elements. Particular shortcomings of the Model include the following (we have verified that Release 3.0 has not corrected any of the problems discussed below):

- The Hatfield Model assumes that the ILEC's present facilities and assets—end offices, interoffice trunks, tandem switches, switching ports, feeder and distribution facilities—will be scrapped.[2] In its place the Model conceptualize an entirely new network utilizing the most streamlined loop structures, one that claims to use the most efficient technology at the lowest possible cost. The Model endows firms with perfect hindsight which provides cost savings not available to any real company operating in a forward-looking environment. Indeed, it models a firm where there is no uncertainty, no technological change, and no growth, thus ignoring the very concerns that are paramount in the telecommunications environment today

- The Model's predictions do not agree with those of other industry models that are based on *firm specific* data. The Model incorrectly identifies GTE and other ILEC serving areas, grossly underestimates, in some cases by factors of 10, actual plant needed to serve areas. Moreover, it builds plant in other firms' serving areas, erroneously identifies other ILECs' wire centers as GTE's, and similarly identifies GTE's wire centers as belonging to other ILECs.

- Its input price assumptions (e.g., wire center equipment prices and switch prices) are consistently lower than what ILECs actually pay. For example, comparison of actual GTE California switch contracts show that the Model's switch cost per line predictions are uniformly 56% of actual GTE contract prices . Many of these assumptions are user adjustable while some are either hard wired data or intrinsic modeling components of the cost function and cannot to be adjusted.

[2] The Model's only likeness to reality in this regard is in building networks based on existing wire-center locations - often employing inaccurate data that either omit from or add to the existing wire-centers.

- The Model claims to consider only "forward-looking technology" which reflects "forward-looking cost". This concept, however, is used only as a way of justifying lower costs. On the expense side, its methodology is entirely backward looking—entirely predicated on past demand and past costs as published in ARMIS. On the investment side, it builds plant incapable of meeting the present demand and even more incapable of meeting the future demand. The understatement of investments and costs is done only in the name of eradicating stranded infrastructure—although the infrastructure it attempts to eradicate is exactly the infrastructure, except for a very small percentage, that is in use today and will be for the foreseeable future.

- The Model is entirely static. Growth is not factored in, and the Hatfield modelers assume that the cost of building and maintaining spare capacity for future expansion should not be considered. The rapid increase in the need to create new area codes, increased Internet usage and the popularity of second and third residential phone lines all point to a necessity for expansions in the local loop plant everywhere, in the present time and in the future. These facilities must be built by existing ILECs. The Model simply ignores these actual costs, market realities and demand considerations and therefore, fails to estimate a real "forward-looking cost".

- In the Model, ILECs are subject to the cost reducing effects of using the latest technology, while at the same time their equipment depreciates at agency-prescribed rates, their cost-of-capital is the same as for regulated utilities, and they are guaranteed the full level of demand that a monopoly carrier would enjoy. In competitive markets, these three features are inconsistent.

- The Model employs artificial jurisdictional cost allocations to determine its cost factors. One problem caused by this methodology is that costs incurred by a home office in one state of a firm operating in many states show up as revenue rather than cost flows with the consequence that the expenses calculated by the Model can be negative. This biases the costs in that state downward.

- Its assumptions that all volumes currently served by local exchange carriers will be served by a brand new entrant and that a brand new infrastructure instantly materializes are inconsistent with both reality and sound economics. Accordingly, costs based on such a model will *not* be representative of the costs ILECs incur providing services and unbundled network components.

- Its method of equating the lowest observed expense to investment ratios in the industry to individual firms' forward-looking expense factor is unjustified. Because it ignores economic tradeoffs and scale differences between firms, such a "pick and choose" approach runs the risk of providing networks that cannot handle any firm's current traffic and service demands.

- Its method of calibrating expenses and common costs by use of constant volume and price insensitive cost factors is econometrically and statistically unsound. Moreover, calculation of the common cost factor, which is based on a ratio of common costs to revenues, is applied to costs rather than revenues and therefore is internally inconsistent as well. In Release 3.0, the common cost factor increased to 10.4% from the 10% used by its predecessor.

