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Economic Evaluation of Proxy Cost Models for Determining Universal Service Support

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I. Introduction

On November 8, 1996, the Federal-State Joint Board on Universal Service ("Joint Board") issued their Recommended Decision in CC Docket 96-45.[1] In their Recommended Decision, the Joint Board stated that a properly crafted cost proxy model can be used to estimate the forward-looking economic costs of providing telephone service for the purpose of determining the universal service support levels for particular geographic areas.

Christensen Associates has been retained by the United States Telephone Association to provide an economic evaluation of the proxy models submitted in this proceeding: the Benchmark Cost Model 2 ("BCM2"), sponsored by US West and Sprint; and the Hatfield Model Version 2.2, Release 2 ("HM2.2.2"), sponsored by AT&T and MCI. We have evaluated these models according to the criteria specified in the Joint Board's order, as well as general economic principles. The Joint Board's criteria establish that the appropriate cost standard is the long-run economic cost of an efficient market entrant

The Hatfield model produces lower cost estimates than BCM2. In simulations of the models, we found that most, if not all, of the cost differences

[1] Federal-State Board on Universal Service, CC Docket 96-45, Recommended Decision, November 8, 1996, ("Joint Board Decision").

can be explained by differences in the default assumptions between the two models and the fact that the Hatfield model only estimates costs for Bell-served territories. Because the Hatfield model estimates costs for Bell-served territories only, the default results of the Hatfield model can be misleading for non-Bell-served portions of a state. We have found that cost estimates for Bell-served territories significantly understate the costs for non-Bell regions of the states we have analyzed. In light of this flaw, we must conclude that the BCM2 better satisfies the Joint Board's criteria for estimating Universal Service support levels.

Section II outlines the Joint Board's criteria for evaluating proxy models. Section III provides our interpretation of the Joint Board's criteria and Section IV contains an economic analysis of the criteria. Section V provides an assessment of the proxy models in the context of the criteria spelled out in the previous sections. Section VI analyzes the results of both models for selected states, and Section VII contains our concluding remarks.

II. Joint Board Criteria for Evaluating Proxy Models

In their Recommended Decision, the Joint Board stated that "a properly crafted proxy model can be used to calculate the forward-looking economic costs for specific geographic areas, and be used as the cost input to determine the level of support."[2] However, they also stated that none of the proxy models submitted in the proceeding thus far is satisfactory for determining universal

[2] Joint Board Decision, para 268.

service support levels, and that work should be continued on developing an adequate proxy model.[3]

The economic criteria spelled out by the Joint Board are based on forward-looking economic costs to determine the cost of providing universal service:

> "We find that forward-looking economic costs should be used to determine the cost of providing universal service. Those costs best approximate the costs that would be incurred by an efficient competitor entering the market. We believe that support should be based on the cost of an efficient carrier and should not be used to offset the cost of inefficient provision of service or cost associated with services that are not included in our definition of supported services, such as private lines, interexchange service, and video services."[4]

The Joint Board established eight criteria that it recommended the FCC employ in evaluating the reasonableness of proxy models for determining the forward-looking economic costs of supported services:[5]

> (1) Technology is the least-cost, most efficient and reasonable technology for providing supported services that is currently available. Models will use incumbent wire centers as the center of the loop network,
>
> (2) Any network function or element, such as loop, switching, transport, or signaling necessary to produce the supported services must have an associated cost.
>
> (3) Only forward-looking costs should be included. No embedded costs of facilities, functions, or elements should be included.
>
> (4) Include a forward-looking cost of capital and the recovery of capital through economic depreciation expenses. The long run period is a period long enough that all costs are treated as variable and avoidable.

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[3] Id.
[4] Joint Board Decision, para 270.
[5] Joint Board Decision, para 277.

(5) The model should estimate the cost of providing services for all businesses and households within a geographic region. This includes the provision of multi-line business services. Such inclusion allows the models to reflect the economies of scale associated with the provision of these services.

(6) A reasonable allocation of joint and common costs should be assigned to the cost of supported services.

