that carriers will respond to when making investment and entry decisions. This price, from the perspective of the universal service provider, will be the sum of (1) the price the end-user pays, and (2) the amount of universal service support. If this total is set too low, it will have the same effect as any other price control that seeks to hold the price in a market below its equilibrium level: new firms will be discouraged from entering, and existing firms will be encouraged to exit the market or to reduce their investment levels. Conversely, if the amount is too high, it will create an artificial incentive for firms to enter.[13] In sum, the Commission's public policy goals can never be achieved, and significant damage to the economy may result, if the estimate of market price used to calculate universal service support (or prices for access, or for local interconnection) is in error.

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[12] *See* 47 U.S.C. ' 254(e). In the calculation of support in the Federal plan, the comparison might be between the cost estimate and a Federal benchmark. Nonetheless, the combined effect of the Federal plan and any state plan should support the entire difference between the cost of complying with government-imposed requirements and the market-determined price. Otherwise, the effect of pricing restrictions become confiscatory inasmuch as the shortfall cannot be recovered from other services. *See* 47 U.S.C § 254(k).

[13] Note, however, that the market will act to mitigate the effects of a support level that is too high, because firms, in competing among themselves for customers, will return any excess support amount to end-users in the form of lower prices. No such mitigating effect can occur if the support is too low.

B. At Any Given Time, The Price In A Market Reflects The Actual Costs Of Firms In That Market.

As noted in the *Staff Analysis* (at ¶ 9), the Joint Board's *D.96-45 Recommended Decision* proposes that the cost estimated for universal service should be the "forward-looking costs of an efficient entrant." The *Staff Analysis* suggests (*id.*) that these costs are appropriate, because firms "base their actions on the relationship between market-determined prices and forward-looking economic costs."

The staff's observation in fact confirms an essential point: the market price at any given time need not be the same as the forward-looking cost of a particular firm; and should well exceed that cost at least some of the time if a venture involving competitive risk is to be sufficiently successful to attract investors. An essential part of the Commission's task in setting the level of universal service support is to estimate the "market-determined price" so as to compare that level with an "affordable" price. Each firm in the market will estimate its own costs, and will react accordingly to the Commission's decision.[14]

The average price in the market at any given time will reflect <u>an average of the actual costs of the firms that supply that market</u>. This must be the case for the market to be in equilibrium. Today, the firms that supply the local exchange market are the ILECs. For a cost estimate to be useful as a measure of the market price, it must therefore take account of the actual costs of the ILECs.

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[14] The Commission's role, therefore, is not to attempt to guess each firm's cost estimate, but to give all of the firms a price to respond to that approximates, as closely as possible, what the market price would be at that moment.

In a competitive market, the introduction of a new development, such as a change in technology, may make it possible to produce at a lower cost.[15] When this occurs, the average price does not immediately fall to the new, lower cost level. Some firms will enter using the new technology, or some incumbents will begin to adopt it, or both. Significantly, however, the market price will still be determined by the older technology, because the majority of the capacity in the industry is still based on that technology. The firms introducing the new technology need not reduce their price based on the specific cost of new equipment they may install; instead they can sell at the current price. Firms in competitive markets employ a mix of technology from different generations, because this is the best way to minimize their overall costs.[16]

This optimal mix will evolve over time, as firms adopt new technology, and the average price of output will adjust with it. But, while changes in forward-looking cost will drive the adjustment process, at any given point the average price in the market will be consistent with the average of the actual cost of firms in the market. Professor Alfred Kahn observed in his recent letter to the Commission: "In unregulated markets, prices

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[15] Of course, the possibility that an innovation might reduce cost does not necessarily mean that it will do so successfully. At any given time, there are many possible innovations being explored by firms; many of these will fail. While the possibility of new technology might affect firms' expectations, it will only drive the market price down as it is actually implemented in the form of real capacity, and as the anticipated efficiencies actually materialize.