- Finally, the Model simply fails to provide external or internal justification of its validity, thereby giving its intended audience not even the slimmest hope of trusting the Model's output. Externally, its predictions of presently necessary investments and costs do not comply with real data. Internally, it fails all consistency checks on necessary features of mathematical structure capable of representing the minimum cost of producing telecommunications services using the most efficient forward-looking technology[3].

[3] By the most efficient forward looking technology, we mean the least cost technology taking the installed network as a base and building from that using the least cost technology available for producing the services required. Ignored in most "greenfield" or "scorched node" arguments is that to actually use them one would have to tear up useful plant. None of these methods take into account either the direct or indirect costs of such a strategy.

Basing prices on costs that no real-world provider could hope to achieve without service degradation or outright network failure will tend to stifle, not promote, facilities-based competition.

SECTION I Introduction and Description

A. Introduction

The Hatfield Model Version 2.2, Release 2—as is Release 3.0—is a cost proxy model which purports to calculate Total Element Long Run Incremental Cost (TELRIC) as an estimate of forward-looking economic cost of unbundled network elements. In a separate calculation the Model attempts to estimate the cost of universal service. In this paper we primarily describe the workings of Hatfield Model Version 2.2, Release 2 (Hatfield Model or Model) and assess its economic feasibility. Our preliminary analysis showed that the Hatfield Model Release 3.0 (Release 3.0) has not corrected any of its deficiencies we refer to in this paper in regard to the Hatfield Model Version 2.2, Release 2.

To outline the failure of the Hatfield Model, our analyses emphasize the Model's deficiencies in network engineering and cost estimating methods, and examine its external (statistical) and internal (theoretical) validity.

The findings contained in this paper are primarily based on Hatfield Associates' documents[4] and an extensive examination of the Model's computer code. The incomplete documentation of the Model's hundreds, and possibly thousands, of algorithms require the intensive review of the code to gain a true understanding of its workings.

Despite, or perhaps because of the complexity of the programming and the vastness of real and discretionary input data used to run the Model, its output is entirely unreliable. This

paper will demonstrate that the Hatfield Model does *not* provide reasonable estimates of the costs of local exchange company network elements, either for ILECs in general or for any particular ILEC, because the Model (1) is based on a hypothetical and unrealistic local exchange network system, (2) departs from fundamental economics in a number of significant ways, (3) produces results that are inconsistent with what is actually observed and (4) implies an unrealistic version of both regulated and competitive markets.

B. The Operation of the Model

Microsoft Excel 7.0 and Windows 95 or Windows NT are required to run the Hatfield Model. Hardware requirements are a PC with Pentium 133MHz or higher chip and 128 MB of RAM or more.[5] The entire model comprises 7 modules that are Microsoft Excel workbook files.[6] The model interface automates the running process of the model. Operationally, a user loads the interface file of the model and then runs the state specific BCM-Plus Loop Data Input File.

In Release 3.0, several operational changes were made to the model. The run time of the model has been decreased by approximately 70-80% (the run time on California GTE on a Pentium 200MHz machine was reduced to approximately 12 minutes from 50 minutes). Data

(...continued)

[4] *Model Description, Hatfield Model, Version 2.2, Release 2*, September 4, 1996

[5] Instruction Manual, Hatfield Model Version 2.2, Release 2, Automated Interface.

[6] The 7 modules are the following: 1) BCM-PLUS Loop Input Data File, 2) Line Converter Module, 3) BCM-PLUS Data Module, 4) BCM-PLUS Loop Module 5) Wire Center Module 6) Convergence Module, 7) Expense Module.

files needed to run Release 3.0 are managed by the Microsoft Access application; Microsoft Excel managed data files in the Hatfield Model.

C. Model Network Engineering Methods

Instead of building the Model as a reflection of the present local exchange networks configurations, its authors elected to create networks based on an abstract view of the real world. The Hatfield Model assumes that the ILEC's present facilities and assets will cease to exist, replaced by the most streamlined loop structures built with what it considers the most efficient technology at the lowest possible cost.