(7) The model and all underlying data, formulae, computations, and software should be available to all interested parties. All data should be verifiable, engineering assumptions reasonable, and outputs plausible.

(8) The model should include the capability to examine and modify the critical assumptions and engineering principles. This includes, cost of capital, depreciation rates, fill factors, input costs, overhead adjustments, retail costs, structure sharing percentages, fiber-copper cross-over points, and terrain factors. The models should also allow for different costs of capital, depreciation, and expenses for different facilities, functions, or elements.

Below, we evaluate the Benchmark and Hatfield models in the context of these criteria. However, prior to this evaluation, we examine the economic implications of the Joint Board's criteria.

III. Interpretation of the Joint Board's Recommended Decision

In order to evaluate the BCM2 and HM2.2.2 models, it is important to discuss the implications of the principles laid out in paragraphs 270, as discussed above, and paragraph 276, which states that forward looking common costs should be estimated, in order that a reasonable contribution to these costs by supported services can be determined.

The first principle stated in paragraphs 270 and 276 is that forward-looking costs should be used. This principle is expanded on in the fifth point of

paragraph 277, which states that the forward-looking costs should be computed for a company that provides services for all businesses and households within a geographic area. This allows all services to benefit from economies of scope and economies of density.[6]

The second principle stated in paragraph 270 is that the costs should be those of an efficient competitor entering the market. A common interpretation of this principle is that the entrant will provide the full array of services currently provided by the incumbent LEC, but the entrant has no sunk investment and therefore is not constrained by past decisions in its network investments. However, this interpretation of the efficient entrant represents a static ideal, rather than the actual performance of an efficient incumbent or entrant. It is important to realize that actual incumbents or entrants will generally deviate from this hypothetical static standard because of uncertainty, the capital intensive nature of the telecommunications industry, and its rapid rate of technological change.

Finally, we interpret the Joint Board's concept of efficient entrant as requiring the entrant to meet the same quality of service obligations imposed on

[6] Because of economies of scope, the incremental cost of providing supported services by a telephone company providing a full range of supported and non-supported services will be less than the stand-alone cost of providing supported services only. One should also note that if the Joint Board was requiring a stand-alone cost calculation, their instructions to calculate forward-looking joint and common costs and provide a reasonable allocation to supported services would be inconsistent. This is because there are no joint and common costs with other services in a stand-alone company providing supported services only. In this case, all costs would be fully attributable to the supported services. Economies of density result in lower costs of serving customers because fixed network costs are spread over greater numbers of customers.

the incumbent LEC. To the extent that the hypothetical entrant is not required to meet these same service standards, its costs will be reduced.

IV. Economic Evaluation of Joint Board's Principles

The capital-intensive nature of the telephone industry and its rapid rate of technical progress create cost differences between an efficient incumbent and the Joint Board's hypothetical efficient entrant. Investments must be made based on expectations of customer demand, input prices, and technologies available. After the investments are made, because of uncertainty, actual customer demands, input prices, and technologies will differ from the expectations and, thus, investment that is optimal based on prior expectations will deviate from optimality after the investments are made. For example, an incumbent LEC currently serving an area with 1,200 pair copper cable may have arrived at that cable size over time through a series of four discrete placements of 300-pair cables, based on expected demand at the time the cables were placed. Although this was the most efficient way for the incumbent to proceed, the incumbent's cost of obtaining that 1,200 pair capacity exceeds that of a hypothetical entrant who instantaneously places a 1,200 pair cable.

Technical change in the industry will also create a situation where the incumbent carrier provides service using both old and new technologies. In contrast, the hypothetical statically efficient entrant, with instantaneous creation of a new network, will employ only the new technology. It would obviously not be

cost effective for the incumbent to replace all of its capital stock as each new technology becomes available. Rather the incumbent makes an economic comparison between continued use of the previously installed older technology with the installation and use of the new technology. At the point where the new technology becomes cost effective, the incumbent begins to change over. However, this change-over is not instantaneous; it occurs at an economically feasible rate for the incumbent. Similarly, an actual entrant, behaving in a dynamically efficient manner would not instantaneously construct a network to serve all the incumbent's customers.