[16] *See, e.g.,* Ralph Turvey, "Marginal Cost" ("*Turvey Marginal Cost*") The Economic Journal, June 1969, at 285-286: Productive capacity at any point includes "a whole range of plants of various vintages. Thus the cost structure of the industry in any year depends upon the past evolution of its gross investment, its technology and relative factor prices."

tend to be set on the basis of the actual costs of incumbent firms."[17] This is what takes place in competitive markets, and this is what the Commission's policies should try to replicate.

C. Firms In A Competitive Market Minimize Cost Over Time Through A Dynamic Optimization Process.

The mix of technology in use in a market at any given time is the result of each firm's efforts to manage its business as efficiently as possible. A commonly cited example of this technology "blend" is found in the airline industry. Despite the availability of newer, more efficient aircraft, airlines continue to fly a mix of aircraft that includes older, less efficient planes. The older planes have higher operating costs than the latest aircraft, but airline management has found this mix to be more cost efficient than purchasing all new aircraft overnight. This is precisely the business strategy taken recently by American Airlines, which plans to phase out older planes in its fleets over a period of twenty years.[18] Other such examples can be found in any competitive industry characterized by durable investments.[19]

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[17] *See* letter from Alfred E. Kahn to the Hon. Reed E. Hundt, at 2 (January 14, 1997) ("*Kahn Letter*").

[18] *See* Scott McCartney and Jeff Cole, "American Airlines Signs Exclusive Pact To Buy Boeing Jets For Two Decades," The Wall Street Journal, November 22, 1996, at A3. For some airlines, the optimal mix also includes pilots of different vintages.

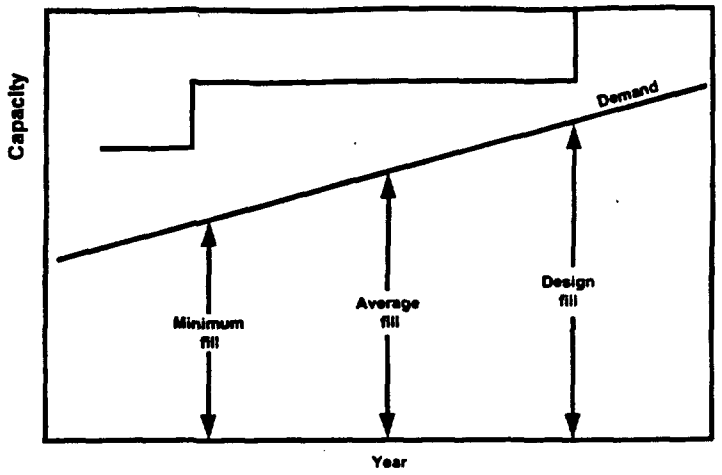
[19] For example, in an automobile industry full of new, automated factories, Ford continues to operate the River Rouge plant, that was built early in this century. In fact, airlines have more flexibility in altering their mix of equipment than do local telephone companies, because it is easier to move an airplane to another market, or to sell it to another carrier, than it is to transplant telecommunications equipment once it has been placed.

This common-sense discussion of how competitive markets operate is supported by well established economic principles. Airlines, car manufacturers, and telecommunications firms all face a dynamic cost minimization problem. Simply stated, these firms must seek to minimize costs over time, not merely for a given moment. A carrier's total investment in its network, for example, will not be placed in its entirety the moment the carrier enters the market. Instead, the carrier will seek to build and maintain its network over time in a manner that best minimizes costs over the carrier's planning period. In seeking to solve this dynamic cost minimization problem, a carrier must consider a number of factors.