1. Loop

The Hatfield Model's engineering methods incorporate loop data from the BCM-PLUS model (hence the name of the input file, BCM-PLUS Loop Data Input File).[7] BCM-PLUS data are the fundamental inputs with which the Model constructs local exchange network systems from the ground up.[8] Census Block Groups (CBGs) are assigned by the model to their closest wire center[9] and many wire centers are assigned to serve an incumbent local exchange carrier's (ILEC's) total service area. The CBG specific raw data used to construct the network are the following:

1. the location of CBGs in relation to their closest wire centers.
2. total households.

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[7] "The BCM-PLUS model is a derivative of BCM1 that has been developed for and is copyrighted by MCI Telecommunications Corporation.", *Model Description, Hatfield Model Version 2.2, Release 2*, p.2.

[8] "[T]he Hatfield Model became a "scorched node" model...", Id, p.2.

[9] The wire center is a facility that includes a building and at least one end office switch and also may contain a tandem office, a signal transfer point, and an operator tandem. Feeder routes start from wire centers.

3. total area in square miles.
4. depth to bedrock.
5. rock hardness.
6. surface texture.
7. depth of water table.
8. business employees.

The Model starts to build its loop network on a per CBG basis, and in the process, derives the structure of the model loop network from the characteristics of CBGs. Data derived from the raw data include CBG specific total access lines[10] for each service category. The Model calculates residential lines in a CBG by multiplying its household count by the ratio of total reported residential access lines to the total households in the study area (an ILEC's service area for example). The Model similarly calculates business lines in each CBG by applying the ratio of total business lines to total business employees in a study area as a factor to CBG specific business employees data. Special access and public lines calculations also are based on study area ratios of these respective lines to business lines. Hatfield Associates attempted to refine their calculations in connection with CBG line estimation per line category in Release 3.0 by incorporating the following: 1) PNR & Associates survey information, 2) Dun & Bradstreet business establishment information, and 3) a Donnelley Marketing household database.

The Hatfield Model's inaccuracy in estimating the correct numbers of access lines were well chronicled in various states' interim rate arbitration proceedings. Release 3.0 is still inept in this regard. Among the wire centers that Release 3.0 assigns correctly to GTE in California,

over 700,000 lines are misallocated on per-wire center basis. For example Release 3.0 assigns 14,090 total access lines to a wire center in Thousand Oaks, CA when in actuality that particular wire center serves 38,058 total access lines. For some wire centers Release 3.0 overstates the total number of access lines. The magnitude of misallocation would be greater on CBG or line category level. As does the Hatfield Model, the new Release 3.0 calculates loop and wire center investments as a function of the number of access lines (both models are extremely inaccurate in assigning the correct number of access lines to wire centers, leading to inaccuracies in its cost predictions)

The estimated numbers of access lines and fill factors are major determinants in the size of loop structure—cable sizes, switching capacity, etc.—built in a particular CBG. For example, the number of lines divided by the area of a CBG (line density) dictates the thickness and the number of distribution cable lines that the Model will employ in that CBG.

Once the necessary size of the loop structure is calculated, the Model lays down the loop structure according to a simplistic and hypothetical blueprint based on its assumptions: 1) every CBG is serviced in its entirety by a single wire center, so there is no splitting of a CBG, 2) every wire center emanates four main feeder routes that are orthogonal to each other, 3) all distribution cables serving a CBG are equal in length, their lengths are 0.625 times the square root of the area of a CBG, and the access line density of CBGs determines the number of distribution cables—either two, four, six, or eight (Release 3.0 attempts to include more

(...continued)

[10] Access lines consist of lines in Residential, Business, Public, and Special Access categories.

demographic information such as high-rise buildings), 4) if a CBG does not lie in the path of a main feeder, a smaller sub-feeder that branches out orthogonally from the main feeder serves that CBG, and 5) a CBG whose center is more than a 9,000 foot threshold away from its assigned wire center is served with fiber-fed DLC equipment in the feeder. Only the threshold value in this last point is user-adjustable.