The regulatory treatment of depreciation can also lead to a difference between the book cost of an efficient incumbent and the book cost of the hypothetical efficient entrant. When regulatory depreciation rates do not adequately account for the impact of technical change on the value of plant and equipment, the incumbent LEC is not allowed to recover in a timely fashion the cost of its investment. The net book value of the plant is consequently greater than its economic value. Under cost of service regulation, the difference between net book value and economic value of plant is eventually recovered through rates. With competitive entry, however, the incumbent would be faced with "stranded investment" equal to the difference between the book value and the economic value of the plant.

Introduction of competition in the local exchange has implications for the appropriate cost of capital and depreciation rates to be used. To the extent that the proxy models use current regulatory cost of capital and depreciation figures,

they will likely understate the costs of new entrants and incumbents in a competitive setting. Both the entrant and the incumbent would have a higher cost of capital than the incumbent would in a non-competitive environment, due to greater uncertainty regarding their profits. Firms engaged in competition would also need to recover the economic depreciation of their assets in order to remain financially viable. Were firms only able to recover a fraction of their economic depreciation, they would be faced with the problem of stranded investment, which competition would not allow them to recover.[7]

To summarize, the criteria established in paragraphs 270 and 276 pertain to the forward looking incremental cost and forward looking common cost of an efficient competitor entering the market. A common interpretation of this standard is that of an idealized statically efficient entrant. However, this interpretation does not represent the performance of an actual entrant or incumbent who is dynamically efficient. Actual entrants and incumbents will generally deviate from this ideal because of uncertainty, the capital intensive nature of the telecommunications industry, and its rapid rate of technological change. Therefore, if rates were strictly based on the cost levels produced from models adhering to the standard of this idealized entrant, cost recovery problems would be created for both incumbent LECs and actual market entrants.

[7] This could occur, for example, if the assets of the hypothetical entrant are claimed to have longer lifetimes under the erroneous assumption that the entrant only provides supported services in a non-competitive environment. This erroneous claim is made by Economics and Technology, Inc ("ETI") in their various reports on cost proxy models. For example, see Susan M. Baldwin and Lee L. Selwyn, "Converging on a Cost Proxy Model for Primary Line Basic Residential Service: A Blueprint for Designing a Competitively Neutral Universal Service Fund," Economics and Technology, Inc, August 1996, p. 22.

V. Evaluation of Benchmark and Hatfield Proxy Models

In this section, we evaluate the Benchmark Cost Model 2 and the Hatfield Model, Version 2.2, Release 2. The criteria established by the Joint Board provide the perspective. At the time we performed our evaluation, these were the most recent versions of the respective models that were available. We compare the overall designs of the BCM2 and HM2.2.2 by major component—loop, switching, interoffice trunking, and annual cost factors. In Section VI, we compare the results of the models for five states—Arkansas, California, Texas, Utah, and Washington—noting the significant drivers of cost differences between the models.

As discussed above, the Joint Board's criteria establish that a proxy model should cost out a forward-looking network that is based on the current distribution of customers and usage patterns. Furthermore, the network should be designed for the efficient provision of all services—supported and not supported—to maximize economies of scope and economies of density. From this design, the cost of supported services is determined.

Even though supported services have traditionally tended to be basic, non-competitive services, the fact that the models must take the perspective of an efficient entrant in a competitive market means that the cost of capital and depreciation rates should reflect this competitive environment. In other words, regulatory-prescribed cost of capital and depreciation rates will not be appropriate under these conditions.

A. Loop

Both the BCM2 and HM2.2.2 models employ Census Block Group (CBG) data to lay out their loop plant from existing LEC wire centers. BCM2 currently uses 1990 Census data and HM2.2.2 uses a 1995 update to the 1990 Census. The more recent data is preferable and, since the efficient network design should accommodate growth, the ability to adjust for differential growth rates by areas would also be desirable. A major drawback of HM2.2.2 is that it only uses CBGs served by Bell Operating Companies (BOCs) and cannot be readily expanded to add non-Bell CBGs. As we discuss in Section VI, it is likely that many independents serve proportionately more high-cost territory and, therefore, HM2.2.2 understates costs for USF purposes.