First, the carrier must consider growth in demand over time, and create a plan to invest in network capacity to accommodate the expected growth. The carrier, however, cannot simply add to its capacity on a continuous basis, because capacity comes in discrete "lumps," and the carrier incurs discrete placement costs each time it installs an increment in capacity. This "indivisibility" is a well-known problem in economics, and the standard solution, as illustrated in Figure 1, is to add capacity in a kind of "stair step" process that follows the growth in demand: the carrier establishes an upper bound

for the utilization of its existing capacity, and an optimal increment of capacity to be added each time this upper bound is reached.[20]

Figure 1



In implementing this "stair step" solution, the carrier must make tradeoffs among a number of competing interests, such as (1) the cost of placement incurred each time capacity is added, (2) the "utilization" achieved over time, and (3) the cost of the capacity, which varies with the size of each increment to capacity. For example, to achieve a high "capacity utilization rate" where most of the carrier's capacity is being

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[20] These are often referred to as (S,s) models. This approach has been applied to a variety of issues. Starrett, for example, deals with optimal additions to capacity over time. *See* David A. Starrett, "Marginal Cost Pricing of Recursive Lumpy Investments," Review of Economic Studies, 45-2, at 215-227 (June 1978). Sheshinski and Weiss apply a similar model to the problem of a firm setting prices during a period of inflation when there is a discrete cost for each price adjustment (such as the cost of printing catalogs). *See*, Eytan Sheshinski and Yoram Weiss, "Inflation and the Costs of Price Adjustment," Review of Economic Studies, 44, at 287-303 (1977). Scarf has examined the problem of maintaining an optimal level of inventory when there are discrete costs associated with each order purchased. *See* Herbert Scarf, "The Optimality of (S,s) Policies in the Dynamic Inventory Problem," in Optimal Pricing, Inflation, and the Cost of Price Adjustment at 49-56 (Sheshinski & Weiss, Eds. MIT Press 1993).

used at any point in time, the carrier would constantly incur placement costs (such as digging up streets and sidewalks) to install needed facilities and would necessarily install small increments in capacity (*e.g.*, many small cables on a given route), thereby forgoing the economies associated with larger pieces of equipment.[21] Installing capacity in this fashion would, of course, be inefficient. On the other hand, it would rarely be optimal to place, at the outset, enough capacity to serve all of the anticipated demand over an indefinite period, since this would involve very low capacity utilization in the beginning.[22]

Second, the carrier in a competitive marketplace also must allow for changes in technology and other "input" prices, such as labor, land and electric power. In general, improvements in telecommunications technology have reduced the price of some equipment, whereas labor, land, and power costs have increased. If equipment prices are falling due to technological innovation, this does not mean that a carrier would immediately discard its existing equipment and replace it with the "state of the art" equipment. In fact the opposite is true; a carrier attempting to solve the "stair step" problem in the face of declining prices would choose to purchase new equipment later,

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[21] Similarly, in the case of switching, there is a tradeoff between the size of the switch when it is first placed, and subsequent additions to the switch's capacity that usually cost more per line than if purchased when the switch is new. *See* GTE's Responses to Questions Addressed To Model Proponents By The Federal-State Joint Board On Universal Service ("*GTE Model Responses*"), *D.96-45*, January 7, 1997, at 5.

[22] In general, it is easier to add capacity -- and the placement costs are relatively less -- the farther in the network the component is from the customer. Thus, it will usually be optimal to add capacity more often to switches and feeder plant, less often to distribution plant.

rather than sooner. Professor Kahn explains why it is not cost-minimizing -- in the dynamic sense -- for a firm to constantly replace its facilities with the latest equipment:

> [As Professor William J. Fellner pointed out many years ago, firms even in competitive industries would systematically practice what he calls "anticipatory retardation," adopting the most modern technology only when the progressively declining real costs had fallen sufficiently below currently prevailing prices as to offer them a reasonable expectation of a return on those investments over their entire economic life.[23]

Third, a carrier must deal with the problem of "indivisibilities" in installing capacity. For example, standard-sized copper cables contain, at a minimum, 25 pair. Although smaller cable sizes exist, they are rarely used and generally cost more per foot than standard 25 pair cable.[24] If there are only two houses on a given street, then the level of capacity utilization that can be achieved will necessarily be low, because only two or four of the 25 pairs would normally be used.[25] Does this mean the carrier

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[23] *Khan Letter* at 2. *See also Turvey Marginal Cost at 285-286:* "New plants reflect current technology and changing relative factor prices and will be built when price exceeds their average total costs" *See* William E. Taylor, "Efficient Pricing of Telecommunications Services: The State of Debate," Journal of Industrial Organization, 8, at 26 (1993); Economic Evaluation of Proxy Cost Models for Determining Universal Service Support, Christensen Associates (January 9, 1997) ("*Christensen Evaluation*"), attached to Reply Comments of the United States Telephone Association at 6-7, *D.96-45* (January 10, 1997).