2. Wire Center

The Model calculates the total network investments by adding investments associated with wire center, switching, transport, signaling, and operator systems to loop investments. While the loop investment is calculated on a per-CBG basis, other investments are calculated on a per-wire center basis. Among other things, these other investment calculations are sensitive to factors such as: 1) the number of lines served by a wire center, 2) interoffice distance, 3) assumptions about the sizes of end offices, 4) "sharing" factors that incorporate structure sharing of interoffice routes by different utilities.[11]

For switching, the Model equips a wire center with a size and number of switches predicated on the total number of telephone lines it serves. It calculates the cost of the switch or number of switches using a cost relationship described on pages 23 through 25 of Hatfield Associates' *Model Description*. The Model's method of calculating switching costs are explained in more detail in Section II C2.

[11] The same sharing factors are used in the loop plant as well.

The Model also calculates other investments associated with wire centers: buildings, land, power systems, and distribution frames. These wire center investments required to house and support end office and tandem switches, have a direct relationship to the size and number of switches, which are in turn tied to the number of access lines. In addition, the Model calculates necessary investments in networks for signaling, transport, and operator system; these last investments tend to make up well under 10% of the total network cost. Calculations for transport facilities and signaling investments are also linked to the number of access lines and other factors.

Section II Economic Modeling Deficiencies

Our assessment of the Hatfield Model starts with a review of its underlying economic theory. Next, we consider the issue of external validity check followed by the results of detailed analyses on the reasonableness of the Model's major parts. We end this section with a discussion on proper methods of generating econometric or statistical estimation of expense factors.

A. Economic Theory

The Hatfield Model documentation characterizes the model as "scorched node"—it starts with the existing locations of wire centers, then builds a brand new system instantaneously from the ground up. While proponents of this approach claim that it approximates the textbook definition of long-run cost, it is quite at odds with how real businesses incur costs, especially capital-intensive firms that expand their facilities by adding capacity in discrete modules.[12] In 1991, Professor Alfred Kahn advised the FCC of the need to employ a realistic and practical perspective:

> In strict economic terms, the concept of long-run marginal costs relates to a hypothetical situation in which <u>all</u> inputs are variable, and a supplier confronts the possibility of installing entirely new facilities, in effect from the ground up. And the "marginal" relates to the incremental cost of a single unit of output. The concept of long-run incremental cost, in contrast, is more pragmatic: it

[12] Even the theoretical definition must be conditioned by reality. For example, Professor Varian has noted: "Long run and short run are of course relative concepts. Which factors are considered variable and which are considered fixed depends on the particular problem being analyzed. You must consider over what time period you wish to analyze the firm's behavior and then ask what factors can the firm adjust during that time period." Hal R. Varian, *Microeconomic Analysis, Third Edition*, New York: Norton, 1992, p. 66.

takes a firm's past history as given, does not assume that it is writing on a blank slate, but recognizes that it will ordinarily be planning the installation of new capacity, at whatever that additional investment will cost given its current situation, and it spreads the costs over either the total output of that additional capacity—in that sense it is a kind of average incremental cost—or over the additional output that is likely to be induced by a price reduction under consideration (or curtailed in response to a price increase.)[13]

Additionally the Hatfield Model's scorched node view of the world ignores the fact that in an industry experiencing rapid technological change, which clearly characterizes telecommunications, no company would set prices based upon such costs. Basing prices on the Hatfield view of the world would never recover costs. Professor Kahn and Dr. Tardiff noted this phenomenon as follows:

> In a world of continuous technological progress, it would be irrational for firms constantly to update their facilities in order completely to incorporate today's lowest-cost technology, as though starting from scratch: investments made today, totally embodying today's most modern technology, would instantaneously be outdated tomorrow and, in consequence, never earn a return sufficient to justify the investments in the first place. For this reason, as Professor William J. Fellner pointed out many years ago, firms even in competitive industries would systematically practice what they call "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 earning a return on those investments over their entire economic life. In consequence even perfectly competitive prices would not be set at the level of these (totally) current costs—unless, to put

[13] Affidavit of Alfred E. Kahn, Before the Federal Communications Commission, In the Matter of Expanded Interconnection with Local Telephone Company Facilities, CC Docket No. 91-141, August 6, 1991.