As many comments in the universal service proceeding have noted, population is not uniformly distributed throughout CBGs and geographic features, such as bodies of water and mountains are not accounted for in the network design in the proxy models. The BCM2 has the advantage of adjusting low-density CBGs so that all population is assumed to be within 500 feet of roads. This adjustment overcomes these problems to some extent. HM2.2.2 does not make such an adjustment in low-density CBGs.

HM2.2.2 attempts to account for population distribution differences by having the number of distribution legs vary by a predetermined amount by density zone. BCM2 is more flexible because it relates the number of distribution legs to the number of households in a CBG, and uses average lot size in a CBG to determine the length of distribution cable and drop wires.

The Joint Board's criteria specify that incumbents' wire centers are to be used as the basis of the loop design.[8] However, the CBG layout does not necessarily match telephone company territories or serving wire centers. Both proxy models currently assign a CBG to the closest serving wire center, which is not necessarily the actual wire center for the area. Therefore, a better mapping of geographic areas to actual serving wire centers is needed. In addition, a finer level of geographic detail, such as the Census Block level or the grid system used by the Cost Proxy Model ("CPM"), sponsored by Pacific Bell in this proceeding, would provide a better mapping and also provide a better match to actual population distributions[9] This finer level of detail has the potential to improve the design of outside plant to develop more accurate costs.

Both proxy models attempt to capture economies of scope by including residence and business lines. The estimation of business lines is largely based on establishing a relationship between the number of employees per CBG and the number of business lines. However, it is likely that this ratio varies significantly by industry. Further investigation into the estimation of business lines is warranted in both models.

The Joint Board's criteria specify a long-run analysis where all costs are variable and avoidable and, furthermore, require that all costs necessary to produce the supported services have an associated cost.[10] ETI criticizes the BCM2 for including structures costs. ETI contends that many network

[8] Joint Board Decision, para 277.
[9] The grids used in the CPM are approximately 3,000 feet by 3,000 feet.

elements—including poles, conduits, and other supporting structures—would not be replaced even if a new network were to be constructed from scratch.[11] However, this logic is inconsistent with the requirements of the Joint Board's long-run criteria. Given the Joint Board's requirements, the inclusion of structures costs, as if all structures were newly-placed is appropriate. Therefore, the ETI criticism that BCM2 inappropriately includes structures costs is at odds with the Joint Board's costing criteria.

There may be occasions where structure sharing is appropriate, and user-defined parameters to account for this is a desirable feature. However, the HM2.2.2 default assumption that structure sharing always occurs and that the efficient entrant will always incur only one-third of all structures-related costs is not reasonable. It is not appropriate to assume, as the HM2.2.2 default does, that this proportion of structure sharing always occurs. A proxy model should have the flexibility to determine when structure sharing is appropriate and the amount of sharing that occurs.[12]

Both models use two sizes of Digital Loop Carriers ("DLC") when fiber feeder is placed. For smaller numbers of lines served, the BCM2 assignment of DLC size and cost is based on the number of lines served per feeder leg. This is preferable to the HM2.2.2 assignment based on density group, because it is based directly on the number of lines served by the DLC. ETI has noted instances where the HM2.2.2 method of assigning smaller DLCs may result in

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[10]Joint Board Decision, para 277

[11] Baldwin and Selwyn, August 1996, pp. 76-78.

inconsistencies.[13] The BCM2 also includes a user-adjustable parameter for a percentage discount on DLC costs, as it does for switching. HM2.2.2 does not include a user-adjustable parameter for DLC discounts.[14]

B. Switching

Both models need better documentation of switching costs to ensure their accuracy and to ensure that appropriate switching costs are included for non-Bell companies. It is important that switching costs be adequately identified so that only the incremental switching costs necessary to provide supported services are included. At this time, neither model provides the necessary detail to verify that the appropriate switching costs are being used.