[24] Use of more sizes of cable also creates additional costs of ordering and warehousing these items and of having the correct mix of cables available at the installation site. Similarly, switches have minimum getting started costs at each switch location. The use of remote switches minimizes, but does not eliminate, this indivisibility, since each remote has its own getting started cost, and there are costs associated with software in the host as well as host-remote links.

[25] *See* Figure 3, *infra*, for an illustration of a typical residential neighborhood and the distribution facilities that would be placed to serve it.

should install a smaller-sized but higher-cost cable to serve that street? Of course not. The prudent course to follow would be to install the standard-sized cable.

Fourth, the firm must deal with uncertainty. The firm cannot predict the demand for its services with certainty; neither can it perfectly anticipate changes in input prices or in technology. When the firm is unable, because of capacity constraints, to satisfy demand for service, it faces penalties imposed by regulators, who may enforce service quality standards, as well as by customers, who may take their business elsewhere.[26] Thus, in solving the "stair step" problem, the carrier must allow for uncertainty in demand by providing a higher average level of capacity than would be needed if demand were perfectly anticipated.[27]

The problem of matching demand with capacity is more severe for components of the network closer to the residential customer. Even if demand is predicted accurately at some aggregate level, such as a metropolitan area, the demand in one neighborhood may grow well beyond the level forecast, while demand in another neighborhood may fall below expectations. For some network components, such as

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[26] The recent experience of America Online is a good example of the costs a firm can experience when it fails to provide enough capacity to maintain its service quality.

[27] At the same time, when demand is uncertain, the firm will be more likely to forego scale economies, and add plant in smaller "stair step" increments, as a way to reduce its risk. *See* Avinash K. Dixit and Robert S. Pindyck, "The Options Approach to Capital Investment" ("*Dixit and Pindyck*"), Harvard Business Review, May-June 1995.

feeder cable, a certain amount of capacity can be transferred from one neighborhood to another through rearrangements, but the carrier will incur significant costs in doing so.[28]

Similarly, the carrier will face uncertainty regarding future changes in technology and in input prices. This uncertainty would mean that when they practice the "anticipatory retardation" described by Fellner, firms will adopt new technology more slowly than they would if these developments could be predicted with certainty.[29] Further, uncertainty about demand, technology, and prices will add to the risk that investors associate with the firm, which in turn will raise the cost of capital to the firm, and raise the "hurdle rate" the firm's managers require in order to justify a new project.[30]

The preceding discussion leads to the common-sense conclusion that the long-run, forward-looking cost of a firm in a competitive market can be developed only with reference to the dynamic "cost minimization problem," and must take into account factors such as growth, changes in input prices, indivisibilities, and constraints on the

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[28] Rearrangements are thus a partial substitute for capacity. The same is true for maintenance. If the firm runs at a very high utilization level, it will have less spare capacity to deal with breakage, and will have higher repair costs in that repair must occur as rapidly as possible in order to meet quality objectives. Note that local networks do not benefit from the smoothing effect of aggregating demand, as toll networks do; nor is capacity as fungible in a local network as it is in a high level toll network.

[29] *Dixit and Pindyck* explain this behavior in terms of the theory usually applied to financial options markets. Delaying an investment may be costly; that cost represents the "price" of the option to invest later. *See* n.27 *supra.*

[30] The effect of market risk on the cost of capital will be discussed *infra. Dixit and Pindyck* report (at 108) that "More recent studies have confirmed that managers regularly and consciously set hurdle rates that are often three or four times their weighted average cost of capital."