> it another way, the calculated costs of the new plant included an extremely high rate of return and of depreciation, in reflection of the exposure of any such investments to costs and prices progressively declining in real terms over their life.[14]

Another problem with the Hatfield Model's scorched node approach to cost modeling is the implicit assumption that ILECs lose one hundred percent of their demand for telephone services on day one. In effect, ILECs would hand over their entire business to each newcomer, which in turn would instantly size its plant to perfectly accommodate this demand, taking advantage of all the economies that come with serving the demand with perfectly sized facilities obtained at the maximum volume discounts. But the assumption is counterfactual; real firms grow to meet demand as it materializes. As such, it adds capacity taking into account the trade-off between the lower per unit costs of bigger modules (e.g., larger cable sizes) and the costs of carrying the unused capacity that deploying larger modules would entail.

The Model's static nature, its failure to incorporate demand growth and underestimation of the true forward-looking cost of capital or, equivalently, its failure to suitably account for economic depreciation, are primary deficiencies resulting from static characteristics of the model. It totally ignores growth in demand and, in doing so, it mischaracterizes the spare capacity which results from optimal timing of laying discrete plant, instead labeling it as inefficient over-capacity. Consequently, Hatfield proponents concentrate and insist on fill

[14] Declaration of Alfred E. Kahn and Timothy J. Tardiff, before the Federal Communications Commission, In the Matter of Implementation of the Local Competition Provisions in the Telecommunications Act of 1996, CC Docket No. 96-98, May 30, 1996. (footnote omitted). Professor Jerry Hausman's reply affidavit, filed in this docket on the same day, makes a similar point in the context of depreciation. Professor Hausman's findings will be discussed later when depreciation issues are addressed.

factors that are too high. In fact, at least since the mid 1970's, it has been well known that in a dynamic context the problem of optimally investing in discrete plant when there is growth has a component not found in static situations. In his 1978 paper in the *Review of Economic Studies*, David Starrett shows that the cost minimizing firm in a dynamic situation trades off some spare capacity against the economies of scale in construction. The firm minimizes cost by choosing the lengths of the intervals between which it invests. During periods between investments there will always be spare capacity so it is often optimal and cost minimizing to have substantial spare capacity. Moreover, the mathematical structures that might be appropriate in a static situation may not be in the dynamic one. To determine whether or not they are appropriate requires the kind of empirical testing that the Hatfield Model has not undergone.

In an advanced economics graduate textbook, authors Professors Avinash Dixit and Robert Pindyck write on the theory of investment decisions of firms, stressing the irreversibility of most investment decision and the ever present uncertainty of the economic environment in which those decisions are made.[15]

> The theory of how firms make intertemporal choices gives us rules for determining the firm's desired or optimal capital stock at each point in time. The demand for gross investment during any one time period can then be calculated: gross investment equals the desired capital stock at the end of the period, minus the actual capital stock at the beginning, plus the depreciation that occurs during the period. Any shocks that occur, for example, demand shifts or interest rate changes, alter the desired capital stock. In practice, the effects of such shocks on investment have been found to be more gradual and spread out

[15] Avinash K. Dixit and Robert S. Pindyck *Investment Under Uncertainty*, Princeton University Press, Princeton, New Jersey, 1994, Chapter 10, Incremental Investment and Capacity Choice, p. 381.

over many future periods. Economists rationalized this by positing the existence of adjustment costs—costs of changing the capital stock too rapidly—and modifying their theories of investment to account for such costs.