The user-adjustable discount factor in BCM2 is a desirable feature, since discounts on switching equipment are likely to vary by company. Smaller companies, with less volume, are likely to receive lower discounts than companies purchasing larger quantities of switches. The BCM2 can be run on non-Bell CBGs only with a smaller discount factor to reflect this. This type of scenario is not possible with HM2.2.2.

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[12] For example, sharing may vary by cable type or density of the serving area.
[13] Susan M. Baldwin and Lee L. Selwyn, "Continuing Evaluation of Cost Proxy Models for Sizing the Universal Service Fund: Analysis of the Similarities and Differences Between the Hatfield Model and the BCM2," Economics and Technology, Inc., October 1996, p. 73.
[14] The models also differ in their choices of technology for larger DLC equipment. BCM2 uses three different sizes of Lucent SLC systems, while HM.2.2.2 uses a 672 line integrated DLC. The choice here depends on which type of system is viewed as the appropriate forward-looking technology.

The BCM2 model documentation provides more switching detail than HM2.2.2, allowing for better identification of fixed and per-line switching costs. HM2.2.2 only provides a switching cost curve with no documentation or supporting calculations provided to determine the reasonableness of the curve.[15] In addition, the BCM2 includes an explicit fixed cost figure for remote switching, with remote switches located in those wire centers that are currently designated as remote locations.

Although BCM2 includes more switching cost detail, BCM2 could improve its switching costs by providing a finer disaggregation of fixed costs for switches of less than 10,000 lines. For example, separate categories for under 1,000 lines, 1,000 to 5,000 lines, and 5,000 to 10,000 lines would be an improvement, since many smaller companies purchase switches in these smaller sizes.

C. Interoffice Transport

The BCM2 model currently lacks an explicit calculation of interoffice facilities and simply adds a user-adjustable factor to its switching costs to account for these costs. The explicit modeling of interoffice facilities would be an improvement to the model.

HM2.2.2 assumes all interoffice transport is carried over 24-strand fiber with OC12 electronics equipped with 12 DS3s. While this may be appropriate for

[15] The switching data used in the Hatfield model was obtained from a McGraw-Hill publication, U.S. Central Office Equipment Market—1994. This data can only be audited by purchasing the publication for approximately $2,000.

many high-density routes (and, in fact, may not be sufficient for some very high traffic routes), it vastly overstates the needed capacity for lower-density routes. This may be a result of HM2.2.2's exclusive focus on Bell-only territory. For example, many smaller companies often use OC3 electronics and may not fully equip them, needing only 1 or 2 DS3s to accommodate current and anticipated traffic. Furthermore, smaller routes often use 12-strand fiber cable, not 24-strand. Therefore, HM2.2.2 understates transport costs in low-density locations.

D. Annual Cost Factors

The components of the annual cost factors (ACF) for translating investments into annual charges include the cost of money, taxes, depreciation, plant-related, and non-plant-related expenses. In addition, both models include factors to allocate joint and common costs to supported services, as mandated by the Joint Board's criteria. The factors should be forward-looking and reflect the fact that supported services will be provided in a competitive environment. In addition, specific components of the annual cost factors and joint and common cost allocators should be clearly identified and be user-adjustable.

The cost of money should reflect the expected forward-looking cost of money in a competitive environment. This is especially true given the Joint Board's criteria that require the proxy models estimate the cost of a market entrant. It is inconsistent with this principle and economically meaningless to assign a different cost of capital for the provision of supported services than for

the rest of the company. Given the added risk premium for competitive markets, both the FCC authorized 11.25% used by BCM2 and HM2.2.2's 10.01% appear to be too low. In fact, any regulatory-authorized rate of return, federal or state, is likely to be too low for a competitive environment.

Similarly, depreciation rates authorized by regulatory bodies are likely to be too low to reflect the forward-looking competitive environment. Again, it is inconsistent with the Joint Board's criteria and economically meaningless to assign a different depreciation rate for supported services than for the rest of the company.