In fact we need something stronger than the mere existence of adjustment costs to explain why a firm's investment choices might respond gradually to a shock. Specifically, we need costs that are a strict convex function of the rate of investment. In other words, it would have to be the case that the marginal cost of investment is an increasing function of the rate of investment. Then the optimal rate of investment is determined at the point where the marginal cost of speeding up the adjustment of capital to its desired level is just equal to the marginal benefit of doing so.

In the case of ILEC investments in feeder and distribution facilities, the marginal cost of investment is indeed an increasing function of the rate of investment. Therefore ILECs would prefer a relatively slow rate of investment, i.e. build facilities in modular fashion thereby spreading out effects of demand shocks on investment over many future periods. For ILECs, at the optimal investment decision point, the marginal cost of speeding up the adjustment of capital (adding incremental facilities) would be high if the marginal benefit for installing incremental facilities is high—as would be in the case when the fill capacity of feeder or distribution facilities is continually close to being exhausted.

As a result of ignoring economic principles referenced and discussed above, the Model advocates higher than optimal fill factors and underestimates the real cost of capital by ignoring the effects on the cost of capital that account for (a) the increased riskiness of an industry

moving rapidly into competition, and (b) the increased economic depreciation rates required to recover investment in current plant and equipment.

Failure to recover sunk investment has severe economic consequences, for the rate and level of capital recovery not only tell firms how to use their existing equipment but also dictate whether or not they should replace equipment, as it becomes obsolete, with the next generation. Indeed, by ignoring dynamics altogether, the Model fails to be forward looking even in concept.

According to the Hatfield model, a firm is subject to the cost reducing effects of using the latest technology, while at the same time its equipment depreciates at regulatory-prescribed rates. Furthermore, its cost-of-capital is the same as for regulated utilities and it is guaranteed the full level of demand that a monopoly carrier would enjoy. Unfortunately, as discussed by Dr. Hausman[16], competitive markets are inconsistent with low depreciation rates, guaranteed demand and guaranteed returns.

B. External Validity Check

The Hatfield Model is not a valid economic cost model because it either fails the external validity check required of any cost model or the checks were never performed. By external validity we mean the simple comparison of the predictions of the model to actual occurrence in the real world. For example, a cost model that predicts a particular cost per line

[16] Hausman, Jerry A. (1996) Reply Affidavit Before the Federal Communications Commission In the Matter of Implementation of Local Competition Provisions in the Telecommunications Act of 1996 CC docket No. 96-98.

is invalidated if the actual cost turns out to be substantially different most of the time. Ordinarily, this verification is done as part of the estimation of the model.

A cost model is chosen from a set of reasonable cost models by finding the one that reproduces actual data the best. For an econometric model, one collects from a firm (or from a set of similar firms) data on all of its costs, all of its input prices, the levels of its outputs, and the levels of each of its factors of production. Using economic theory as a guide, the analyst statistically determines a cost function and a set of input, or factor demand functions whose predictions for costs and inputs for each combination of outputs, fixed factors and input prices, come closest to the observed costs and factors for those same combinations. To use a model that has not been externally validated is much like allowing a new type of plane, a type that has never even been test flown, to carry passengers.

The Hatfield proponents admit the desirability of external validation but claim it is impossible. They specifically respond to this criticism by claiming that to use historical or even current data is to use embedded costs, claiming further that using embedded costs and therefore historical cost data is precluded by the desire to estimate "forward-looking" costs. Such an assertion demonstrates a lack of understanding about cost modeling, and the relationship between forward-looking costs and embedded costs.

Forward looking costs merely refer to the minimum cost of producing current and anticipated flows of outputs, e.g. subscriber lines, minutes of use, toll minutes, using the best technology currently employed today and using inputs purchased or valued at current prices. Embedded costs refer to any or a combination of three things: 1) using book value of capital or

the unrecovered part of past investments in a depreciation account as a measure of the capital input or investment, 2) using the prices at which inputs were purchased historically as current prices, or 3) basing the relationship between observed costs, outputs, inputs, and input prices on outmoded technologies. An example of the latter might be to have an accurate cost model for the relationship between costs and its drivers for a firm that had only old electromechanical switches. Using such a model would be inappropriate for ILECs whose network facilities are all digital or nearly so. However, no one proposes tearing down the entire network of any LEC and building it up again using a substantially different or lower cost technology.