Currently, both models estimate expense levels with a series of factors that represent ratios of various expenses to investments, and joint and common costs to investments. In addition, the BCM2 includes a per-line factor that represents the amount of customer operations and corporate overhead expense per-line. An in-depth analysis is required to develop the appropriate drivers of these costs to determine if they are best represented as a ratio to investment or if they are line-related. A detailed examination of ARMIS data provides a good starting point for establishing appropriate forward-looking direct expenses and joint and common costs. Full documentation should be required to support the resulting estimates.

Both models account for network support and general support expenses. However, it does not appear that full recovery of network support and general support investment is accounted for by BCM2. BCM2 includes a depreciation term for these categories, but does not appear to account for a return on

investment for these asset categories. While HM2.2.2 accounts for recovery of general support assets, such as furniture, office equipment, and general purpose computers, it does not appear to recover investments in network support assets, other than land and buildings. Better documentation is required by both models to ensure that all expenses and support assets are fully accounted for.

VI. Comparison of Proxy Model Cost Results

This section compares estimates of loop, switching, and overhead costs per line produced by the BCM2 and HM2.2.2 proxy models. We chose five states for the comparison—Arkansas, California, Texas, Utah, and Washington. The first three are states analyzed by the FCC in their examination of proxy models, and the last two are states analyzed by ETI in their reports. We performed baseline runs for each model in each state using the models' default parameter values and inputs. We also ran several additional scenarios to establish an "apple-to-apples" comparison between the BCM2 and HM2.2.2, and to conduct sensitivity analyses to determine which of the models' user-adjustable inputs have the largest impact on costs in each state. After discussing the baseline and alternative scenarios, we compare results between Bell CBGs and non-Bell CBGs.

A. Proxy Model Baseline and Alternative Scenario Results

Table 1 compares default per-line costs for BCM2 and HM2.2.2 in each of the five states we analyzed. BCM2 default costs include loop, switching and BCM2's $8.33 per-line customer and corporate operations factor. HM2.2.2 default costs include loop, switching, HM2.2.2's 10% variable overhead factor, and per-line charges for billing, directory listings, and local number portability.

Table 1
Average Monthly Cost Per Line
Benchmark Cost Model 2 and Hatfield Version 2.2, Release 2
Default Parameter Settings

	Arkansas	California	Texas	Utah	Washington
BCM2	$40.97	$24.50	$29.98	$31.21	$29.41
HM2.2.2	$21.59	$14.86	$16.80	$20.43	$16.89
Difference	$19.38	$9.64	$13.18	$10.78	$12.52

Below is a listing of the scenarios we ran with the BCM2 and HM2.2.2 models. Because there were features of each model that could not be changed to obtain comparability between the models, we had to manipulate both models to converge to an "apples-to-apples" comparison. For example, since HM2.2.2 only has the capability of using Bell-only CBGs, BCM2 was adjusted to Bell-only CBGs. Similarly, the variable overhead factor is adjustable in HM2.2.2, and this parameter was changed to achieve comparability with BCM2's overhead cost per line of $8.33 per month.

BCM2 Scenarios

B1. BCM2 with default parameters. We ran the BCM2 without modification.

B2. BCM2 with selected HM2.2.2 default parameters. We adjusted several BCM2 parameters to corresponding HM2.2.2 default values. The specific modifications are described in Appendix A. We employed the full set of CBG data for each state.

B3. BCM2 with default parameters, Bell CBGs only. We edited the BCM2 data files for each state to remove records for CBGs not served by Bell companies. We ran the BCM2, otherwise unmodified.

B4. BCM2 with selected HM2.2.2 defaults, Bell CBGs only. We changed the BCM2 user parameters as in scenario (B2), above, and ran the model using the edited CBG data as in scenario (B3).

B5. BCM2 with selected HM2.2.2 defaults, Bell CBGs only, business line density adjustment set to 1. This scenario is a variation on scenario (B4) with all of the BCM2 density group-related computations based on CBG lines per square mile rather than service points per square mile.

B6. Scenario (B5) results by density group were averaged using HM2.2.2 line distribution as weights. We constructed a weighted average of the monthly loop costs by density group from scenario (B5) using the HM2.2.2's distribution of lines by density group.

Hatfield Scenarios

H1. HM2.2.2 with default parameters. We ran the HM2.2.2 unmodified.

H2. HM2.2.2 with selected BCM2 default parameters, HM2.2.2 default structure sharing. We implemented the BCM2 cost of capital as described in Appendix A and changed the overhead calculation to a fixed $8.33 per line per month. However the HM2.2.2 assumption that 33% of structures costs are borne by telephony was retained.

H3. HM2.2.2 with selected BCM2 default parameters including telephony shares of structure costs. The cost of capital and overhead treatments for this scenario are as per scenario (H2), and additionally the structure cost share parameters were set to assign 100% of structure costs to telephony.

Table 2 presents our analysis of the sources of difference in the BCM2 and HM2.2.2 default results. This analysis is based on Tables A1 and A2 in

Appendix A. We found that we could explain most, if not all, of the differences in average monthly costs per line between the default runs of BCM2 and HM2.2.2 by modifying user-adjustable inputs (including the BCM2 input CBG data).

Table 2
Explanation of Difference Between BCM2 and HM2.2.2 Cost Proxy Models
Per-Line Costs

		Arkansas	California	Texas	Utah	Washington
1.	Default Difference: BCM2 - HM2.2.2	$19.38	$9.64	$13.18	$10.78	$12.52
2.	Overheads, Cost of Money (H2 - H1)	$5.61	$5.88	$5.83	$5.64	$5.79
3.	Structures cost sharing (H3 - H2)	$ 3.71	$3.12	$3.80	$3.68	$3.67
4.	Bell-only data (B1 - B3)	$6.73	$0.53	$2.73	$2.39	$3.24
5.	HM2.2.2 fills and buried / aerial mix (B3 - B4)	$(0.13)	$1.94	$0.11	$1.23	$0.43
6.	Setting BCM2 Density Adj = 1 (B4 - B5)	$(0.75)	$(1.33)	$(0.77)	$(1.64)	$(0.70)
7.	Density distribution controlled to HM2.2.2 (B5 - B6)	$ 0.09	$0.07	$0.75	$0.72	$0.23
8.	Total of Difference Accounted For	$15.26	$10.21	$12.45	$12.02	$12.66
9.	Percent of Difference Accounted For	79%	106%	94%	111%	101%

The top row of Table 2 is the baseline difference in costs between the models for each state from Table 1, where costs are based on the default input values of each model. The second row represents the difference in Hatfield scenarios H2 and H1. This consists of replacing HM2.2.2's 10% variable overhead factor with the BCM2 $8.33 per line customer and corporate operations loading, and using the BCM2's 11.25% cost of capital. The third row represents the difference between Hatfield scenarios H3 and H2. This represents the elimination of structure sharing so that the entire cost of structures is borne by the telephone company.

The fourth row in Table 2 represents an adjustment to BCM2 so that Bell-only CBGs are represented. The difference attributed to this change is given by the difference between BCM2 scenarios B3 and B1. The fifth row represents the difference between BCM2 scenarios B4 and B3. This difference represents the effect of using HM2.2.2 default values for fill factors and mix of buried and aerial cable on the BCM2 model estimated on Bell-only CBGs. The sixth and seventh rows reflect the adjustment of the BCM2 line distribution by density categories to comport with the HM2.2.2's density distribution.

Each model computes average costs for a number of density categories (measured either by lines or households per square mile). The average loop cost that is calculated for each density category is weighted by the relative proportion of access lines in that category to obtain the statewide average loop cost. The BCM2 and the HM2.2.2 do not assign CBGs to density categories the same way.[16] To make the BCM2 results more comparable to the Hatfield results, two adjustments were made to the BCM2's density distribution: the BCM2 was run with the business line density adjustment set to 1 (BCM2 scenario B5); and the HM2.2.2 density distribution was used to weight the results for each density cell into an overall result to control for differences due to using the 1990 Census versus the 1995 Census update and to control for BCM2's low-density area reduction (BCM2 scenario B6). The differences in BCM2 results (where BCM2 is

[16] Appendix B explains how each model assigns CBGs to density categories and compares the density distributions of both models with the actual line distribution for California.

estimated on Bell-only CBGs) attributable to these density adjustments are found in rows 6 and 7 of Table 2.