Consider a simple example of a firm that produces a single output, y, using one fixed factor, K, and one variable factor X, whose price is p_x. Suppose that costs, and the drivers, output, capital, and the price of the input were observed over time and for a number of similar firms. Suppose that a Hatfield type model were proposed to predict costs for a combination of the drivers that had never been observed in that particular combination before. The Hatfield proponents would assert that their model could not be validated because of the fact that the particular combination of drivers had never been seen before. This is wrong. Validation of the model could be done in the following simple manner: use the Hatfield Model to predict the costs for the combinations that can be observed and compare its predictions to the actual observed costs that attended those combinations. If the model predicts these well and if the new combination of drivers is not too far out of the range of the observed combinations of drivers, then one has a reasonable confidence the model will predict the new cost for the new combination.

Other less direct tests are also available. For example, if, instead of the cost, one were to observe the level of the input X, the model could be used to predict the level of X for each combination of observed X and cost drivers. If the predicted X's did not agree with those observed, the model's validity would be seriously compromised, if not completely destroyed.

An indirect test of this type for the Model would be to compare the actual miles of cable and/or cable pair miles with what Hatfield predicts, or to see if it predicts the right number and type of switches or switching facilities. In any case, the claim that a forward looking model cannot be externally validated is without merit because it is has been and continues to be done by econometricians and statisticians.

No one can have any confidence in a model without compelling validation tests to support it. The fact that the Model may not be able to be externally validated has less to do with the question of embeddedness versus forward looking than it does with an incomplete modeling approach which makes the Model not only difficult to use, but difficult to test in an economically meaningful fashion. Without testing, without external validation, the Model is simply a speculative construct, totally hypothetical, and is not a basis to determine the costs of a real functioning firm.

As our own partial test, we offer two comparisons using: 1) Hatfield Model predictions of the amount of sheath-miles of feeder and distribution cables needed for a random sample of GTE wire centers with actual street miles in those wirecenters as a proxy for sheath miles (Table 1 below), 2) dollar amount investments and expenses predicted for GTE companies by the Model with amounts reported to ARMIS by those same GTE companies. (Table 2 below).

Table 1 illustrates the extent to which the Hatfield Model 2.2.2's forward-looking feeder and distribution loop investment predictions fall short of actual investment necessary to meet current demands. The lack of necessary structural investments of the loop, and possibly other network elements, explains, to a great extent, why model predicted investments are much lower than investments reported in ARMIS.

The measure of the magnitude of feeder and distribution investment (copper cable investment) used in our analysis is sheath-miles. Actual sheath miles were estimated based on the lengths of streets in wire centers' service areas. The Model calculates sheath-miles in its process of building loop networks.

Table 1

Comparison of Copper Feeder and Distribution Cable Investment
Actual GTE vs. Hatfield Model 2.2.2

Hatfield Area Adjusted to Match Actual

State	Wire Center	Feeder and Distribution Sheath Miles[1]		Ratio of Copper Cable Investment Hatfield/GTE
		Actual[1]	per Hatfield	
(1)	(2)	(3)	(4)	(5) (4)/(3)
California	Arrowhead	262.4	40.0	0.15
California	Banning	510.8	202.2	0.40
California	Pinyon	110.5	42.0	0.38
California	Carpenteria	159.9	59.4	0.37

[1] Actual Sheath Miles are estimated by actual street miles.

Source: Actual data: U.S. Streets Data Technology Inc., U.S. Streets 95 CD-Rom.
Hatfield data: State specific BCM Loop Module of the Hatfield Model 2.2.2.

As the comparison shows, the Model consistently underestimates the feeder and distribution cable sheath-miles and by substantial amounts. The same analysis conducted in other states using randomly selected wire centers confirmed that the Model systematically attributes less than necessary feeder and distribution cable lengths to wire centers.