Finally, rows 8 and 9 of Table 2 show the amount of the difference between BCM2 and HM2.2.2 results accounted for by these adjustments. Overall, these adjustments account for most of the differences between the two models. In fact, for three of the states--California, Utah, and Washington—more than the entire amount of the difference between the two models can be explained by the factors we have analyzed. In general, the majority of the difference is attributed to three of the adjustments: (1) the use of Bell-only CBGs to estimate costs (California is the exception); (2) the HM2.2.2 10% variable overhead factor and 10.01% cost of capital; and (3) HM2.2.2's default assumption that only 33% of structures-related costs are borne by the telephone company.

Our analysis demonstrates that assumptions regarding parameter input values are critical to the proxy models' results. Therefore, it is extremely important that parameter input values be extensively documented and fully justified in order that the proxy models produce appropriate results. It is also very important to have a clear understanding of the geographic area being estimated by the models. As Table 2 demonstrates and we further illustrate below, there are significant cost differences between Bell and non-Bell territories.

B. Costs in Bell versus Non-Bell Territories

Because HM2.2.2 only estimates costs for CBGs served by Bell companies, it is likely that many high-cost areas are not included in the Hatfield results. Table 3 shows BCM2 average monthly costs for all CBGs, Bell-only CBGs, and non-Bell CBGs. To make the comparison comparable to the Hatfield Bell-only results, the BCM2 model was run with the HM2.2.2 user input assumptions specified in Appendix A (Scenario B4 from above). Table 3 indicates that by restricting its input data to only those CBGs served by Bell companies, HM2.2.2 is eliminating many of the highest-cost CBGs from its calculations. Using the Bell-only costs to portray costs for the rest of the state results in a significant understatement of non-Bell costs. Even in California, there is a 10 percent difference between Bell and non-Bell CBGs.

Table 3
Comparison of BCM2 Results for Bell and Non-Bell CBGs

	All CBGs	Bell CBGs	Non-Bell CBGs
Arkansas	$41.41	$34.37	$53.03
California	$22.60	$22.04	$24.42
Texas	$30.12	$27.14	$38.28
Utah	$29.96	$27.59	$79.00
Washington	$29.04	$25.74	$34.84

C. Other

Overall, we found that the BCM2 was easier to use and offers greater flexibility. As we tested the models, the advantages of the BCM2 became

apparent. Testing and sensitivity analysis was much easier with BCM2 than with HM2.2.2.

The BCM2 is also more of an open model. While the cells may be locked, the formulas are all visible and can be traced through. All of the model calculations are done on one worksheet as opposed to the multiple modules of HM2.2.2. Each module of HM2.2.2 is an extremely large Excel spreadsheet with many worksheets within it. It is very difficult to trace calculations because the Excel auditing features have been disabled and many cells are locked.

Both models can take a long time to process (over two hours in some cases) and require tremendous computing power, particularly the recommended 128 MB of RAM. HM2.2.2 would often stop processing or run out of memory despite the 128 MB or RAM installed on our test computers. The models' inability to run in a short period of time on a typical desktop computer with 16 MB of RAM appears to depend on the choice of Excel as the development platform rather than the models' inherent complexity. The model sponsors should determine if Excel is the appropriate platform for the models. The models might be programmed in a standard environment, such as C++ or Visual Basic. Alternatively, a relational database program, such as Microsoft Access or Microsoft FoxPro, may be better suited to processing the large data sets required.

Both models should have the flexibility to compute costs and support levels at various geographic areas, such as sub-wire center, wire center, etc. At the current time, neither model has this capability. But the BCM2 offers more