In our second validation analysis we compare the amount of dollar investments and expenses predicted by the Hatfield Model to those reported to ARMIS 43-08 (ARMIS) by two ILECs—GTE Northwest in Washington and GTE of California. The difference between investments or expenses recorded in ARMIS and its counterparts—predictions made by the

Model—should serve as proxy for the stranded costs. Our analysis shows that the Model essentially designates inordinate portions of ILECs' investment and expense costs as being economically stranded.[17] In the case of switching expenses for GTE Northwest in the state of Washington, shown in Table 2 below, the Model designates 86% of what is reported by ARMIS as being stranded. Network investment cost, which makes up the greatest portion of the total cost, is 57% stranded according to the Hatfield Model.

Table 2

Actual versus Hatfield 2.2.2 Comparison
GTE Northwest in Washington State
($1,000,000)

Cost Category	Actual	Model	Model/Actual
(1)	(2)	(3)	(4) (3)/(2)
Network Investment	1,528	660	43.17%
Switching Investment	381	98	25.81%
Indirect Investment	123	35	28.48%
Total Investment	1,651	695	42.07%
Network Expenses	80	17	21.47%
Switching Expenses	19	3	14.11%
Indirect Expenses	62	38	61.30%
Corporate Expenses	73	16	22.55%
Total Expenses	214	71	33.33%

[17] The difference between current booked costs and a correct estimate of forward-looking costs represents costs that would not be recovered at prices based completely on forward-looking costs, and, therefore are stranded in this sense.

Table 3

Actual versus Hatfield 2.2.2 Comparison
GTE of California, Inc.
($1,000,000)

Cost Category	Actual	Model	Model/Actual
(1)	(2)	(3)	(4) (3)/(2)
Network Investment	3,759	2,598	69.11%
Switching Investment	902	366	40.58%
Indirect Investment	2,823	1,060	37.39%
Total Investment	4,042	2,704	66.8 %
Network Expenses	197	81	41.35%
Switching Expenses	55	10	17.78%
Indirect Expenses	165	171	103.66%
Corporate Expenses	175	70	39.70%
Total Expenses	536	322	60.00%

Our comparison of different components of network costs as reported by ILECs (i.e. GTE companies) in their ARMIS reports to those estimated by the Hatfield Model shows irreconcilable differences between the Hatfield Model's results and available *actual* data. Results of our comparison for GTE California are similar to those of GTE Northwest in Washington. [18] The trend seems clear—the Model predicts costs that are significantly below what GTE has reported to ARMIS.

Similar comparisons based on GTE companies in other states corroborate the above analysis for GTE companies in Washington and California, thereby adding to the list of items refuting the appropriateness of the Hatfield Model to provide realistic estimates for the costs of

[18] Among several states in which we carried out this analysis, the results for GTE California reported herein show the smallest understatement of investments and expenses.

unbundled network elements. Comparisons based on Release 3.0 yielded similar results (see below).

Table 4

Actual Versus Hatfield Model Release 3.0 Comparison
GTE Telephone Operations, Texas
($1,000,000)

Cost Category	Actual	Model	Model/Actual
(1)	(2)	(3)	(4) (3)/(2)
Network Investment	3,399	2,220	65.3%
General Support Investment	562	132	23.4%
Total Investment	3,976	2,352	59.1%
Network Expenses	119	59	49.1%
Support Expenses	171	72	42.2%
Corporate Expenses	159	53	33.6%
Total Expenses	449	184	41.0%

The main cause of such a large discrepancy between observed data and the Model's predictions is the fact that the Model produces estimates of network element costs based on an *abstract* representation of network service costs. Left to its own devices the Model constructs insufficient amounts of facilities to be able to serve the demand that exists in the real world.

Another insight into a cost model's validity or lack thereof can be gained through comparison of the results to those produced by other models, and the extent to which the model satisfies internal validity checks. Internal validity will be discussed in Section III where the structural deficiencies of the Model are addressed.